

Documentation | EN

EL6233

EtherCAT Terminal | Two Channel Communication Interface, Ethernet-APL



1 Foreword

1.1 Notes on the documentation

Intended audience

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

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

The qualified personnel is obliged to always use the currently valid documentation.

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

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

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1.2 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!

Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability

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

Personnel qualification

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

Signal words

The signal words used in the documentation are classified below. In order to prevent injury and damage to persons and property, read and follow the safety and warning notices.

Personal injury warnings

DANGER

Hazard with high risk of death or serious injury.

WARNING

Hazard with medium risk of death or serious injury.

CAUTION

There is a low-risk hazard that could result in medium or minor injury.

Warning of damage to property or environment

NOTICE

The environment, equipment, or data may be damaged.

Information on handling the product



This information includes, for example:
recommendations for action, assistance or further information on the product.

1.3 Guide through documentation

NOTICE



Further components of documentation

This documentation describes device-specific content. It is part of the modular documentation concept for Beckhoff I/O components. For the use and safe operation of the device / devices described in this documentation, additional cross-product descriptions are required, which can be found in the following table.

Title	Description
EtherCAT System Documentation (PDF)	• System overview • EtherCAT basics • Cable redundancy • Hot Connect • EtherCAT devices configuration
Explosion Protection for Terminal Systems (PDF)	Notes on the use of the Beckhoff terminal systems in hazardous areas according to ATEX and IECEx
Infrastructure for EtherCAT/Ethernet (PDF)	Technical recommendations and notes for design, implementation and testing
Software Declarations I/O (PDF)	Open source software declarations for Beckhoff I/O components

The documentations can be viewed at and downloaded from the Beckhoff website (www.beckhoff.com) via:

- the “Documentation and Download” area of the respective product page,
- the [Download finder](#),
- the [Beckhoff Information System](#).

If you have any suggestions or proposals for our documentation, please send us an e-mail stating the documentation title and version number to: documentation@beckhoff.com

1.4 Documentation Issue Status

Version	Comment
0.2	• Chapter <i>Technical data</i> updated
0.1	• First draft

2 Product overview

2.1 EL6233 - Introduction

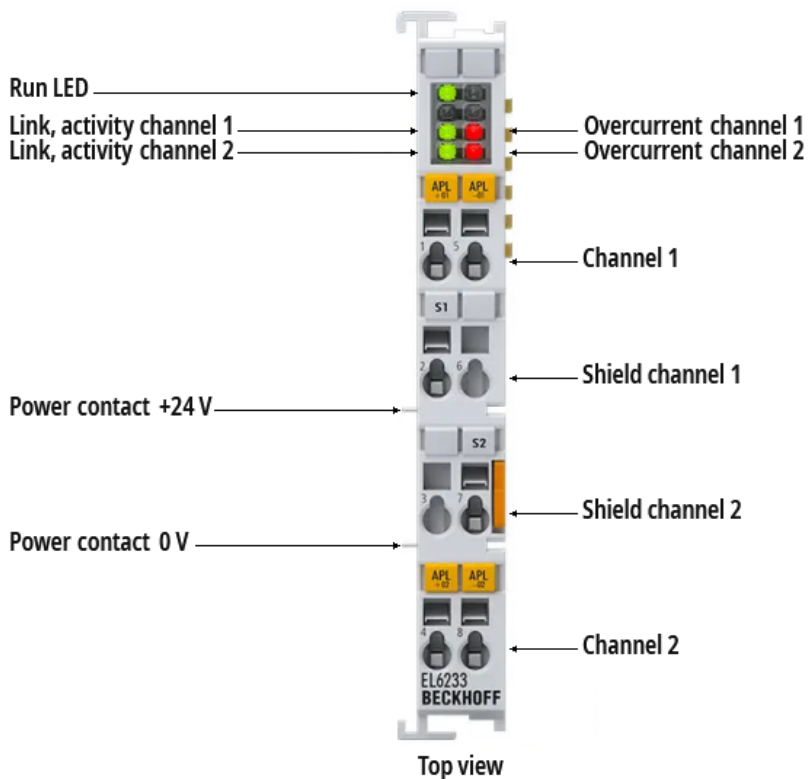


Fig. 1: EL6233 | Two channel communication interface, Ethernet-APL

The EL6233 EtherCAT Terminal allows direct connection of Ethernet-APL-capable field devices. The sensors are supplied in accordance with the SPCX port profile and integrated via PROFINET. Thanks to the flexible EtherCAT system architecture and the EL portfolio, Ethernet-APL, HART or simple digital signals can be integrated in the same terminal segment.

The Ethernet Advanced Physical Layer is a communication technology specially developed for the requirements of the process industry. Ethernet-APL describes only the physical transmission layer, based on the 10BASE-T1L single-pair Ethernet standard, and is therefore protocol-independent. Regarding use in hazardous areas, the IEC defines limits for the power supply to the field devices. The TS10186 technical specification developed by the Ethernet-APL project group prescribes guideline values based on these limit values and divides them into port profiles to simplify connectivity. Field devices from zones of the hazardous area can be connected depending on the port profile.

2.2 Technical data

Technical data	EL6233
Technology	Ethernet-APL
Number of Ethernet APL ports	2
Connection technology	terminal contact
Ethernet interface	10BASE-T1L, single pair ethernet
Cable length	max. 200 m
Data transfer rates	10 Mbit/s
Protocol	PROFINET
Configuration	via the EtherCAT-Master from TwinCAT 3.1, build 4024.58 or build 4026
Current consumption from the E-bus	typ. 60 mA
Current consumption from the power contacts	typ. 25 mA + load (load = max. 22.5 mA per channel)
Power supply of the electronics	24 V _{DC} (via power contacts), supplied by ELX9560
Connection type	SPCX
Rated power	1.1 W
Permissible ambient temperature range during operation	-25 °C ... + 60 °C
Permissible ambient temperature range during storage	-40 °C ... + 85 °C
Permissible relative air humidity	95 %, no condensation
Weight	approx. 60 g
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27
EMC immunity / emission	conforms to EN 61000-6-2 / EN 61000-6-4
Protection rating	IP20
Correct installation position	See chapter installation positions [► 12]
Approvals / markings*	CE

*) Real applicable approvals/markings see type plate on the side (product marking).

Housing data

Technical data	EL6233
Design	compact terminal housing with signal LEDs
Material	Polycarbonate, blue
Size (W x H x D)	approx. 23 mm x 100 mm x 68 mm (width aligned: 12 mm)
Mounting [► 9]	on 35 mm mounting rail according to EN 60715 with locking
Stackable by	double groove-tongue connection
Labelling	Labeling of the BZxxx series
Power contacts	2 blade/spring contacts

3 Mounting and wiring

3.1 Instructions for ESD protection

NOTICE

Destruction of the devices by electrostatic discharge possible!

The devices contain components at risk from electrostatic discharge caused by improper handling.

- When handling the components, ensure that there is no electrostatic discharge; also avoid touching the spring contacts directly (see illustration).
- Contact with highly insulating materials (synthetic fibers, plastic films, etc.) should be avoided when handling components at the same time.
- When handling the components, ensure that the environment (workplace, packaging and persons) is properly earthed.
- Each bus station must be terminated on the right-hand side with the [EL9011](#) or [EL9012](#) end cap to ensure the degree of protection and ESD protection.

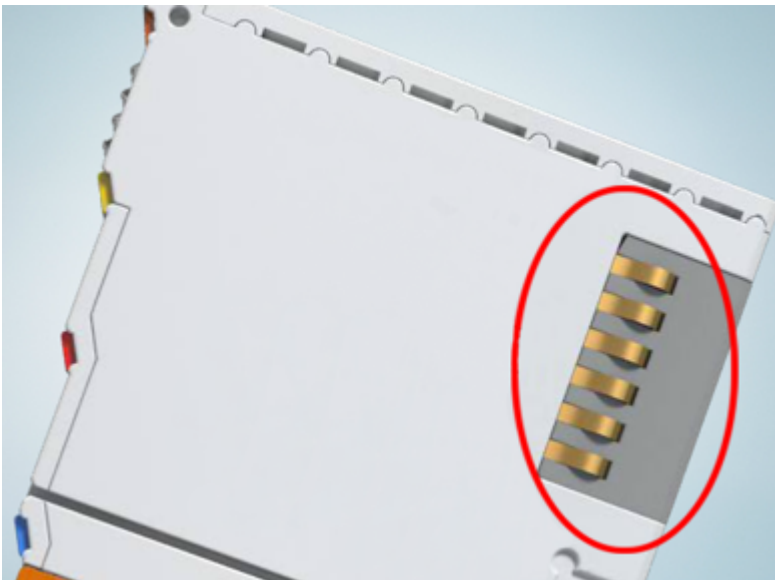


Fig. 2: Spring contacts of the Beckhoff I/O components

3.2 Installation on mounting rails

⚠ WARNING

Risk of electric shock and damage of device!

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

The Bus Terminal system and is designed for mounting in a control cabinet or terminal box.

Assembly

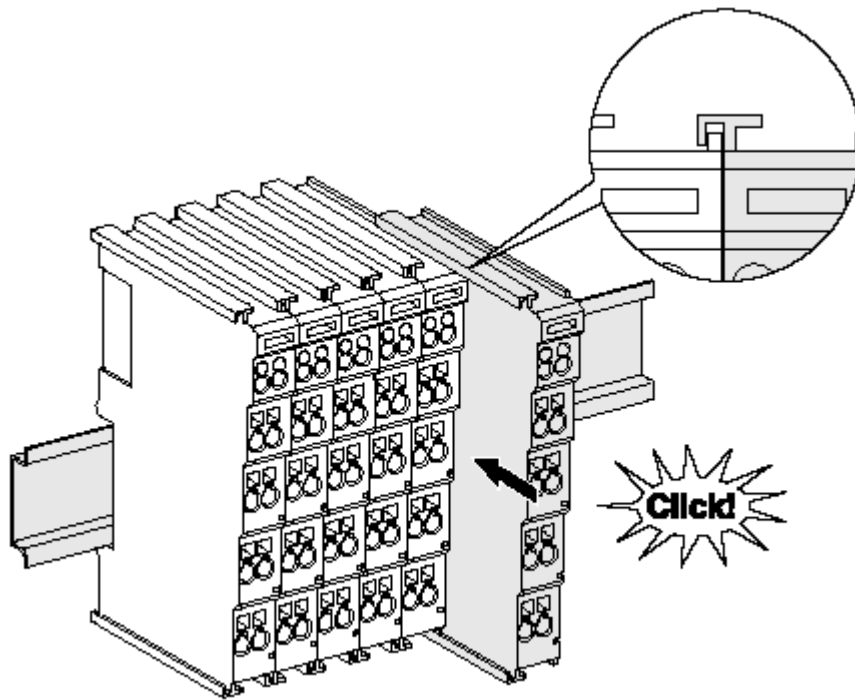


Fig. 3: Attaching on mounting rail

The bus coupler and bus terminals are attached to commercially available 35 mm mounting rails (DIN rails according to EN 60715) by applying slight pressure:

1. First attach the fieldbus coupler to the mounting rail.
2. The bus terminals are now attached on the right-hand side of the fieldbus coupler. Join the components with tongue and groove and push the terminals against the mounting rail, until the lock clicks onto the mounting rail.

If the terminals are clipped onto the mounting rail first and then pushed together without tongue and groove, the connection will not be operational! When correctly assembled, no significant gap should be visible between the housings.

i Fixing of mounting rails

The locking mechanism of the terminals and couplers extends to the profile of the mounting rail. At the installation, the locking mechanism of the components must not come into conflict with the fixing bolts of the mounting rail. To mount the mounting rails with a height of 7.5 mm under the terminals and couplers, you should use flat mounting connections (e.g. countersunk screws or blind rivets).

NOTICE

Ground the mounting rail!

Ensure that the mounting rail is sufficiently grounded.

Connections within a bus terminal block

The electric connections between the bus coupler and the bus terminals are automatically realized by joining the components:

- The six spring-loaded contacts of the E-bus/K-bus deal with the transfer of the data and the supply of the bus terminal electronics.
- The power contacts deal with the supply for the field electronics and thus represent a supply rail within the bus terminal block. The power contacts are supplied via terminal points on the bus coupler (up to 24 V) or via power supply terminals for higher voltages.

i Power contacts

When configuring a bus terminal block, note the contact assignments of the individual bus terminals, as some types

- do not loop through the power contacts or do not loop them through completely (e. g. analog bus terminals or digital 4-channel bus terminals),
- the power contacts are disconnected, thus marking the start of a new supply rail (power supply terminals).

Power contact $\perp$

The power contact labeled $\perp$ (earthing connection according to IEC 60417-5017, British English: earth, American English: ground) can be used as grounding. For safety reasons this contact mates first when plugging together, and can ground short-circuit currents of up to 125 A.

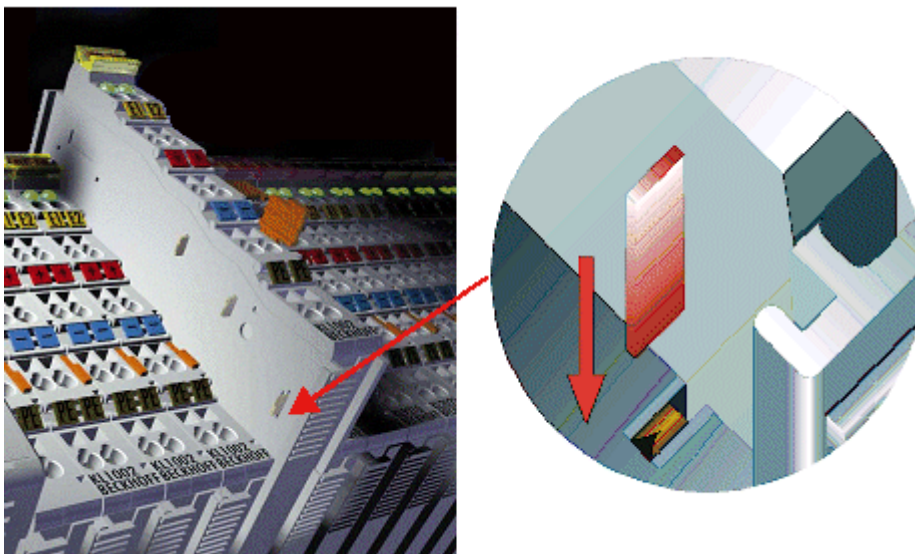


Fig. 4: Power contact on left side

⚠ WARNING

Risk of electric shock!

The power contact labeled $\perp$ must not be used for other potentials!

NOTICE

Possible damage of the device

Note that, for reasons of electromagnetic compatibility, the earthing contacts are capacitatively coupled to the mounting rail. This may lead to incorrect results during insulation testing or to damage on the terminal (e.g. disruptive discharge to the earthing line during insulation testing of a consumer with a nominal voltage of 230 V). For insulation testing, disconnect the earthing supply line at the Bus Coupler or the Power Feed Terminal! In order to decouple further feed points for testing, these Power Feed Terminals can be released and pulled at least 10 mm from the group of terminals.

Disassembly

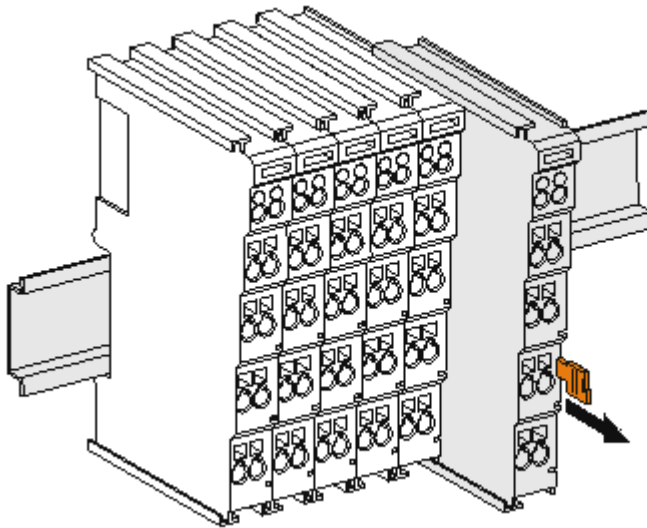


Fig. 5: Disassembling of terminal

Each terminal is secured by a lock on the mounting rail, which must be released for disassembly:

1. Pull the terminal by its orange-colored lugs approximately 1 cm away from the mounting rail. In doing so for this terminal the mounting rail lock is released automatically and you can pull the terminal out of the bus terminal block easily without excessive force.
2. Grasp the released terminal with thumb and index finger simultaneous at the upper and lower grooved housing surfaces and pull the terminal out of the bus terminal block.

3.3 Disposal



Products marked with a crossed-out wheeled bin shall not be discarded with the normal waste stream. The device is considered as waste electrical and electronic equipment. The national regulations for the disposal of waste electrical and electronic equipment must be observed.

3.4 Installation positions

NOTICE

Constraints regarding installation position and operating temperature range

- Please refer to the technical data of the device to ascertain whether any restrictions regarding the installation position and/or the operating temperature range have been specified.
- When installing devices with increased heat dissipation, ensure that there is sufficient space above and below the devices during operation to guarantee adequate ventilation!

The installation positions and their names for mounting devices on mounting rails are specified below. The illustration of the devices in the following figures is an example.

The following applies to all installation positions: The reference direction "down" (see arrow) is the acceleration of gravity.

Horizontal installation (standard installation)

The mounting rail is mounted horizontally on a vertical mounting plate.
The connection level of the devices points to the front.

The devices are ventilated from below, which enables optimum cooling of the electronics through convection. This is therefore also the recommended installation position.

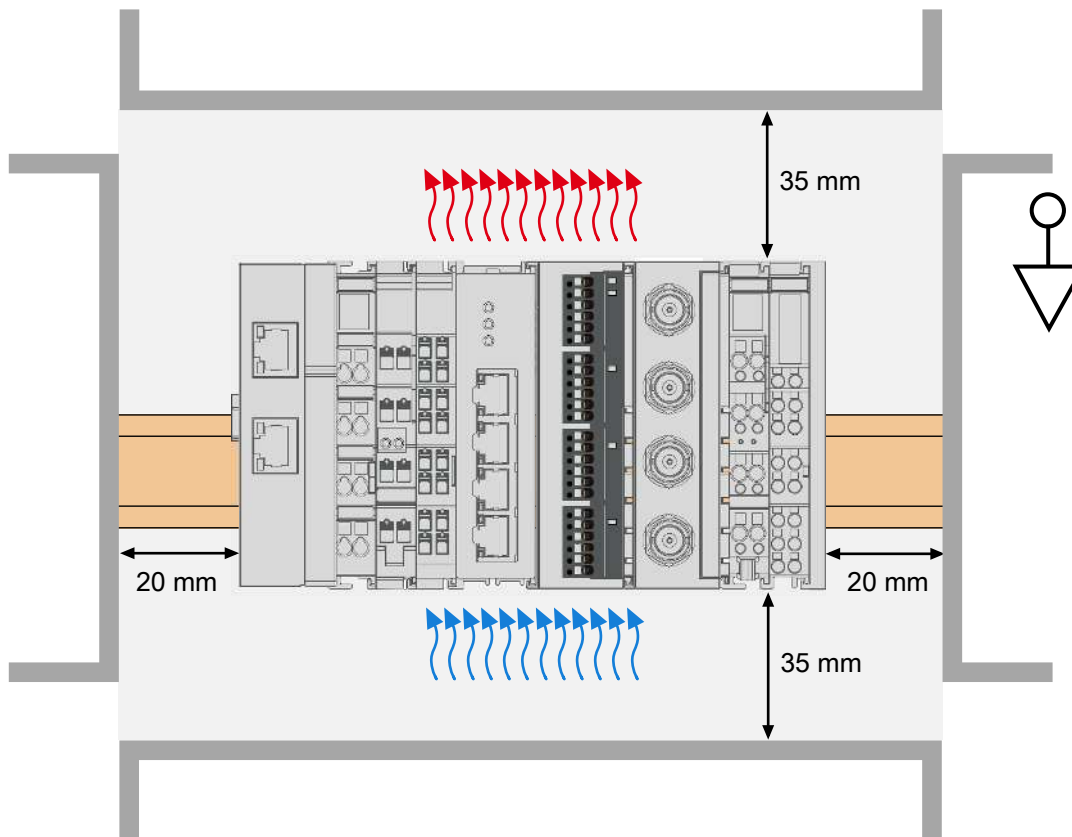


Fig. 6: Recommended minimum distances for standard installation position

NOTICE

Compliance with the minimum distances

Compliance with the minimum distances shown in the figure "Recommended minimum distances for standard installation position" is strongly recommended in all installation positions.

Vertical installation

The mounting rail is mounted vertically on a vertical mounting plate.
The connection level of the devices points to the front.
The devices can be arranged as follows:

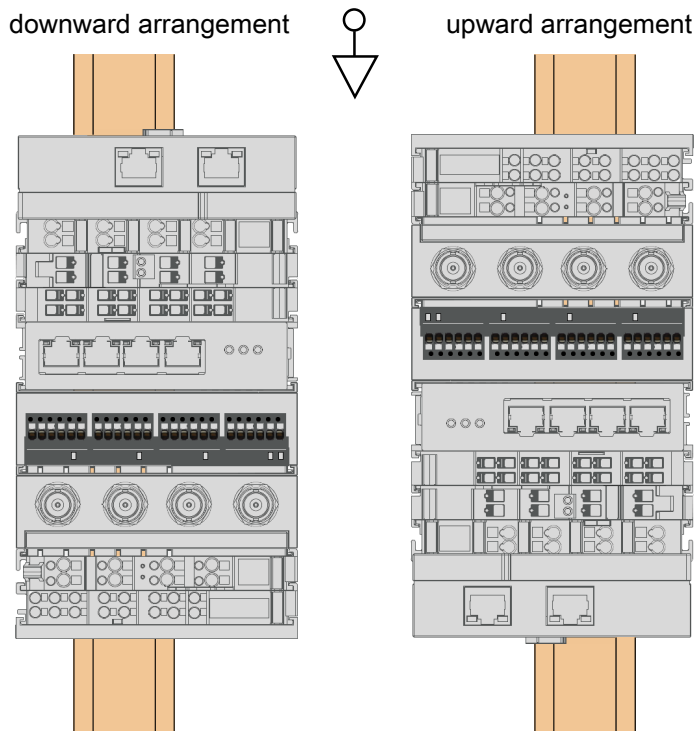


Fig. 7: Installation position Vertical, downward arrangement (left) / upward arrangement (right)

Flat installation

In the flat installation position, the mounting rail is laid on a horizontal mounting plate.
The connection level of the devices points upwards.

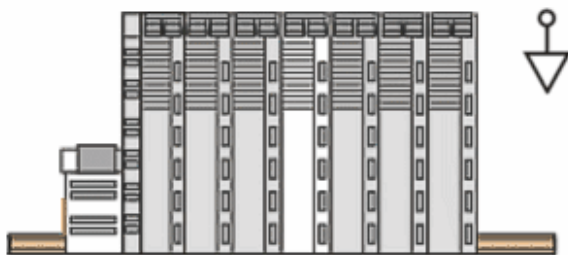


Fig. 8: Flat installation position

NOTICE

Danger of sliding off the mounting rail

Particularly in the "vertical" installation position, but also in other installation positions under corresponding mechanical load, the terminal segment may move on the mounting rail. These can lead to undesirable malfunctions.

- If this risk exists, secure the terminal segment with appropriate locking devices, e.g. by clamping it to the mounting rail.

NOTICE

Compliance with the minimum distances

Compliance with the minimum distances shown in the figure "Recommended minimum distances for standard installation position" is strongly recommended in all installation positions.

Installation positions with **ZB8610** fan cartridge

If the cooling should or must be increased for the intended application, the ZB8610 fan cartridge can be mounted on the underside of the device. In the horizontal installation position, the devices are ventilated from bottom to top by the fan cartridge. The optimum cooling is further enhanced by convection ventilation (see following figure).

The fan cartridge can be used in any installation position.

Further information on operation with and without a fan can be found in the technical data for the device (e.g. derating, information on installation positions, etc.).

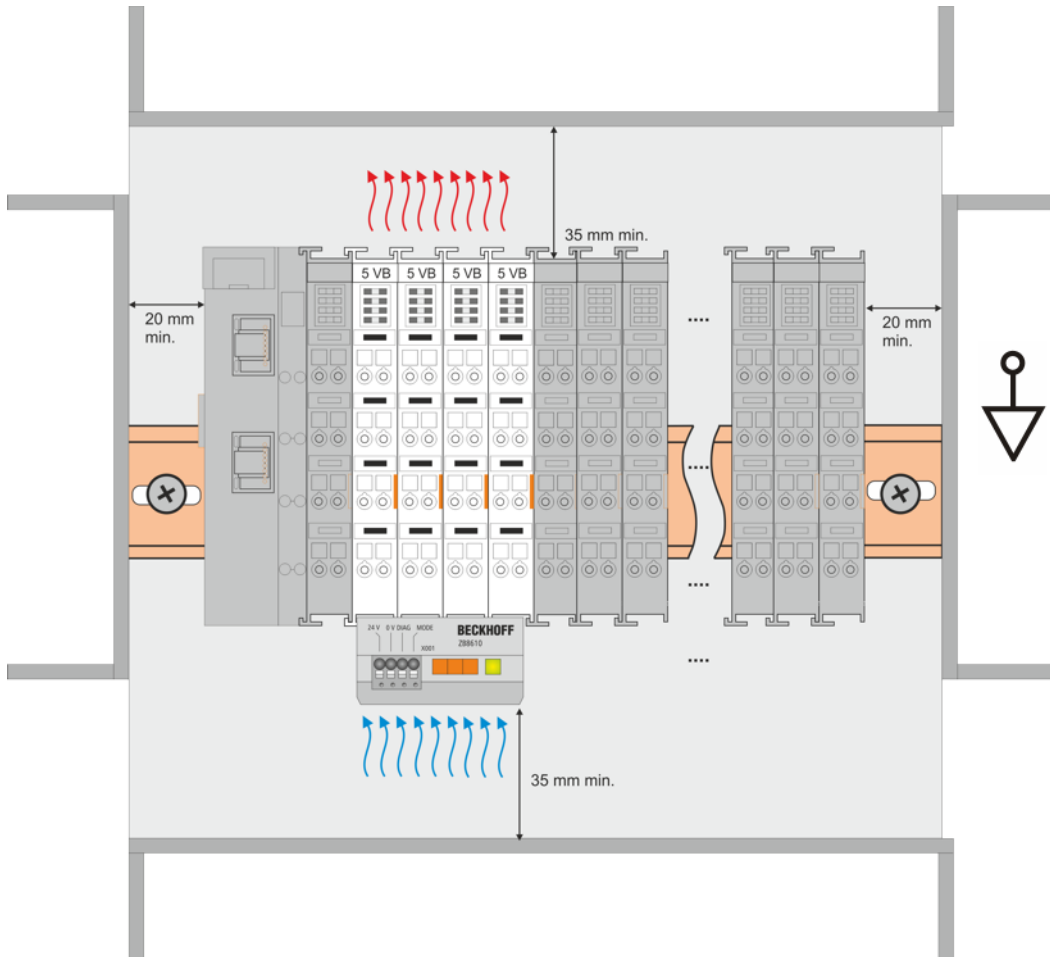


Fig. 9: Recommended minimum distances for operation with fan, using horizontal installation position as an example

NOTICE

Compliance with the minimum distances

Compliance with the minimum distances as shown in the figure "Recommended minimum distances for operation with fan" is strongly recommended.

3.5 Positioning of passive Terminals



Hint for positioning of passive terminals in the bus terminal block

EtherCAT Terminals, which do not take an active part in data transfer within the bus terminal block are so called passive terminals. The passive terminals have no current consumption out of the E-Bus.

To ensure an optimal data transfer, you must not directly string together more than two passive terminals!

Examples for positioning of passive terminals (highlighted)

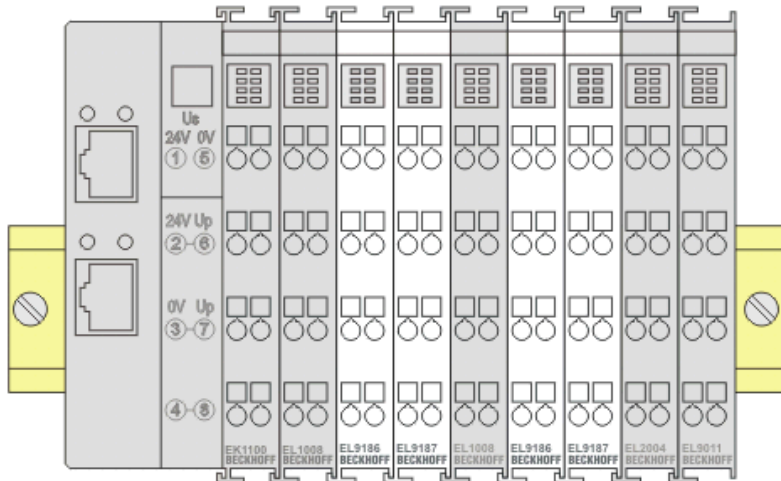


Fig. 10: Correct positioning

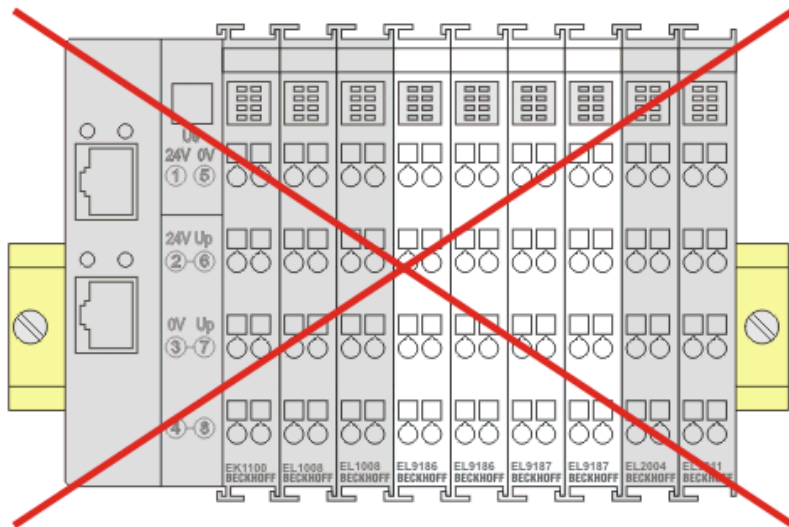


Fig. 11: Incorrect positioning

3.6 Connection

3.6.1 Connection system

⚠ WARNING

Risk of electric shock and damage of device!

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

Overview

The bus terminal system offers different connection options for optimum adaptation to the respective application:

- The terminals of ELxxxx and KLxxxx series with standard wiring include electronics and connection level in a single enclosure.
- The terminals of ESxxxx and KSxxxx series feature a pluggable connection level and enable steady wiring while replacing.
- The High Density Terminals (HD Terminals) include electronics and connection level in a single enclosure and have advanced packaging density.

Standard wiring (ELxxxx / KLxxxx)



Fig. 12: Standard wiring

The terminals of the ELxxxx and KLxxxx series integrate screwless spring-cage technology for quick and easy wiring.

Pluggable wiring (ESxxxx / KSxxxx)



Fig. 13: Pluggable wiring

The terminals of ESxxxx and KSxxxx series feature a pluggable connection level. The assembly and wiring procedure is the same as for the ELxxxx and KLxxxx series. The pluggable connection level enables the complete wiring to be removed as a plug connector from the top of the housing for servicing. The lower section can be removed from the terminal block by pulling the unlocking tab. Insert the new component and plug in the connector with the wiring. This reduces the installation time and eliminates the risk of wires being mixed up.

The familiar dimensions of the terminal only had to be changed slightly. The new connector adds about 3 mm. The maximum height of the terminal remains unchanged.

A tab for strain relief of the cable simplifies assembly in many applications and prevents tangling of individual connection wires when the connector is removed.

Conductor cross sections between 0.08 mm² and 2.5 mm² can continue to be used with the proven spring force technology.

The overview and nomenclature of the product names for ESxxxx and KSxxxx series has been retained as known from ELxxxx and KLxxxx series.

High Density Terminals (HD Terminals)



Fig. 14: High Density Terminals

The terminals from these series with 16/32 terminal points are distinguished by a particularly compact design, as the packaging density is twice as large as that of the standard 12 mm bus terminals. Massive conductors and conductors with a wire end sleeve can be inserted directly into the spring loaded terminal point without tools.



Wiring HD Terminals

The High Density Terminals of the ELx8xx and KLx8xx series doesn't support pluggable wiring.

Ultrasonically compacted (ultrasonically welded) strands



Ultrasonically compacted (ultrasonically welded) strands

Ultrasonically compacted (ultrasonically welded) strands can also be connected to the standard and high-density terminals. In this case, please note the tables concerning the wire-size width [► 19]!

3.6.2 Wiring

⚠ WARNING

Risk of electric shock and damage of device!

Bring the bus terminal system into a safe, powered down state before starting installation, disassembly or wiring of the bus terminals!

Terminals for standard wiring ELxxxx/KLxxxx and for pluggable wiring ESxxxx/KSxxxx

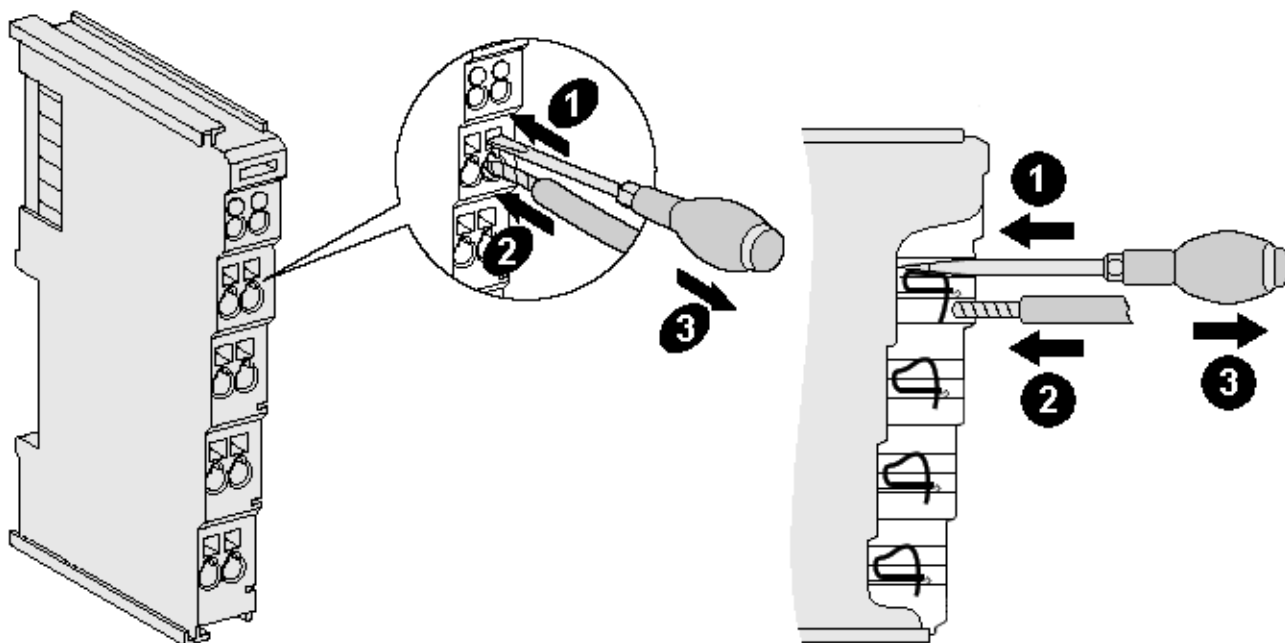


Fig. 15: Connecting a cable on a terminal point

Up to eight terminal points enable the connection of solid or finely stranded cables to the bus terminal. The terminal points are implemented in spring force technology. Connect the cables as follows (see fig. "Connecting a cable on a terminal point"):

1. Open a terminal point by pushing a screwdriver straight against the stop into the square opening above the terminal point. Do not turn the screwdriver or move it alternately (don't toggle).
2. The wire can now be inserted into the round terminal opening without any force.
3. When the screwdriver is removed, the terminal point closes automatically and holds the wire securely and permanently in place

See the following table for the suitable wire size width:

Terminal housing	ELxxxx, KLxxxx	ESxxxx, KSxxxx
Wire size width (single core wires)	0.08 ... 2.5 mm ²	0.08 ... 2.5 mm ²
Wire size width (fine-wire conductors)	0.08 ... 2.5 mm ²	0.08 ... 2.5 mm ²
Wire size width (conductors with a wire end sleeve)	0.14 ... 1.5 mm ²	0.14 ... 1.5 mm ²
Wire stripping length	8 ... 9 mm	9 ... 10 mm

High Density Terminals (HD Terminals [► 17]) with 16/32 terminal points

The conductors of the HD Terminals are connected without tools for single-wire conductors using the direct plug-in technique, i.e. after stripping the wire is simply plugged into the terminal point. The cables are released, as usual, using the contact release with the aid of a screwdriver. See the following table for the suitable wire size width.

Terminal housing	High Density Housing
Wire size width (single core wires)	0.08 ... 1.5 mm ²
Wire size width (fine-wire conductors)	0.25 ... 1.5 mm ²
Wire size width (conductors with a wire end sleeve)	0.14 ... 0.75 mm ²
Wire size width (ultrasonically compacted [ultrasonically welded] strands)	only 1.5 mm ² (see <u>notice</u> [► 17])
Wire stripping length	8 ... 9 mm

3.6.3 Shielding**Shielding**

Encoder, analog sensors and actuators should always be connected with shielded, twisted paired wires.

3.6.4 Contact assignment and LEDs

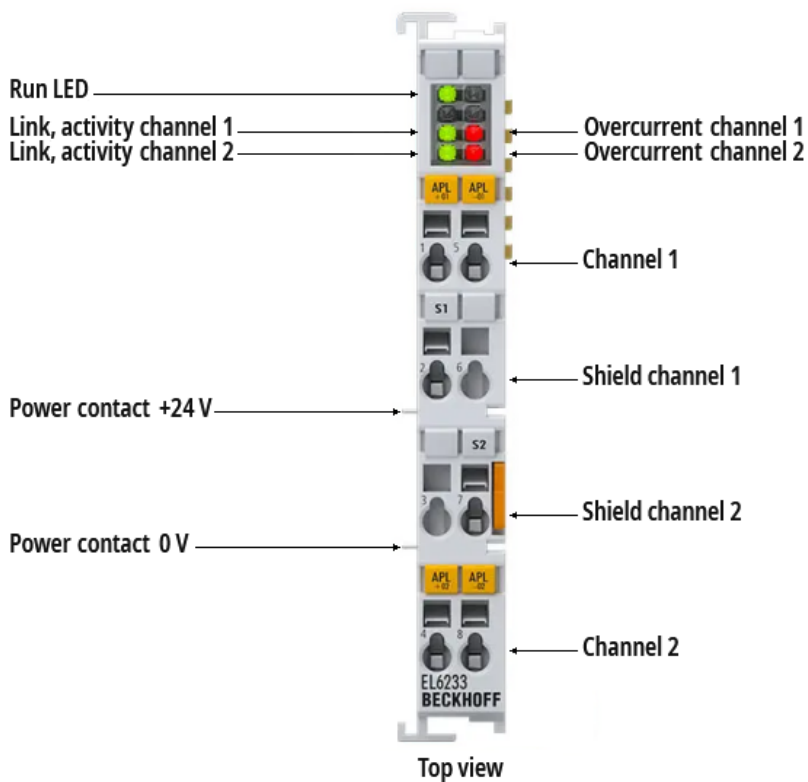


Fig. 16: EL6233 | Connection and LEDs

EL6233 | Connection

Terminal point		Description
Name	No.	
APL+01	1	Signal channel 1
S1	2	Screen channel 1
	3	not used
APL+02	4	Signal channel 2
APL-01	5	Signal channel 1
	6	not used
S2	7	Screen channel 2
APL-02	8	Signal channel 2

EL6233 | LED displays

LED	Color	Meaning
Run	green	This LED indicates the terminal's operating state:
		off State of the EtherCAT State Machine: INIT = initialization of the terminal or BOOTSTRAP = function for terminal firmware updates
		flashing State of the EtherCAT State Machine: PREOP = function for mailbox communication and different default settings set
		single flash State of the EtherCAT State Machine: SAFEOP = verification of the Sync Manager channels and the distributed clocks. Outputs remain in safe state
		on State of the EtherCAT State Machine: OP = normal operating state; mailbox and process data communication is possible
Link/Act Ch1	green	Link/Activity channel 1
Overcur. Ch1	red	Overcurrent channel 1
Link/Act Ch2	green	Link/Activity channel 2
Overcur. Ch2	red	Overcurrent channel 2

4 PROFINET controller protocol

4.1 Integration of the TwinCAT PROFINET controller protocol via the EL/ELX6233 interface

The controller protocol is appended directly to the I/O device. Use the ELx623x protocol. If such a terminal is present in the projected EtherCAT segment, the associated adaptor is directly displayed when appending the protocol. If there are several terminals the corresponding one can be selected.

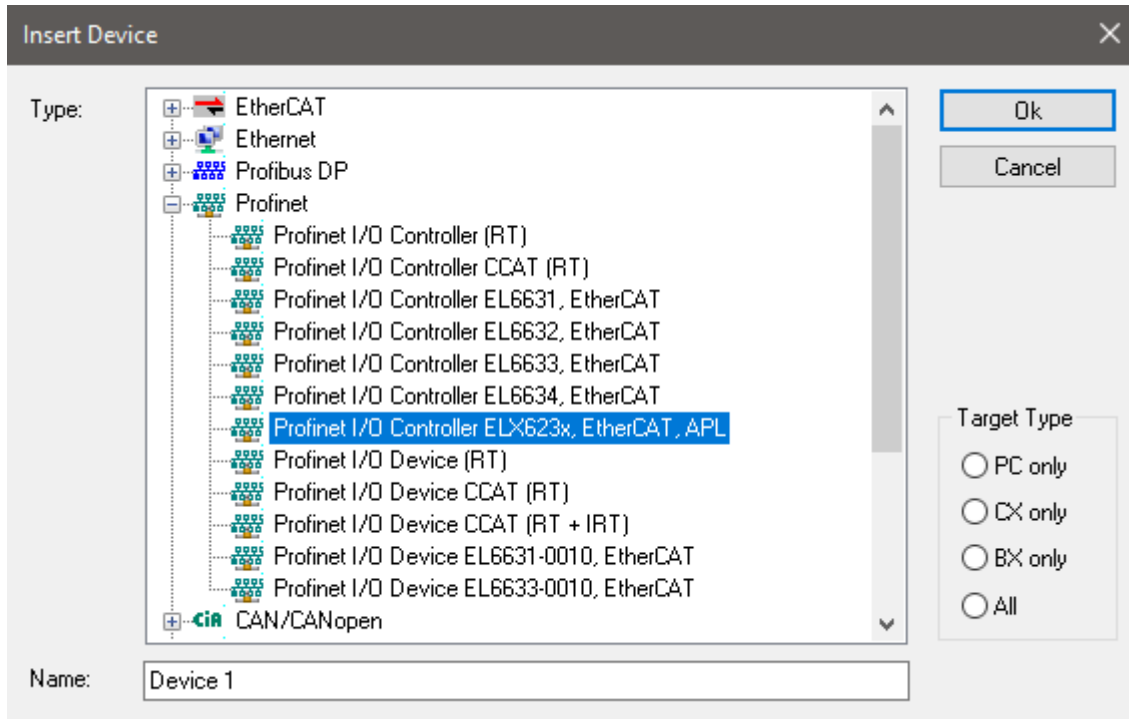


Fig. 17: Selection of the terminal for integrating the protocol

For the operation of several EL/ELX6233 terminals the corresponding PROFINET protocol must be appended several times. If the terminal assignment is to be modified or checked afterwards, this can take place on the *Adapter* tab.

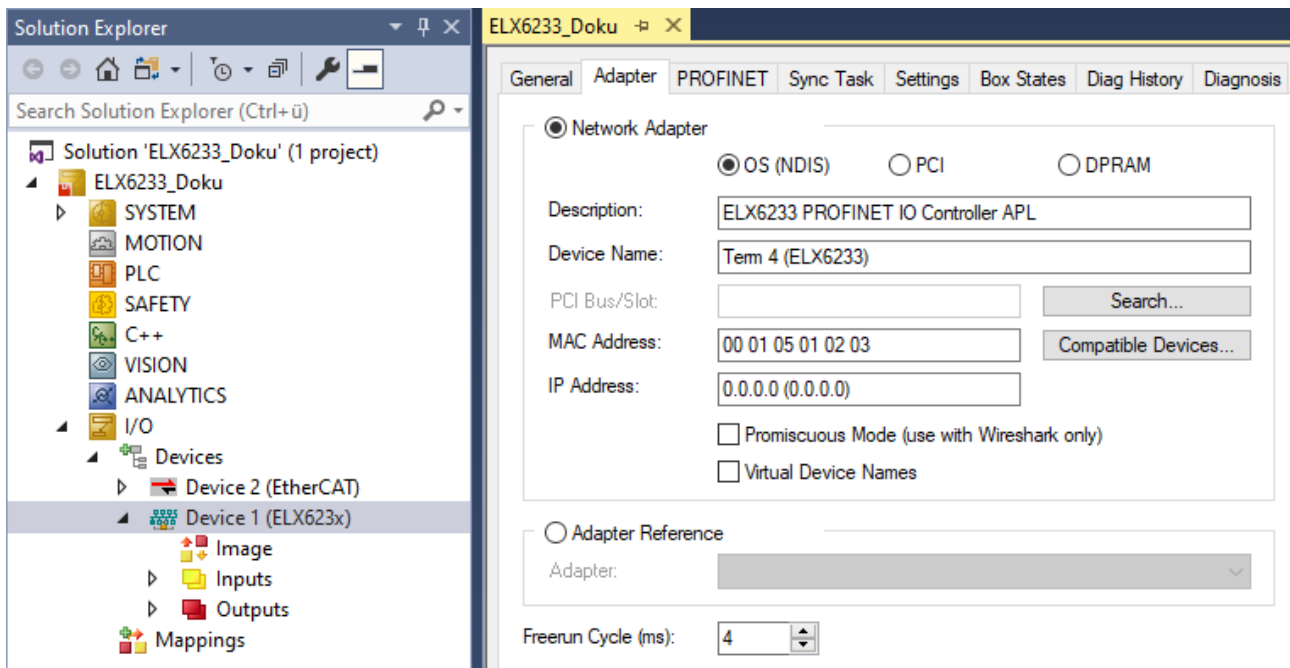


Fig. 18: Adapter tab - Changing the terminal assignment

4.2 EL/ELX6233 and PROFIsafe

The EL/ELX6233 can also be used for PROFIsafe in combination with the [EL6930 TwinSAFE Logic Terminal with PROFIsafe Gateway](#).

NOTICE



For information on using the EL/ELX6233 with the EL6930, please refer to the following documentation:

- EL6930 - TwinSAFE Logic Terminal with PROFIsafe Gateway: [Operating Instructions](#)
- EL9930 - PROFIsafe Segment End Terminal: [Operating Instructions](#)
- [Application Guide TwinSAFE](#)

4.3 Settings / diagnostics

4.3.1 PROFINET

4.3.1.1 AMS Settings

Protocol AMS NetID text field

This is the NetID via which the PROFINET controller protocol can be reached via AMS.

Protocol AMS PortNo text field

This is the PortNo via which the PROFINET controller protocol can be reached via AMS. This is always fixed to 0xFFFF.

Server AMS NetID text field

This is the NetID to which certain AMS messages (e.g. PN records within the index range 0x1000 - 0x1FFF) are forwarded by the PROFINET driver. Currently this is always the SystemNetId.

Server AMS PortNo text field

This is the PortNo to which certain AMS messages (e.g. PN records within the index range 0x1000 - 0x1FFF) are forwarded by the PROFINET driver. By default this is the PLC Port 802 of runtime system 1.

4.3.1.2 Button Port settings

This feature is presently only enabled for the real-time Ethernet protocol (no EL/ELX6233). With this a second PROFINET port and an intelligent switch can thus be realized with a second network card (Intel chipset). It is intended to repeat this feature x times; however, it is presently limited to one additional port.

General Adapter **PROFINET** Sync Task Settings Box States Diag History Diagnosis

Protocol AMS NetId: 5.85.198.214.4.1 Import GSDML...

Protocol AMS PortNr.: 65535 Scan PNIO Devices...

Server AMS NetId: 5.85.198.214.1.1 Topology...

Server AMS PortNr.: 851 IRT Settings...

PN SW Version: Interface Settings...

Port Settings...

I-Device...

MRP...

ELx663x...

☐ Info Data Support

☐ Cyclic Receive Timestamp

Port Settings

Port	Description	Value
Port_1	Link Speed Selection	Not Available
Port_2	Link Speed Selection	Not Available

Read

Write

Advanced Settings

OK

Fig. 19: *PROFINET Port Settings* dialog

In future, the MRP functionality (Media Redundancy Protocol) can also be enabled via this menu. Various settings can be made for this.

4.3.1.3 Button Scan PNIO Devices

This feature is comparable with the *ScanBoxes* feature, which is only available in CONFIG mode.

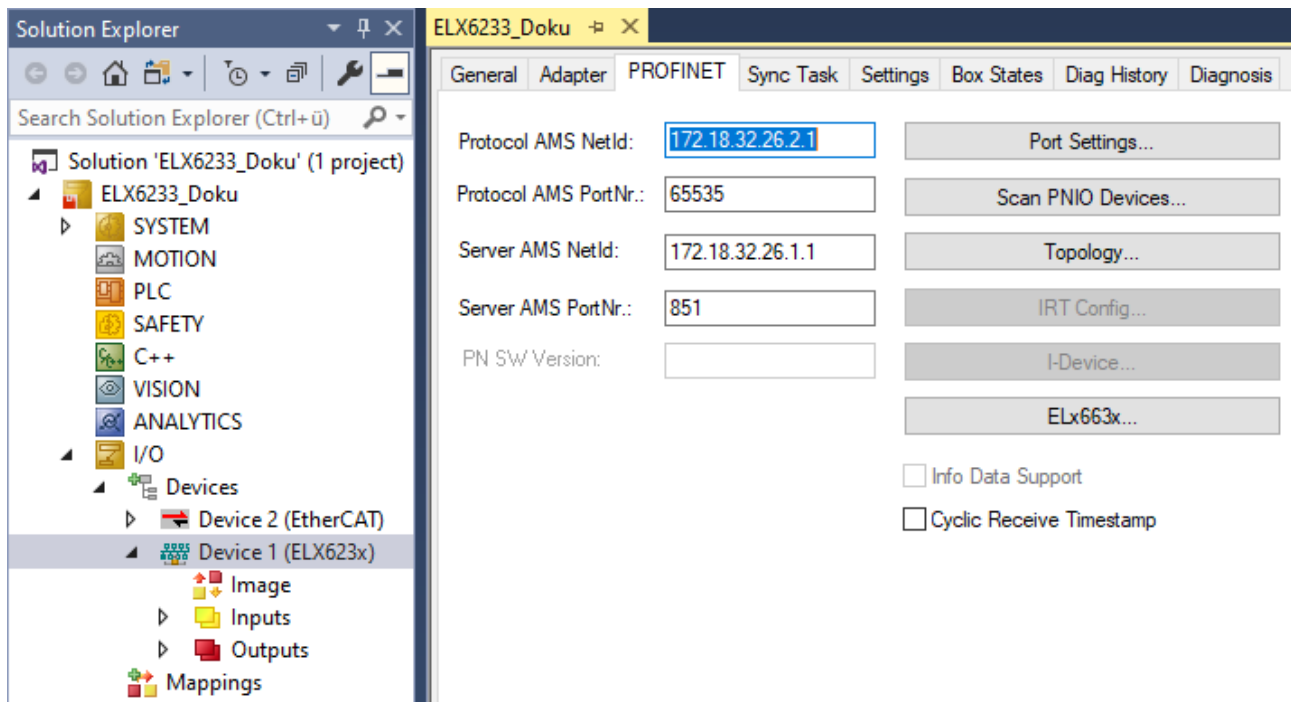


Fig. 20: Scan PNIO Devices

After successful scanning the following dialog opens (if devices were found).

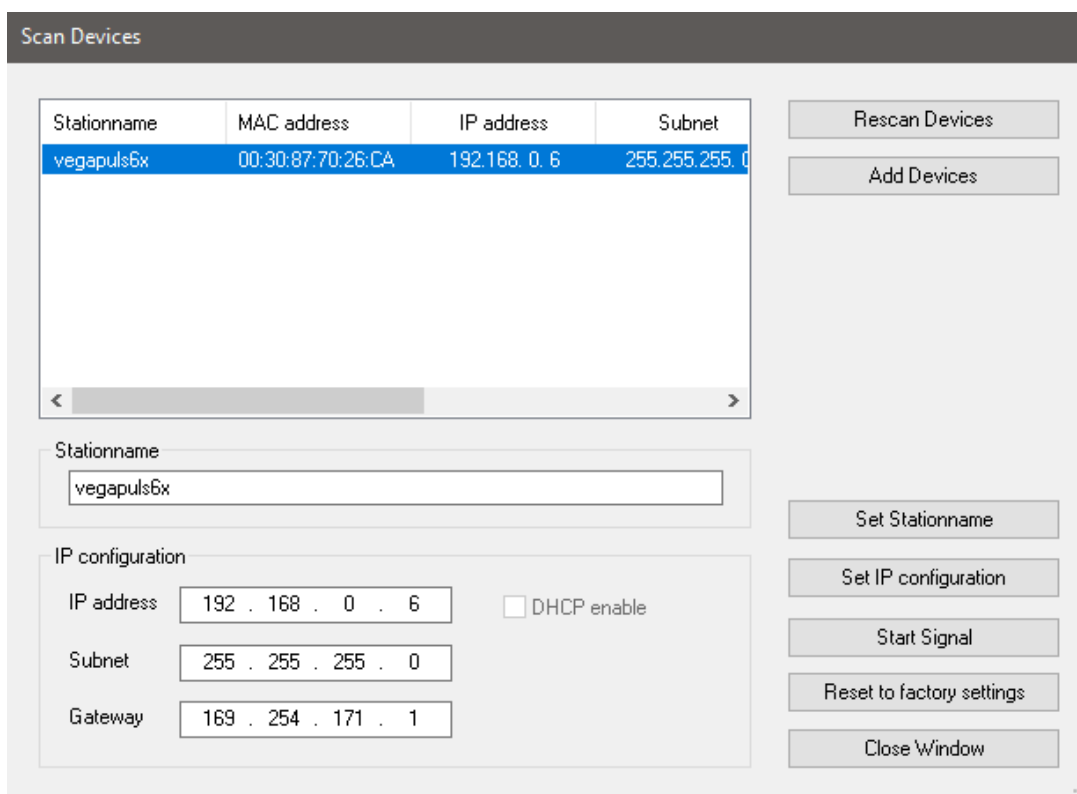


Fig. 21: Scan Devices dialog

Various device settings and configurations can be made here. These are adopted only when the corresponding button is explicitly pressed. When setting the name, care must be taken that only PROFINET-compliant characters are used. This also applies to the IP address; only valid combinations of IP and subnet

are to be used. Name and IP are checked for correctness when setting PROFINET devices. If this is not the case, DCP_SET is acknowledged with an error. By pressing the *Rescan* button, any changes that were made can be read back.

In addition the selected device can be signaled. This functionality is PROFINET-specific. The signaling is vendor-specific. However, the standard is that the signal must arrive at a frequency of 2 Hz.

As an example, the Beckhoff BK9103 Bus Coupler signals itself by alternately flashing two LEDs at 2 Hz. This function is very helpful for identifying the devices in this list. Press the button again to stop the flashing. The flashing is stopped by closing the *Scan Devices* window.

Subsequently, one or more devices can be marked with the Ctrl button. Press *Add Devices* to add the selected devices to the project.



Devices GSDML

The associated devices GSDML must be located in the folder
 "..\TwinCAT\Io\ProfiNet" (TC2) or
 "..\TwinCAT\3.1\Config\Io\Profinet" (TC3)!

Upon pressing *Add Devices*, the following prompt appears:

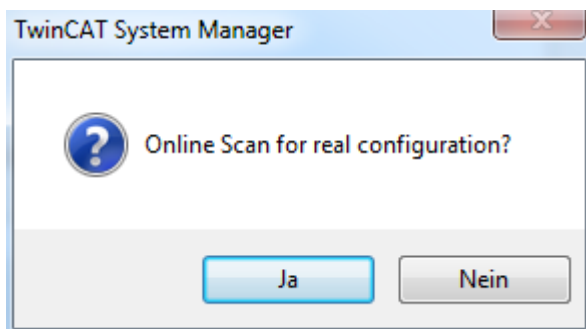


Fig. 22: Confirmation *Add Devices*

Yes button

An attempt is initially made to determine the ModuleIdentNumber of the DAP (Device Access Point) by an implicit read access. If this fails, a corresponding dialog opens with the possible DAPs, which must be selected manually.

After all box modules have been appended, a *Reload Devices* is performed automatically, i.e. the devices (adapters) created are transferred to the PROFINET driver. A distinction is then made as to whether the box is a normal device or a drive with Profidrive support.

In the case of a normal device, the real module configuration (RealIdentificationData) is read out again via an implicit read access. With a Profidrive device, however, the required information is read out via Profidrive access. A Supervisor AR is established for this purpose. The required write accesses can take place within this. The Submodule interface on the DAP is used here as the Parameter Access Point. Parameters are accessed via data record 47, similar to PROFIBUS. When using Sinamics, however, it must be noted that such an access is only permitted from version 4.3 SP2. If an older version is used, a corresponding error message appears and the parameterization must take place manually.

Once the automatic module parameterization has been completed, the prompt to automatically read in the port data appears. Here again, the port interconnection of the individual devices is read out via an implicit read access.

The real port interconnection must be known for various services. These can simply be diagnostic services, but the automatic device start-up also requires this (via alias), or the creation of the IRT planning.

If this dialog is acknowledged with *No* or the read access has failed, such interconnection can also be carried out manually in the TwinCAT project on the individual ports.

If the port interconnection has been successfully generated automatically, in the case of an IRT controller (e.g. configuration on an EL/ELX6233), you will be asked whether all devices (if they support it) should be automatically switched to IRT mode (RTClass3).

If the answer is yes, the cable length on all configured ports is also set to 10 m copper cable. The IRT algorithm requires this information for the calculation of the signal propagation times. The precise cable

length is not so important here (approx. +/-10 m), because the propagation delays tend to be small at 100 Mbit/s (5 ns/m). If automatic switching is not to take place immediately, these points can also be changed later either on the protocol or on the individual devices (on the interface or port submodule).

No button

For each device a check is performed to ascertain whether the GSDML is present in the respective folder (..\TwinCAT\Io\ProfiNet). If this is the case, the list of possible DAPs is read in. A selection dialog is then opened to select the corresponding DAP.

Once the devices have been added to the project, you can then go to the API under the box and add the modules and submodules manually.

4.3.1.4 Button Topology

The offline topology can be compared with the online topology via this dialog.

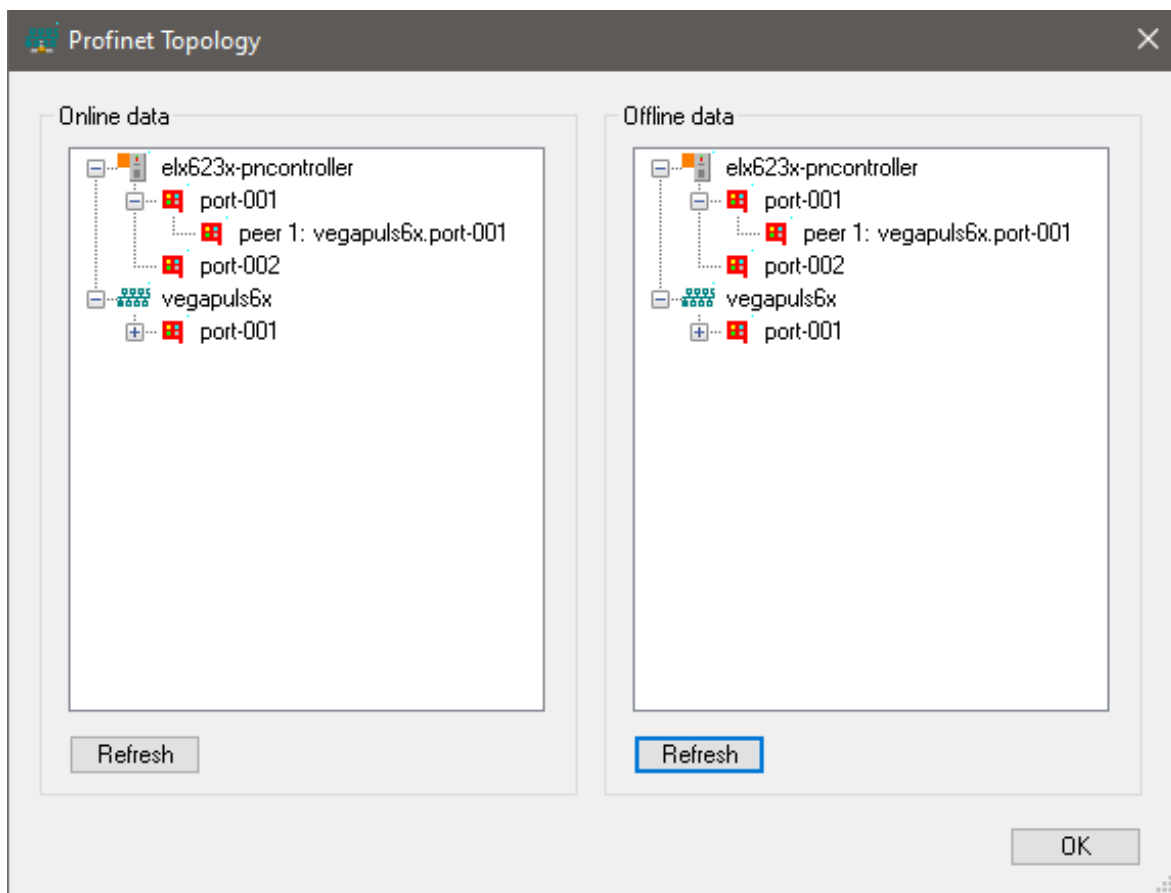


Fig. 23: *PROFINET Topolgy* dialog

It is quite possible for a device to have several partners on a port in the online view. This is the case, for example, if a switch is used in PROFINET that does not support LLDP (protocol for neighborhood ID).

In the offline view, on the other hand, partners may have been assigned that don't exist in the project. This takes place if the reading of the port properties was enabled during scanning and automatic appending. In this case the device has a 'neighbor' that is adopted into the project, but the associated device box is missing in the *.tsm file. On enabling this project the 'neighbor' which does not exist in the .tsm file is ignored in the driver.

4.3.1.5 ELx663x Settings

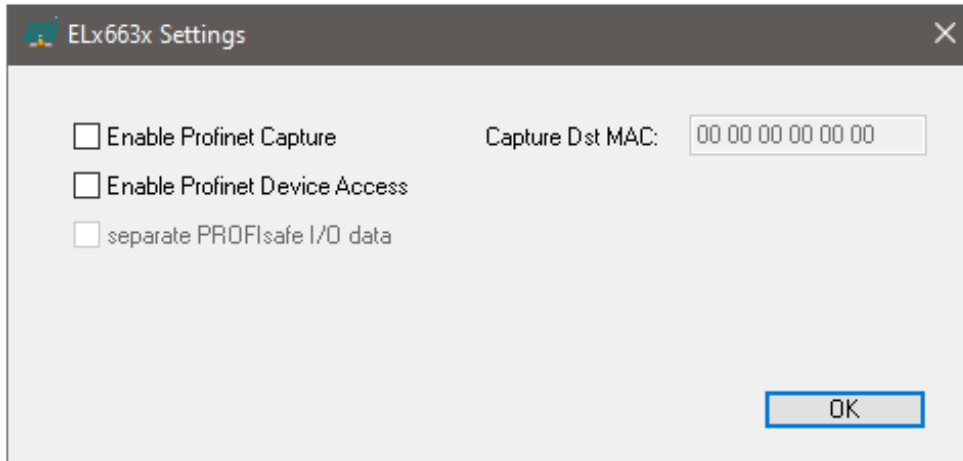


Fig. 24: *ELx663x Settings* dialog

Enable PROFINET Capture

All PROFINET frames are forwarded to the EtherCAT master via EoE. The DstMac can be used to change the target MAC address of all PROFINET frames to EtherCAT. If this remains unchanged at NULL, the frames are sent to the EtherCAT master in their original format. This can then be used to start an Ethernet capture (e.g. via Wireshark).

Note: As this feature places a considerable load on the E-bus, it should only be enabled for short-term troubleshooting.

Enable PROFINET Device Access

Access to the PROFINET devices is enabled here, i.e. all EoE frames that are not directed to the terminal itself are forwarded to the individual APL ports. This also enables access to web servers of the connected PROFINET devices, for example. This feature is disabled by default, i.e. the integrated firewall blocks access to the individual PROFINET devices.

4.3.2 Task configuration

The PROFINET controller protocol must always be linked to a task. The protocol is also processed with the set task time. Theoretically, the controller can also be processed via a PLC or NC task, for example. However, if a PLC project is stopped (e.g. due to a restart or debugging), the PROFINET part is also stopped. To avoid such a side effect, it is advisable to always create a free-running SyncTask.

The screenshot shows the 'Sync Task' configuration window. At the top, there are tabs: General, Adapter, PROFINET, Sync Task (selected), Settings, Box States, Diag History, and Diagnosis. The 'Settings' section has two radio buttons: 'Standard (via Mapping)' and 'Special Sync Task' (selected). Below the radio buttons is a dropdown menu showing 'Task 2' and a button labeled 'Create new I/O Task'. The 'Sync Task' section contains the following fields: 'Name:' with a text box containing 'Task 2'; 'Cycle ticks:' with a spinner set to '4' and a text box showing '4.000 ms'; an unchecked checkbox labeled 'Adjustable by Protocol'; and 'Priority:' with a spinner set to '1'.

Fig. 25: Sync Task tab

Make sure that the task cycle is in a PROFINET cycle. This means that the basic cycle for PROFINET is 31.25 μ s. This cycle is then always multiplied by the SendClockFactor (SCF) to obtain the basic cycle. The SendClockFactor is usually set to 32 for RTClass1. This is also the minimum PN cycle for RTClass1 for the Beckhoff PROFINET controller and results in the smallest cycle time of 1 ms. Further reductions take place using a ReductionRatioFactor. This always corresponds to a multiple of the minimum PN cycle. For RTClass1 the smallest cycle must always be doubled (permissible cycle times (for RTC1) with an SCF of 32 are 1, 2, 4, 8, ... ,512).

The SCF can and must be reduced in order to achieve faster cycle times for RTClass3 as well. This is presently at least 16 for a Beckhoff IRT controller (EL6632), which corresponds in turn to a basic cycle of 500 μ s. If the PROFINET clock is reduced in this way, it must also be ensured that the time of the triggering task is adjusted accordingly.

4.3.3 PROFINET controller - specific settings

Settings that directly affect the controller can be made via the *Settings* tab.

The screenshot shows the 'Settings' tab of the Beckhoff software interface. The tab is selected among a row of tabs: General, Adapter, PROFINET, Sync Task, Settings, Box States, Diag History, and Diagnosis. The Settings tab contains several configuration sections:

- IP configuration:** Includes three input fields for IP address (192 . 168 . 1 . 1), Subnet (255 . 255 . 255 . 0), and Gateway (192 . 168 . 1 . 1). To the right of these fields is a button labeled 'Set IP settings...'.
- Name of PnIo Controller Station:** A text input field containing 'elx623x-pncontroller'. To the right is a button labeled 'Set System name...'.
- VendorId:** An input field containing '0x0120'.
- DeviceId:** An input field containing '0x002C'.
- Server UDP Port:** An input field containing '0xEE48'.
- Client UDP Port:** An input field containing '0xEA60'.
- StationName settings:** A section containing a checkbox labeled 'Automatic NameOfStation assignment', which is currently unchecked.

Fig. 26: *Settings* tab

An IP setting can take place here. The selection of the address range need not correspond to the network card settings. The PROFINET communication spreads its own net, which can be selected here. The IP settings shown in the above figure are the default settings. This means that if nothing is changed, the controller uses these settings. The same applies to the controller name (system name). To change both settings, press the corresponding button. A check is made to ascertain that the input is correct (e.g. the format of the controller name must correspond to the PN spec.). These data are then permanently adopted. When changing the subnet or gateway, the settings are also applied to any projected devices. It is also possible to change these settings via a supervisor tool.

In addition the VendorID and DeviceID of the controller can be read out in this dialog. The server and client UDP port employed can also be set here. However, the default settings should be sufficient in most cases.

Furthermore there is a possibility in this dialog to enable an automatic PROFINET start-up following a device exchange (including devices without removable media). For correct functioning the nominal topology must be specified once. On the basis of this information the controller can query the alias names of the individual devices. Every device that supports alias names generates such a name for each of its ports. This is composed of the neighborhood IDs (PortId.ChassisId). If this name is queried, the 'new' device answers. If VendorId and DeviceId are correct the device is named with the actual name and a normal PROFINET start-up can subsequently take place. With this mechanism a complete PROFINET system could also start up without having named an individual device beforehand.

4.3.4 Analysis of the box states

There is a collective PROFINET error and a collective PROFINET state directly under the PROFINET controller protocol. Both show the number of devices for which a problem has occurred or for which a diagnosis is available. The error indicates possible problems with the connection establishment or reasons for a termination. The diagnosis provides state information about an existing connection.

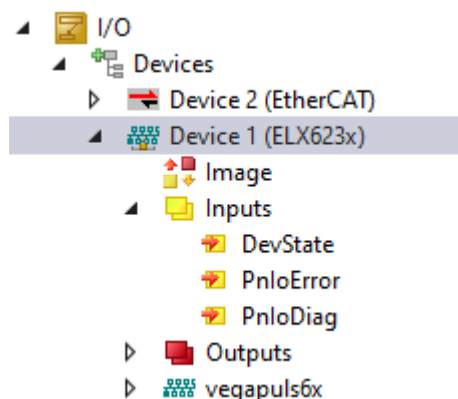


Fig. 27: TwinCAT tree - Inputs for analysis

PnIoError - Number of PROFINET IO devices that have an error

PnIoDiag - Number of PROFINET IO devices that have a diagnosis pending

It is possible to check at a glance which device or box has a problem in the protocol under Box States.

General	Adapter	PROFINET	Sync Task	Settings	Box States	Diag History	Diagnosis
StationName	BoxState	BoxDiag	DeviceCycleTime				
vegapuls6x	No Error (0x0)	Communication established (0x2)	64 ms				

Fig. 28: Box States tab

The following error messages are currently displayed via the *PnIoState*.

Number	Text	Description	Remedial action / reason
0	No error	No error	No error
1	PROFINET Device state machine is in boot mode	PROFINET Device StateMachine is in boot mode	Not an error, wait
2	Device not found	Device does not reply to the Identify Request	Check connection, device connected, has the device been given the correct name?
3	The station name is not unique	The station name is not unique	There are two or more devices with the same PROFINET name in the network. Correct identification is not possible.
4	IP could not set	IP address could not be set	The PROFINET device has refused to set the IP settings for some reason. Check whether the IP settings are correct.
5	IP conflict	An IP conflict has occurred in the network	A possible cause is that several devices have the same IP address.
6	DCP set was not successful	There was no reply or an erroneous reply to a DCP set	Check connection, device connected, has the device been given the correct name?
7	Watchdog error	The connection was interrupted with a watchdog error	Check the cycle time, check the connection, if necessary increase the Watchdog factor.
8	Datahold error	The connection was interrupted with a Datahold error	Frame Data state was invalid for the length of the DataHoldTimer. Restart the device if necessary.
9	RTC3: Sync signal could not started	Only for IRT: The Sync signal could not be started.	Is EtherCAT Sync signal correct or has Sync0 started?
10	PROFINET Controller has a link error	The PROFINET Controller has no link	Check cable and connection.
11	The alias name is not unique	The alias name is not unique	There are two or more devices in the network with the same alias name. This is made up of the neighborhood information (PortId.ChassisId). A correct identification cannot take place.
12	The automatic name assignement isn't possible - wrong device type	The automatic name assignment isn't possible	The expected PROFINET device is not in the projected position (VendorId or DeviceId does not correspond). Hence, no automatic naming and thus no device start is possible.
31	Only for EtherCAT gateways: WC-State of cyclic EtherCAT frame is 1	Only for EL6631: EtherCAT WC State is set to 1	Check the mode on the EtherCAT master + slave (OP?).

As opposed to the State, more than one state can be displayed in the *BoxPnIoDiag*, i.e. the whole thing is bit-coded and up to 16 pieces of information can be displayed. The following states are currently displayed.

0x0000 = No diagnosis
 0xXXX1 = IOC-AR is not established
 0xXXX2 = IOC-AR is established
 0xXXX4 = IOC-AR is established but no ApplReady
 0xXXX8 = IOC-AR is established but module difference
 0xXX1X = At least one AlarmCR get diagnosis alarm
 0xX1XX = At least one InputCR is invalid
 0xX2XX = At least one InputCR Provider is in stop
 0xX4XX = At least one InputCR Problemindicator is set
 0x1XXX = At least one OutputCR is invalid
 0x2XXX = At least one OutputCR Provider is in stop
 0x4XXX = At least one OutputCR Problemindicator is set

On the one hand information about the state of the IO Controller Single AR is displayed here. In addition, collective states are formed from the Frame Data states of the individual CRs. This applies to the input and output CRs (currently only one CR is possible, in future several). A PROFINET alarm is also displayed in *PnIoDiag*.

Readout via ADS

The Box Status can be read out via an ADS Read.

ADS Read:
 NetId = AMSNETID des PROFINET Controllers
 Port = BoxPort (0x1000 + BoxId)
 Indexgroup = 0xF829
 IndexOffset = 0
 Length = sizeof(TPnIoDeviceDiagData);

where:

```
typedef struct
{
  WORD pnioState;
  WORD pnioDiag;
  WORD NrOfInputCRs;
  WORD NrOfOutputCRs;
  WORD reserved[8];
} TPnIoDeviceDiagData, *PTPnIoDeviceDiagData;
```

4.3.5 Diagnosis history on the controller protocol

Logged diagnosis messages from the controller protocol can be read out on the *Diag History* tab. The diagnosis buffer operates as a ring buffer with a current maximum size of 1000 entries.

Type	Timestamp	Message	AddInfo	MessageID
Info	12.07.2024 08:25:57 343 ms	vegapuls6x: AR is established (got ApplReady).	No	3
Info	12.07.2024 08:25:57 211 ms	vegapuls6x: Controller send PmEnd.	No	2
Info	12.07.2024 08:25:57 171 ms	vegapuls6x: Controller start the parameterization.	No	1
Info	12.07.2024 08:25:57 073 ms	vegapuls6x: Controller send ConnectReq to device.	No	0

Fig. 29: *Diag History* tab

The possible errors are grouped into three types:

- Info: e.g. information about the connection establishment
- Warning: e.g. PROFINET diagnosis alarms
- Error: e.g. connection interrupted

AddInfo indicates whether additional information about the event is available. If this is marked by "Yes", the additional information can be fetched and displayed by clicking on the respective message. In the case of a diagnosis alarm (Diagnosis appears), the precise diagnosis information can be fetched at the corresponding level (device, API or module).

The complete diagnosis buffer is cleared by pressing the *Clear Diag History* button.

The displayed messages can be saved in a .TXT file by pressing the *Export Diag History* button.

4.3.6 Diagnosis tab

This tab includes additional tools for monitoring and troubleshooting PROFINET communication.

Name	Value
Last Update	12.07.2024 08:28:40 999 ms
[-] Protocol Settings	Settings
Name	elx623x-pncontroller
Task Time	4 ms
[-] Port Statistic	2 Ports
+ Port 1	FrameRecv = 106, FrameSend = 106
+ Port 2	FrameRecv = 0, FrameSend = 0
[-] Netload Statistic	No Errors detected!
Rt NetloadMaxExpInputCr	1%
Rt NetloadMaxExpOutputCr	1%
Rt NetloadRealInputCr	1%
Rt NetloadRealOutputCr	1%
+ InternalFrameFilter	No Errors detected!
[-] Profinet Devices	1 Devices
[-] vegapuls6x	No Errors detected!
+ FrameStatistic	FrameCnt = 210

Fig. 30: *Diagnosis* tab

Statistics on the current connection can also be found here.

4.3.7 Cyclic data

There are several cyclic process data directly below the PROFINET controller protocol. These data are only exchanged between the PROFINET driver and the System Manager. They provide general information about the state of the PROFINET communication.

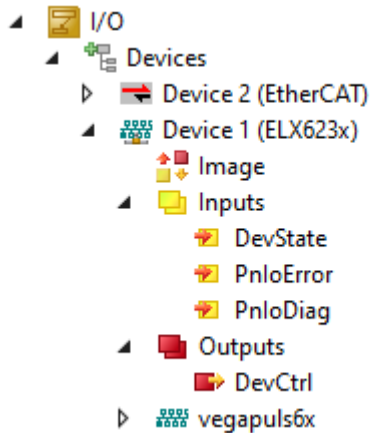


Fig. 31: TwinCAT tree - Inputs for information

The variable *DevState* contains information about the phys. communication state of the controller, such as the link state or whether the send resources are still sufficient.

The other variables are the collective PROFINET error and the collective PROFINET state. Both show the number of devices for which a problem has occurred or for which a diagnosis is available. This means that the Error variable indicates possible problems when establishing a connection or reasons for an interruption. The diagnosis variable provides state information about an existing connection.

The output variable *DevCtrl* currently has no function.

For further information, please also read the chapter Box States.

4.3.8 Acyclic data

The ADS blocks are used to send acyclic data. These then access the PROFINET record data. So that acyclic data can be read or written, the PROFINET device must be in data exchange mode.

An *ADSReadWrite* is set.

ADS settings

AMSNetID: The AMSNetID of the PROFINET controller

PORT: Port number of the device (take this from the system manager)

Index GROUP: 0x0000_F823

Index OFFSET: 0x0000_0000

```
DATA
typedef struct {
    WORD        RW;
    #define      PN_READ      0
    #define      PN_WRITE     1
    WORD        NrOfAR;
    DWORD       API;
    WORD        Slot;
    WORD        SubSlot;
    PNIO_RECORD RecordData;
} PNIO_CONFIGRECORD
```

Structure of the record data frame

nRW	nNr	nAPI	nSlot	nSubSlot	nIndex	nLen	nTrans	nReserved	Data (only write)
2 bytes	2 bytes	4 bytes	2 bytes	2 bytes	2 bytes	2 bytes	2 bytes	2 bytes	n bytes

Meaning of data from the record data frame

Designation	Values	Description
nRW	0 – READ 1 - WRITE	read- or write-access
nNr	normally „0“dec	it is possible to put multiple ARs (application relations) to one device (Controller, Supervisor, DeviceAccess). This indicates in which AR the data is exchanged -> normally there is only one AR, in this case zero.
nAPI	normally „0“dec	-> otherwise, the corresponding application profile should be placed here
nSlot	variable	Slot number
nSubSlot	variable	SubSlot number
nIndex	variable	Index number
nLen	variable	READ if nRW = 0: if the value „0“ is used when reading, the request is sent with the maximum buffer size, if nLen ≠ 0, the corresponding length is used. WRITE if nRW = 1: when writing: number of bytes, which follow from or after the “nReserved” word
nTrans	starts with „1“dec	If multiple records are downloaded at once, this transfer sequence number determines the order in which the data is processed.
nReserved	„0“dec	2 byte alignment
Data	variable	Data (from here the „nLen“ for the data length counts (writing only))

Sample:

Send a read request for I&M function 0

nRW	nNr	nAPI	InSlot	SubSlot	nIndex	nLen	nTrans	nReserved
00 00	00 00	00 00 00 00	00 00	01 00	F0 AF	00 00	01 00	00 00

Make sure that the receive data memory is large enough!

5 Devices at protocol

5.1 Appending PROFINET devices

Select *Append Box* by right-clicking on the protocol. The following dialog then opens:

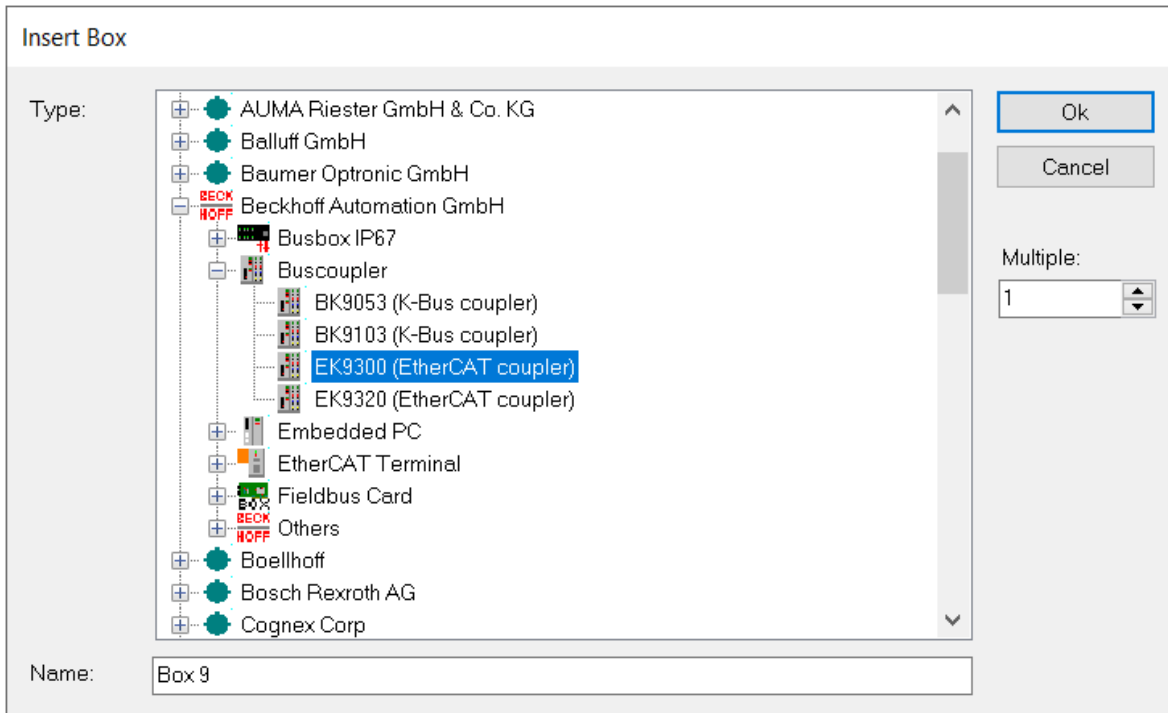


Fig. 32: *Insert Box* dialog

Here you can select different PROFINET devices. For Beckhoff devices, the GSDML is searched for under a defined path:

“..\TwinCAT\IO\PROFINET” (TC2) or

“..\TwinCAT\3.1\Config\Io\Profinet” (TC3).

These should be already present with the TwinCAT installation. If there are several GSDMLs for the same device here, the one with the latest date is taken. If no device description is found, a corresponding error message appears. Either the GSDML is copied into the folder and the menu is opened again, or the same procedure is selected as for the third-party devices. If you click on PROFINET IO Device, an option is offered to navigate to the corresponding GSDML in Windows Explorer. This is then integrated into the project.

The DNS name from the GSDML is taken as the default name. When appending several devices simultaneously, the default name is always supplemented by “-No.” (where No. = 1...n). The name that was assigned (and with which the device also appears in the tree), is at the same time also the “PROFINET Station Name”, i.e. the name that must correspond to the name in the device. The device name can be checked by scanning.

The modules can be appended to the API (Application Profile Interface). The DAP (Device Access Point), which already brings along fixed properties from the GSDML (e.g. process data, interface and port submodules, etc.), is always on Slot 0.

This module is always there and cannot be deleted or shifted. Each further module is assigned to a certain API. The information regarding its identity comes from the GSDML. By default this is always API 0. Alternatively, an API e.g. for the PROFIDRIVE profile or a fieldbus API is also conceivable. By clicking in the API on *Append PROFINET modules...* a device catalog is opened from which the corresponding modules can be selected and appended. If the modules support it (described in GSDML), the submodules can in turn be appended to them in the same way.

5.2 Comparison of nominal and actual configuration

If a connection exists, the project planning can be checked on the “Diagnosis” tab. At this level “Real Identification Data” returns the actually existing modules in an AR, “Expected Identification Data” indicates the expected modules (i.e. those projected in the controller) and “Module Difference” shows the differences to the device found in the nominal-actual comparison.

ModuleInfo	SubModuleInfo	APINumber	SlotNumber	SubSlotNumber
DAP Module	Interface 1	0x00000000	0	32768
DAP Module	Port 1	0x00000000	0	32769
DAP Module	Port 2	0x00000000	0	32770
DAP Module	EK9300 V2.25, 2 Port	0x00000000	0	1
EL1004	EL1004	0x00000000	1	1
EL2008	EL2008	0x00000000	2	1
EL3314	EL3314	0x00000000	3	1
EL4004	EL4004	0x00000000	4	1
EL2521	EL2521	0x00000000	5	1

At the display are the expected identification data from one AR.

Module Difference Get Real Configuration Diagnosis Data

Real Identification Data API Number Expected Identification Data

Fig. 33: "Diagnosis" tab, checking the project planning

If you are on the “Diagnosis” tab within the API, you can select the corresponding API about which information is to be obtained. If, for example, the PROFINET device is a drive, then this usually supports the Profidrive profile, which is identified in turn via API 0x3A00. If the Real Identification Data is to be read from this API, for example, then this access takes place via the Profidrive profile.

DriveType	ModuleInfo	SubModuleInfo	APINumber	SlotNumber	SubSlotNumber
Sinamics_S	DO Control Unit	SIEMENS Teleqramm 390, PZD-2/2	0x00003A00	1	3
Servo	DO Servo	SIEMENS Teleqramm 102, PZD-6/10	0x00003A00	2	3
Servo	DO Servo	SIEMENS Teleqramm 105, PZD-10/10	0x00003A00	3	3
Servo	DO Servo	Standard Teleqramm 3, PZD-5/9	0x00003A00	4	3
Servo	DO Servo	Standard Teleqramm 3, PZD-5/9	0x00003A00	5	3
Vector	DO Vector	Standard Teleqramm 1, PZD-2/2	0x00003A00	6	3
Vector	DO Vector	Standard Teleqramm 2, PZD-4/4	0x00003A00	7	3

At the display are the real identification data for API 0x00003A00

Module Difference Get Real Configuration Diagnosis Data

Real Identification Data API Number Expected Identification Data

Fig. 34: "Diagnosis" tab, API selection

In addition, the “Get Real Configuration” button becomes active within an API (except for drives). It is possible via this to adopt the read-in data record into the current project. Note that modules that have already been created will be overwritten when doing this. This means that the links are lost, even in the case of previously correctly created modules.

When displaying the module differences, additional information is displayed by marking the message.

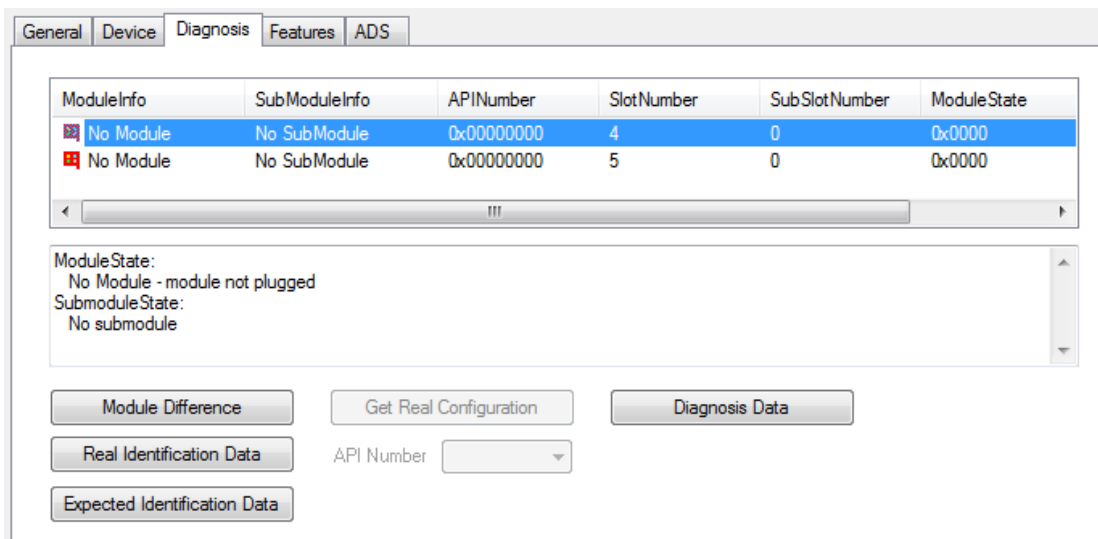


Fig. 35: "Diagnosis" tab, adopt data set into project

Diagnosis Data

The available diagnosis can be read out by pressing the "Diagnosis Data" button. At device level all available diagnosis data for the existing AR is read out here.

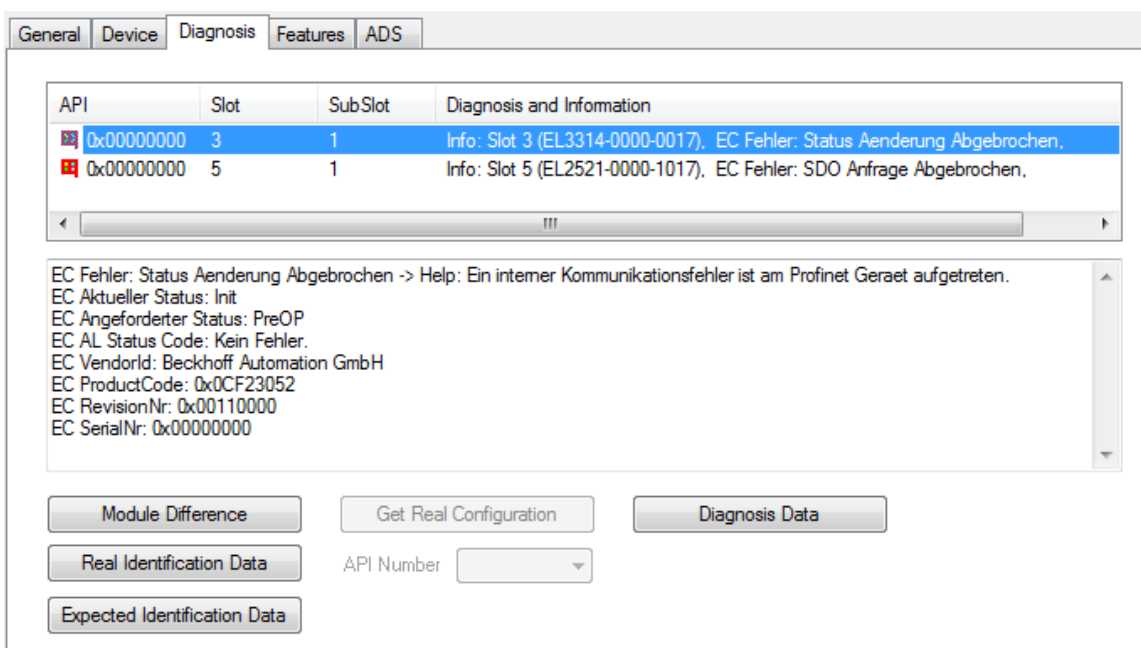


Fig. 36: "Diagnosis", Button Diagnosis Data

A maximum of two diagnosis parameters are displayed in the list; others are marked by "...". If the individual message is clicked, all available diagnosis information is displayed in the window below.

Cyclic diagnosis via "PnIoBoxState" and "PnIoBoxDiag"

These variables are cyclically exchanged with the process image between the PROFINET driver and the System Manager.

Presently the following error messages are displayed under the PnIoBoxState.

Number	Text	Description	Remedial action / reason
0	No error	No error	No error
1	PROFINET Device state machine is in boot mode	PROFINET Device State Machine is still in the start-up phase	Not an error, wait
2	Device not found	Device does not reply to the Identify Request	Check connection, device connected, was the device called by its correct name?
3	The stationname is not unique	The station name is not unique	There are two or more devices in the network with the same PROFINET name. A correct identification cannot take place.
4	IP could not set	IP address could not be set.	The PROFINET device has rejected the IP settings for some reason. Check whether the IP settings are correct.
5	IP conflict	An IP conflict has occurred in the network.	A possible cause is that several devices have the same IP address.
6	DCP set was not successful	There was no reply or an erroneous reply to a DCP Set.	Check connection, device connected, was the device called by its correct name?
7	Watchdog error	The connection was broken off with a Watchdog error.	Check the cycle time, check the connection, if necessary increase the Watchdog factor.
8	Datahold error	The connection was broken off with a Datahold error.	Frame Data status was invalid for the length of the DataHoldTimer. Restart the device if necessary.
9	RTC3: Sync signal could not started	For IRT only: the Sync signal could not be started.	Is EtherCAT Sync signal correct or has Sync0 started?
10	PROFINET Controller has a link error	The PROFINET controller has no link.	Check cable and connection.
11	The aliasname is not unique	The alias name is not unique	There are two or more devices in the network with the same alias name. This is made up of the neighbourhood information (PortId.ChassisId). A correct identification cannot take place.
12	The automatic name assignment isn't possible - wrong device type	The automatic name assignment is not possible.	The expected PROFINET device is not in the projected position (VendorId or DeviceId does not correspond). Hence, no automatic naming and thus no device start is possible.
31	only for EtherCAT gateways: WC-State of cyclic EtherCAT frame is 1	For EL6631 only: EtherCAT WC State is 1	Check the mode on the EtherCAT master & slave (OP?).

As opposed to the state, more than one status can be displayed in the "PnIoBoxDiag", i.e. the whole thing is bit-coded and up to 16 pieces of information can be displayed. The following statuses are currently displayed.

0x0000 = No diagnosis
 0xXXX1 = IOC-AR is not established
 0xXXX2 = IOC-AR is established
 0xXXX4 = IOC-AR is established but no ApplReady
 0xXXX8 = IOC-AR is established but module difference
 0xXX1X = At least one AlarmCR get diagnosis alarm
 0xX1XX = At least one InputCR is invalid
 0xX2XX = At least one InputCR Provider is in stop
 0xX4XX = At least one InputCR Problemindicator is set

0x1XXX = At least one OutputCR is invalid

0x2XXX = At least one OutputCR Provider is in stop

0x4XXX = At least one OutputCR Problemindicator is set

On the one hand information about the status of the IO Controller Single AR is displayed here. In addition, collective statuses are formed from the Frame Data statuses of the individual CRs. The whole thing happens for the input and the output CRs (currently only one is possible; in future the controller will support several CRs). In addition a PROFINET alarm is also displayed in the "PnIoBoxDiag"

5.3 Settings

5.3.1 Project planning of the PROFINET device

When establishing a PROFINET connection the controller always assigns an IP address to the device from its own address space (if the device does not yet have one or if it has a different one). In TwinCAT the next higher address is taken for a device by default (starting from the controller adapter class); the subnet and gateway are the same as those of the controller. Before the actual assignment of the IP address to the device by the controller, an ARP is used to test for a possible address conflict or to check whether the device already has this IP address. If there is a conflict, e.g. that the IP address is already assigned in the network, the IO driver determines this and outputs a corresponding message in the logger window. If there is no reply to the ARP, this means that no device (the projected device included) is using this IP configuration, which in turn results in the controller assigning the IP settings to the device via a DCP_SET. Setting is skipped if it is determined via the ARP that the device sought already has the projected IP address.

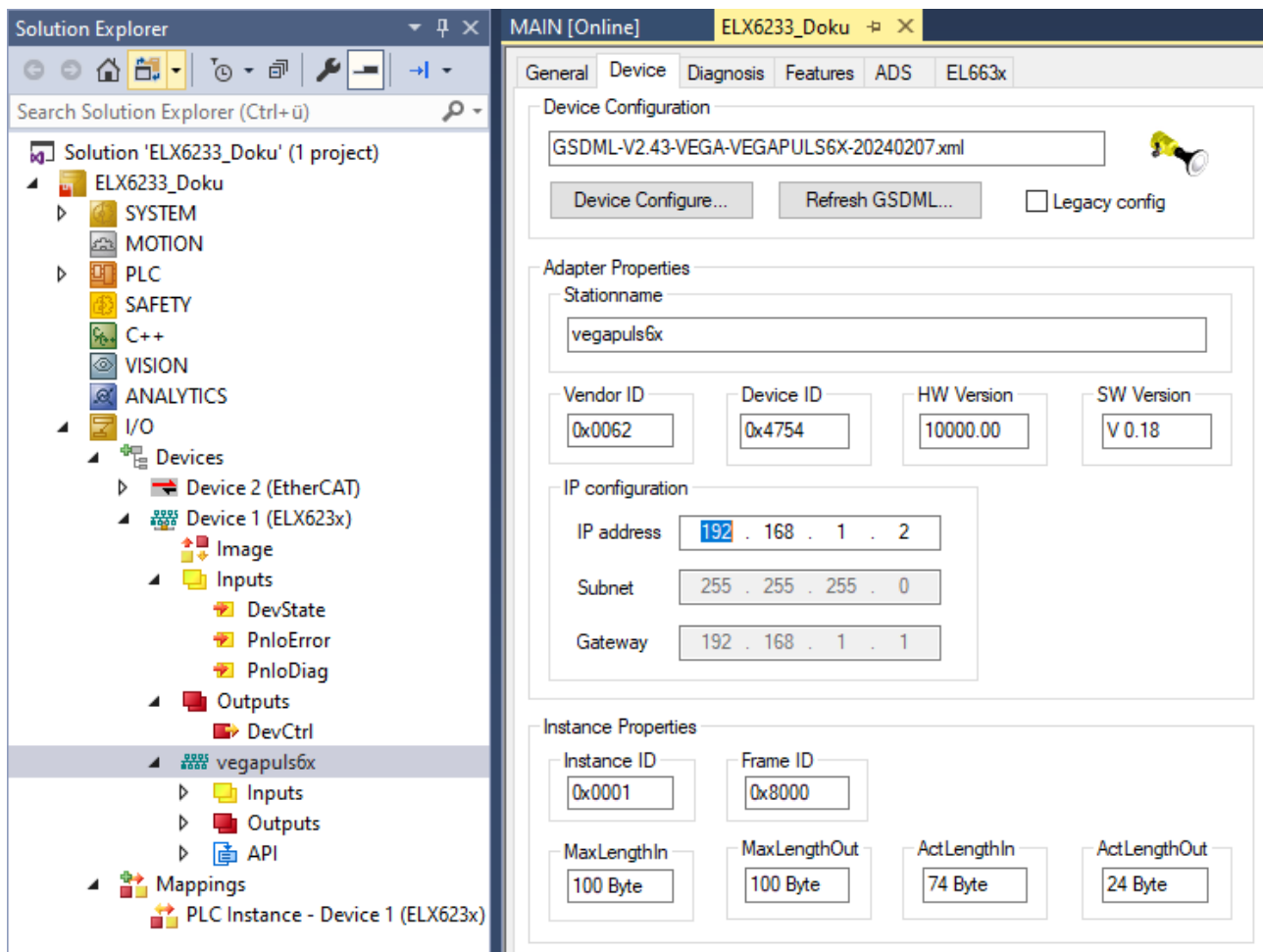


Fig. 37: Device tab

In addition the "InstanceID" and the "FrameID" can be changed in this window. However, the default settings are sufficient for most applications. The Instance ID is incorporated into the formation of the UUID object. A change should therefore be made only in exceptional cases. When changing the Frame ID the employed RTClass must be taken into account (e.g. for RTClass1 unicast 0xC000 - 0xFAFF). If the device is on an IRT controller and all devices have been switched automatically to RTClass3, the Frame ID is managed automatically and there is no input option (marked by "Fast Config").

The current process data length can also be checked in this menu. This means that the MaxLengths indicate which process data size is supported by the corresponding device, while the ActLengths indicate the current process data length (incl. IOPS and IOCS). The corresponding error message appears if the maximum lengths are exceeded on appending further modules/submodules.

Various settings for the cycle time can be made on the "Features" tab. The cycle time of the controller must always correspond to a power of two for RTClass1, starting at 1 ms (1, 2, 4, 8...). If an incorrect base time has been selected, this is indicated by a corresponding message. For RTClass3 the 1 ms base time can be divided again and again by two (down to min. 31.25 µs). The device cycle time can be changed via the exponent. The minimum is always the Controller CycleTime, unless the minimum cycle time defined in the GSDML is greater than that of the controller. The maximum for RTClass1 is 512 ms. The "SendClockFactor" is fixed to the value 32 ($31.25 \mu s * 32 = 1 \text{ ms}$) as the time base. The "ReductionRatioFactor" also refers to this, i.e. an RRFactor of 4 means a cycle time of 4 ms. The transmission time can be shifted again within a cycle via the phase, i.e. with $RR = 4$, the phase can be 1 - 4. However, this value is only of importance in the case of a synchronized transmission.

General Device Diagnosis **Features** ADS EL663x

IO Cyclic Data

Controller Cycle Time	4 ms	☒ Cycle time from master task
Device Cycle Time	64 ms	$DevCycleTime = SendClockFactor * 31.25\mu s * RedRatio$
Min Device Interval	2048	
Send Clock Factor	32	
Reduction Ratio	64	
Phase	1	
Watchdog Factor	3	Default = 3
Watchdog Time	192 ms	$Watchdog Time = Watchdog Factor * DevCycleTime$

Comment

Fig. 38: *Features* tab

The PROFINET Watchdog Factor can also be adjusted here. Each device monitors the input of the cyclic data based on this factor. If the factor is set to the default value (3) this means that, with an RR of 4, three cycles require 12 ms. Hence, a device reacts after 12 ms to missing telegrams (e.g. with an alarm and/or disconnection of the AR). The limits and values are recalculated each time when adjusting the individual factors.

5.3.2 EL663x

If the controller protocol is operated via an EL663x, then an additional menu appears on the devices.

General settings

- ☐ alternative mapping model
- ☐ get PN-Stationname from ECAT
- ☐ get PN-IP-Settings from ECAT

IP configuration

IP address

Subnet

Gateway

PDO mapping

- ☒ Submodule data (0x6nn1, 0x7nn1)
- ☐ Module data (0x6nn2, 0x7nn2)
- ☐ Submodule data and IOPS (0x6nn3, 0x7nn3)
- ☐ Module data and IOPS (0x6nn4, 0x7nn4)

PN output behaviour if EC state is not OP

- ☐ Outputs set to 0, IOxS is GOOD
- ☐ Outputs frozen, IOxS is GOOD
- ☒ Outputs set to 0, IOxS is BAD

Fig. 39: "EL663x" tab

Currently only the PDO mapping can be selected for the controller. This sets the form in which the PROFINET process data are mapped to the EtherCAT-side PDOs.

5.3.3 Shared Device

The SharedDevice feature is available from TwinCAT 2 build 22.50 or TwinCAT 3 build 4019.

The dialogue appears if the device supports "SharedDevice". The information for this comes from the GSDML.

General	Device	Diagnosis	Features	ADS	Shared Device
Name	Slot	Subslot	Access	SharedInput	
[-] Term 1 (DAP Module)					
[-] Subterm 1 (EK9300 V 2.31 (at least FW 2.00))	0	1	true	has output data	
[-] Subterm 2 (Interface)	0	32768	false	no access	
[-] Subterm 3 (Port 1)	0	32769	false	no access	
[-] Subterm 4 (Port 2)	0	32770	false	no access	
[-] Term 2 (EL1018)					
[-] Subterm 1 (EL1018)	1	1	true	true	
[-] Term 3 (EL2008)					
[-] Subterm 1 (EL2008)	2	1	false	no access	
[-] Term 4 (EK1110)					
[-] Subterm 1 (EK1110)	3	1	false	no access	
[-] Term 5 (EK1100)					
[-] Subterm 1 (EK1100)	4	1	true	no input data	
[-] Term 6 (EL3004)					
[-] Subterm 1 (ModuleAccessPoint)	5	1	true	no input data	
[-] Subterm 2 (Standard)	5	2	true	false	
[-] Term 7 (EL4012)					
[-] Subterm 1 (EL4012)	6	1	true	has output data	

Fig. 40: "Shared Device" tab

There is an option here to allow or forbid the controller to access the individual sub-modules. By default the controller may access all sub-modules; if SharedInput is supported it is switched off.

The text messages for SharedInput have the following meanings:

- "not supported" - SharedInput is not supported by the device (info from the GSDML)
- "has output data" - the sub-module has outputs - activation of SharedInput not possible
- "no input data" - the sub-module has no inputs (and also no outputs)
- "no access" - access is blocked
- "true" or "false" - set value for SharedInput

The settings can be changed by double-clicking on the individual sub-modules. If the access to a port or interface sub-module is changed, then it is changed for all ports or interfaces.

5.4 Modules

5.4.1 Diagnosis at module level

The slot number of the modules always corresponds to the position in the tree, i.e. the DAP module always starts with slot number 0 and so on in order. At module level there is an option on the Diagnostic tab to compare the nominal and actual data for the respective module. In addition the existing diagnosis for the module can be read out.

5.4.2 Diagnosis at submodule level

PROFINET currently distinguishes between 4 types of submodule.

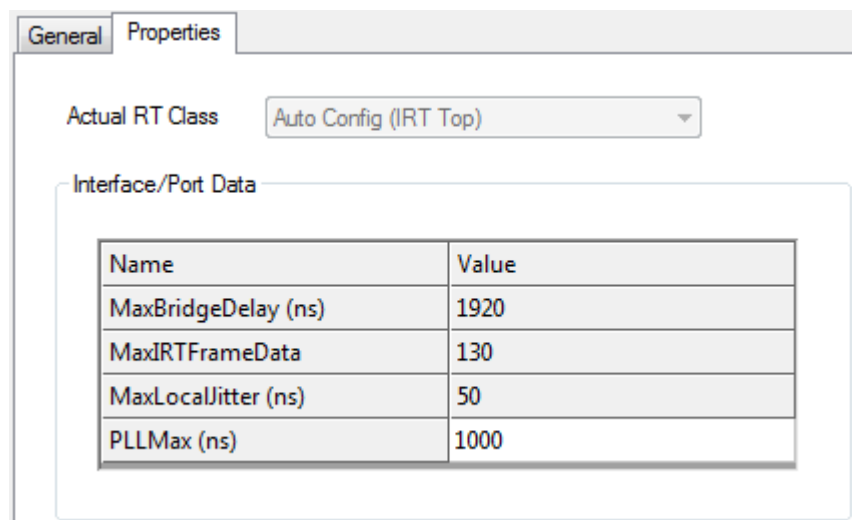
- Virtual submodules:
The virtual submodules are always permanently connected to a module, i.e. when inserting a module the virtual submodules defined with it are also always inserted in the specified subslot. This kind of submodule is presently the commonest method.
- Real submodule:
Here there is a possibility to select the pluggable submodules from a submodule list and to append them to the module. The necessary information is procured from the GSDML. In TwinCAT a module can be selected from such a list with the right mouse button (provided this is supported by the device).
- Port submodule:
The physical properties of a network port are reproduced in such a submodule.
- Interface submodule:
Device-specific properties are defined in the interfaces submodules. These can be, for example, additionally supported protocols, timing properties, supported MIBs etc.

In general the submodules have the same diagnostic properties as the modules, i.e. in this case also it is currently only possible to read out the nominal and actual configuration in TwinCAT. The order of the subslot numbers is not necessarily the same as the order in the TwinCAT project. Hence, for example, the order in DAP always starts with the interface submodule (ISM); however, the subslot number of the ISM is defined in the GSDML and starts at 0x8000. There are 16 possible interfaces (0x8000), each with up to 256 ports (0x80xx). An ISM is followed by the Port submodule with the aforementioned subslot number.

5.4.3 Interface Submodule

The type of communication can always be set on the interface submodel (at present RTClass1 or RTClass3). The only exception is in the case that a generally valid RTClass was set via the 'Auto Config...' menu.

If communication takes place over RTClass3, then the PLL window can additionally be set at the interface.



The screenshot shows the 'Properties' tab of an interface submodule. The 'Actual RT Class' is set to 'Auto Config (IRT Top)'. Below this, the 'Interface/Port Data' section contains a table with the following data:

Name	Value
MaxBridgeDelay (ns)	1920
MaxIRTFrameData	130
MaxLocalJitter (ns)	50
PLLMax (ns)	1000

Fig. 41: "Properties" tab, "PLL Window" setting

5.4.4 Port Submodule

Port-specific settings can be made on the 'Properties' tab. The menu of possible settings always depends on the RTClass employed.

Name	Value
MaxPortRxDelay (ns)	374
MaxPortTxDelay (ns)	280
RemotePeerPort	sinamics2.port-001
LengthOfCable (m)	10

Fig. 42: "Properties" tab

In addition some port properties can be read out.

Local Port Data

Name	Value
Port Number	2
Port ID	port-002
Port Description	Siemens, SIMATIC S7, Ethernet Switch Po...

Get local port data

Remote Port Data

Name	Value
Port ID	port-001
Port Description	ek9300 - port-001
System Name	ek9300
System Description	Beckhoff TwinCAT PROFINET IO Prot...

Get remote port data

Port Statistic

Name	Value
Speed	100 MBit/sec
Phys MAC	0x00 0x0e 0x8c 0xac 0x6a 0xf7
Operating status	up
Rx octets	692

Get port statistic

Fig. 43: "Port Diagnosis" tab

The information here is subdivided into local port information and remote port properties. I.e. the LLDP protocol (IEEE Std 802.1AB) is prescribed in PROFINET from Conformance Class A (CCA). The devices exchange neighbourhood IDs via this protocol, so that each port is known to its neighbor. Furthermore, the Simple Network Management Protocol (SNMP) can be used as an aid at this point. On opening the 'Port

Diagnosis' tab, TwinCAT acts as a Network Management Station (NMS) and collects the required device information via SNMP. In the above illustration, for example, it can be seen that the local Port 1 of the BK9053 is connected to Port 2 of the BK9103. For correct topology recognition it is important that only devices are present in the strand that also support the LLDP protocol (this is also applies to switches!).

5.4.5 Real / virtual submodules

If these submodules have paramétrisation data they will be displayed as shown in the illustration below.

Name	R/W	Offline Value	Online Value
Sammeldiagnose	R/W	0	
Diag: Über-/Unterlauf	R/W	0	
Diag: Drahtbruch E-Kanal 0	R/W	0	
Diag: Drahtbruch E-Kanal 1	R/W	0	
Glättung E-Kanal 0	R/W	keine	
Glättung E-Kanal 1	R/W	keine	
Messart/-bereich, E-Kanal 0	R/W	Spannung +/- 10 V	
Messart/-bereich, E-Kanal 1	R/W	Spannung +/- 10 V	
Prozessalarm bei Grenzwertüberschre...	R/W	0	
Oberer Grenzwert E-Kanal 0	R/W	32511	
Unterer Grenzwert E-Kanal 0	R/W	33024	
Prozessalarm bei Grenzwertüberschre...	R/W	0	
Oberer Grenzwert E-Kanal 1	R/W	32511	
Unterer Grenzwert E-Kanal 1	R/W	33024	

Klicken Sie auf das Feld, um sich die verfügbaren Meßarten und Meßbereiche anzeigen zu lassen und auszuwählen. Empfehlung: Nichtbeschaltete Eingangskanäle sollten Sie deaktivieren (Eingabeart: deaktiviert), um die Baugruppenzykluszeit zu verkürzen.

Fig. 44: "Parameterize Module" tab, parameter display

Selection can be made here between the individual indices. The data can be read and/or written depending on the access method. The online values are updated when reading back. If an individual index is marked, then all values within an index will be set to default; if individual values are marked, only these will be reset. Writable values are changed by double-clicking on the respective line.

6 Appendix

6.1 EtherCAT AL Status Codes

For detailed information please refer to the [EtherCAT system description](#).

6.2 Support and Service

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