KENDRION

Kuhnke FIO Controller 111

Instruction Manual

E 864 GB 21.02.2025

PRECISION. SAFETY. MOTION.

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1 Preface

1.1 Legal Notice

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Document history

Modification History

Date	Comments / Modifications
13.02.2024	Original version
20.03.2024	X3 Module Connector: Slot assignment added PTO Interface: Error code description added
2/2025	X3 Module Connector: Order data supplemented

1.2 About this Manual

This technical information is primarily directed to system designers, project engineers and device developers. It does not contain any availability information. We reserve the rights for errors, omissions and modifications. Pictures are similar.

1.2.1 Limitation of Liability

Specifications are for description only and are not to be understood as guaranteed product properties in a legal sense. Exact properties and characteristics shall be agreed in the specific contract. Claims for damages against us - on whatever grounds - are excluded, except in instances of deliberate intent or gross negligence on our part.

1.2.2 Terms of Delivery

The general conditions of sales and service of Kendrion Kuhnke Automation GmbH & Co. KG shall apply.

1.2.3 Copyright

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

Further information about the PLCopen organisation is available at www.plcopen.org. CiA® and CANopen® are registered joint brands of CAN in Automation e.V. Title to all companies and company names mentioned herein as well as to products and product names is held by the respective enterprises.

CODESYS© is a product of CODESYS GmbH.

1.2.4 Software licences

Firmware

The units' firmware contains open source software. Some of this software is subject to the following and other open source licences:

- GNU General Public License (GPL)
- MIT License
- BSD Zero Clause License
- GNU Lesser General Public License (LGPL)
- Mozilla Public License (MPL)
- FreeType License (FTL)

Within three years of delivery, customers may buy the source code of the free software from Kendrion Kuhnke's product management at net costs.

CODESYS

Like all other CODESYS products, the CODESYS runtime version installed in this system is subject to CODESYS GmbH's end user licence agreement (EULA) as published on the CODESYS website.

1.2.5 Warranty

Warranty is subject to the provisions of the conditions of sale of Kendrion Kuhnke Automation GmbH or any contractual agreements between the parties.

1.3 Reliability, Safety

1.3.1 Applicability

For reasons of personal safety and to avoid material damages when working with or handling this Kuhnke product, you are advised to take heed of the notes and information contained in this instruction manual.

1.3.2 Target Group of the Instruction Manual

This instruction manual contains all information necessary for the use of the described product (control unit, control terminal, software, etc.) according to instructions. It is written for design, project planning, servicing and commissioning experts. For proper understanding and error-free application of technical descriptions, instructions for use and particularly of notes of danger and warning, extensive knowledge of automation technology is compulsory.

1.3.3 Intended Use

Kuhnke's products are designed, developed and manufactured for standard industrial use. They must not be used for any other purposes than the ones specified in the catalogue or the associated technical documentation. Proper and safe operation depends on the products being transported, stored, lined up, mounted, installed, put into service, operated, and serviced correctly. Ambient conditions must be within the admissible limits. Notes and information in the associated documentation apply at all times.

1.3.4 Reliability

Reliability of Kuhnke products is brought to the highest possible standards by extensive and cost-effective means in their design and manufacture.

These include:

- selecting high-quality components,
- quality agreements with our suppliers,
- actions to avoid static charges when handling MOS circuits,
- worst case planning and design of all circuits,
- visual inspections at various stages of fabrication,
- computer-aided tests of all assemblies and their interaction in the circuit,
- statistical assessment of the quality of fabrication and of all returned goods for the immediate taking of appropriate corrective actions.

1.3.5 Hazard and Other Warnings

Despite the actions described in section 1.3.3, the occurrence of faults or errors in electronic control units - even if most highly improbable - must be taken into consideration.

Please pay particular attention to the additional notices which we have marked by symbols throughout this instruction manual. While some of these notices make you aware of possible dangers, others are intended as a means of orientation. They are described further down below in descending order of importance.

Every alert and hazard warning is made up as follows:

Type and source of risk

Potential consequences of non-observance

⇨ Preventive measures

	***DANGER***
	A DANGER warning makes you aware of an immediately hazardous situation which WILL cause a serious or fatal accident if not observed.

	***WARNING***
	A WARNING makes you aware of a potentially hazardous situation which MAY cause a serious or fatal accident or damage to this or other devices if not observed.

	***CAUTION***
	A CAUTION alert makes you aware of a potentially hazardous situation which MAY cause an accident or damage to this or other devices if not observed.

	***NOTE***
	A NOTE makes you aware of a potentially hazardous situation which MAY cause damage to this or other devices if not observed.

1.3.6 Other Notices

	***Information***
	This symbol draws your attention to additional information concerning the use of the described product. This may include cross references to information found elsewhere (e.g. in other manuals).

1.3.7 Safety

Our products normally become part of larger systems or installations. The information below is intended to help you integrate the product into its environment without dangers to humans or material/equipment.

DANGER

Non-observance of the instruction manual

Measures for the prevention of dangerous faults or errors may be rendered ineffective or new hazard sources created.

- ⇨ *Thoroughly read the instruction manual*
- ⇨ *Take particular heed of the hazard warnings*

Information

To achieve a high degree of conceptual safety in planning and installing an electronic controller, it is essential to exactly follow the instructions given in the manual because wrong handling could lead to rendering measures against dangers ineffective or to creating additional dangers.

Project Planning

- 24 VDC power supply: generate as electrically safely separated low voltage. Suitable devices include split-winding transformers built in compliance with European Standard EN 60742 (corresponds to VDE 0551).
- Power breakdowns or power fades: the program structure is to ensure that a defined state at restart excludes all dangerous states.
- Emergency-off installations must comply with EN 60204/IEC 204 (VDE 0113). They must be operative at any time.
- Safety and precautions regulations for qualified applications have to be complied with.
- Please pay particular attention to the notices of warning which, at relevant places, will make you aware of possible sources of dangerous mistakes or faults.
- Relevant standards and VDE regulations are to be complied with in every case.
- Control elements are to be installed in such a way as to exclude unintended operation.
- Lay control cables such that interference (inductive or capacitive) is excluded if this interference could influence controller operation or its functionality.

Maintenance and Servicing

- Precautions regulation VBG 4.0 to be observed when measuring or checking a controller after power-up. This applies to section 8 (Admissible deviations when working on parts) in particular.
- Repairs must be carried out by specially trained Kuhnke staff only (usually in the main factory in Malente). Warranty expires in every other case.
- Only use parts approved of by Kuhnke. Only genuine Kuhnke modules must be used in modular controllers.
- Modular systems: always plug or unplug modules in a power-down state. You may otherwise damage the modules or (possibly not immediately recognisably!) inhibit their functionality.
- Always dispose of (rechargeable) batteries as hazardous waste.

1.3.8 IT Security

Kendrion Kuhnke products are designed for use in closed (private) industrial network environments.

In case such industrial networks are open to public access (e.g. via fully accessible network interfaces) or otherwise externally accessible (e.g. via data links and public (Internet) traffic), the integrator and operator must take appropriate organisational and technical precautions to protect the in-house network and ensure IT security.

	***Information***
	To find information about how to safely operate equipment, systems and networks, please refer to the texts published by BSI (Federal Office for Information Security), other publicly available sources and IEC 62443.

1.3.9 Electromagnetic Compatibility

Definition

Electromagnetic compatibility is the ability of a device to function satisfactorily in its electromagnetic environment without itself causing any electromagnetic interference that would be intolerable to other devices in this environment.

Of all known phenomena of electromagnetic noise, only a certain range occurs at the location of a given device. It is defined in the relevant product standards.

The design and immunity to interference of programmable logic controllers are internationally governed by standard
IEC 61131-2 which, in Europe, has been the basis for European Standard
EN 61131-2.

	***Information***
	Refer to IEC 61131-4, User's Guideline, for general installation instructions to be complied with to ensure that hardware interface factors and the ensuing noise voltages are limited to tolerable levels.

Interfering Emission

Interfering emission of electromagnetic fields, HF
compliant to EN 55011, limiting value class A, Group 1

	***Information***
	If the controller is designed for use in residential areas, high-frequency emissions must comply with limiting value class B as described in EN 55011. *Fitting the controller into earthed metal cabinets and installing filters in the supply lines may produce a shielding compliant to the above standard.*

General Notes on Installation

Electronic control systems, if run as component parts of machines, facilities and systems, must comply with valid rules and regulations, depending on their field of application.

General requirements concerning the electrical equipment of machines and aiming at the safety of these machines are contained in Part 1 of European Standard EN 60204 (same as VDE 0113).

Electrical Immission Safeguard

To eliminate electromagnetic interference, connect the control system to the protective earth or functional earth conductor. Practice best cable routing.

Cable Routing and Wiring

Keep power circuits separate from control circuits:

- DC voltages 60 V ... 400 V
- AC voltages 25 V ... 400 V

Joint laying of control circuits is allowed for:

- shielded data signals
- shielded encoder signals
- shielded analogue signals
- unshielded digital I/O lines
- unshielded DC voltages < 60 V
- unshielded AC voltages < 25 V

NOTE

In the case of EtherCAT data links, we recommend using Cat5e SF/UTP network cables. Do not use unshielded cables.

Location of Installation

Ensure that temperatures, contaminations, impact, vibration or electromagnetic interference are no impediment to the installation.

Temperature

Consider heat sources such as general heating of rooms, sunlight, heat accumulation in assembly rooms or control cabinets.

Contamination

Use suitable casings to avoid possible negative influences due to humidity, corrosive gas, liquid or conducting dust.

Impact and Vibration

Consider possible influences caused by motors, compressors, transfer lines, presses, ramming machines and vehicles.

Electromagnetic Interference

Consider electromagnetic interference from various local sources: motors, switching devices, switching thyristors, radio-controlled devices, welding equipment, arcing, switched-mode power supplies, converters / inverters.

Particular Sources of Interference

Inductive actuators

Switching off inductances (such as from relays, contactors, solenoids or switching magnets) produces surge voltages. It is necessary to reduce these extra voltages to a minimum.

Reducing elements may be diodes, Z-diodes, varistors or RC elements. Their rating should conform to the specifications provided by the manufacturer or supplier of the actuators.

2 System Description

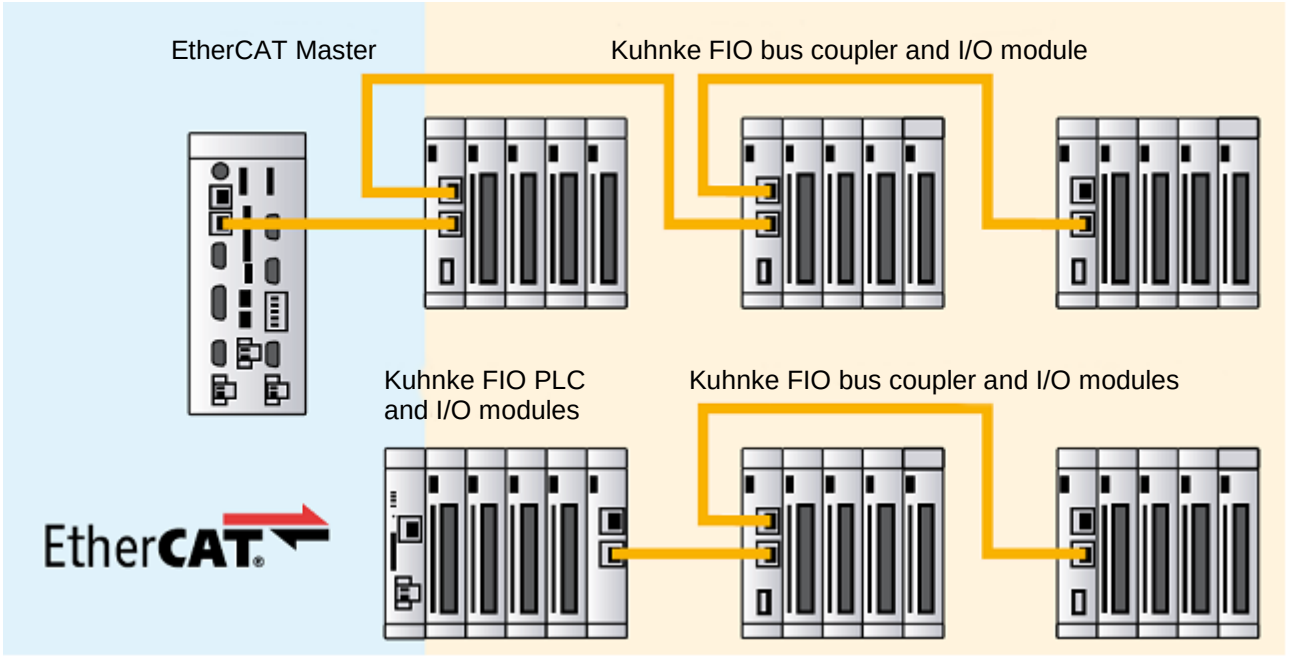
2.1 Kuhnke FIO

Kuhnke's FIO is a system of I/O modules for interconnecting the process signals in an EtherCAT network.

Kuhnke FIO consists of the Kuhnke FIO controller, Kuhnke FIO bus coupler and various Kuhnke FIO I/O modules.

Kuhnke FIO Controller 111 is a PLC equipped with a CODESYS V3 runtime system. It also supplies the system voltage to the FIO modules directly connected to it.

The Kuhnke FIO bus coupler converts the physical transfer technology (twisted pair) to LVDS (E-bus) and generates the system voltages required by the LVDS modules. The standard 100 Base Tx lines used for office network communications connect to the one side, the Kuhnke FIO I/O modules for the process signals connect to the other. This is how the Ethernet EtherCAT protocol is retained right through to the last I/O module.



2.2 CODESYS V3

CODESYS is a software platform designed to handle many tasks of industrial automation technology. It is based on the IEC 61131-3 programming system. The tool benefits users with integrated solutions tailored to their practical work and aimed at providing hands-on support with whatever job needs to be done.

CODESYS supports all five languages specified in IEC 61131-3 (International Electrotechnical Commission):

- IL (Instruction List)
- ST (Structured Text), based on PASCAL for structured programming
- LD (Ladder Diagram)
- FBD (Function Block Diagram)
- SFC (Sequential Function Chart)

Apart from the standard IEC languages, CODESYS also supports:

- CFC (Continuous Function Chart) is a FD (function diagram) editor with a fully configurable graphical layout: whereas FD editors are network-based and automatically arrange the function blocks, CFC lets users place the blocks anywhere such that feedback effects can be created without any temporary variables. This feature makes the language the perfect choice for creating an overview of the application.

Fieldbus Technology

The CODESYS programming system allows the direct configuration of the CANopen and EtherCAT fieldbuses. Protocol stacks can be separately installed as CODESYS libraries for some systems.

CODESYS Control

CODESYS Control is a soft PLC runtime system installed in Kuhnke Controller 111 and adapted to its hardware. It turns Kuhnke Controller 111 into an industrial controller in conformity with IEC 61131-3. This runtime system also features some extra functions that let the controller communicate with other components in its automation environment.

CODESYS visualisation

An editor integrated in the CODESYS programming system allows users to create complex visualisation screens and to animate them by means of the application variables. The appropriate visualisation elements are provided by the software. Once created, the screens may help to test an application or to start it up in the programming system's online mode, for example. Running the optional visualisation clients **CODESYS HMI** and **CODESYS WebVisu** makes the screens a means of operating the machine or system.

Software Releases

Various software options or combined software options are available for installation in the devices. Please ask product management for the combination that best fits your needs.

Software Options		
Option	**Identification**	Function
CODESYS Control	**V3**	This basic software package processes the programmed IEC 61131-3 code and debugs the code when working with CODESYS. This software is a main feature of all Scout-series devices
CODESYS TargetVisu	**TV**	CODESYS control unit extension for outputting visualisation screens to the control unit display. Generates the TargetVisualization immediately in the CODESYS Development System
CODESYS WebVisu	**WV**	A control unit running CODESYS WebVisu lets you display your own screens created in CODESYS in any web browser environment anywhere in the world.
CODESYS SoftMotion	**SM**	Use your standard IEC 61131-3 development interface to plan single or multi-axis movements up to and including the plotting of curves - together with the logic application. A Motion Controller running CODESYS SoftMotion provides the PLC programming system with a kit of motion functions. Motion Controllers running CODESYS SoftMotion support many user project planning variants for the given motion tasks by providing PLCopen-certified motion modules, the entire functionality of the IEC 61131-3 programming interface and other tools.
CODESYS SoftMotion CNC+Robotics	**SM+CNC**	3D-CNC motion control for Motion Controllers with a complete set of 3D-CNC and/or robotics functions including interpolator and kinematic transformations. CODESYS SoftMotion CNC+Robotics provides you with an editor as a convenient way of configuring complex groups of robot axes. Run the editor, choose the appropriate kinematics, set its parameters and link them to the physical robot axes. Standardised function blocks process the robot functions in conformity with PLCopen MotionControl Part 4.

For further details, please visit the product pages of the CODESYS GmbH:

https://www.codesys.com/

3 Product Description

3.1 General Description of FIO Controller 111

Kuhnke FIO Controller 111 is an embedded PLC based on a microcontroller architecture equipped with a CODESYS runtime system, which is programmed by means of CODESYS V3.

A micro SD card can be attached to expand the memory to save larger volumes of parameters or process data process data. The micro SD card also benefits you with the option of changing system settings or backing up and restoring the control program.

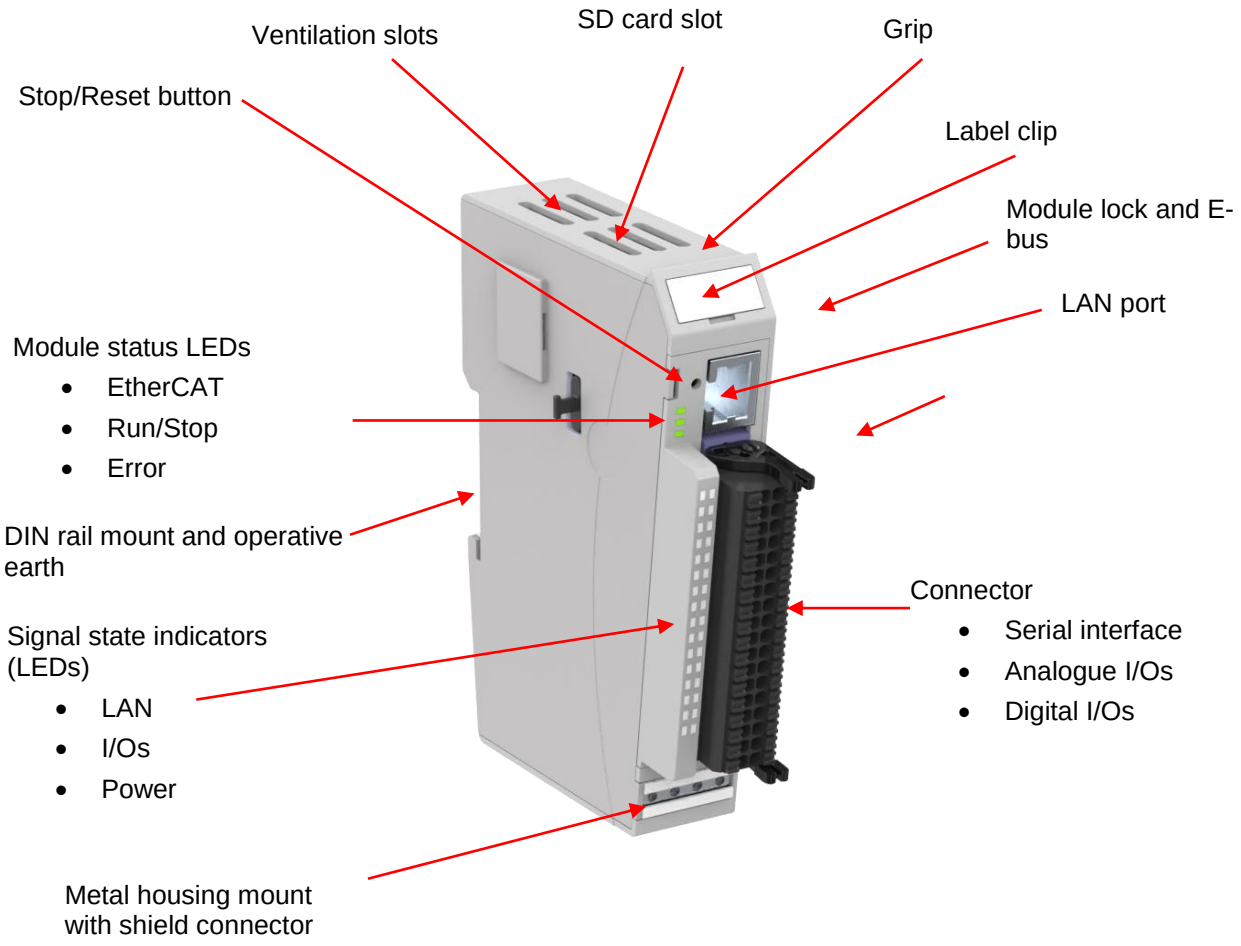
On one side of the modular control unit, there is an E-bus connector which provides for a flexible extension by Kuhnke FIO-series EtherCAT I/O modules. Or link in an extender module if you wish to actuate external EtherCAT slaves.

One way of exchanging data with other systems is to go through the on-board interfaces, i.e. Industrial Ethernet and RS485. Another way is to plug in interface and bus modules to provide further communication links and to facilitate system integration in existing control architectures.

Properties

- CODESYS V3 control unit
- Fieldbus master: EtherCAT®, CANopen®, Modbus RTU and TCP
- Pluggable Kuhnke FIO EtherCAT I/O expansion modules
- Multifunctional on-board I/O

3.2 View of the Product



3.3 Application

3.3.1 Intended Use

Kuhnke FIO Controller 111 is an embedded PLC, i.e. it features an on-board CODESYS PLC and on-board digital and analogue inputs and outputs. It also acts as a master of the KUHNKE FIO system I/O modules, which allow process signals to be directly attached to the control unit.

3.3.1 Foreseeable Misuse

Place of Installation

The unit is solely permitted for use in fully enclosed control cubicles or rooms.

Exhaust heat of the unit dissipates through the (top and bottom) ventilation slots and the aluminium U-profile. Verify that the place of installation is ventilated properly.

	***NOTE***
	Damage to the unit
	Choosing the wrong place of installation may cause damage to the unit.
	⇨ Check section 3.4 Technical Data for the admissible ambient conditions and the unit's mounting position.

3.4 Technical Data

3.4.1 Kuhnke FIO Controller 111

Technical data	
System data	
Product name	FIO Controller 111
Article number	694 300 11 000
Processor	STM32H7
On-board memory	Flash: 16 Mb for application, 2 Mb for data RAM: 16 Mb for application Remanent data: 8136 bytes
Disk drives	1x micro SD card slot (user)
Software	Operating system: free RTOS; Application: CODESYS Control V3 embedded, ...
Ports	Electrical insulation: 1 x Ethernet 100MBit – RJ45; No electrical insulation: 1 x EtherCAT E-Bus, 1 x RS484 / CAN
Fieldbus	CANopen® master, EtherCAT® master using E-Bus system connector, Modbus RTU master, Modbus TCP master
On-board I/Os	8x digital input (adjustable filtering times, configurable special functions) 8x digital output, 4 x 0.5A / 4 x 0.2A (configurable special function) 2x analogue output (0…10V, 0…20mA, 4…20mA, 0…2.5V, 12 bit) 2x analogue input (0…10V, 0…20mA, 4…20mA, 0…2.5V, 12 bit) Special functions (fewer digital I/Os) 2x analogue input (0…10V, 12 bit) 2x A/B/Ref encoder 4x event counter (up to 100kHz) 4x PWM (up to 100kHz, pulse-duty factor 0.0 … 100.0%) 2x frequency generator output (up to 100kHz, pulse-duty factor 50%) 2x PTO axis interface (similar to DS402)
Clock	Real-time clock, buffer capacitor (SuperCap), power reserve >= 3 months
Power supply	24 VDC (-15 … 20%)
E-bus power supply	2A @ 55°C
Output	Approx. 3.5 W (@ 24 VDC)
Noise immunity	Zone B to EN 61131-2, mounted on earthed DIN rail in earthed control cubicle
Service conditions	
Ingress protection	IP20
Mounting position	Vertical, stackable
Storage temperature	-25°C ...+85°C
Operating temperature	0°C ...+55°C
Rel. humidity	5% … 95%, non-condensing
Mechanical properties	
Installation	35 mm DIN rail (top-hat rail)
Dimensions	25 mm x 120 mm x 90 mm (W x H x D)
Housing mount	Aluminium
Shield	Connects straight to module housing

	NOTE
	Real-time clock
	The built-in real-time clock (RTC) is powered by a buffer capacitor (SuperCap). A complete charging cycle takes about 24 hours of operation.
	⇨ Shorter charging times will reduce the RTC's power reserve

3.4.2 System Priorities

FIO Controller 111's operating system FreeRTOS has 32 priorities, 0 (low prio) to 31 (high prio).

Information on the running tasks can be found in the web interface in the "System Information" menu.

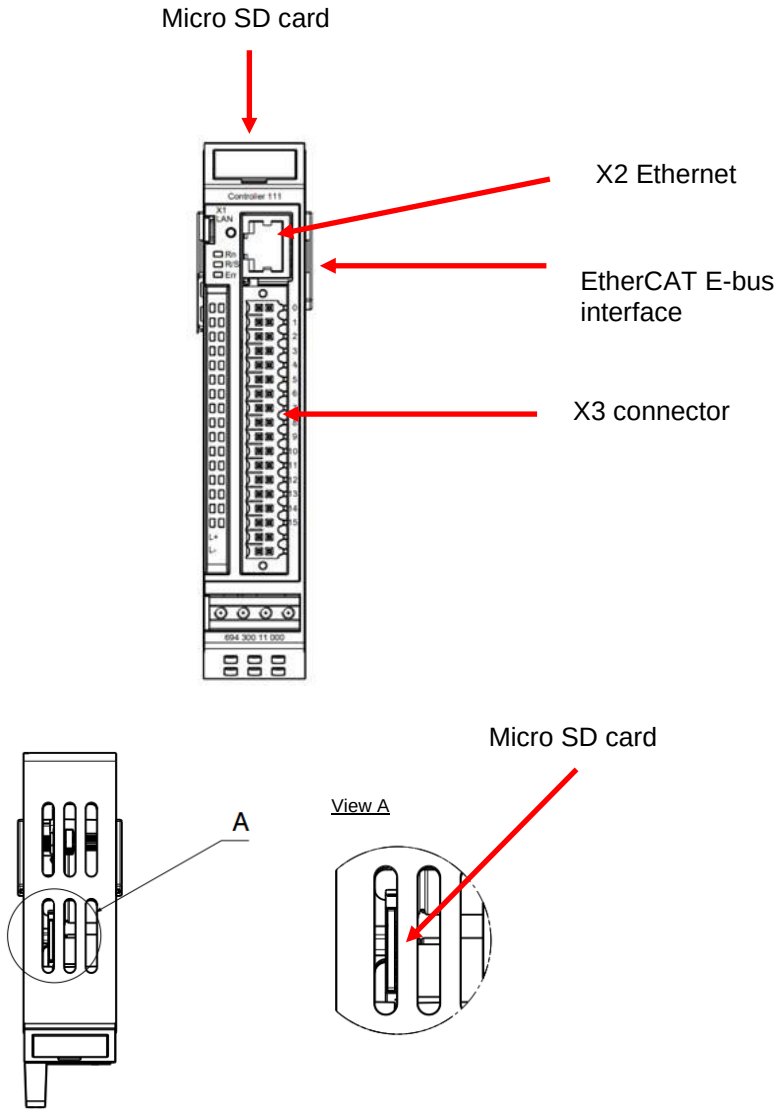
A FreeRTOS task is only created for cyclical CODESYS tasks. CODESYS task priorities from 1...8 are permitted.

PRIO	FreeRTOS task	Comment
28	ECAT_Rx	Real-time EtherCAT fieldbus communication
27	CAN1_Rx	Real-time CAN fieldbus communication
26	RTS_1ms_IST	Cyclic polling of various signals such as low voltage every 1 ms, push-buttons every 10 ms, SD card plugged/unplugged every 100 ms etc.
25	IEC_TASK_0	Real-time CODESYS IEC task prio 1
24	IEC_TASK_1	Real-time CODESYS IEC task prio 2
23	IEC_TASK_2	Real-time CODESYS IEC task prio 3
22	IEC_TASK_3	Real-time CODESYS IEC task prio 4
21	ETH0_Rx	Ethernet communication (data in)
20	ETH0_IST	Ethernet communication (interrupt service task)
19	ETH_TcpIp	Ethernet communication (TCP/IP stack)
18	defaultTask	Higher-level system state machine
15	IEC_TASK_4	Default CODESYS IEC task prio 5
14	IEC_TASK_5	Default CODESYS IEC task prio 6
13	IEC_TASK_6	Default CODESYS IEC task prio 7
12	IEC_TASK_7	Default CODESYS IEC task prio 8
4	ETH_Http	Web configuration interface
1	RTS_Background	CODESYS background task
0	IDLE	Idling task

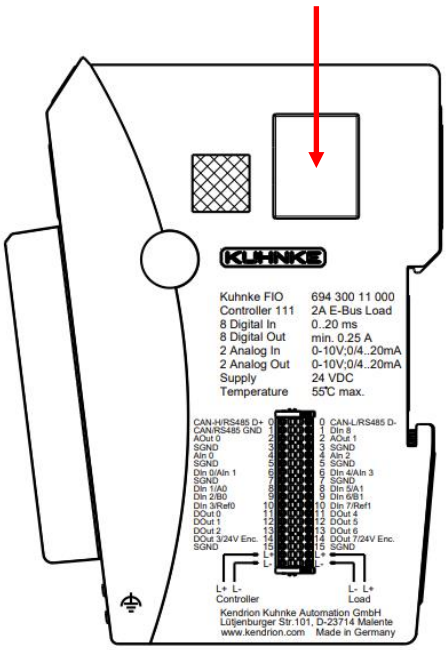
4 Construction and Functionality

4.1 Connectors

While all external connectors plug in at the front of the unit, the modules of the FIO EtherCAT I/O system connect to the EtherCAT E-bus interface on the right side



EtherCAT E-bus interface



4.1.1 X2 Ethernet "LAN"

The on-board 10/100 Mbit base-T Ethernet adapter attaches the unit to a network through its RJ-45 connector. The LAN configuration lists this connector as LAN1. The LEDs labelled "LNK" and "Activity" tell you whether the unit is properly connected to the network.

Pin wiring:

LAN		
Male plug	**Pin**	Function
RJ45	**1**	TX+
	2	TX-
	3	RX+
	4	75 Ohm
	5	75 Ohm
	6	RX-
	7	75 Ohm
	8	75 Ohm

Information

The E-bus connector on the side is provided for use as EtherCAT fieldbus interface.

NOTE

Unauthorised access to the computer

Controller failure and data loss

⇨ Integration in networks granting public access requires the user to take appropriate measures aimed at preventing unauthorised access.

4.1.2 X3 Module Connector

The system connector pins carry different signals reflecting the many different configuration options of both the local inputs and outputs and the serial interfaces.

Slot	Signal		Pin	Pin	Signal		Slot
	RS485 D+	CAN H	0	0	RS485 D-	CAN L	
	RS485 GND	CAN GND	1	1	DI09 (IRQ)		
1	Ao01		2	2	Ao02		1
	GND		3	3	GND		
2	Ai01		4	4	Ai03		2
	GND		5	5	GND		
3	DI01 (Ai02)		6	6	DI05 (Ai04)		4
	GND		7	7	GND		
5	DI02 (CNT1, ENC1 A, PTO02 LS-)		8	8	DI06 (CNT3, ENC2 A, PTO02 LS-)		6
	DI03(ENC1 B, PTO02 LS+)		9	9	DI07 (ENC2 B, PTO02 LS+)		
	DI04 (CNT2, ENC1 Z, PTO02 Ref)		10	10	DI08 (CNT4, ENC2 Z, PTO02 Ref)		
7	DO01 (PWM01, FG01, PTO01 Clk)		11	11	DO05 (PWM03, FG02, PTO02 Clk)		8
	DO02 (PWM02, PTO01 Dir)		12	12	DO06 (PWM04, PTO02 Dir)		
9	DO03 (PTO01 enable)		13	13	DO07 (PTO02 enable)		9
	DO04 (ENC1 24V)		14	14	DO08 (ENC2 24V)		
	GND		15	15	GND		
	Logik 24V DC		16	16	Last 24 VDC		
	GND		17	17	GND		

Abbreviations: Ao = analogue output, Ai = analogue input, DO = digital output, DI = digital input, ENC = encoder (A/B/Z)

In brackets: special functions of that channel

4.1.2.1 Local Inputs and Outputs

Configuration of the local inputs and outputs of FIO Controller 111 is very variable and flexible. CODESYS configures easily by means of plug-in modules.

AI: Analogue Inputs

There are up to 4 analogue inputs when fully configured. Parameters are set using a drop-down menu.

- Simple assignment: AI1, AI3
- Multiple assignments: AI2 (DI1), AI4 (DI5)

AO: Analogue Outputs

There are 2 analogue outputs.

- Simple assignment: AO1, AO2

DI: Digital Inputs

There are up to 9 analogue inputs, depending on your configuration. Plugging in a module selects the type of input. Parameters are set using a drop-down menu.

- Simple assignment: DI9
- Multiple assignments: DI1 (AI2), DI2 (CNT1, PTO1, ENC1 A), DI3 (PTO1, ENC1 B), DI4 (CNT2, PTO1, ENC1 Z),
  DI5 (AI4), DI6 (CNT3, PTO2, ENC2 A), DI7 (PTO2, ENC2 B), DI8 (CNT4, PTO2, ENC2 Z)

DI Special Function: Event Counter

Inputs 2 & 4 and inputs 6 & 8 provide an optional event counter function.

Parameters are set using a drop-down menu.

DI Special Function: Encoder A/B/Z

Input 2 to 4 and inputs 6 to 8 provide an optional A/B/Z encoder function. Plugging in the correct module selects this special function.

DO: Digital Outputs

There are up to 8 inputs, depending on your configuration.

- Multiple assignments: DO1 (FG, PWM, PTO Clk), DO2 (PWM, PTO Dir), DO3 (FG, PWM, PTO enable), DO4 (ENC1 24V),
  DO5 (FG, PWM, PTO Clk), DO6 (PWM, PTO Dir), DO7 (FG, PWM, PTO enable), DO8 (ENC2 24V)

DO Special Function: Pulse-width Modulation (PWM)

Plugging in the correct module selects this special function.

This special function is provided by digital outputs DO1 & DO2 and DO5 & DO6.

DO Special Function: Frequency Generator (FG)

Plugging in the correct module selects this special function.

This special function is provided by digital outputs DO1 and DO5.

DO Special Function: Pulse-train Output (PTO)

Plugging in the correct module selects this special function.

This special function is provided by digital outputs DO1 & DO2 and DO5 & DO6.

DO Special Function: PTO Enable

Plugging in the correct module selects this special function.
This special function is provided by digital outputs DO3 and DO7.

DO Special Function: Encoder Power Supply

Plugging in the correct module selects this special function.
This special function is provided by digital outputs DO4 and DO8.

4.1.2.2 Connector Details

The spring-assisted PUSH-IN connector allows you to quickly attach the wires by direct insertion without any tools. Just insert the connector sleeve end of the stripped solid or fine wire in the correct opening.

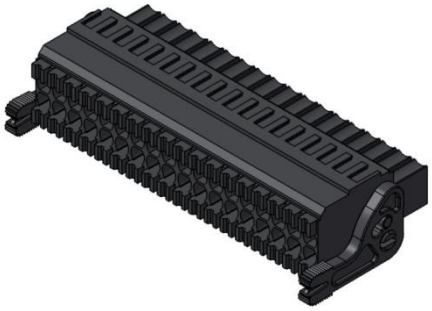
Two rows:

Wires: 320V / 13.4 A / 0.14 - 1.5 mm² (IEC)

Nominal current: 300V/ 9.5A/ 26-16 AWG (UL)

PUSH IN connector with release lever

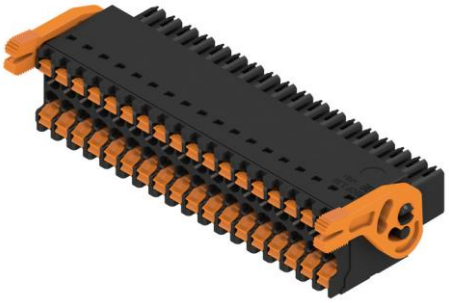
Number of poles: 36



Weidmüller Order-No. 1460200000

PUSH IN connector with release lever

Number of poles: 36



Weidmüller Order-No. 1375880000

Supported wires with connector sleeves:

	Wire cross section [mm²]						
Connector sleeve type	0.14	0.25	0.34	0.50	0.75	1	1.5
Connector sleeve w/ collar to DIN 46 228-4	8 / 10	8 / 10	8 / 10	10 / 12	12 / 14	12 / 15	
Connector sleeve w/o collar to DIN 46 228-1	10 / 10	10 / 10	10 / 10	10 / 10	10 / 10	10 / 10	10 / 10
	Stripped end [mm] / sleeve length [mm]						

4.1.2.3 Power Supply

On-board Power Supply Unit (PSU)

The FIO Controller features an on-board power supply unit (PSU) designed for an input voltage of 24 VDC (18 V ... 32 V). The PSU is protected against reverse polarity. It supplies power to the FIO Controller's CPU core and to the FIO modules connected to the E-bus.

Verify that both the cord and the PSA are externally protected against short circuit and overload triggering at max. 10 A.

4.1.3 Operative Earth

Connect operative earth to the protective earth conductor of the switching cabinet or the system that Kuhnke FIO Controller 111 is installed in. Connection is made via the earthed DIN rail. In special cases you may attach the earth wire straight to the module.

Verify that the cross section is not less than 2.5 mm^2. Try to keep the lead to the cabinet terminal as short as possible.

	***Information***
	A low-impedance earth conductor improves the dissipation of interference received via external power supply cables, signal cables or cables of peripheral units.

4.1.4 Micro SD Card

FIO Controller 111 features a micro SD card slot in a ventilation slot on top of the unit.

The micros SD card slot has a push-in/push-out plug & eject mechanism. You may use a flat object to help you plug in or eject the card.

You will find the micro SD card at: 0:/

Micro SD card properties

- Supported format(s): FAT32, 512 bytes per sector
- Maximum memory size: 32 Gb
- Maximum file size: 4 Gb – 1 byte
- Quality: industrial grade
- Technology: SLC

	***NOTE***
	Electrostatic discharge (ESD) *Inappropriate handling will destroy the memory card* ⇨ SD cards are susceptible to electrostatic discharge (ESD). Please take account of the instructions on how to handle memory cards.

	***Information***
	The SD card slot has no hot-plug capability. They will therefore detect cards only if they were plugged in at the time of booting the unit. SD cards have no hot-swap capability.

4.2 Labelling and Identification

Laser marking on the front and the right side wall
Label with serial number on aluminium frame
Label with software licence on aluminium frame

4.3 Contents of Package

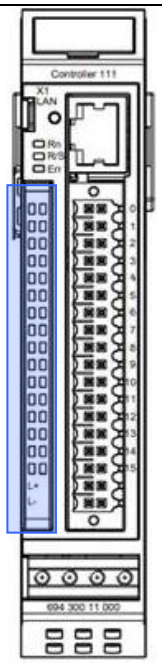
The Kuhnke FIO Controller 111 package includes:

- Kuhnke FIO Controller 111
- 36-pin male connector

4.4 Indicators and Controls

4.4.1 Status LEDs

The status LEDs at the front indicate the status of both the PLC and the local ports. The LEDs next to the inputs and outputs are allocated to the channels.

Status				**Description**	
RN				EtherCAT run	
R/S				PLC run, PLC stop, system function enabled	
Err				PLC error, feedback S/R button	
Channel			**Channel**		
Activity			Link	Ethernet	
			DI9	Digital input signal	
AO1			AO2	2-col. LED: analogue output enabled, error	
AI1			AI3	Analogue input	
DI1			DI5	Digital input signal	
DI2			DI6	Digital input signal	
DI3			DI7	Digital input signal	
DI4			DI8	Digital input signal	
DO1			DO5	2-col. LED: output enabled, error	
DO2			DO6	2-col. LED: output enabled, error	
DO3			DO7	output enabled	
DO4			DO8	output enabled 2-col. LED: output enabled, error (DO3, 4, 7, 8)	
Logic circuitry			Load	Supply voltage	

LED EtherCAT Run:

State	LED, flash code	Explanation
Init	Off	Initialising, no data exchange
Pre-Op	Off/green, 1:1	Pre-operational, no data exchange
Safe-Op	Off/green, 5:1	Safe operation, inputs readable
Op	On	Operational, unrestricted data exchange

LED R/S

State	LED, flash code	Explanation
SPS Run	Green	CODESYS Application running
SPS Stop	Red	CODESYS Application stopped
System function	Yellow	Maintenance Mode, SD-Card Update
Firmware update	red blinking	The R/S LED flashes irregularly during the firmware update. Once the firmware update is complete, the R/S LED flashes green briefly.

LED Err

State	LED, flash code	Explanation
Ok	Off	No error present
Error	Red on	Fatal error
	Red 1x	Short circuit I/Os
	Red 2x	Undervoltage Logic / Load
	Red 3x	Watchdog
	Red 5x	Overtemperature
	Red 6x	Module-specific error message
	Red 7x	I/O Configuration error
	Red 8x	No boot application available

4.4.2 Stop/Reset Button

The Stop/Reset button is located underneath the status indicators at the front of the unit.

To avoid it being pushed unintentionally, the Stop/Reset button can be operated using a pointed object (pen, screwdriver) only.

Its function depends on the current state of FIO Controller 111.

CODESYS Stop – Start – Reset

Briefly press the button to stop the running CODESYS application. Run/Stop changes from green to red.

Briefly press the button again to restart the CODESYS application. Run/Stop changes from red to green.

Service Mode

Service mode is enabled by turning off FIO Controller 111. Now press and hold the button to restart FIO Controller 111. Keep pressing the button until Run/Stop lights up yellow every 2 seconds.

5 Operation

5.1 Installation

5.1.1 Mechanical Installation

⇨ Kuhnke FIO I/O modules are intended for mounting rail installation (DIN EN 50022, 35 mm x 7.5 mm).

To Snap on a Single Module

⇨ Push up the module against the mounting rail from below, allowing the metal spring to snap in between mounting rail and mounting area as illustrated.
⇨ Push the top of the module against the mounting wall until it snaps in.

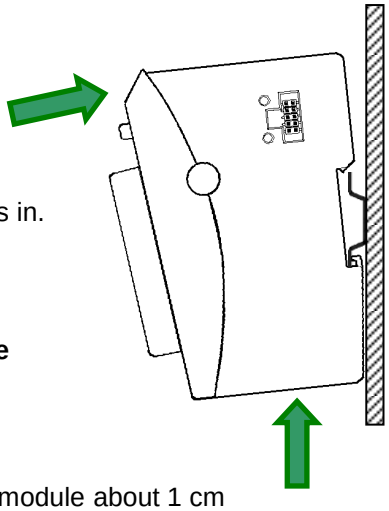


Figure1: Rail mounting of module

To Interconnect Two Modules

⇨ After snapping on the first module to the rail, snap on the second module about 1 cm away towards the right of the first module.
⇨ Push the second module along the rail towards the first module until you hear the locking device snap in.

To Disconnect Two Modules

⇨ Push down the unlock button (see Figure 2) of the module that you wish to disconnect from the module to the left of it.
⇨ With the button still pressed, push both modules away from one another until they are about 1 cm apart.

To Take Down a Single Module

⇨ Push the module up and against the metal spring located on the underside of the rail guide.
⇨ Tip the module away from the rail as shown in the illustration.
⇨ Pull the module down and out of the mounting rail.

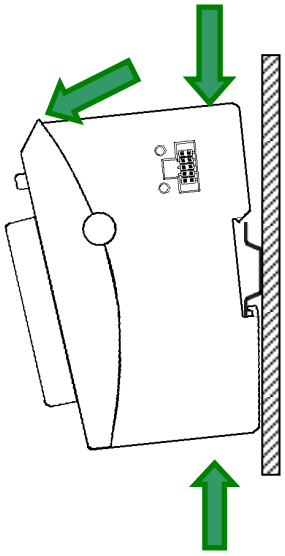
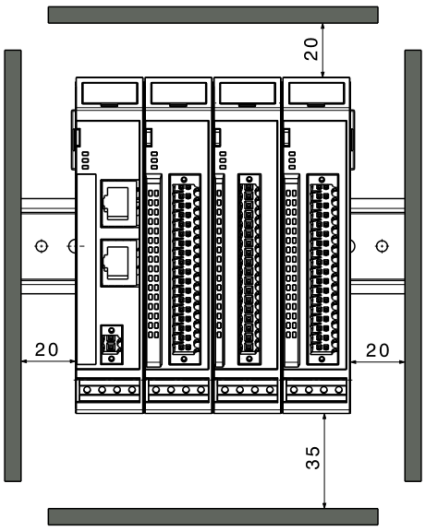


Figure 2: Uninstalling a module

Mounting Position

Mount with rail horizontally with the modules' multiple socket connectors pointing away from the wall. To ensure that enough air gets in through the ventilation slots, leave at least 20 mm to the top and 35 mm to adjacent devices or cabinet surfaces. Leave at least 20 mm of lateral distance to third-party units and cabinet surfaces.



Order of Modules in Multi-FIO Systems

	NOTE
	In order to ensure that the entire FIO system works properly, arrange the FIO modules by their specific E-bus load, placing the modules with the highest E-bus load immediately next to the head module (bus coupler or controller). Take account of the head module's maximum bus load. *If possible, place the Kuhnke FIO Safety I/O modules immediately next to the head module.*

5.1.2 Electrical Installation

⚠	***WARNING***
	Potentially hazardous failures due to wrong voltages supplied
	Supplying the wrong voltages may damage or destroy the unit and may provoke potentially hazardous failures.
	Preventive measures:
	⇨ We recommend only using PELV/SELV-ready power supply units to EN50178 or EN60950-1 to supply 24 VDC to bus couplers or compact PLCs.
	⇨ Only use the GND terminal to connect the power supply unit to earth (PELV system). Do not use earthing variants that connect earth to +24V.
	⇨ Remember that, even in case of a fault, a maximum voltage of U max. < 33 V may be supplied to these assemblies. Externally pRedecting the power supply unit is compulsory if you cannot exclude this risk.
	⇨ To ensure that there is as little interference as possible, install a central power supply point and establish a star topology of as short wires as possible between the central point and the block of FIO modules.

Earthing

Connect the Kuhnke FIO modules to earth by attaching the metal housing to functional earth.

Since the functional earth connector dissipates HF currents, it is of utmost importance for the module's noise immunity.

HF interference is dissipated from the electronics board to the metal housing. The metal housing therefore needs to be suitably connected to a functional earth connector.

You will normally have to ensure that

- the connection between module housing and DIN rail conducts well,
- the connection between DIN rail and switching cabinet conducts well,
- the switching cabinet is safely connected to earth.

In special cases you may attach the earth wire straight to the module.

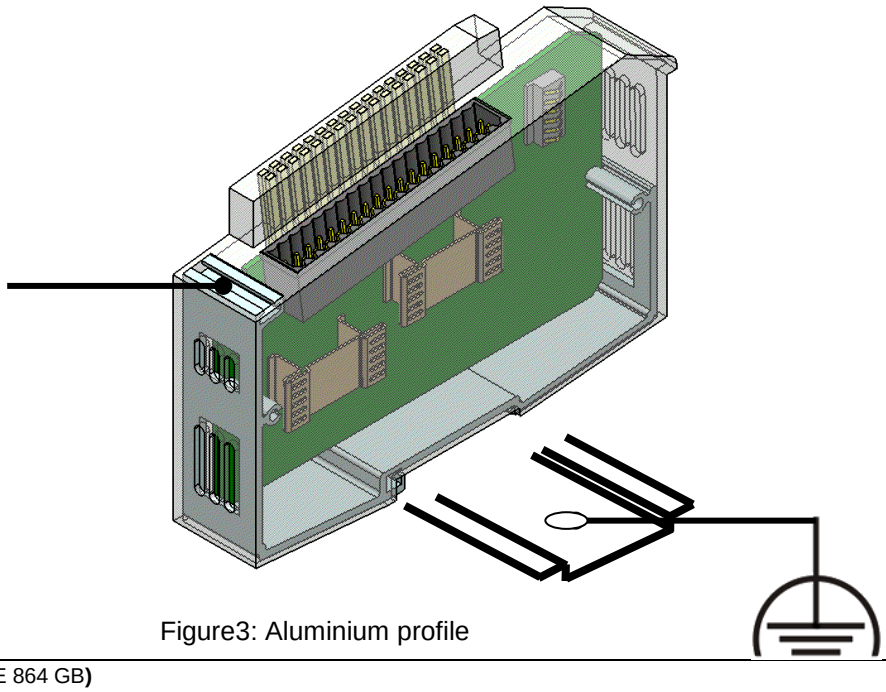


Figure3: Aluminium profile

	Information
	Earth wires should be short and have a large surface (copper mesh). Refer to http://de.wikipedia.org/wiki/ground_(electronics) for further details

Module Interconnection

The FIO modules electrically connect by completely pushing the modules together. This automatically connects them to the EtherCAT bus system and supplies power to the EtherCAT communication modules. FIO Controller 111 is always the first module of a FIO I/O block.

Please note that the power supplied by FIO Controller 111 limits the number of FIO modules you may connect to a single block.

Logic Power Supply (24 VDC)

Power to the logic circuitry is supplied through lines L+ and L- of the module plug.

	NOTE
	Risk of electric voltage
	Supply voltages outside of the admissible range may destroy the unit.
	⇨ Before turning on the supply voltage, verify that it is within the admissible voltage range.

Load Power Supply (24 VDC)

Power to the load is supplied through lines L+ and L- of the module plug.

Digital and Analogue I/Os

Note that the leads of digital and analogue I/Os must not be longer than 30 m.

5.2 Web Interface

5.2.1 Login

First of all, run a browser application on your PC to launch the web interface of FIO Controller. Internet Explorer, Chrome and Firefox are the current choice of browsers.
Type the following IP address of FIO Controller into your browser's address bar:

http://<IP address>

The following web site displays:

The password in the delivery status is the serial number of the device. Enter the password and then click on the "Login now" button.

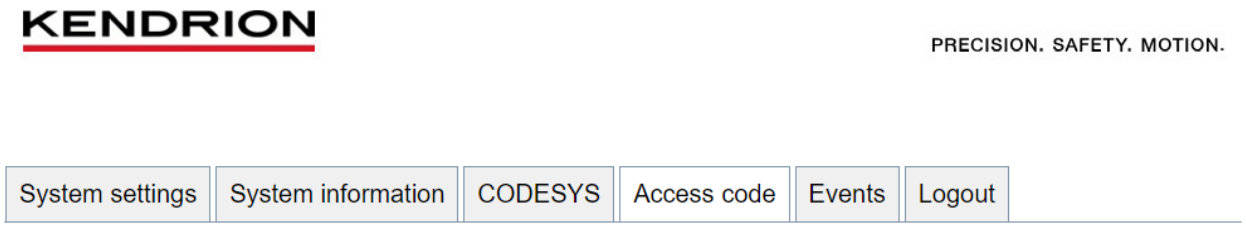
After successfully logging in, you will be prompted to change the password as long as the default password is used.

A new password must be assigned at this point. Enter the old password and then enter the new password twice. Then press the "Check password" button.

Then click on the "Change password" button. The new password is valid from this point on.

	NOTE
	Change of passwords
	Change the passwords of the user accounts before setting the control unit to productive or network use. Otherwise, the control unit can easily be accessed by using the default passwords.
	⇨ Write down the password and keep it in a suitable place.

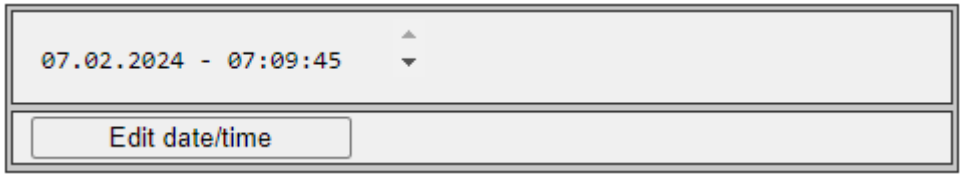
After the login procedure, you will see the following menu:



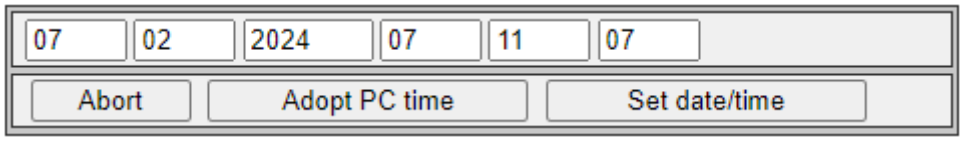
5.2.2 System Settings

On this page you have the option of changing the time and the IP address. It is also possible to restrict access to the web interface. In service mode, the control unit can be reset to factory settings.

Time



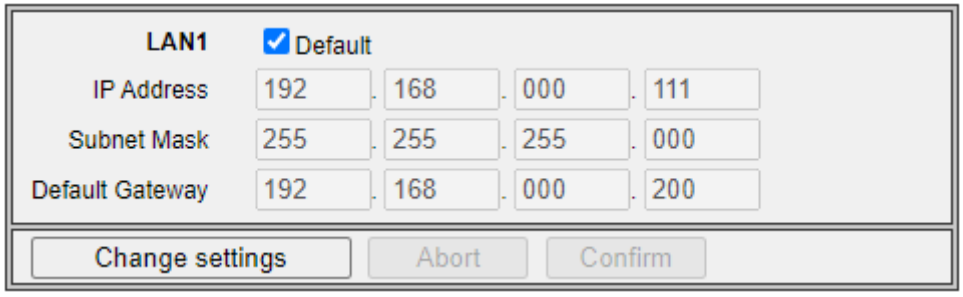
To change the time, press the "Edit date/time" button.



Use the "Adopt PC time" button to adopt the time from your PC.

However, you can also set the date and time manually. The settings are adopted by pressing the "Set date/time" button.

IP Address



The FIO Controller is set to a permanent IP address and subnet mask in the factory.

IP address: 192.168.0.111

Subnet mask: 255.255.255.0

Before you connect to FIO Controller for the first time, verify that your PC is set to the same IP address range as FIO Controller. This many involve changing your PC's IP address.

IP Address for Service Mode

In service mode, FIO Controller always defaults to the factory IP address. This allows you to access FIO Controller even if you don't know the current IP address setting.

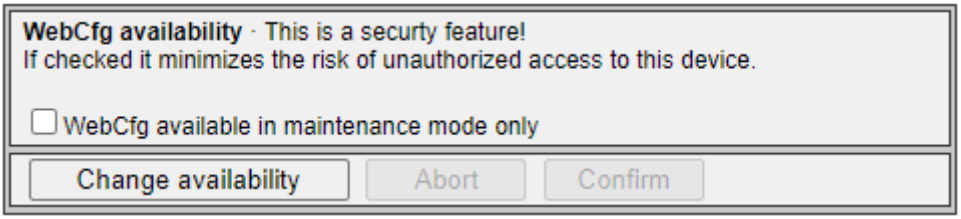
IP address: 192.168.0.111

Subnet mask: 255.255.255.0

	NOTE
	Duplicate IP addresses
	Assigning the same IP address to two different devices may cause serious network problems.
	⇨ Check your network for duplicate IP addresses.
	⇨ In order to put FIO Controller into operation for the first time, we recommend using a direct network connection between set IP addresses of FIO Controller and the programming PC. You may have to use a cross-over network cable.

	NOTE
	Unknown IP Address
	⇨ In case connecting to FIO Controller fails because the IP address is not known, you may start FIO Controller in service mode (see section 5.3.1)

WebCfg availability



This setting prevents the web interface from being accessed during normal operation. The web interface is then only accessible in service mode.

5.2.3 System Information

The page displays general system information.

5.2.4 CODESYS

This page displays the CODESYS version. You also have the option of changing the name of the node or the operating state (Run, Stop, Reset xy) of the control unit.

5.2.5 Access Code

This page lets you change the password of the web interface.

5.2.6 Events

This page displays a history of various system events.

5.2.7 Logout

Tapping the "Logout" item directly logs you out of the web interface and returns to the "Login" page.

5.3 System Functions

5.3.1 Service Mode

To enable service mode, first of all turn off FIO Controller. Now press and hold the On/Off button to restart FIO Controller. Keep pressing the button until Run/Stop lights up yellow every 2 seconds.

Service mode differs from normal operation in the following points:

- Factory defaults will be loaded when configuring the network to ensure that every control unit can be addressed by a unique IP address. To learn more about this kind of network configuration, refer to section 5.2.3 System Information
- The web interface can be accessed via the default password
- CODESYS V3 Runtime will not run, i.e. no control programme will be running,The "System" item on web interface tab "System information" displays the following:
  FIO Controller 111 (running in MAINTENANCE mode)
- To save the SysLog, go to web interface tab "Events" and remember to insert an SD card first (i.e. before turning on).

5.3.2 SD Card Functions

You can use an SD card to update your FIO Controller 111 or to back up the previously configured unit.

5.3.2.1 Application Update

These functions are controlled by file "sysconf.txt". Make sure to keep in the SD card's root directory. Since "sysconf.txt" is just a specially formatted text file, you can load it into any text editor to edit it.

The file contains sections [Section] and keys similar to those you would find in an *.ini file.

- Section "[load]": SD card -> FIO Controller 111
  - Key "ipconfig": Loads the IP configuration from the SD card to your control unit
  - Key "bootapp": Loads the boot application from the SD card to your control unit
  - Key "retain": Loads the retain variables from the SD card to your control unit

- Section "[save]": FIO Controller 111 -> SD card
  - Key "ipconfig": Saves the IP configuration from your control unit to the SD card
  - Key "bootapp": Saves the boot application from your control unit to the SD card
  - Key "retain": Saves the retain variable from your control unit to the SD card

- Section "[start]":
  - Key "bootapp": Runs the boot application loaded from the SD card

- Section "[init]": Initialises the hardware
  - Key "web***": Disables the web interface
  - Key "web***": Enables the web interface

A key in a section will initiate the associated action.

LED Run/Stop turns orange and keeps flashing to confirm ongoing activity. Completion of the action is confirmed by the LED flashing twice.

Example #1

Backing up the system configuration and the boot application to the SD card

Create an empty text file and save it as "sysconf.txt". Open that text file into a text editor and enter the lines of text below or simply copy them to the text editor:

```
[save]
Ipconfig
bootapp
```

Turn off FIO Controller 111 and insert the SD card.

Now restart FIO Controller 111.

Example #2

Restoring the system configuration and the boot application from the SD card to a FIO Controller 111.

NOTE

Check that the backup was created using the backup mechanism of FIO Controller 111

The unit may malfunction

⇨ Always follow the manual instructions to create a backup

```
[load]
Ipconfig
bootapp
```

5.3.2.2 Firmware Update

To update the firmware, FIO Controller 111 can stay in the field. Please contact the support of Kendrion Kuhnke's Industrial Control Systems if you need further information on how to handle firmware updates.

FIO Controller 111's firmware comprises 2 parts.

- "updateM4.hex": I/O software
- "updateM7.hex": Free RTOS and CODESYS Runtime

Copy one or both update files to the root directory of the SD card. Turn off FIO Controller 111 and insert the SD card. Now restart FIO Controller 111.

5.3.2.3 Special Functions

Special functions are run if a file of a particular name is in the root directory of the SD card.

- killboot.txt: deletes controller boot application
- denyboot.txt. prevents the controller boot application from running
- factory.txt: resets the unit to factory defaults

5.4 Maintenance / Servicing

5.4.1 General

Only qualified persons are allowed to work on Kuhnke FIO Controller.

	***NOTE***
	Do not plug, unplug, mount or touch the connectors during operation. *Risk of destroying the unit or provoking malfunctions* ⇨ Before working on the unit, turn off all power sources including those feeding power to peripherals such as externally fed sensors, programming devices etc.

	***NOTE***
	Overheating *Risk of destroying the unit or provoking malfunctions* ⇨ Verify that the unit's ventilation slots are not covered and that air is able to circulate.

5.4.2 Servicing

Kuhnke FIO Controller requires neither servicing for the specified service life nor any action if it is kept and operated at the admissible ambient conditions specified in section Technical Data.

5.4.3 Maintenance

Cleaning

Prevent inadmissible contamination while operating and storing Kuhnke FIO Controller.

To replace modules

Refer to section 5.1.1 Mechanical Installation

5.4.4 Repairs / Customer Service

	***Information***
	Only the manufacturer or customer service providers authorised by the manufacturer are allowed to do repairs and perform corrective maintenance.

5.4.5 Warranty

The statutory period and conditions of warranty apply. Warranty expires if unauthorised attempts are made to repair the unit / product or any other intervention is performed.

5.5 Error Handling

FIO Controller features maintenance and error handling solutions you can operate without a monitor, keyboard or mouse.

5.6 Taking out of Service

5.6.1 Disposal

Before disposing of Kuhnke FIO Controller you must disassemble it and completely take it apart. All metal components can be given to metal recycling.

Electronic Scrap

Sort and dispose of electronic components by type. For details on proper disposal please check your national laws and regulations making sure that your method of disposal complies with them.

Treat the packaging as recyclable paper and cardboard.

6 CODESYS V3 Development Environment

6.1 Installing CODESYS on the Project Engineering PC

CODESYS is a device-independent control unit programming system. It conforms to standard IEC 61131-3 and supports all standardised IEC programming languages plus the integration of C code routines and object-orientated programming.

In conjunction with runtime system CODESYS Control Win V3 it also allows the use of "multi-device" and "multi-application" programs. Owing to its component-based architecture, it supports customer-specific configurations of and extensions to the user interface.

Before installing CODESYS, please read and take note of the system requirements:

Windows XP / 7 / 8 / 10 (32/64 bit), appropriate PC hardware matching the Windows version installed.

6.1.1 Installing the Device Description in CODESYS V3

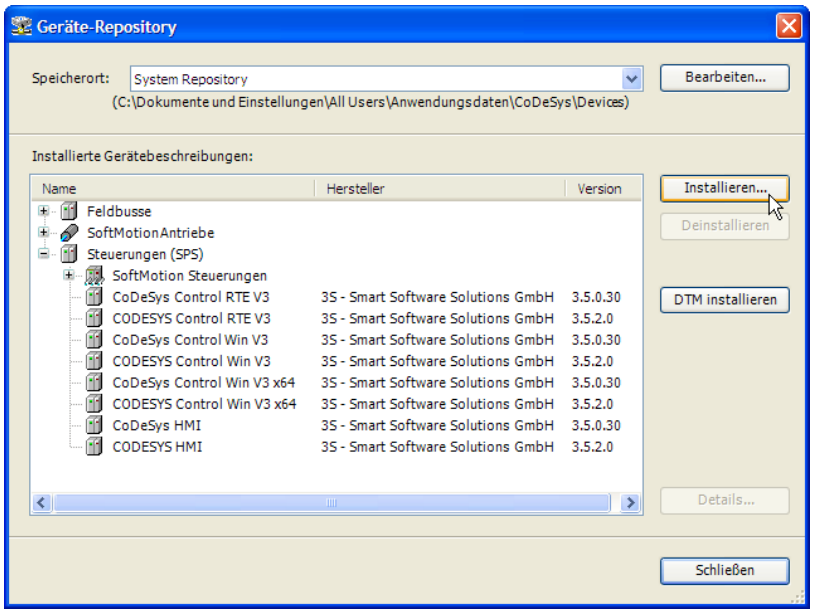
Before the IEC 61131-3 development tool CODESYS V3 can be used to operate a device, the device and its properties are to be made known to the runtime system.

A separate plug-in, the Device Repository, provides the local system and your projects with the device definition management functions. Among other features, it contains commands of category Devices which you will normally find in the Tools menu.

- ⇨ Open the Tools menu and pick Device Repository...
- ⇨ Screen Device Repository is displayed
- ⇨ Expand the tree at Control Units (PLC)

The Device Repository hosts the descriptions of all devices currently installed on the local system and makes the devices available for CODESYS programming. Devices are installed in and uninstalled directly from the Device Repository.

Screen Device Descriptions Installed displays the Name, Vendor and Version of every device that is currently installed. Click on the plus and minus signs to expand or collapse the branches.



Click on Install... to install a new device on the local system and make it available for use in the programming system.

Dialog Device Descriptions Installed is displayed. Use it to search the system for a specific device description file. If you are looking for a standard device, set the file type filter to "*.**devdesc.xml**" (device description). Another option is to find vendor-specific description files such as *gsd files of Profibus DP modules or *.eds and *.dcf files of CAN devices.

Clicking on OK confirms your settings, closes the screen and adds the device to the tree shown on screen Device Repository. Look at the bottom of screen Device Repository to find messages on any installation error (e.g. missing files referenced by the device description).

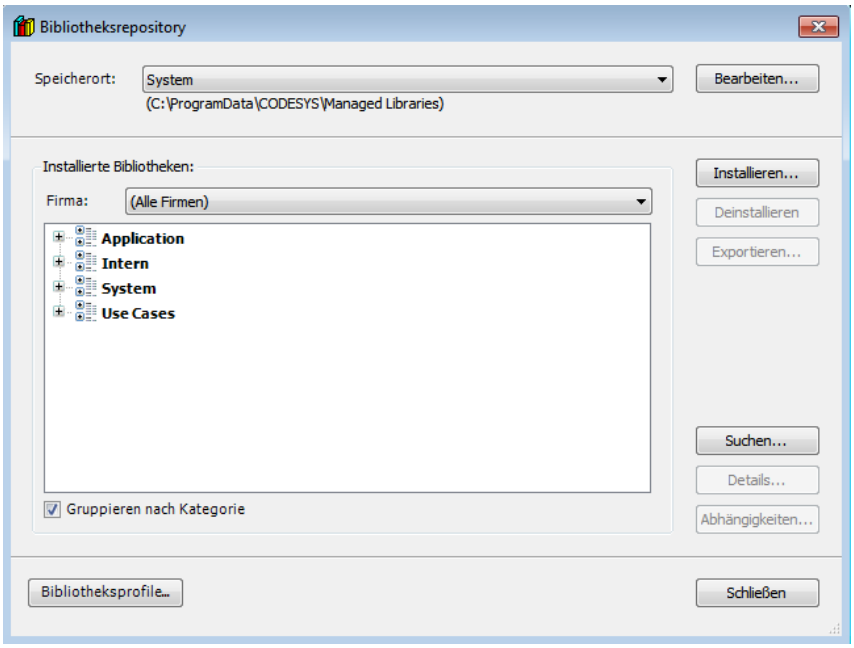
6.1.2 Installing Device-specific Libraries

Similar to the device description files, CODESYS keeps libraries in a dedicated repository, i.e. the Library Repository in this case.

The following device-specific library is available for FIO Controller 111:

- KICS FIO Controller 111 System Library (KICS_C111_SYS)
  Library for accessing the system information

⇨ Open the Tools menu and pick Library Repository...
⇨ The Library Repository dialog is displayed



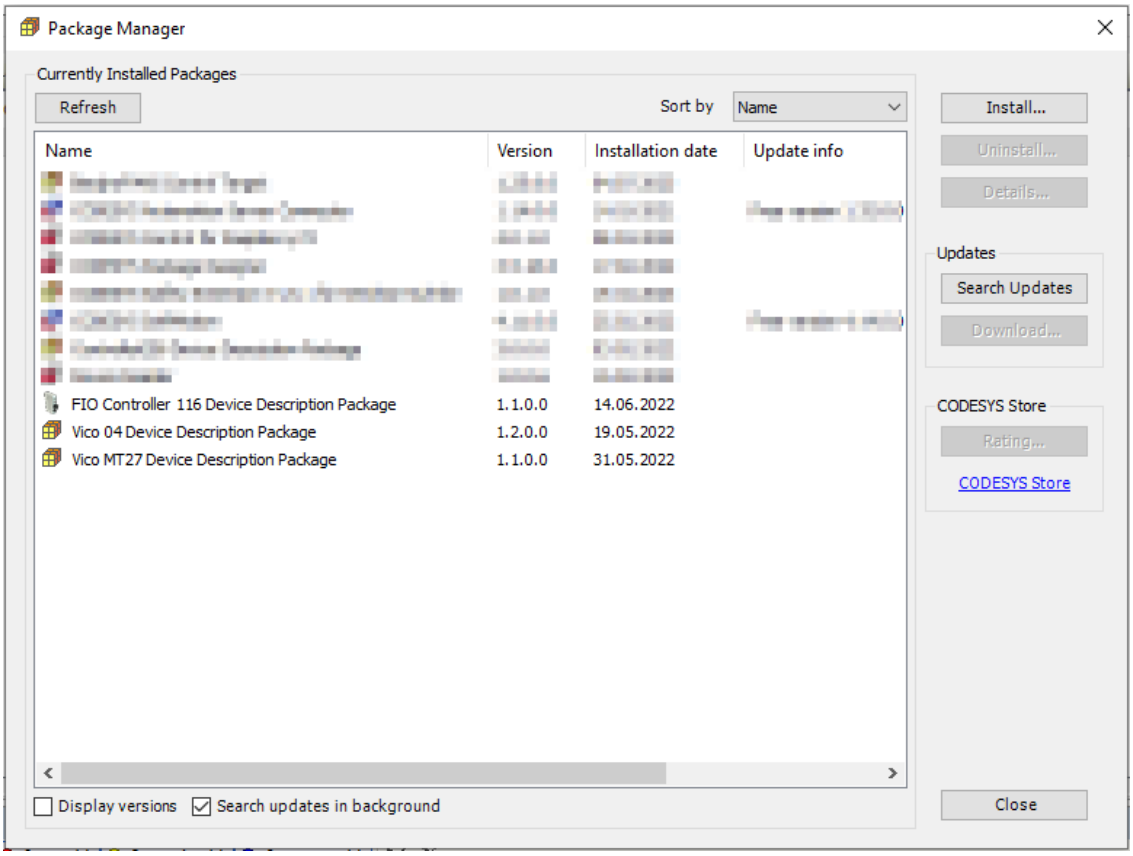
Click on Install... to install a new library in the local system and make it available for use in the programming system.

Browse to the location where your libraries are saved. The default filter is Compiled Libraries (*.compiled-library) which is the format in which libraries are normally made available. Choose the library you wish to install and click on Open. Once installed, the library will appear on tree Installed Libraries.

6.1.3 Installing the device package

Our device packages contain the device descriptions and libraries required for control. Optionally, sample projects and manuals can also be included. Installation is carried out via the CODESYS Package Manager.

Open the Package Manager in CODESYS via the "Tool" -> "Package Manager" menu.



Then click on the "Install" button and browse to the directory in which the package is saved. Select the package and click the "Open" button. Confirm the following prompts. Wait for the installation to be completed and exit the dialog by clicking the "Finish" button.

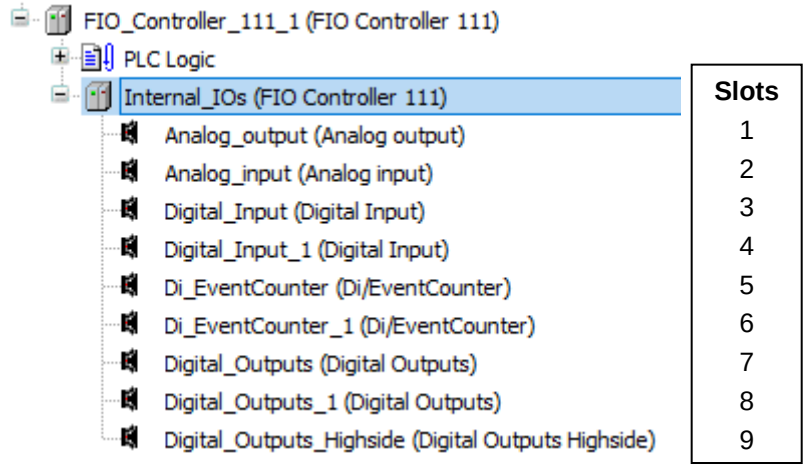
6.2 FIO Controller 111 and CODESYS

FIO Controller 111 supports various CODESYS options of capturing and processing signals. The signals can be provided locally or by various bus systems. This requires you to first of all add the devices concerned to the device list by right-clicking on "Device (FIO Controller 111)" and picking "Add device …" from the popup menu.

Now

6.2.1 Local Multifunctional I/O Interface

The local multifunctional I/O interface is automatically added to the CODESYS devices explorer below the control unit:

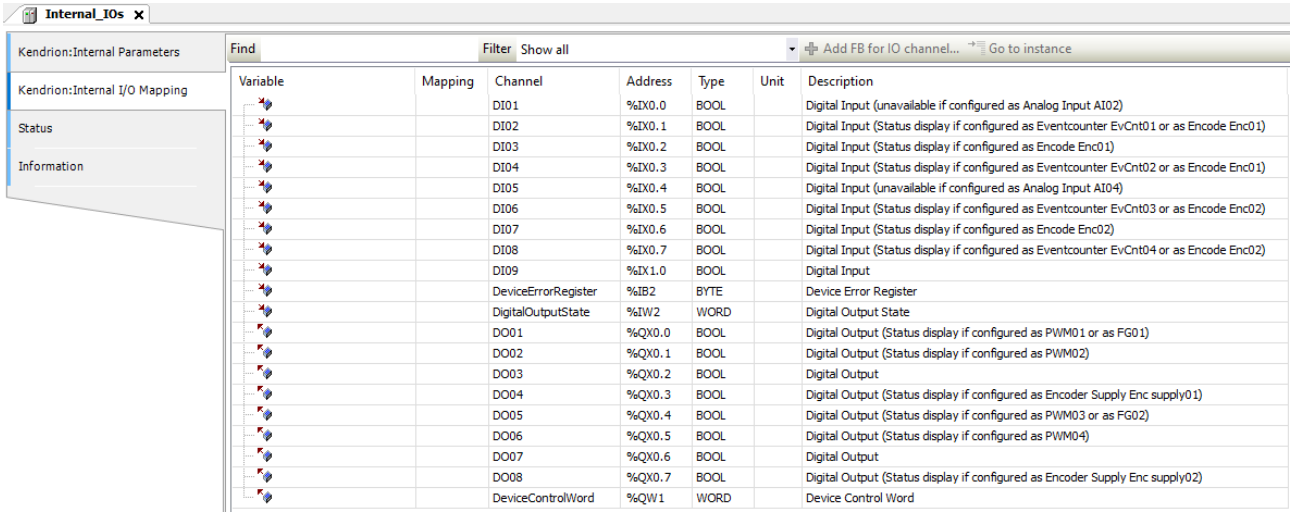


Slots
1
2
3
4
5
6
7
8
9

Default settings of the local IOs:

- Analogue outputs: 2 (output off)
- Analogue inputs: 2 (0…10V)
- Digital inputs: 8 (filter time: 0.3 ms)
- Digital outputs: 8

Always look for the mapping of unit "Internal_IOs" to find the process data of the digital IOs.



Variable	Mapping	Channel	Address	Type	Unit	Description
		DI01	%IX0.0	BOOL		Digital Input (unavailable if configured as Analog Input AI02)
		DI02	%IX0.1	BOOL		Digital Input (Status display if configured as Eventcounter EvCnt01 or as Encode Enc01)
		DI03	%IX0.2	BOOL		Digital Input (Status display if configured as Encode Enc01)
		DI04	%IX0.3	BOOL		Digital Input (Status display if configured as Eventcounter EvCnt02 or as Encode Enc01)
		DI05	%IX0.4	BOOL		Digital Input (unavailable if configured as Analog Input AI04)
		DI06	%IX0.5	BOOL		Digital Input (Status display if configured as Eventcounter EvCnt03 or as Encode Enc02)
		DI07	%IX0.6	BOOL		Digital Input (Status display if configured as Encode Enc02)
		DI08	%IX0.7	BOOL		Digital Input (Status display if configured as Eventcounter EvCnt04 or as Encode Enc02)
		DI09	%IX1.0	BOOL		Digital Input
		DeviceErrorRegister	%IB2	BYTE		Device Error Register
		DigitalOutputState	%IW2	WORD		Digital Output State
		DO01	%QX0.0	BOOL		Digital Output (Status display if configured as PWM01 or as FG01)
		DO02	%QX0.1	BOOL		Digital Output (Status display if configured as PWM02)
		DO03	%QX0.2	BOOL		Digital Output
		DO04	%QX0.3	BOOL		Digital Output (Status display if configured as Encoder Supply Enc supply01)
		DO05	%QX0.4	BOOL		Digital Output (Status display if configured as PWM03 or as FG02)
		DO06	%QX0.5	BOOL		Digital Output (Status display if configured as PWM04)
		DO07	%QX0.6	BOOL		Digital Output
		DO08	%QX0.7	BOOL		Digital Output (Status display if configured as Encoder Supply Enc supply02)
		DeviceControlWord	%QW1	WORD		Device Control Word

Process data:

- DI01 … DI09 (BOOL): digital inputs
    - Default configuration: TRUE: input signal available / FALSE: Input signal not available

- DO01 … DO08 (BOOL): digital outputs
- DigitalOutputState (WORD): state of the digital outputs
  - Bit0, Bit2, … , Bit14: ACT – Output has been set via the process image
  - Bit1, Bit3, … , Bit15: OT – overtemperature error is set (overload / short circuit)

Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8
DO08 OT	DO08 ACT	DO07 OT	DO07 ACT	DO06 OT	DO06 ACT	DO05 OT	DO05 ACT
Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
DO04 OT	DO04 ACT	DO03 OT	DO03 ACT	DO02 OT	DO02 ACT	DO01 OT	DO01 ACT

- DeviceErrorRegister (BYTE): The DeviceErrorRegister contains device-specific errors.
  - Bit0: general error
- DeviceControlWord (WORD)
  - Bit0 (Reset Error): a rising edge clears previous errors

All other process data is allocated to the mapping of the module in question.

Look underneath the unit to find 9 slots provided for the different modules. These modules contain various configurations and process data objects for the I/O channels associated with the slots.

- Slot 1:
  - **Module 1: analogue outputs**
    - Channels: Ao01OutputValue, Ao02OutputValue, Ao01ErrorRegister, Ao02ErrorRegister, Ao01Controlword, Ao02Controlword,
    - Parameters: 0…10V/ 0…20mA/ 4…20mA
- Slot 2:
  - **Module 1: analogue inputs**
    - Channels: AI1, AI3
    - Parameters: 0…10V/ 0…20mA/ 4…20mA
- Slot 3:
  - **Module 1: digital input**
    - Channels: DI1
    - Parameter FilterSelect: no Filter/ 0.3ms/ 1ms/ 3ms/ 5ms/ 10ms/ 20ms
  - Module 2: analogue input
    - Channels: AI2
    - Parameters: 0…10V
- Slot 4:
  - **Module 1: digital input**
    - Channels: DI5
    - Parameter FilterSelect: no Filter/ 0.3ms/ 1ms/ 3ms/ 5ms/ 10ms/ 20ms
  - Module 2: analogue input
    - Channels: AI4
    - Parameters: 0…10V
- Slot 5:
  - **Module 1: digital inputs / event counter**
    - Channels: DI2, DI3, DI4
    - Parameter FilterSelect: no Filter/ 0.3ms/ 1ms/ 3ms/ 5ms/ 10ms/ 20ms
    - Parameter ModeSelect: DigitalInput DI2, DI4 / EventCounter for DI2, DI4
  - Module 2: Encoder A/B/Z
    - Channels: PositionActualValue, VelocityActualValue, IndexCaptureValue
    - Parameter RefIndSensitivity: Reference on rising edge/ Reference on falling edge/ Reference on both edges
  - Module 3: PTO inputs
    - Channels: DI2, DI3, DI4
    - Parameter ModeSelect: DigitalInput, Special Function Enable Low / High active
    - Parameter FilterSelect: no Filter/ 0.3ms/ 1ms/ 3ms/ 5ms/ 10ms/ 20ms
    - Special function for the PTO axis interface: Axis 1:
      - DI2: left limit switch
      - DI3: right limit switch
      - DI4: reference switch
- Slot 6:
  - **Module 1: digital inputs / event counter**
    - Channels: DI6, DI7, DI8
    - Parameter FilterSelect: no Filter/ 0.3ms/ 1ms/ 3ms/ 5ms/ 10ms/ 20ms
    - Parameter ModeSelect: DigitalInput DI6, DI8 / EventCounter for DI6, DI8
  - Module 2: Encoder A/B/Z

        - Channels: PositionActualValue, VelocityActualValue, IndexCaptureValue
        - Parameter RefIndSensitivity: Reference on rising edge/ Reference on falling edge/ Reference on both edges
    - Module 3: PTO inputs
        - Channels: DI6, DI7, DI8
        - Parameter ModeSelect: DigitalInput, Special Function Enable Low / High active
        - Parameter FilterSelect: no Filter/ 0.3ms/ 1ms/ 3ms/ 5ms/ 10ms/ 20ms
        - Special function for the PTO axis interface: Axis 2:
            - DI6: left limit switch
            - DI7: right limit switch
            - DI8: reference switch
- Slot 7:
    - **Module 1: digital outputs (push pull)**
        - Channels: DO1, DO2
    - Module 2: pulse-width outputs (PWM)
        - Channels: PWM01OutputPulseWidth, PWM02OutputPulseWidth
        - Parameter ModeSelect: PWM/ DigitalOutut
        - Parameter OutputFrequency: PWM01OutputFrequency, PWM02OutputFrequency
    - Module 3: pulse-train outputs (PTO)
        - Channels: see separate section
        - Parameters: see separate section
    - Module 4: frequency generator outputs (FG)
        - Channels: DO1, DO2, FG01 Output Frequency
- Slot 8:
    - **Module 1: digital outputs (push pull)**
        - Channels: DO5, DO6
    - Module 2: pulse-width outputs (PWM)
        - Channels: PWM03OutputPulseWidth, PWM04OutputPulseWidth
        - Parameter ModeSelect: PWM/ DigitalOutut
        - Parameter OutputFrequency: PWM03OutputFrequency, PWM04OutputFrequency
    - Module 3: pulse-train outputs (PTO)
        - Channels: see separate section
        - Parameters: see separate section
    - Module 4: frequency generator outputs (FG)
        - Channels: DO1, DO2, FG01 Output Frequency
- Slot 9:
    - **Module 1: digital outputs (high side)**
        - Channels: DO3, DO4, DO7, DO8

6.2.1.1 Module Analogue Output

Module "analogue output" configures and serves analogue outputs AO01 and AO02.

Slot Assignment

- Slot 1

Parameters

- Analogue Output Function (Ao01 / Ao02):
  - Output off
  - Ao 0..10V
  - Ao 0..20mA
  - Ao 4..20mA

Channels

- Ao01Errorregister / Ao02Errorregister (BYTE)
  The error register contains the module-specific errors.
  - Bit0: general error
  - Bit1: current output configuration error
    - Overload
    - High temperature
    - Wire failure
  - Bit2: voltage output configuration error
    - Overload
    - High temperature
  - Bit5: profile error (set in all configurations)
- Ao01Controlword / Ao02Controlword (WORD)
  - Bit0 (Reset Error): A rising edge clears previous errors
- Ao01Outputvalue / Ao02Outputvalue (Real)
  Configuration-dependent output value as volt or milliampere

6.2.1.2 Module Analogue Input Ai01_Ai03

Module "analogue input" configures and serves analogue inputs Ai01 and Ai03

Slot Assignment

- Slot 2

Parameters

- Analogue Input Function (Ai01, Ai03)
  - Ai 0..10V
  - Ai 0..20mA
  - Ai 4..20mA
  - Ai0..2.5V
- Analogue Input Filter (Ai01, Ai03)
  - No filter
  - Pt1 filter
- Filter Constant [ms]
  - PT1 filter time constant, in milliseconds

Channels

- Ai01Errorregister / Ai03Errorregister (BYTE)
  The error register contains the module-specific errors.
  - Bit0: general error
  - Bit1: current input configuration error
    - wire failure
  - Bit2: voltage input configuration error
    - n/a
  - Bit5: profile error (set in all configurations)
- Ai01Controlword / Ai03Controlword (WORD)
  - Bit0 (Reset Error): A rising edge clears previous errors
- Ai01Inputvalue / Ai03Inputvalue (Real)
  Configuration-dependent input value as volt or milliampere

6.2.1.3 Module Analoge Input Ai02_Ai04

Module "analogue input" configures and serves analogue inputs Ai02 and Ai04

Slot Assignment

- Slot 3
- Slot 4

Parameters

- Analogue Input Function (Ai02, Ai04)
  - Ai 0..10V
- Analogue Input Filter (Ai02, Ai04)
  - No filter
  - Pt1 filter
- Filter Constant [ms]
  - PT1 filter time constant, in milliseconds

Channels

- Ai02Errorregister / Ai04Errorregister (BYTE)
  The error register contains the module-specific errors.
  - n/a
- Ai02Controlword / Ai04Controlword (WORD)
  - n/a
- Ai02Inputvalue / Ai04Inputvalue (Real)
  input value in volt

6.2.1.4 Module Digital Input

Slot Assignment

- Slot 3
- Slot 4

Parameters

- Digital Input Filter
  - No filter
  - 0.3 ms
  - 1.0 ms
  - 3.0 ms
  - 5.0 ms
  - 10.0 ms
  - 20.0 ms

Channels

- None (Di01, Di05 are mapped to the main module)

6.2.1.5 Module Di/EventCounter

Module "Di/EventCounter" configures and serves digital inputs Di02, Di03 and Di04 as well as digital inputs Di06, Di07 and Di08. A parameter also allows inputs Di02, Di04, Di06 and Di08 to be used as event counter inputs

Slot Assignment

- Slot 5
- Slot 6

Parameters

- Digital Input Function
  - digital input
  - event counter
- Digital Input Filter
  - No filter
  - 0.3 ms
  - 1.0 ms
  - 3.0 ms
  - 5.0 ms
  - 10.0 ms
  - 20.0 ms

Channels

The digital inputs are mapped to the main module
Slot 5 channels (left side of connector)

- EvCt01Count (UDINT): counter reading of events at Di02
- EvCt02Count (UINT): counter reading of events at Di04
- EvCt0102Controlword
  - Bit0 (Reset Error): n/a
  - Bit8 (ResetEvCt01): resets the counter reading to the preset value (Preset)
  - Bit9 (ResetEvCt02): resets the counter reading to the preset value (Preset)
- EvCt01Preset (UDINT): preset value
- EvCt02Preset (UINT): preset value

Slot 6 channels (right side of connector)

- EvCt03Count (UDINT): counter reading of events at Di06
- EvCt04Count (UINT): counter reading of events at Di08
- EvCt0304Controlword
  - Bit0 (Reset Error): n/a
  - Bit8 (ResetEvCt03): resets the counter reading to the preset value (Preset)
  - Bit9 (ResetEvCt04): resets the counter reading to the preset value (Preset)
- EvCt03Preset (UDINT): preset value
- EvCt04Preset (UINT): preset value

6.2.1.6 Module Encoder

Module "encoder" configures and serves the encoder interface for reading A/B/Ref encoder signals.

Slot Assignment

- Slot 5
- Slot 6

Parameters

- Index Pulse Sensitivity
  - Don’t reference on Index
  - Reference on rising edge
  - Reference on falling edge
  - Reference on both edges

Channels

Slot 5 (left side of connector)

- Enc01Stateword (Word)
  - Bit0 (Ref): encoder is referenced
  - Bit1 (OVF): encoder overflow
  - Bit3 (DIR): 0 = CW | 1 = CCW
- Enc01PositionValue (DINT): position value in increments
- Enc01VelocityValue (DINT): velocity value in increments/seconds
- Enc01IndexCaptureValue (DINT): position value in increments at last index pulse
- Enc01Controlword (Word)
  - Bit0 (Reset Error): n/a
  - Bit8 (Reset Encoder): rising edge clears Enc01Positionvalue and Enc01IndexCaptureValue
  - Bit9 (Clear Reference): rising edge clears the reference bit of the state word
  - Bit10 (Mask Index): 0 = analyse index track, 1 = DO NOT analyse index track
- Enc01Preset (DINT): preset value

Slot 6 (right side of connector)

- Enc02Stateword (Word)
  - Bit0 (Ref): encoder is referenced
  - Bit1 (OVF): encoder overflow
  - Bit3 (DIR): 0 = CW | 1 = CCW
- Enc02PositionValue (DINT): position value in increments
- Enc02VelocityValue (DINT): velocity value in increments/seconds
- Enc02IndexCaptureValue (DINT): position value in increments at last index pulse
- Enc02ControlWord (Word)
  - Bit0 (Reset Error): n/a
  - Bit8 (Reset Encoder): rising edge clears Enc01Positionvalue and Enc01IndexCaptureValue
  - Bit9 (Clear Reference): rising edge clears the reference bit of the state word
  - Bit10 (Mask Index): 0 = analyse index track, 1 = DO NOT analyse index track
- Enc02Preset (DINT): preset value

6.2.1.7 Module PTO Inputs

This module provides a special configuration for the axis interface. If Special Functions are enabled for the inputs, the module directly processes signals Left Limit Switch, Right Limit Switch and Reference Switch.

Slot Assignment

- Slot 5
- Slot 6

Parameters

Slot 5	Slot 6
DI02 Mode Select DI03 Mode Select DI04 Mode Select	DI06 Mode Select DI07 Mode Select DI08 Mode Select
▪ Digital Input ▪ Special Function High Active ▪ Special Function Low Active	
DI02 Filter Select DI04 Filter Select DI04 Filter Select	DI06 Filter Select DI07 Filter Select DI08 Filter Select
▪ No Filter ▪ 0.3 ms ▪ 1.0 ms ▪ 3.0 ms ▪ 5.0 ms ▪ 10.0 ms ▪ 20.0 ms	

Channels

The digital inputs are mapped to the main module.

Enabled special functions are processed directly in the axis interface. The inputs are allocated to the following special functions:

Slot 5 (Inputs Axis 1)	Slot 6 (Inputs Axis 2)
DI2: left limit switch DI3: right limit switch DI4: Reference switch	DI6: left limit switch DI7: right limit switch DI8: Reference switch

	***Information***
	If the limit switches are set up and the configuration is enabled, check that the limit switches are correctly connected because, otherwise, the drive will not start to move.

6.2.1.8 Module Digital Outputs (Push Pull)

The digital outputs are mapped to the main module

Slot Assignment

- Slot 7
- Slot 8

Parameters

- None

Channels

Slot 7

- Do0102ErrorRegister (USINT)
  - Bit 0 Generic Error
  - Bit 1 Overload Error
  - Bit 5 Profile Error
- Do0102Controlword (Word)
  - Bit 0 (Reset Error): A rising edge clears previous errors

Slot 8

- Do0506ErrorRegister (USINT)
  - Bit 0 Generic Error
  - Bit 1 Overload Error
  - Bit 5 Profile Error
- Do0506Controlword (Word)
  - Bit 0 (Reset Error): a rising edge clears previous errors

6.2.1.9 Module Digital Outputs (High Side)

The digital outputs are mapped to the main module

Slot Assignment

- Slot 9

Parameters

- Do03ModeSelect
  - Digital Output
  - PTO Enable
- Do04ModeSelect
  - Digital Output
  - Encoder Supply
- Do07ModeSelect
  - Digital Output
  - PTO Enable
- Do08ModeSelect
  - Digital Output
  - Encoder Supply

Channels

- DoHSErrorRegister (USINT)
  - Bit 0 Generic Error
  - Bit 1 Overload Error
  - Bit 5 Profile Error
- DoHSControlword (WORD)
  - Bit 0 (Reset Error): a rising edge clears previous errors

6.2.1.10 Module Pulse-width Modulated Outputs

Slot Assignment

- Slot 7
- Slot 8

Parameters

Slot 7	Slot 8
▪ Pwm01OutputFrequency o Output frequency in Hz (1 … 100000) ▪ Pwm02OutputFrequency o Output frequency in Hz (1 … 100000) ▪ Pwm01OutputModeSelect o Digital output o PWM ▪ Pwm02OutputModeSelect o Digital output o PWM	▪ Pwm05OutputFrequency o Output frequency in Hz (1 … 100000) ▪ Pwm06OutputFrequency o Output frequency in Hz (1 … 100000) ▪ Pwm05OutputModeSelect o Digital output o PWM ▪ Pwm06OutputModeSelect o Digital output o PWM

Channels

Slot 7

- Do0102ErrorRegister (USINT)
  - Bit 0 Generic Error
  - Bit 1 Overload Error
  - Bit 5 Profile Error
- Do0102Controlword (Word)
  - Bit 0 (Reset Error): a rising edge clears previous errors
- Pwm01OutputPulseWidth (REAL) in percent (0.0 … 100.0)
- Pwm02 OutputPulseWidth (REAL) in percent (0.0 … 100.0)

Slot 8

- Do0506ErrorRegister (USINT)
  - Bit 0 Generic Error
  - Bit 1 Overload Error
  - Bit 5 Profile Error
- Do0506Controlword (Word)
  - Bit 0 (Reset Error): a rising edge clears previous errors
- Pwm05OutputPulsewidth (REAL) in percent (0.0 … 100.0)
- Pwm06OutputPulsewidth (REAL) in percent (0.0 … 100.0)

6.2.1.11 Module Frequency Generator Output

Slot Assignment

- Slot 7
- Slot 8

Parameters

- None

Channels

Slot 7

- Do0102ErrorRegister (USINT)
  - Bit 0 Generic Error
  - Bit 1 Overload Error
  - Bit 5 Profile Error
- Do0102Controlword (WORD)
  - Bit 0 (Reset Error): a rising edge clears previous errors
- Fg01OutputFrequency in Hz (1 … 100000)

Slot 8

- Do0506ErrorRegister (USINT)
  - Bit 0 Generic Error
  - Bit 1 Overload Error
  - Bit 5 Profile Error
- Do0506Controlword (WORD)
  - Bit 0 (Reset Error): a rising edge clears previous errors
- Fg02OutputFrequency (1 … 100000)

6.2.1.12 Module Pulse Train Output

This module provides the PTO axis interface.

Slot Assignment

- Slot 7
- Slot 8

Parameters

Slot 7	Slot 8
PTO01 LimitSwitch Reaction Option Code	PTO02 LimitSwitch Reaction Option Code
Response of the axis to driving over the limit switch • Slow Down Ramp, QSA (Quick Stop Active) • Quick Stop Ramp, QSA (Quick Stop Active) • Fault Reaction Option Code, Fault	
PTO01 Fault Reaction Option Code	PTO02 Fault Reaction Option Code
Response of the axis to errors • Slow Down Ramp (uses ramp Profile Deceleration) • Quick Stop Ramp (uses ramp Quick Stop Ramp) • Hard Stop	
PTO01 Polarity (USINT)	PTO02 Polarity (USINT)
Change of Redation • 0 – no change of Redation (default) • 1 – change of Redation	
PTO01 QuickStop Deceleration (UDINT)	PTO02 QuickStop Deceleration (UDINT)
• 2000 (default) [inc./s^2]	
PTO01 Homing Speed (UDINT)	PTO02 Homing Speed (UDINT)
• 500 (default) [inc./s]	
PTO01 Homing Acceleration (UDINT)	PTO02 Homing Acceleration (UDINT)
• 2000 (default) [inc./s^2]	
PTO01 Ramp Selection Option Code	PTO02 Ramp Selection Option Code
• Trapezoidal Ramp • S Ramp	

Channels

Slot 7	Slot 8
PTO01 Status Word	PTO02 Status Word
Status word of the axis (WORD) Provides status details of the drive controller and the DS402 power state machine.	
PTO01 Modes of Operation Display	PTO02 Modes of Operation Display
Contains the current mode of operation as set in object Modes of Operation (SINT)	
PTO01 Position Actual Value	PTO02 Position Actual Value
Current position of the axis (DINT) [inc.]	
PTO01 Velocity Actual Value	PTO02 Velocity Actual Value
Current velocity of the axis (DINT) [inc./s]	
PTO01 Error Register	PTO02 Error Register

Error register (USINT)

Bit7:	Bit6:	Bit5:	Bit4:	Bit3:	Bit2:	Bit1:	Bit0:
MFS	Res.	PROF	COM	TEMP	Volt	CUR	GEN

MFS: Is set after a global error.
Res.: Always stays 0
PROF: Is set after an interface-related error.
COM: Is set after a communication error.
TEMP: Is set after a temperature error.
VOLT: Is set after a voltage error.
CUR: Is set after a current error.
GEN: Is set after any (unspecific) error.

PTO01 Error Code	PTO02 Error Code

Error code / detailed error message (UINT)

Value (hex)	Type	Error description
2310	Error	Current at the controller output too high
3120	Errorr	Undervoltage error module supply or axis supply
4210	Error	Temperature error within the control unit
6010	Error	Watchdog
6200	Error	Invalid driving order (Limit switch active)
6320	Warning	Acceleration value or deceleration value outside the limits
8100	Error	Internal communication error between PLC and I/O controller
868A	Error	Positive limit switch exceeded
868B	Error	Negative limit switch exceeded

-

PTO01 Control Word	PTO02 Control Word
Control word of the axis (WORD) Controls the DS402 power state machine. The function of some parts of this parts depend on the currently enabled mode.	

PTO01 Modes of Operation	PTO02 Modes of Operation
Operating mode of the axis (SINT) 0: no mode assigned / no mode change 1: Profile Position Mode 3: Profile Velocity Mode 6: Homing Mode	
PTO01 Target Position	PTO02 Target Position
Target position [inc.]	
PTO01 Target Velocity	PTO02 Target Velocity
Target velocity (DINT) [inc./s]	
PTO01 Profile Acceleration	PTO02 Profile Acceleration
Acceleration ramp (UDINT) [inc./s^2]	
PTO01 Profile Deceleration	PTO02 Profile Deceleration
Deceleration ramp (UDINT) [inc./s^2]	
PTO01 Homing Method	PTO02 Homing Method
Selects the homing method (SINT). The following methods are available: 17 Homing on negative limit switch 18 Homing on positive limit switch 19 Homing on positive home switch 20 Homing on positive home switch 21 Homing on negative home switch 22 Homing on negative home switch 23 Homing on home switch, positive initial motion 24 Homing on home switch, positive initial motion 25 Homing on home switch, positive initial motion 26 Homing on home switch, positive initial motion 27 Homing on home switch, negative initial motion 28 Homing on home switch, negative initial motion 29 Homing on home switch, negative initial motion 30 Homing on home switch, negative initial motion 37 Homing on current position	
PTO01 Home Offset	PTO02 Home Offset
Referencing offset (DINT) [inc.]: Value of the offset against the actual machine home position.	
PTO01 Profile Jerk	PTO02 Profile Jerk
Jerk (UDINT) [inc./s^3]	

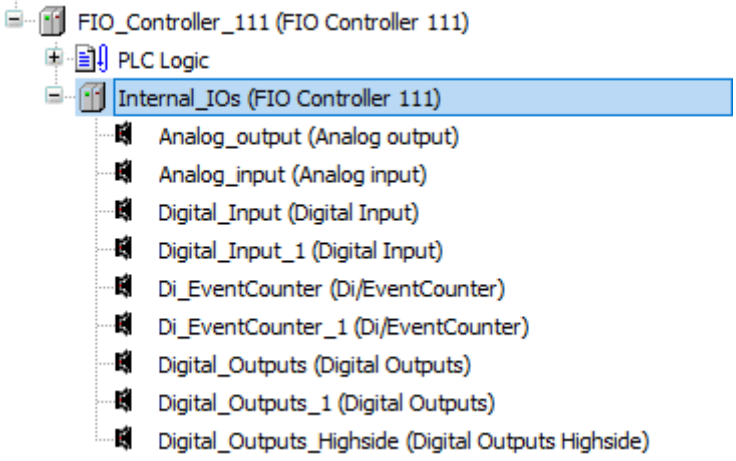
6.2.2 Special Function: PTO Axis Interface

FIO Controller 111 can use pulse-train outputs to address up to 2 motor output stages. The PTO axis interface supports the process with a clock and a direction signal plus an enable signal for the motor output stage. You also have the option of integrating limit and reference switches.

The PTO axis interface was designed based on EtherCAT / CANopen drive controllers to standard DS402. Our motion control library "KICS PTO Controller 111" provides function blocks and visualization templates for operation. The library is installed via the device package in the library cookie repository.

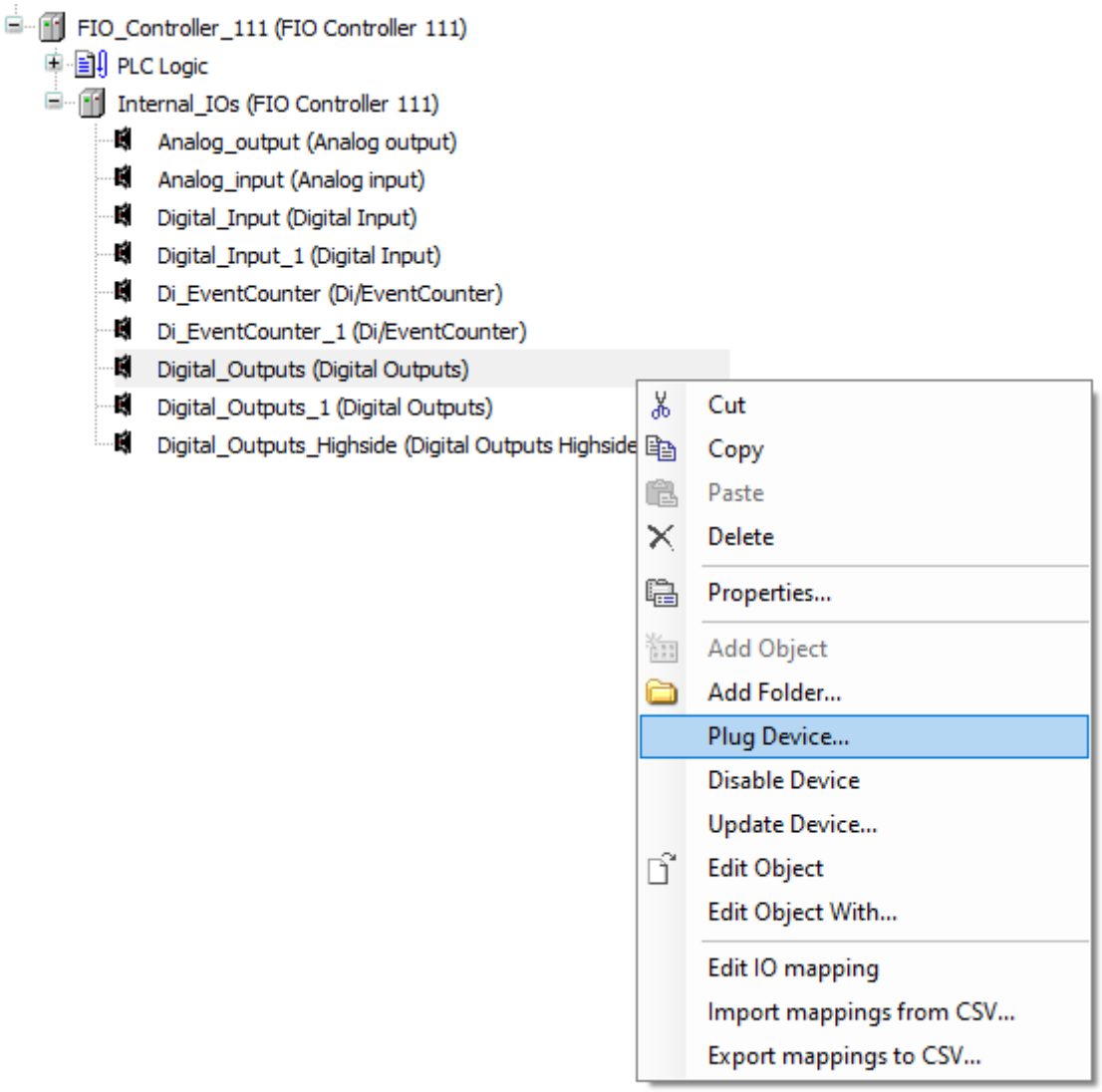
6.2.2.1 Slot assignment of the PTO modules

The image below illustrates the default assignment of the internal I/Os

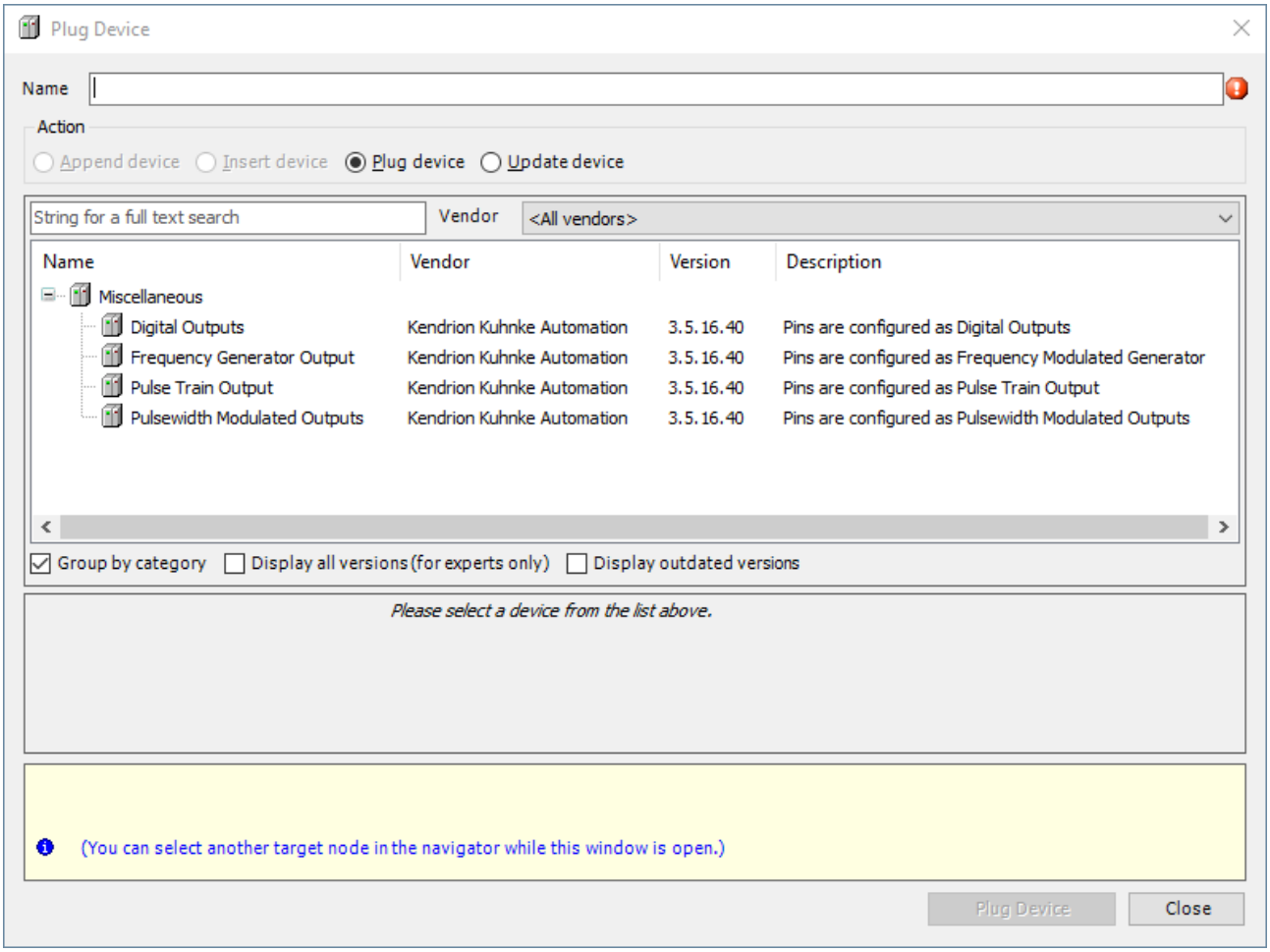


Slots
1
2
3
4
5 PTO01 Inputs
6 PTO02 Inputs
7 PTO01 Outputs
8 PTO02 Outputs
9 Optional PTO01, PTO02 Enable

You can choose to set up slots 5 & 6 as PTO inputs and slots 7 & 8 as PTO outputs. Right-click on the correct slot and choose Plug Device. The example overleaf describes how to proceed with slot 7 PTO01 outputs.

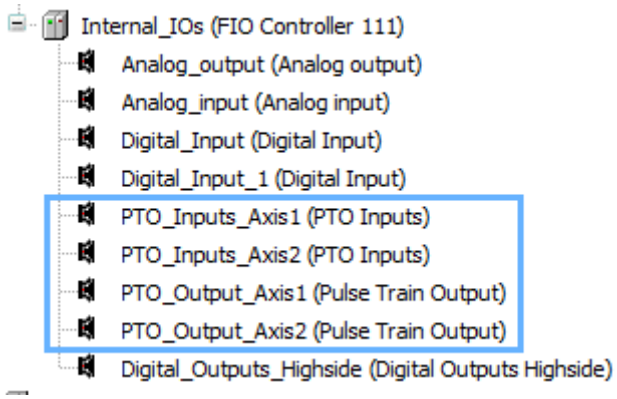


The next screen displays the modules available for the chosen slot. Pick Pulse Train Output for the PTO axis interface.



Confirm your choice by clicking on Plug Device.

Repeat this procedure to assign further PTO modules to the slots. The screen dump below shows the maximum PTO module configuration.



6.2.2.2 Configuring the PTO Modules

PTO Outputs

Module PTO Outputs has the parameters below, which are set by the application:

- Limitswitch Reaction Option Code: Response of the axis to driving over the limit switch
  - Slow Down Ramp, QSA (Quick Stop Active): The motor decelerates down the ramp set in Profile Deceleration [inc./s^2]. Power keeps being supplied to the motor.
  - Quick Stop Ramp, QSA (Quick Stop Active): The motor decelerates down the ramp set in QuickStop Deceleration [inc./s^2]. Power keeps being supplied to the motor.
  - Fault Reaction Option Code, Fault: Runs the response set in Fault Reaction Option Code.
- Fault Reaction Option Code: Response of the axis to errors
  - Slow Down Ramp: The motor decelerates down the ramp set in Profile Deceleration [inc./s^2]. The motor turns off afterwards.
  - Quick Stop Ramp: The motor decelerates down the ramp set in QuickStop Deceleration [inc./s^2]. The motor turns off afterwards.
  - Hard Stop
- Polarity (USINT): Change of Redation
  - 0 – no change of Redation (default)
  - 1 – change of Redation
- QuickStop Deceleration (UDINT): Quick stop deceleration ramp
  - 2000 (default)
- Homing Speed Switch (UDINT): Speed of search [inc./s] for detecting the switch
  - 500 (default)
- Homing Speed Edge (UDINT): Speed of search [inc./s] for detecting the switching edge
  - 50 (default)
- Homing Acceleration (UDINT): Acceleration and deceleration ramp [inc./s^2]
  - 2000 (default)
- Ramp Selection Option Code: Type of Acceleration and deceleration ramp
  - Trapezoidal Ramp
  - S Ramp

Digital Outputs High Side

Module Digital Outputs Highside has 2 parameters, which are provided for using the PTO axis interface.

- Do03ModeSelect
  - Digital Output
  - PTO Enable (PTO01)
- Do07ModeSelect
  - Digital Output
  - PTO Enable (PTO02)

If the motor output stage features an enable input, that input can be accessed by using a PTO Enable output. The PTO Enable output is accessed by the Power State Machine.

PTO Inputs

The PTO module supports the use of reference and/or limit switches. The following parameters are available:

- Di02, Di03, Di04 ModeSelect (PTO01)
  - Digital Input: The input is read as a standard input
  - Special Function Enable, Low Active: The PTO01 axis interface reads the input; logic: normally closed
  - Special Function Enable, High Active: The PTO01 axis interface reads the input; logic: normally open
- Di06, Di07, Di08 ModeSelect (PTO02)
  - Digital Input: The input is read as a standard input
  - Special Function Enable, Low Active: The PTO02 axis interface reads the input; logic: normally closed
  - Special Function Enable, High Active: The PTO02 axis interface reads the input; logic: normally open
- Di02, Di03, Di04, Di06, Di07, Di08 FilterSelect
  - No Filter
  - 0.3 ms
  - 1.0 ms
  - 3.0 ms
  - 5.0 ms
  - 10.0 ms
  - 20.0 ms

6.2.2.3 Power State Machine – state machine of the PTO axis interface

A state machine cycle is required to make a control unit ready to operate. The state machine is subject to CANopen standard DS402. Changes of state are retrieved from object Axis n Controlword 0x6040. Read object Axis n Statusword 0x6041 to find the actual status of the state machine.

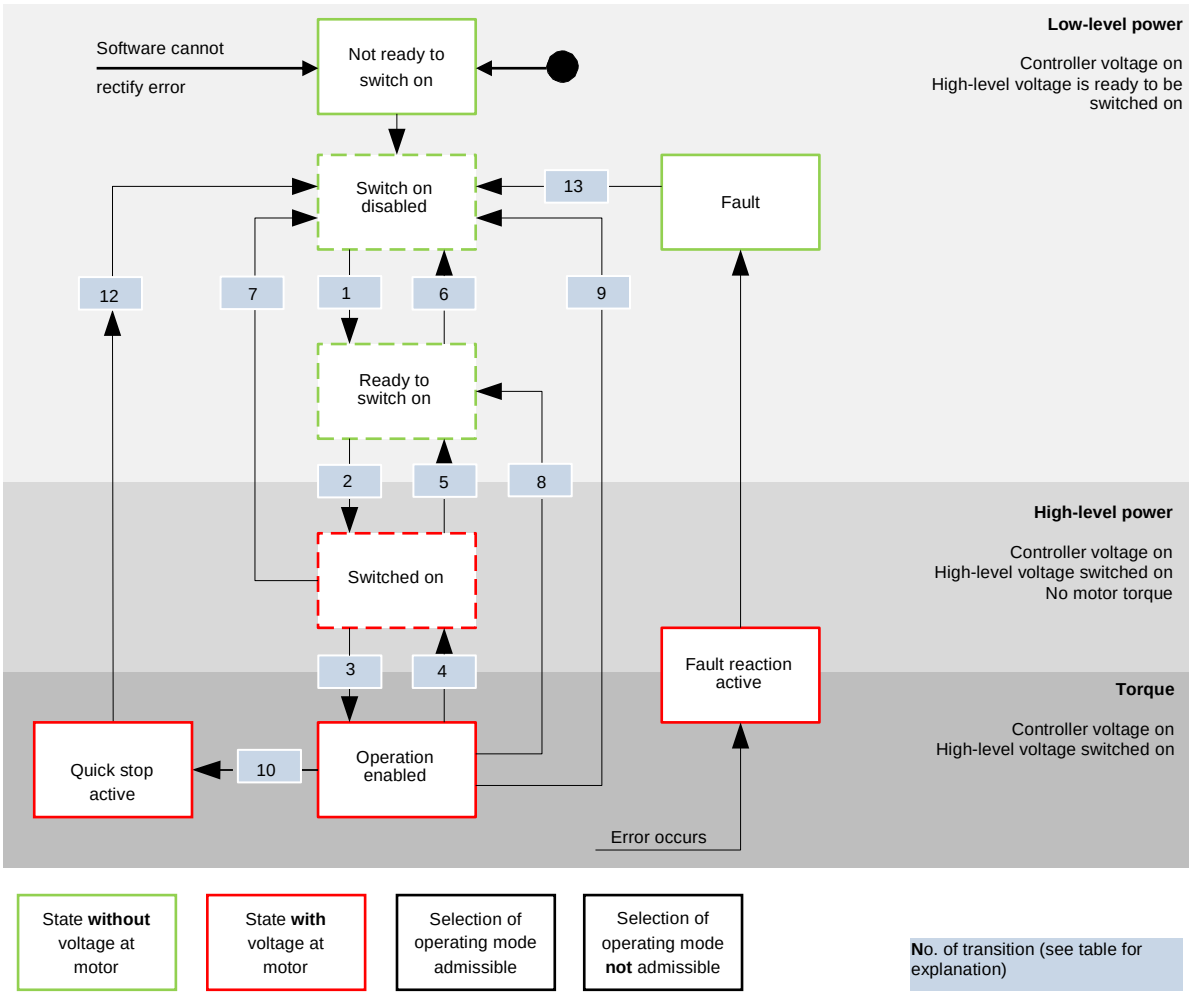
Controlword

Changes of state are retrieved using the control word. The table below summarises the bit combinations that cause the associated state transitions. X marks a bit status that no longer needs to be considered, the only exception being a fault reset: this transition is only requested by the bit's rising edge.

Command	**Control Word Bit**					**Transition**
	7	**3**	**2**	**1**	**0**	
Shutdown	0	X	1	1	0	1, 5, 8
Switch on	0	0	1	1	1	2
Disable voltage	0	X	X	0	X	6, 7, 9, 12
Quick stop	0	X	0	1	X	10
Disable operation	0	0	1	1	1	4
Enable operation	0	1	1	1	1	3, 11
Fault reset		X	X	X	X	13

State Transitions

The picture below illustrates the possible state transitions.



Ready to switch on

State changes 1, 5, 8 to "ready to switch on" (shutdown option)

Switched on

State change 2 to "switched on" (disable operation option):

Halt

When set, control word bit 8 halts the running motion task.

Fault

In case of a fault, the motor will decelerate as defined in object Fault Reaction Option Code.

Quick stop active

State change 10 to Quick Stop Active

Statusword

The table below summarises the bitmasks for decoding the state of the PTO axis interface.

Status Word									**State**
15-8	**7**	**6**	**5**	**4**	**3**	**2**	**1**	**0**	
x	x	0	x	x	0	0	0	0	Not ready to switch on
x	x	1	x	x	0	0	0	0	Switch on disabled
x	x	0	1	x	0	0	0	1	Ready to switch on
x	x	0	1	x	0	0	1	1	Switched on
x	x	0	1	x	0	1	1	1	Operation enabled
x	x	0	0	x	0	1	1	1	Quick stop active
x	x	0	x	x	1	1	1	1	Fault reaction active
x	x	0	x	x	1	0	0	0	Fault
	WARN	SOD	QA	PU	FAULT	OE	SO	RTSO	

After power-up and a successful self-test, the PTO axis interface changes to state Switch on Disabled.
In case of an error, the PTO axis interface changes to state Not Ready to Switch on.

6.2.2.4 Profile Position Mode

Profile Position Mode lets you move either to a relative position (with reference to the last target position) or an absolute position (last reference position). The movement takes account of velocity, acceleration / deceleration ramps and jerk limits.

Profile Position Mode is enabled by "1" in Modes of Operation (see "power state machine").

Control Word

The following control word bits have a special function:

- Bit 4 starts a motion task which is performed when "0" changes to "1".
- Bit 6: "0" sets an absolute target position, "1" sets a target position with reference to the current position.

Status Word

The following status word bits have a special function:

- Bit 10 (Target Reached): changes to "1" when the motion arrives at the last target
- Bit 12 (Set-point acknowledge): acknowledges that a new and valid target has been received. Setting and resetting it is synchronised with setting and resetting bit "new set-point" of the control word. One exception assumes the start of a motion while another motion is still in progress whereas the next motion should not start until the first motion is complete. In this case, the bit will not reset until the command has been accepted and the control unit is ready to execute new drive commands. Sending a new drive command while this bit is still set will lead to the latest drive command being ignored. Any of the conditions below prevent the bit from being set:
    - Assuming that all constraints are met, the motion will fail to arrive at the new target position.
    - A motion a target position is in progress and another target position has been set. A new target position cannot be set until the current motion has been completed.
    - The new position is out of the valid range (Axis n Software Position Limit).

6.2.2.5 Profile Velocity Mode

This mode runs the motor in Profile Velocity Mode with extended ramps.

Profile Velocity Mode is enabled by "3" in Modes of Operation (see "power state machine").

Control Word

The following bits in object Axis n Controlword 0x6040 have a special function:

- Bit 2 initiates an emergency stop. Bit 2 = "0" lets the motor perform rapid braking down the ramp set in object 6085h and changes the state of the control unit to "switch on disabled" (6040h).
- Bit 8 (Halt): when the bit changes from "1" to "0", the motor accelerates up the set starting ramp until running at target velocity. When it changes from "0" to "1", the motor decelerates until it stops.

Statusword

The following bits in object Axis n Statusword 0x6041 have a special function:

Bit 10 (at target velocity; Target Reached): Together with bit 8 of the control word, this bit says whether the motor is running at target velocity, is being decelerated or standing still (see table).

Status Word	**Control Word**	**Description**
Bit 10	**Bit 8**	
0	0	Not at target velocity
0	1	Shaft decelerating
1	0	Target velocity reached
1	1	Axis velocity is 0

6.2.2.6 Homing Mode

In Homing Mode, the actual position of a machine is synchronised with a mechanical reference position.

Homing Mode is enabled by "6" in Modes of Operation (see "power state machine").

Depending on your method of referencing, you need reference and/or limit switches to detect a mechanical reference position of the machine. Using this function requires the associated PTO input module to be shown by the devices explorer, and the module must be configured for the application.

Control Word

The following control word bits have a special function:

- Bit 2: initiates an emergency stop. "0" lets the motor perform rapid braking down the ramp set in Quick Stop Deceleration. The state of the motor then changes to Switch on Disabled (see "power state machine").
- Bit 4: "1" starts referencing which will continue until either the reference position has been reached or bit 4 is reset to "0".

Status Word

The following bits in object Axis n Statusword 0x6041 have a special function:

6041h	**6041h**	**6041h**	**Description**
Bit 13	**Bit 12**	**Bit 10**	
0	0	0	Referencing in progress
0	0	1	Referencing suspended or not started
0	1	0	Referencing started but has not arrived at target yet
0	1	1	Referencing completed
1	0	0	Referencing error, motor is still turning
1	0	1	Referencing error, motor at standstill

Homing Speed

Speed while searching for the reference and/or limit switch

Homing Acceleration

Acceleration and deceleration ramp [inc./s2] for the homing run

Homing Method

The Homing Method defines how homing is done. A numerical value selects the method. Validity:

17 Homing on negative limit switch (falling edge)
18 Homing on positive limit switch (rising edge)
19 Homing on negative home switch (falling edge)
20 Homing on negative home switch (rising edge)
21 Homing on positive home switch (falling edge)
22 Homing on positive home switch (rising edge)
23 Homing on negative home switch (falling edge), positive initial motion
24 Homing on negative home switch (rising edge), positive initial motion
25 Homing on positive home switch (rising edge), positive initial motion
26 Homing on positive home switch (falling edge), positive initial motion
27 Homing on positive home switch (falling edge), negative initial motion
28 Homing on positive home switch (rising edge), negative initial motion
29 Homing on negative home switch (rising edge), negative initial motion
30 Homing on negative home switch (falling edge), negative initial motion
37 Homing on current position

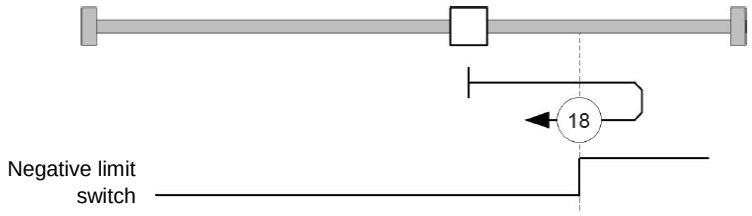
The following homing run parameters are available:

- Homing speed switch: speed while searching for the switch
- Homing speed edge: speed at which the switching edge is detected
- Homing acceleration: acceleration in homing mode

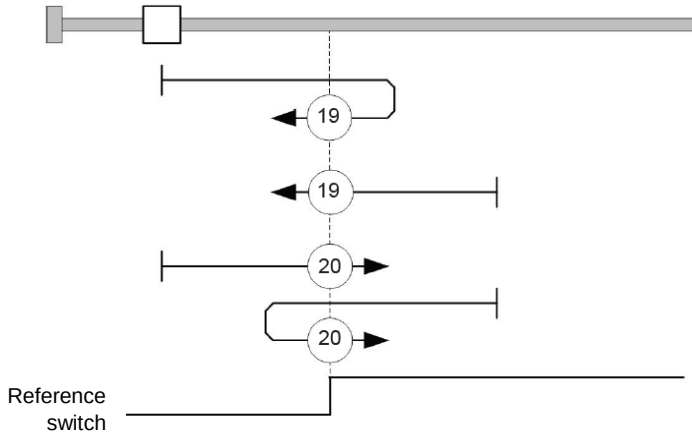
Overview of Homing Methods:

Method 17 homes in on the negative limit switch.

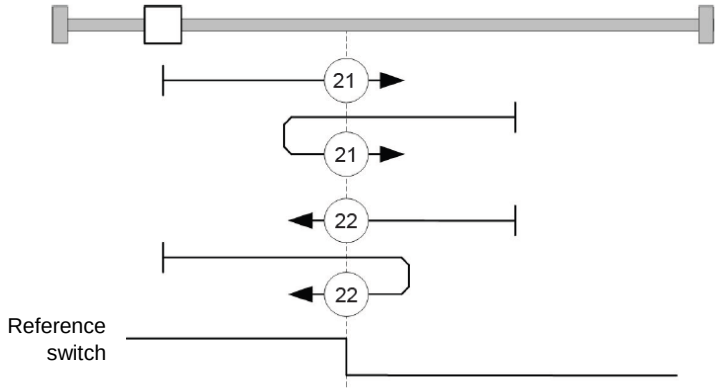
Method 18 homes in on the positive limit switch.



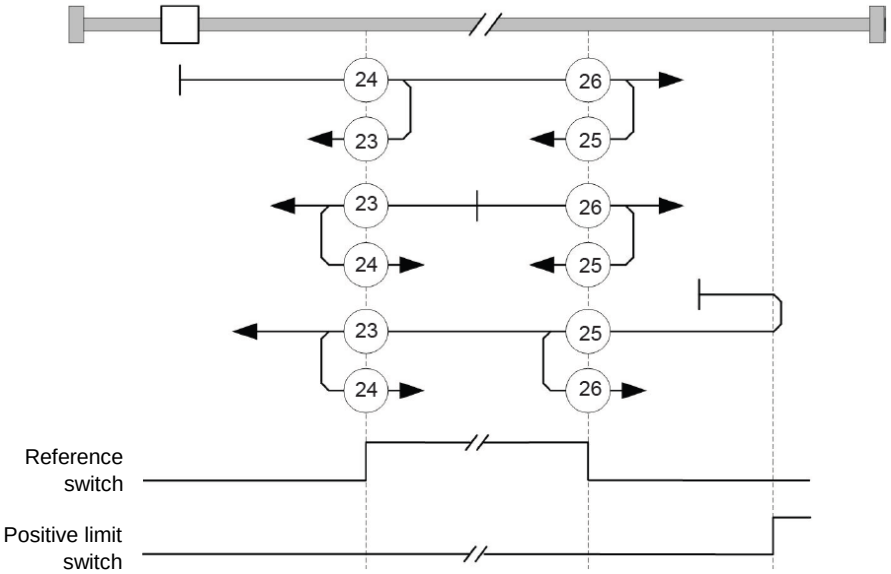
Methods 19 and 20 use the reference switch's left switching edge for homing.



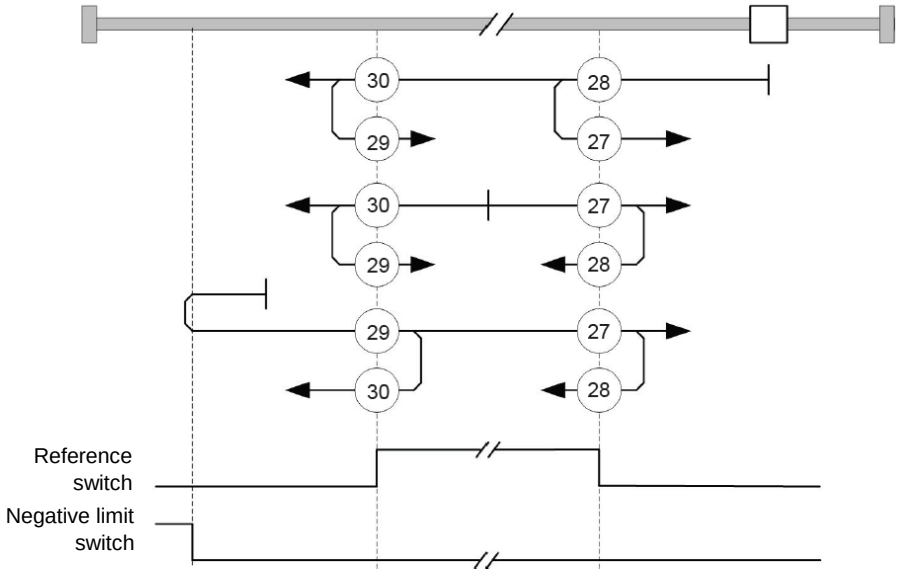
Methods 21 and 22 use the reference switch's right switching edge for homing.



Methods 23 to 26 consider the positive home switch:



Methods 27 to 30 consider the negative home switch:



Method 37 does not start any motion. The Home Offset value is used as the actual position and transferred to Position Actual Value.

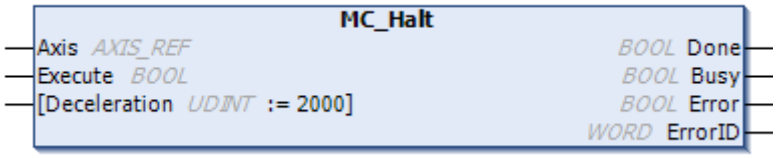
6.2.2.7 CODESYS Motion Library – Overview

CODESYS motion library KICS PTO Stepper Control Library 111 interacts with the power state machine of the axis, controls motions and provides diagnostic functions.

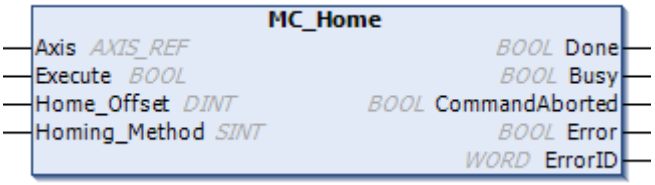
Visit our Internet site where you can download a demo project.

Function blocks:

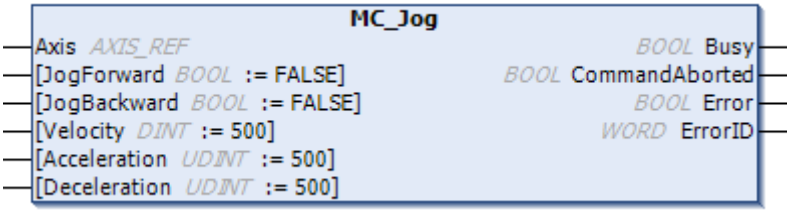
- MC_Halt
  - Halts the axis while retaining the ongoing motion task



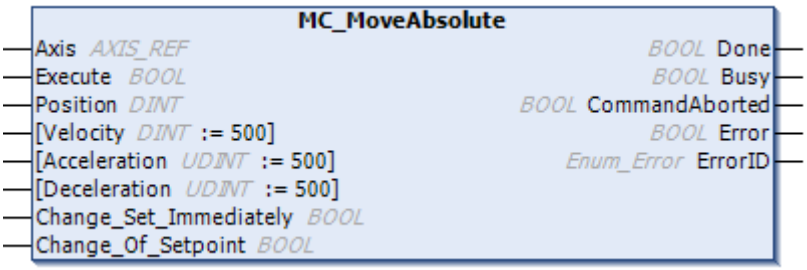
- MC_Home
  - Starts homing the axis



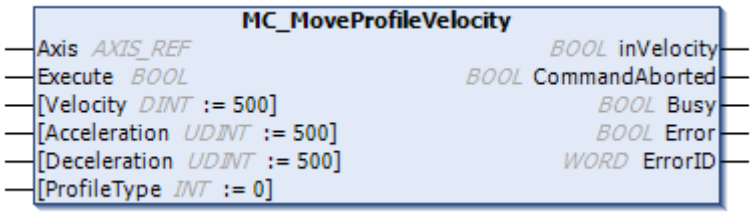
- MC_InitAxis
  - Initialises the process image of inputs and outputs as well as the limit and reference switches
- MC_Jog
  - Enables Profile Velocity Mode to move the axis in positive or negative direction and stop it afterwards



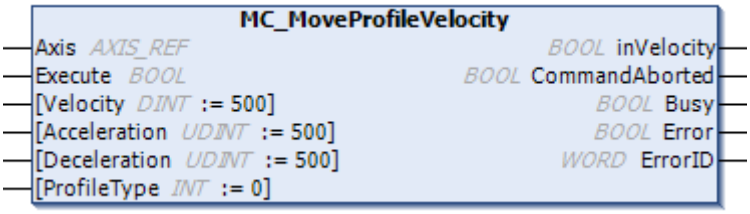
- MC_MoveAbsolute
  - Enables Profile Position Mode and starts a positioning run to an absolute position



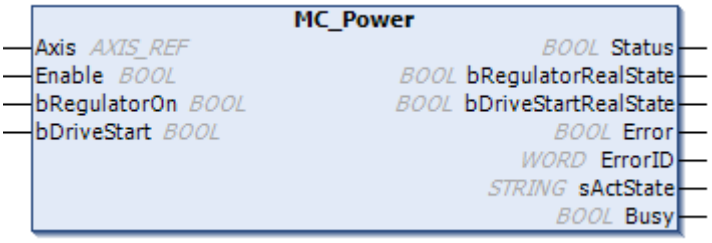
- MC_MoveProfileVelocity
  - Enables Profile Velocity Mode and starts a velocity-controlled motion



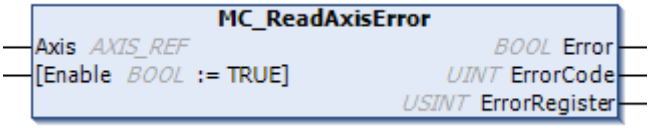
- MC_MoveRelative
  - Starts a relative positioning run at the current set-point position



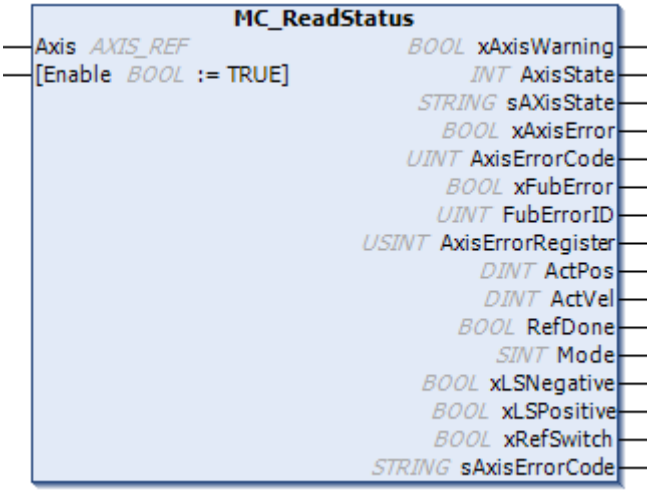
- MC_Power
  - Interacts with the DS402 power state machine of the axis



- MC_ReadAxisError
  - Reads the error messages logged for the axis

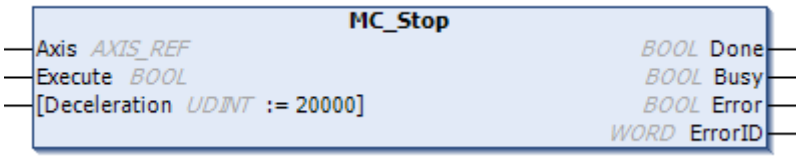


- MC_ReadStatus
  - Reads the status of the axis



- MC_Reset
  - Acknowledges axis/function block errors

- MC_Stop
  - Stops the axis and cancels the current motion task



6.2.2.8 CODESYS Motion Library – Usage

Before you can start using the CODESYS Motion Library, you must first install it in your system. From the menu, pick CODESYS -> Tools -> Library Repository. This opens a window in which you click on Install. Now find the correct path to your library, select the library and click on Open. The library then installs in your system.

Prerequisites

You previously created a CODESYS project and allocated the slots. If not, please create a CODESYS project and allocate the PTO module to the slots first.

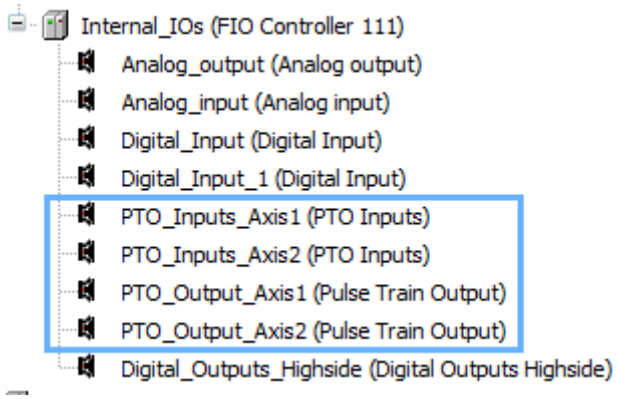
Declarations

First of all, declare the actual axis and the instances of the function blocks required for each PTO axis interface.

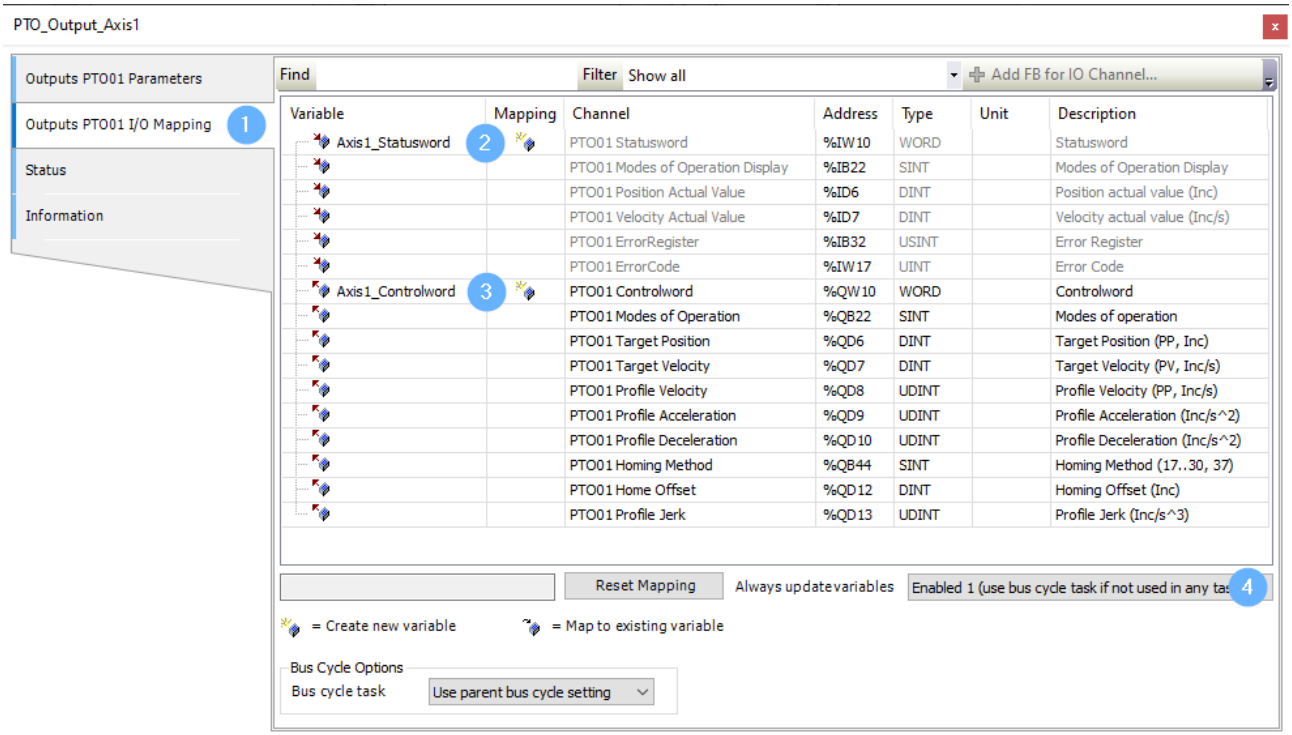
Add object List of Global Variables to your application.

```
{attribute 'qualified_only'}
VAR_GLOBAL
	// PTO01 axis interface
	Axis_1: KICS_PTO.AXIS_REF; // axis structure
	Init_Axis_1: KICS_PTO.MC_InitAxis; // initialisation module
	MC_Power_1: KICS_PTO.MC_Power; // FB instance for operating the power state machine
	MC_Reset_1: KICS_PTO.MC_Reset; // FB instance for error acknowledgement
	MC_Jog_1: KICS_PTO.MC_Jog; // FB instance for manual operations
	MC_MoveAbsolute_1: KICS_PTO.MC_MoveAbsolute; // FB instances for motions in PP mode
	MC_ReadStatus_1: KICS_PTO.MC_ReadStatus; // FB instance for displaying the current status
	MC_Home_1: KICS_PTO.MC_Home; // FB instance for homing runs

	// PTO02 axis interface
	Axis_2: KICS_PTO.AXIS_REF; // axis structure
	Init_Axis_2: KICS_PTO.MC_InitAxis; // initialisation module
	MC_Power_2: KICS_PTO.MC_Power; // FB instance for operating the power state machine
	MC_Reset_2: KICS_PTO.MC_Reset; // FB instance for error acknowledgement
	MC_Jog_2: KICS_PTO.MC_Jog; // FB instance for manual operations
	MC_MoveAbsolute_2: KICS_PTO.MC_MoveAbsolute; // FB instances for motions in PP mode
	MC_ReadStatus_2: KICS_PTO.MC_ReadStatus; // FB instance for displaying the current status
	MC_Home_2: KICS_PTO.MC_Home; // FB instance for homing run END_VAR
```

Also declare a couple of PTO module variables shown by the devices explorer.



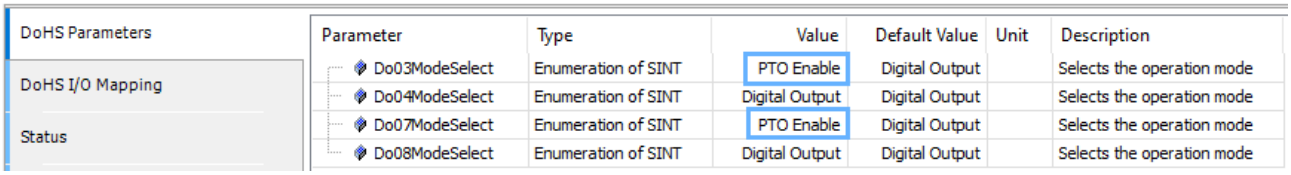
Find your module on the devices explorer screen and double-click on it to run the Device Configurator. The procedure below applies to module Pulse Train Output for PTO01.



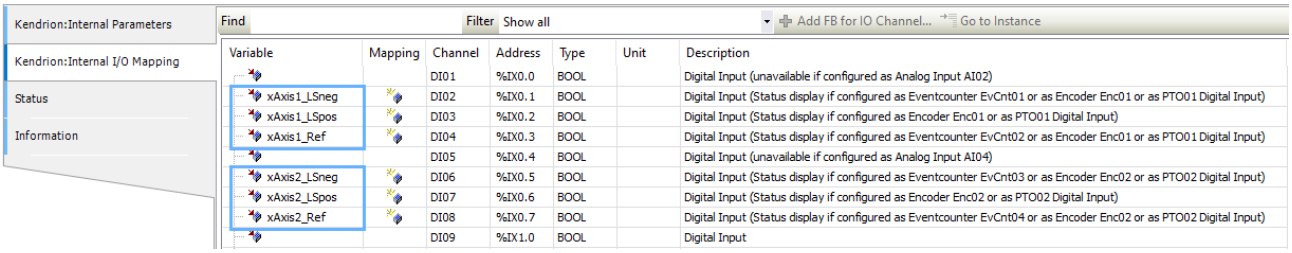
1. On the Device Configurator screen, go to tab PTO01 I/O Mapping.
2. Enter Axis1_Statusword in column Variable as the name of channel PTO01 Statusword
3. Enter Axis1_Controlword in column Variable as the name of channel PTO01 Controlword
4. Choose Enabled 1(…) next to Always Update Variables.

PTO02 works the same as PTO01, except that the name of the variable is Axis2_...

The next step is to set up the PTO_Enable signals. Use module Digital Outputs Highside for configuration. Double-click on the module to run the Device Editor.



The last step is to declare the variables of the digital inputs. The input mapping is stored on device Internal_IOs. Double-click to run the Device Editor.



Programme

In our sample programme, POU "PLC_PRG" initialises the two PTO axis interfaces After that, the function block instances are started cyclically.

```
PROGRAM PLC_PRG
VAR
	xInit: BOOL;
	inci: INT;
END_VAR

inci := inci + 1;

(* Initialising the input and output process data of the axis *)
IF NOT xInit then
	GVL.Init_Axis_1(
		Axis:= GVL.Axis_1,
		pRXPdo:= ADR(Axis1_Controlword),
		pTXPdo:= ADR(Axis1_Statusword),
		xLimitSwitchLeft:= xAxis1_LSneg,
		xLimitSwitchRight:= xAxis1_LSpos,
		xRefSwitch:= xAxis1_Ref);

	GVL.Init_Axis_2(
		Axis:= GVL.Axis_2,
		pRXPdo:= ADR(Axis2_Controlword),
		pTXPdo:= ADR(Axis2_Statusword),
		xLimitSwitchLeft:= xAxis2_LSneg,
		xLimitSwitchRight:= xAxis2_LSpos,
		xRefSwitch:= xAxis2_Ref);

	xInit := TRUE ;
END_IF

IF xInit THEN
	// Once initialised, the required axis blocks
	//are started cyclically

	(* axis 1 *)
	GVL.Init_Axis_1(
		Axis:= GVL.Axis_1,
		pRXPdo:= ADR(Axis1_Controlword),
		pTXPdo:= ADR(Axis1_Statusword),
		xLimitSwitchLeft:= xAxis1_LSneg,
		xLimitSwitchRight:= xAxis1_LSpos,
		xRefSwitch:= xAxis1_Ref);
```

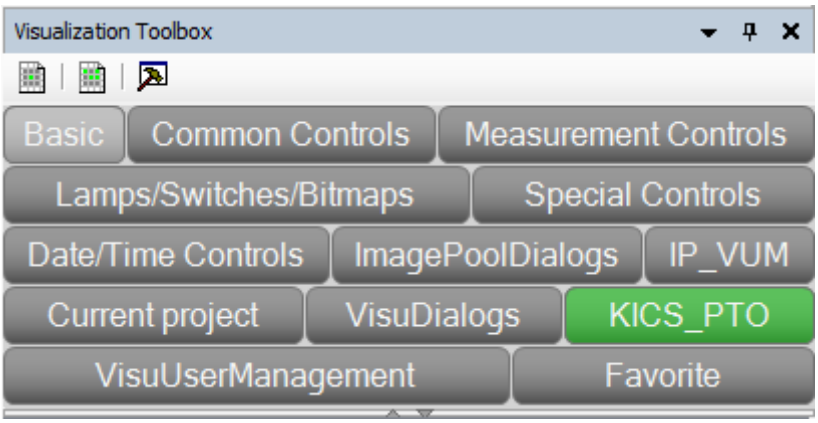
```
        GVL.MC_Power_1(Axis := GVL.Axis_1);
        GVL.MC_MoveAbsolute_1(Axis := GVL.Axis_1);
        GVL.MC_Jog_1(Axis := GVL.Axis_1);
        GVL.MC_ReadStatus_1(Axis := GVL.Axis_1);
        GVL.MC_Reset_1(Axis := GVL.Axis_1);
        GVL.MC_Home_1(Axis := GVL.Axis_1);

        (* axis 2 *)
        GVL.Init_Axis_2(
                Axis:= GVL.Axis_2,
                pRXPdo:= ADR(Axis2_Controlword),
                pTXPdo:= ADR(Axis2_Statusword),
                xLimitSwitchLeft:= xAxis2_LSneg,
                xLimitSwitchRight:= xAxis2_LSpos,
                xRefSwitch:= xAxis2_Ref);

        GVL.MC_Power_2(Axis := GVL.Axis_2);
        GVL.MC_MoveAbsolute_2(Axis := GVL.Axis_2);
        GVL.MC_Jog_2(Axis := GVL.Axis_2);
        GVL.MC_ReadStatus_2(Axis := GVL.Axis_2);
        GVL.MC_Reset_2(Axis := GVL.Axis_2);
        GVL.MC_Home_2(Axis := GVL.Axis_2);
END_IF
```

Visualisation

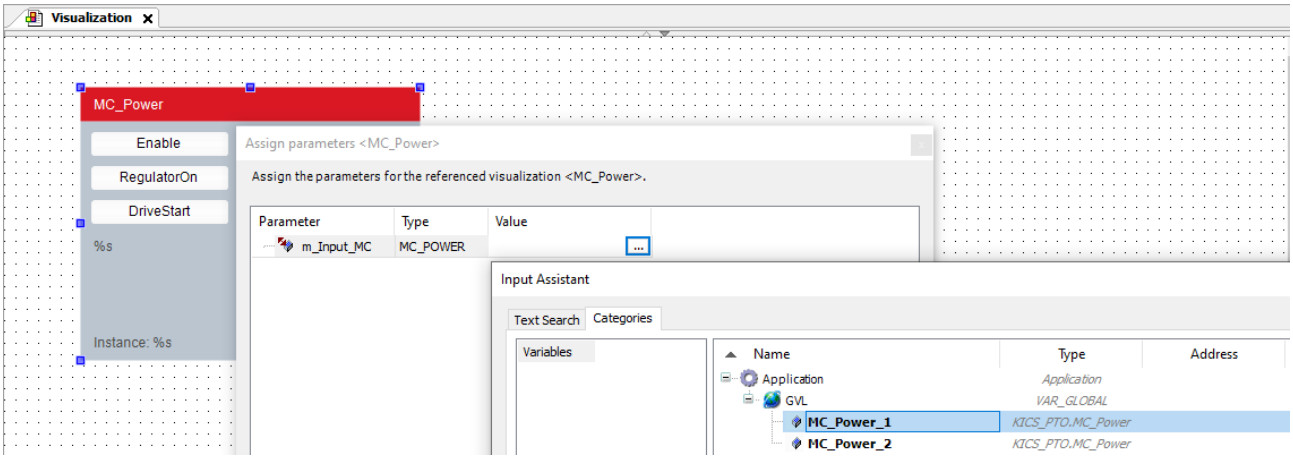
The CODESYS Motion Library contains a visualisation template for ever function block. The templates allow you to test the function without greater programming effort.

Add a visualisation to the application of your project. Right-click on Application and pick Add Object -> Visualization from the popup menu. Now assign a name to the visualisation and click on Add

This starts the Visualisation Editor and the visualisation you just added. The Visualization Toolbox screen shows you the available visualisation objects.



Go to tab KICS_PTO and select visualisation template MC_Power by left-clicking on it, holding the mouse button and dragging it to the worktop of the Visualisation Editor.

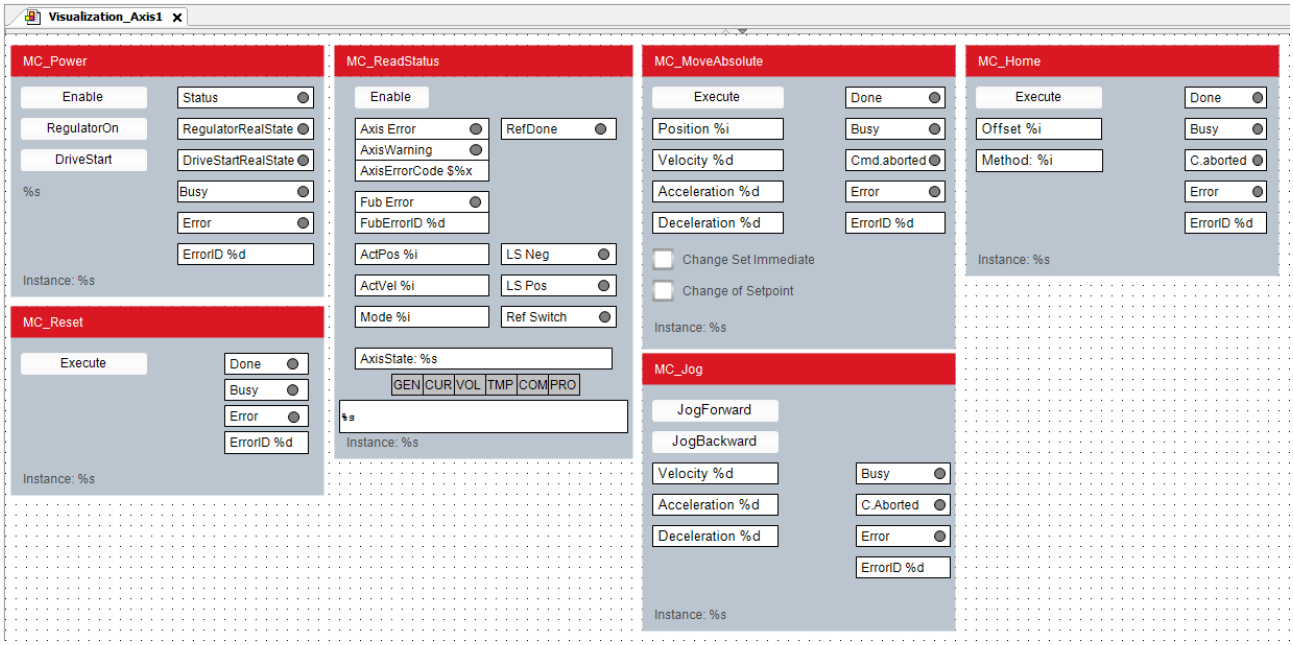


The next dialog that opens is called Assign parameters <MC_Power. Under Value click on ... to display the Input Assistant. Select the associated function block instance and click on OK twice to confirm your selection.

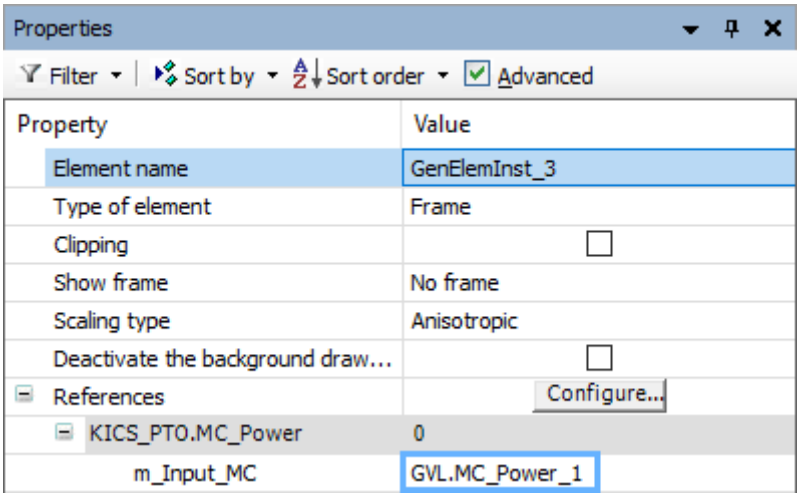
Repeat this procedure to add the following visualisation templates:

- MC_ReadStatus
- MC_Reset
- MC_MoveAbsolute
- MC_Jog
- MC_Home
- Optional: MC_Statusword (uses the axis instead of the FB instance as reference)
- Optional: MC_Controlword (uses the axis instead of the FB instance as reference)

A complete visualisation might look like this:



To set up the second PTO axis interface, you can simply copy the entire visualisation and edit the references of the visualisation templates. Click on one of the visualisations to change the reference to its function block instance. Now check the properties of the reference as appropriate.



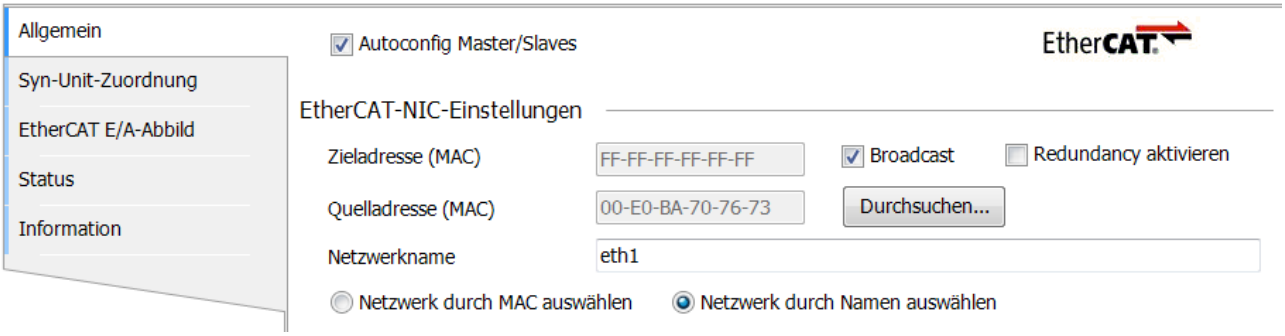
CODESYS Motion Library – Function Test

Run a function test after completing all of the above steps. Compile the project (F11 or Build -> Build from the menu). The compiler should not detect any mistakes.

Now connect to FIO Controller 111 and log in on the device.

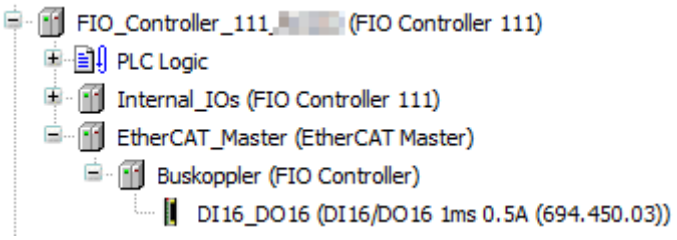
6.2.3 EtherCAT Master

Now append the "EtherCAT Master" to FIO Controller 111. Double-click to configure it. Go to the general settings and enter "eth0" as the interface:



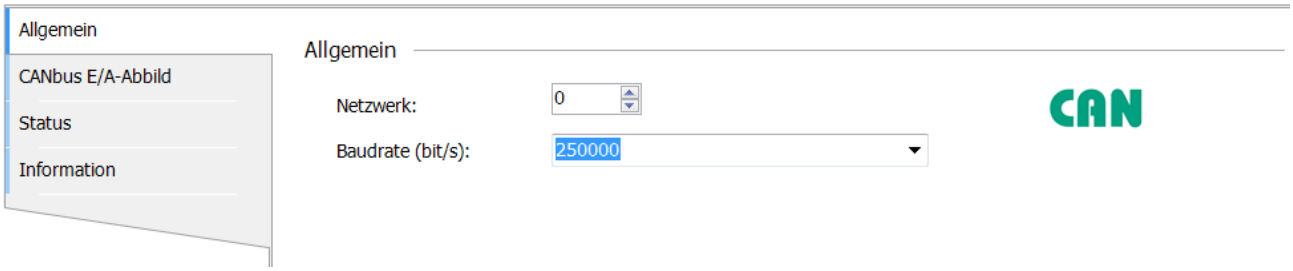
Now append the FIO Controller (Internal E-Bus) to the EtherCAT Master. The device is the starting point of appending all further Kuhnke FIO EtherCAT-series modules, e.g. FIO DI16/DO16

Devices explorer with EtherCAT

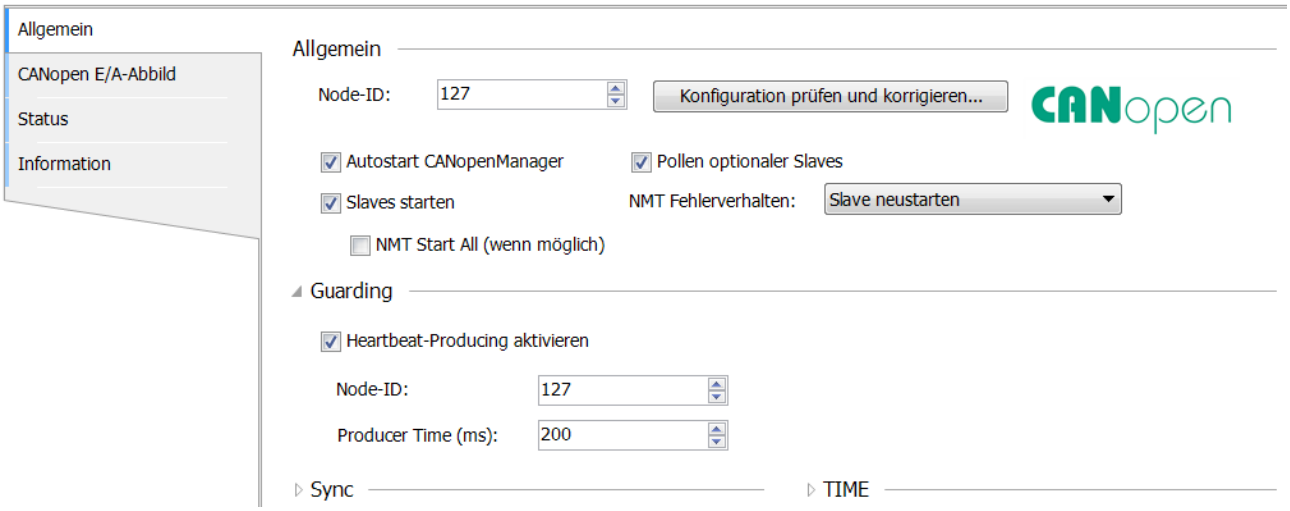


6.2.4 CANopen Master

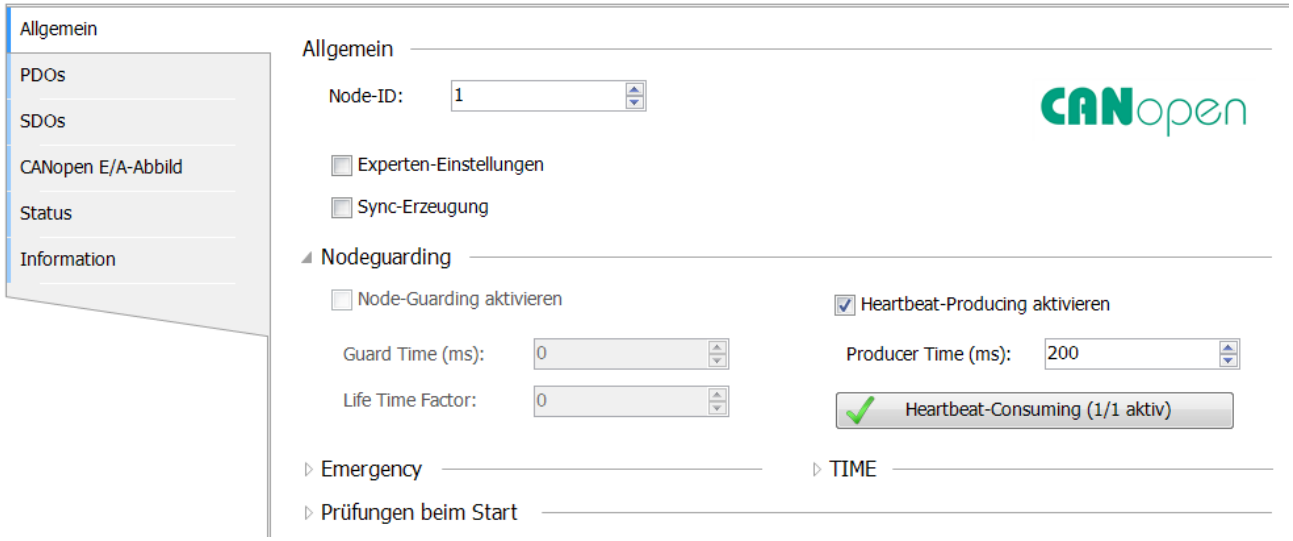
Append the CAN Bus device to FIO Controller 111. Double-click to configure it. Go to the general settings and pick the appropriate baud rate. Do not change the Network (0):



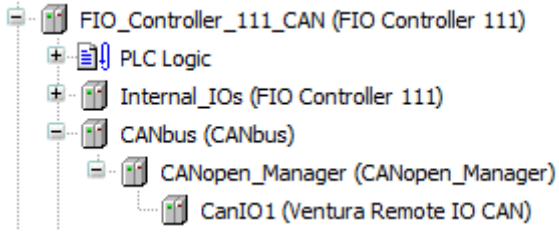
Now append the CANopen_Manager to the CAN Bus. Its settings depend on and may have to be adapted to all later bus stations.



Now append the CANopen slaves to the CANopen_Manager, as appropriate. Refer to the slave manufacturer's instructions to know how to configure the slaves.

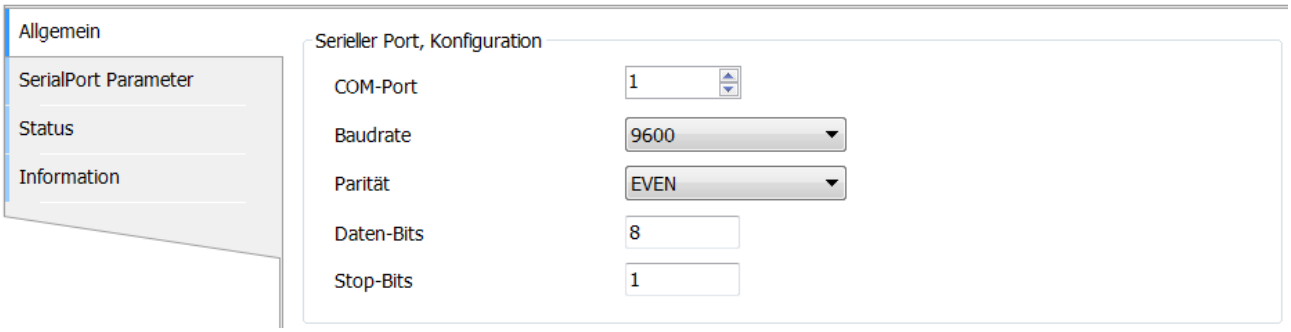


Devices explorer with CAN bus

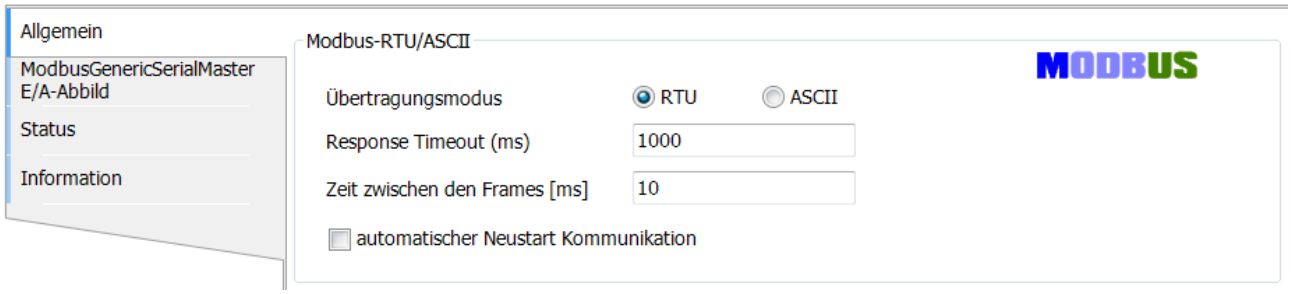


6.2.5 Modbus RTU Master

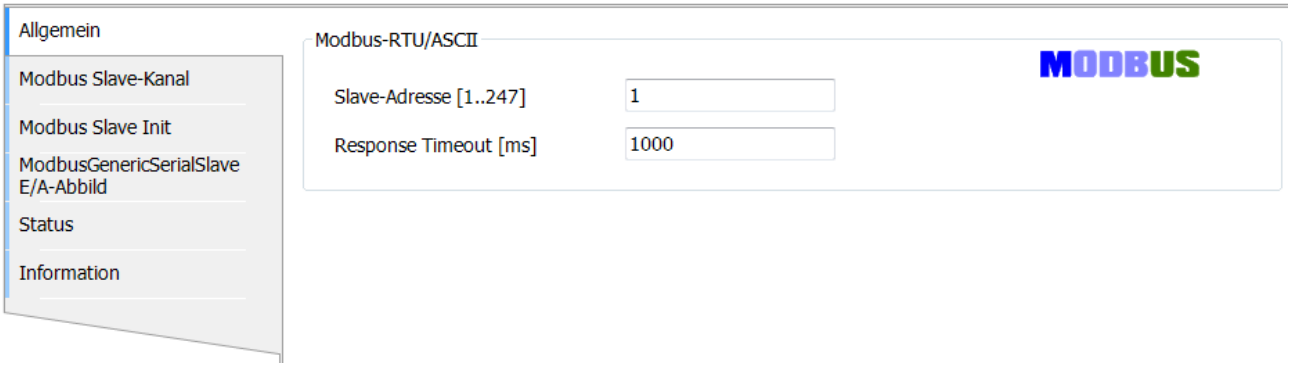
Append the KICS Modbus COM Port device to FIO Controller. Double-click to configure it. Go to the general settings and set up the COM Port (1). Its other settings such as the baud rate, parity, data bits and stop bits depend on and may have to be adapted to all later bus stations.



Now append a Modbus RTU Master. Again, its configuration depends on and may have to be adapted to lower-level bus stations.



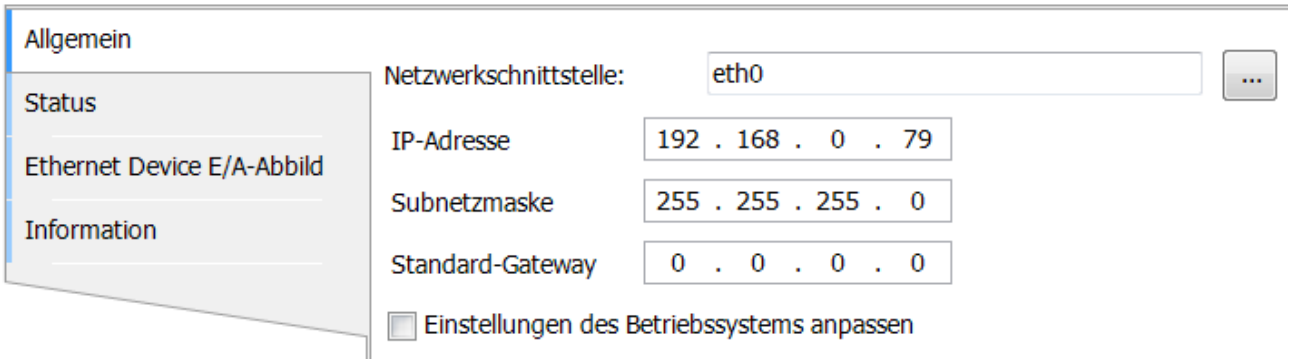
Add the required Modbus RTU slaves to the Modbus RTU Master. Refer to the slave manufacturer's instructions to know how to configure the slaves.



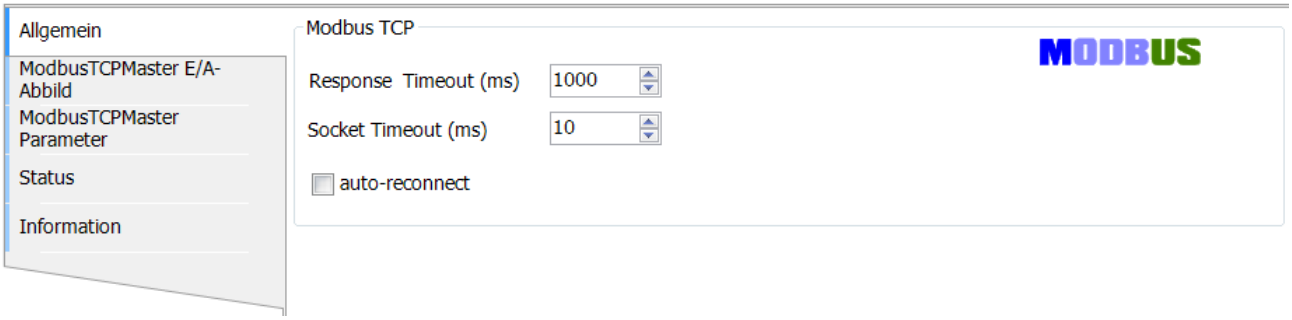
Devices explorer with Modbus RTU

6.2.6 Modbus TCP Master

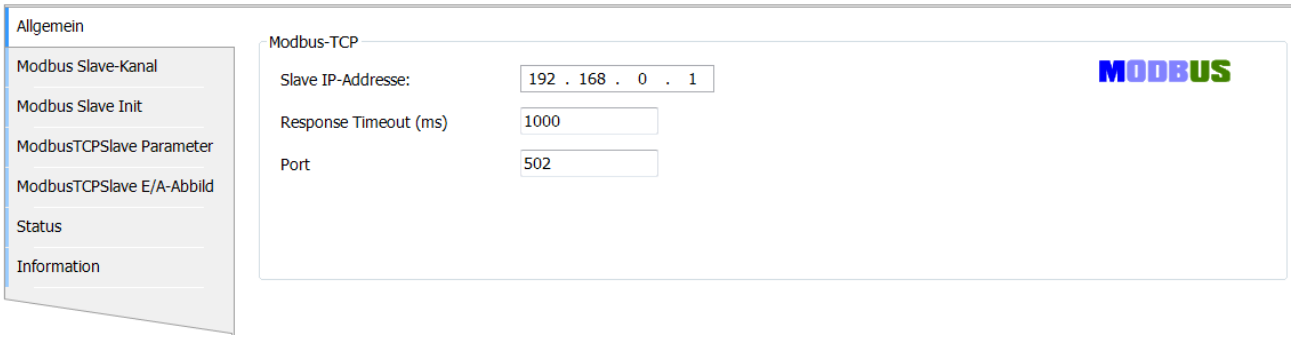
Append the "Ethernet" device to FIO Controller 111. Double-click to configure it. Go to the general settings and enter "eth0" as the interface. If the device is connected to the control unit, click on ... and pick interface "eth0". The control unit will then accept the IP address, subnet mask and standard gateway.



Now append a Modbus TCP Master. Its settings depend on and may have to be adapted to all later bus stations.



Add the required Modbus TCP slaves to the Modbus TCP Master. Refer to the slave manufacturer's instructions to know how to configure the slaves.



6.3 Device-specific Libraries

6.3.1 Kuhnke System Library

Kuhnke System Library iMX6 provides you with various diagnostic and control unit configuration functions.

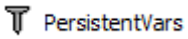
6.4 Remanent Variables

Use keywords RETAIN or PERSISTENT to declare your remanent variables.

6.4.1 Declaring Remanent Variables

To declare a Retain variable, add keyword RETAIN to the declaration section. Sample declaration in the list of global variables:

```
VAR_GLOBAL  RETAIN
       udiCounter: UDINT;
END_VAR
```

To declare a Persistent variable, add object 

to the application. This list of global variables contains the declarations of persistent variables. If variables are assigned keyword PERSISTENT outside of the Persistance Editor, the paths to the instances are added there.

```
VAR_GLOBAL PERSISTENT RETAIN
       udiCounter: UDINT;
END_VAR
```

The difference between Retain and Persistent variables is their lifetime:

	Normal Variables	RETAIN	PERSISTENT RETAIN PERSISTENT PERSISTENT RETAIN
Powerfail	0	X	X
Online change	X	X	X
Hot reset	0	X	X
Cold reset	0	0	X
Load	0	0	X (1)
Reset origin	0	0	0

X = the variable value is retained

0 = the variable is initialised

X (1) = is retained only for as long as the internal structure of the persistent variable remains the same

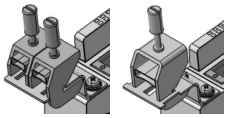
7 Appendix

7.1 Order Specifications

7.1.1 Basic Units

To know which combinations are currently available, browse our Internet home for the Product Finder at:
https://productfinder.kuhnke.kendrion.com/de/modulare-sps/

7.1.2 Accessories – Shield Terminals



- 694 412 01 Kuhnke FIO shield terminal, 2x8 mm
- 694 412 02 Kuhnke FIO shield terminal, 1x14 mm

KENDRION

PRECISION. SAFETY. MOTION.

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