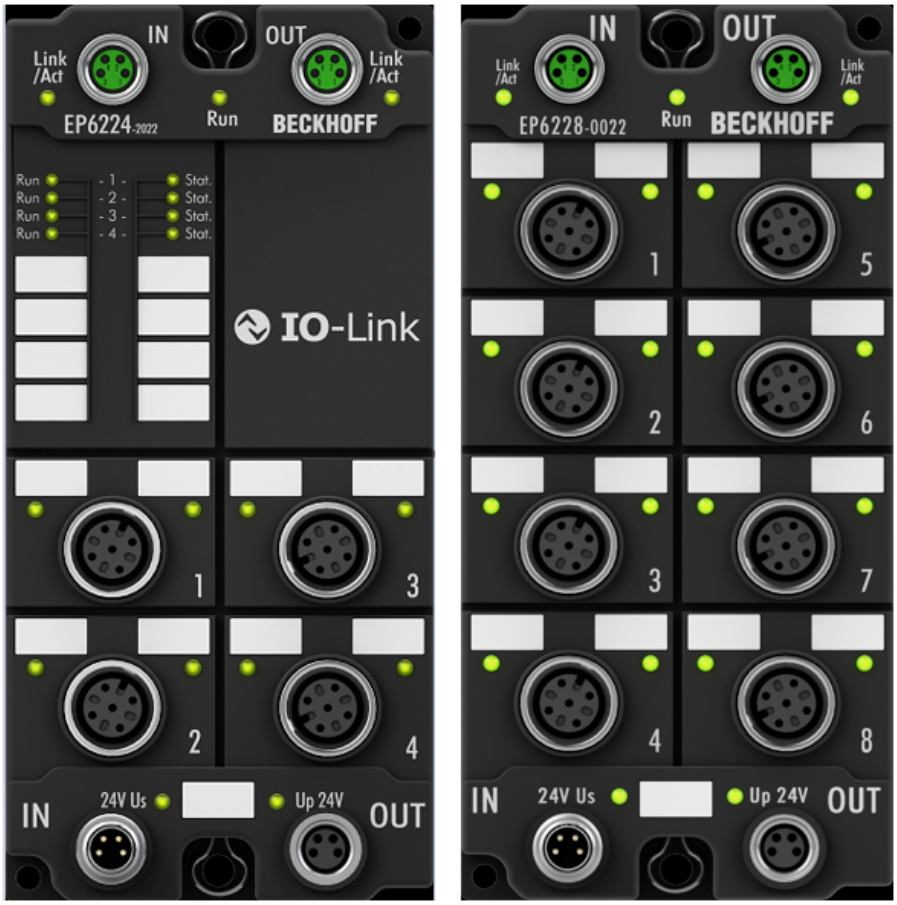

Documentation for

EP6224 and EP6228

IO-Link Master with protection class IP67

Version: 1.3.0
Date: 2019-02-14

BECKHOFF

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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.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

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.

Trademarks

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Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

Patent Pending

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

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

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

Copyright

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.

Description of instructions

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

⚠ DANGER

Serious risk of injury!

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

⚠ WARNING

Risk of injury!

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

⚠ CAUTION

Personal injuries!

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

NOTE

Damage to environment/equipment or data loss

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

Tip or pointer

This symbol indicates information that contributes to better understanding.

1.3 Documentation issue status

Version	Changes
1.3.0	• Update *Technical data* • Design of the safety instructions adapted to IEC 82079-1
1.2.5	• *EP6228-x0x2 – Technical data* updated • Design of the safety instructions adapted to IEC 82079-1.
1.2.4	• EP6228-3032 added • *EP6224-x022 – Technical data* updated • *EP6228-x0x2 – Technical data* updated • *EP6228-x0x2 – Introduction* updated • *EP622x Module overview* updated • *Conductor losses 7/8”* added • *Configuration via TwinCAT* - explanation tabs and *IO-Link master* updated
1.2.3	• *Object description and parameterization* updated • *IP-Link basics* updated
1.2.2	• *Object description and parameterization* updated
1.2.1	• Nut torque for connectors updated
1.2.0	• EP6228-0022 added • *Object description and parameterization* updated • *EP6224-0x22 – Process image* updated • Images of the IO-Link and sensor cables updated
1.1.1	• *EP6224 Module overview* updated
1.1.0	• *Power Connection* updated
1.0.0	• first publication
0.6	• corrections
0.5	• first preliminary version

Firm and hardware version

The documentation refers to the firm and hardware status that was valid at the time it was prepared.

The properties of the modules are subject to continuous development and improvement. Modules having earlier production statuses cannot have the same properties as modules with the latest status. Existing properties, however, are always retained and are not changed, so that these modules can always be replaced by new ones.

The firmware and hardware version (delivery state) can be found in the batch number (D number) printed at the side of the IO-Link box module.

Syntax of the batch number (D number)

D: WW YY FF HH

WW - week of production (calendar week)
YY - year of production
FF - firmware version
HH - hardware version

Example with D No. 29 10 02 01:

29 - week of production 29
10 - year of production 2010
02 - firmware version 02
01 - hardware version 01

2 EtherCAT Box - Introduction

The EtherCAT system has been extended with EtherCAT Box modules with protection class IP 67. Through the integrated EtherCAT interface the modules can be connected directly to an EtherCAT network without an additional Coupler Box. The high-performance of EtherCAT is thus maintained into each module.

The extremely low dimensions of only 126 x 30 x 26.5 mm (h x w x d) are identical to those of the Fieldbus Box extension modules. They are thus particularly suitable for use where space is at a premium. The small mass of the EtherCAT modules facilitates applications with mobile I/O interface (e.g. on a robot arm). The EtherCAT connection is established via screened M8 connectors.

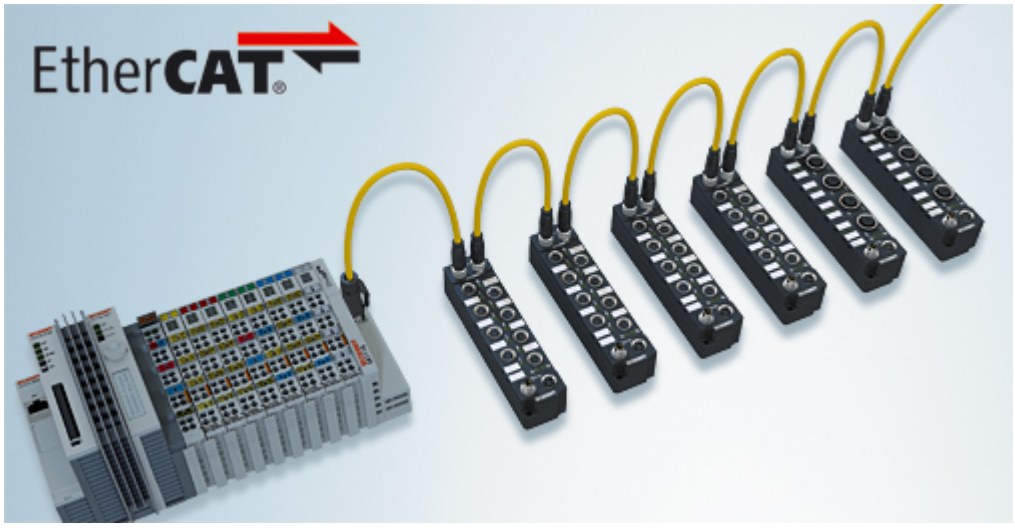


Fig. 1: EtherCAT Box Modules within an EtherCAT network

The robust design of the EtherCAT Box modules enables them to be used directly at the machine. Control cabinets and terminal boxes are now no longer required. The modules are fully sealed and therefore ideally prepared for wet, dirty or dusty conditions.

Pre-assembled cables significantly simplify EtherCAT and signal wiring. Very few wiring errors are made, so that commissioning is optimized. In addition to pre-assembled EtherCAT, power and sensor cables, field-configurable connectors and cables are available for maximum flexibility. Depending on the application, the sensors and actuators are connected through M8 or M12 connectors.

The EtherCAT modules cover the typical range of requirements for I/O signals with protection class IP67:

- digital inputs with different filters (3.0 ms or 10 µs)
- digital outputs with 0.5 or 2 A output current
- analog inputs and outputs with 16 bit resolution
- Thermocouple and RTD inputs
- Stepper motor modules

XFC (eXtreme Fast Control Technology) modules, including inputs with time stamp, are also available.

Fig. 2: EtherCAT Box with M8 connections for sensors/actuators

Fig. 3: EtherCAT Box with M12 connections for sensors/actuators

Basic EtherCAT documentation

You will find a detailed description of the EtherCAT system in the Basic System Documentation for EtherCAT, which is available for download from our website (www.beckhoff.com) under Downloads.

EtherCAT XML Device Description

You will find XML files (XML Device Description Files) for Beckhoff EtherCAT modules on our website (www.beckhoff.com) under Downloads, in the Configuration Files area.

3 Product overview

3.1 EP622x Module overview

IO-Link Master

Module	Signal connection	IO-Link inter-faces	Specification version	Comment
EP6224-2022	4 x M12	4	IO-Link V1.1, Class A	wide body
EP6224-3022	4 x M12	4	IO-Link V1.1, Class B	wide body
EP6228-0022	8 x M12	8	IO-Link V1.1, Class A	wide body
EP6228-3032	8 x M12	8	IO-Link V1.1, Class B	wide body

3.2 EP6224

3.2.1 EP6224-x022 - Introduction

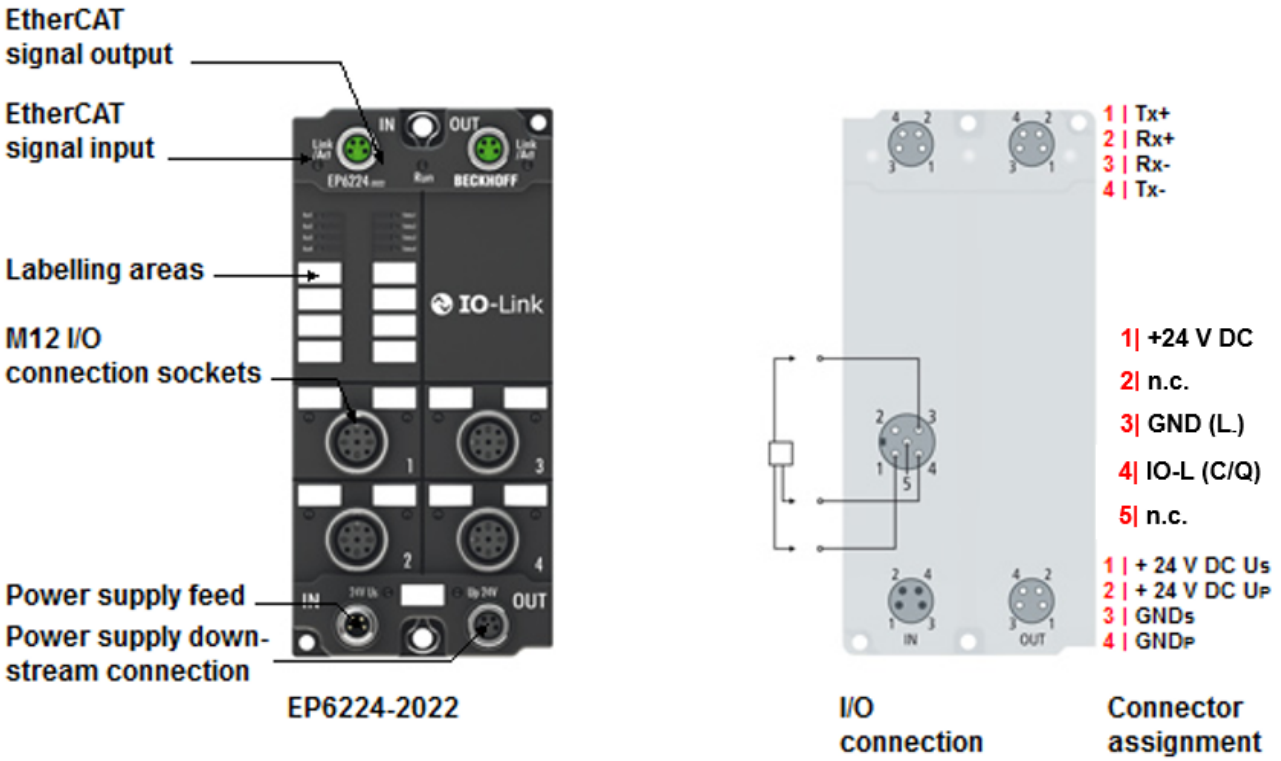


Fig. 4: EP6224-2022

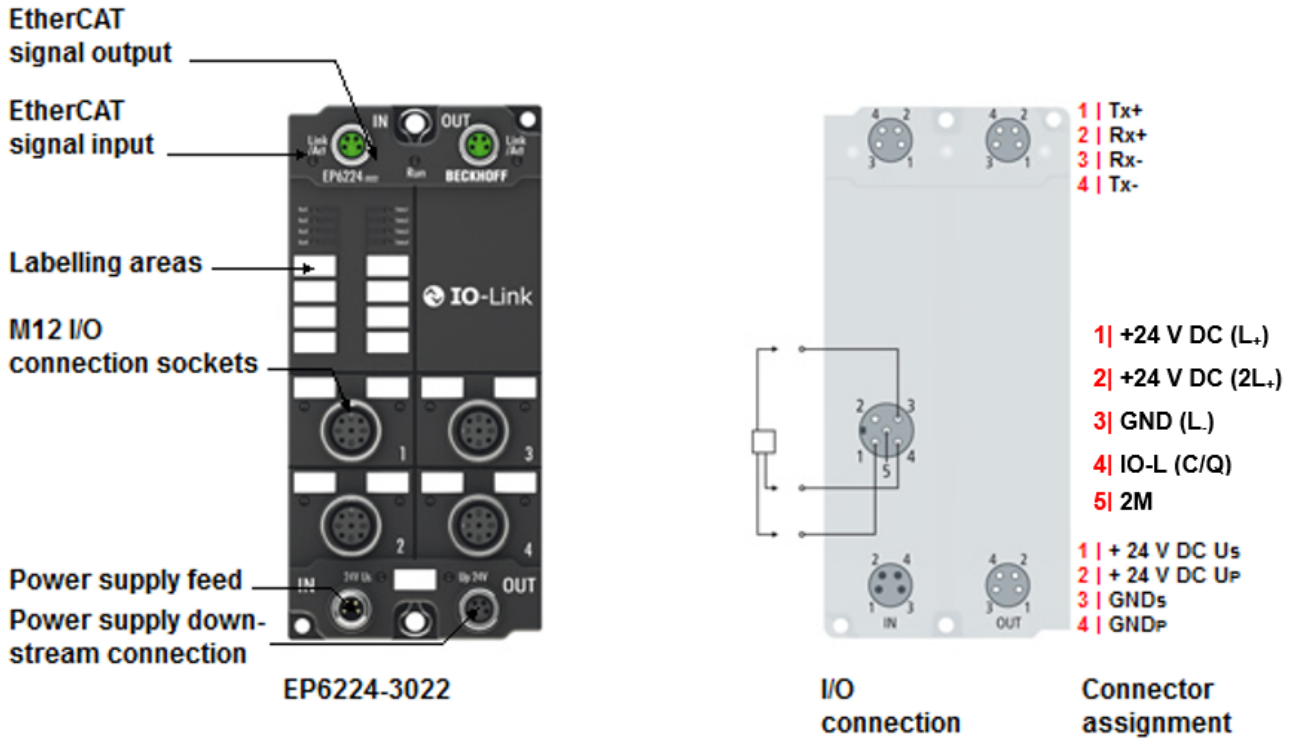


Fig. 5: EP6224-3022

IO-Link master

The EP6224 IO-Link module enables connection of up to four IO-Link devices, e.g. actuators, sensors, combinations of both or the EPIxxxx modules from Beckhoff. A point-to-point connection is used between the module and the device. IO-Link is designed as an intelligent link between the fieldbus level and the sensor, wherein parameterisation information can be exchanged bidirectionally via the IO-Link connection. The parameterisation of the IO-Link devices with service data can be done from TwinCAT via ADS or System Manager.

In the standard setting, the EP6224 functions as a 4-channel input module, 24 V_{DC}, which communicates with connected IO-Link devices, parameterises them and, if necessary, changes their operating mode. Beckhoff offers with the EP6224-2022 a class A master and with the EP6224-3022 a class B master.

Quick Links

Dimensions [▶ 32]

Commissioning/Configuration IO-Link master [▶ 53]

3.2.2 EP6224-x022 - Technical Data

Technical data	EP6224-2022	EP6224-3022
Fieldbus	EtherCAT	
Fieldbus connection	2 x M8 socket (green)	
Data transfer rates	4.8 kBaud (COM 1), 38.4 kBaud (COM 2), 230.4 kBaud (COM 3)	
IO-Link connection [▶ 39]	1 x M12 socket, a-coded	
IO-Link interfaces	4	
Specification version	IO-Link V1.1, Class A	IO-Link V1.1, Class B
Nominal input voltage	24 V_{DC} (-15%/+20%)	
Cable length (IO-Link)	max. 20 m	
Sensor supply	24 V_{DC}, 1.4 A per port (L+), ∑ for all 4 ports 1.4 A	24 V_{DC}, 1.4 A per port (L+), ∑ 1.4 A | 2.0 A per port (2L+), ∑ for 4 ports 2.0 A
Current consumption from U_S (without sensor current)	typ. 130 mA + load	
Power supply connection	Feed: 1 x M8 male socket, 4-pin; downstream connection: 1 x M8 female socket, 4-pin	
Electrical isolation	500 V	
Weight	approx. 250 g	
Permissible ambient temperature during operation	-25°C ... +60°C	
Permissible ambient temperature during storage	-40°C ... +85°C	
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27	
EMC resistance/emission	conforms to EN 61000-6-2 / EN 61000-6-4	
Protection class	IP65, IP66, IP67 (conforms to EN 60529)	
Installation position	variable	
Approvals	CE	

3.2.3 EP6224-x022 - Process image

Channel 1 to Channel 4

The EtherCAT box EP6224-x022 contains 4 IO-Link ports. You can also connect one IO-Link device at one IO-Link Port. In the figure below, you can see as an example the process image of the EP6224-2022. If a digital input module is connected to the Channel 1, the inputs of this IO-Link device are listed in the process image under **IO Inputs Channel 1**.

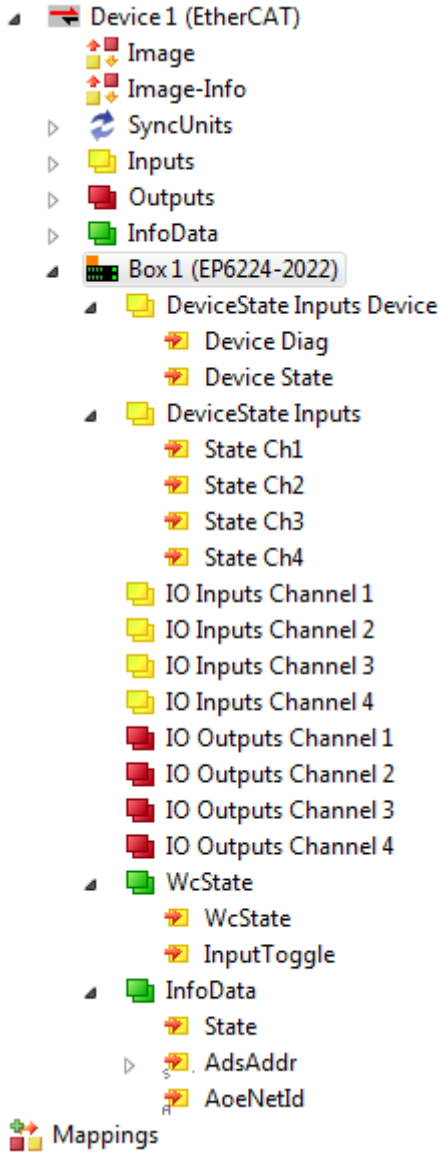


Fig. 6: *EP6224-x022, Process image*

3.3 EP6228

3.3.1 EP6228-x0x2 - Introduction

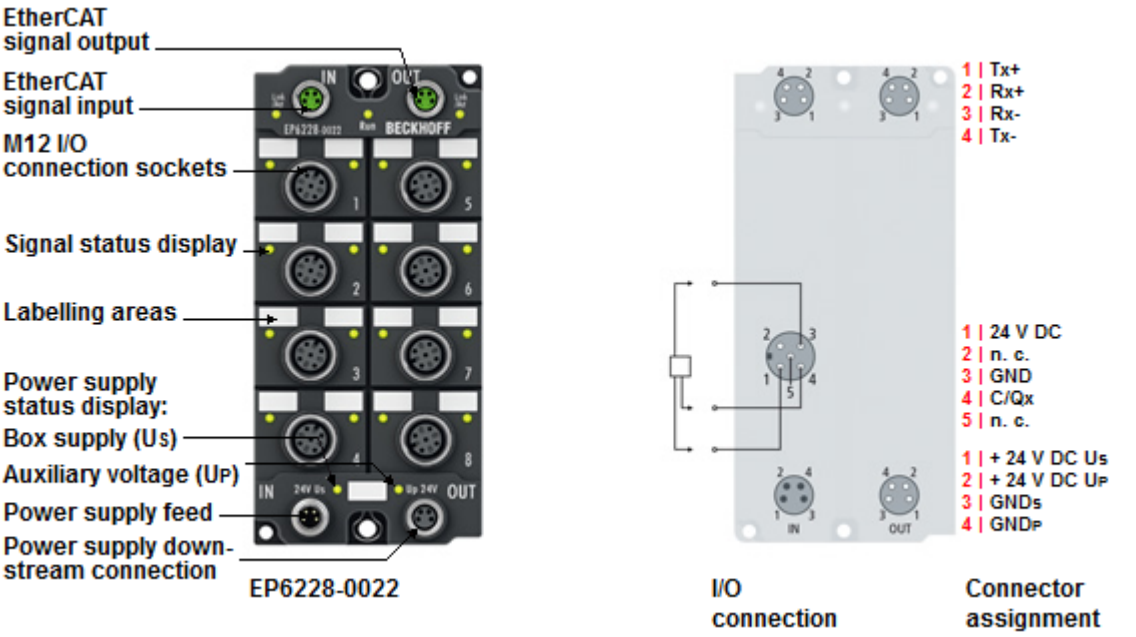


Fig. 7: EP6228-0022

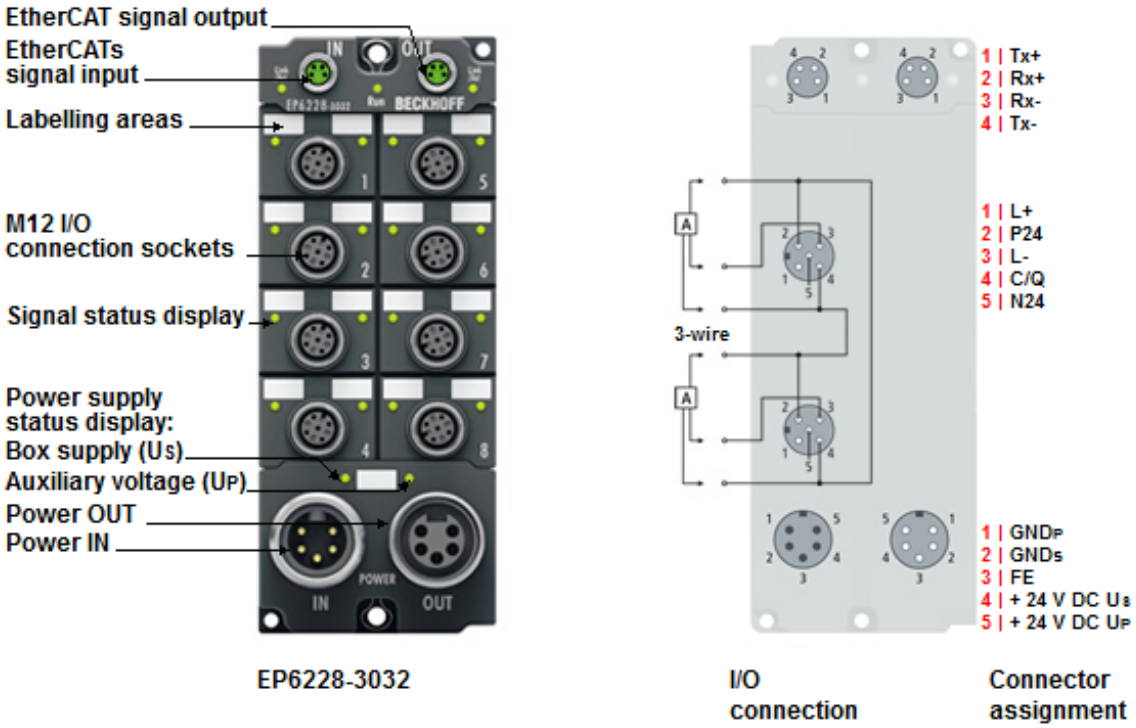


Fig. 8: EP6228-3032

IO-Link master

The EP6228 IO-Link module enables connection of up to eight IO-Link devices, e.g. IO-Link box modules, actuators, sensors or combinations thereof. A point-to-point connection is used between the module and the device. The terminal is parameterised via the EtherCAT master. IO-Link is designed as an intelligent link

between the fieldbus level and the sensor, wherein parameterisation information can be exchanged bidirectionally via the IO-Link connection. The parameterisation of the IO-Link devices with service data can be done from TwinCAT via ADS or very conveniently via the integrated IO-Link configuration tool.

In the standard setting, the EP6228 functions as a 8-channel input terminal, 24 V DC, which communicates with connected IO-Link devices, parameterises them and, if necessary, changes their operating mode.

Quick Links

Dimensions [▶ 32]

Commissioning/Configuration IO-Link master [▶ 53]

3.3.2 EP6228-x0x2 - Technical Data

Technical data	EP6228-0022	EP6228-3032
Fieldbus	EtherCAT	
Fieldbus connection	2 x M8 socket (green)	
Data transfer rates	4.8 kBaud (COM 1), 38.4 kBaud (COM 2), 230.4 kBaud (COM 3)	
IO-Link connection [▶ 39]	1 x M12 socket, A-coded	
IO-Link interfaces	8	
Specification version	IO-Link V1.1, Class A	IO-Link V1.1, Class B
Nominal input voltage	24 V_{DC} (-15%/+20%)	
Cable length (IO-Link)	max. 20 m	
Sensor supply	24 V_{DC}, 1.4 A per port (L+), ∑ for 8 ports 4 A	24 V_{DC}, 1.4 A per port (L+), ∑ 11.2 A | 4.0 A per port (2L+), ∑ 4.0 A for every 2 ports (pairs of ports: 1 & 5, 2 & 6, 3 & 7, 4 & 8)
Current consumption from U_S (without sensor current)	typ. 130 mA + load	
Power supply connection	feed: 1 x M8 male socket, 4-pin; downstream connection: 1 x M8 female socket, 4-pin	feed: 1 x 7/8" plug, 5-pin; downstream connection: 1 x 7/8" socket, 5-pin
Electrical isolation	500 V	
Weight	approx. 250 g	
Permissible ambient temperature during operation	-25°C ... +60°C	
Permissible ambient temperature during storage	-40°C ... +85°C	
Vibration / shock resistance	conforms to EN 60068-2-6 / EN 60068-2-27	
EMC resistance/emission	conforms to EN 61000-6-2 / EN 61000-6-4	
Protection class	IP65, IP66, IP67 (conforms to EN 60529)	
Installation position	variable	
Approvals	CE, UL	CE, UL in preparation

4 Basic communication principles - EtherCAT

4.1 Configuration via TwinCAT – explanation tabs

In the left-hand window of the TwinCAT System Manager, click on the branch of the IO-Link box you wish to configure.

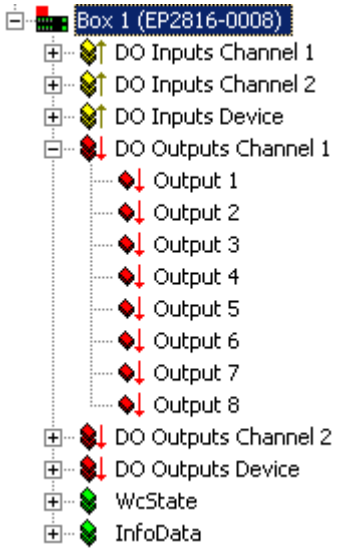


Fig. 9: Branch of the IO-Link box to be configured

In the right-hand window of the TwinCAT System manager, various tabs are now available for configuring the IO-Link box.

General tab

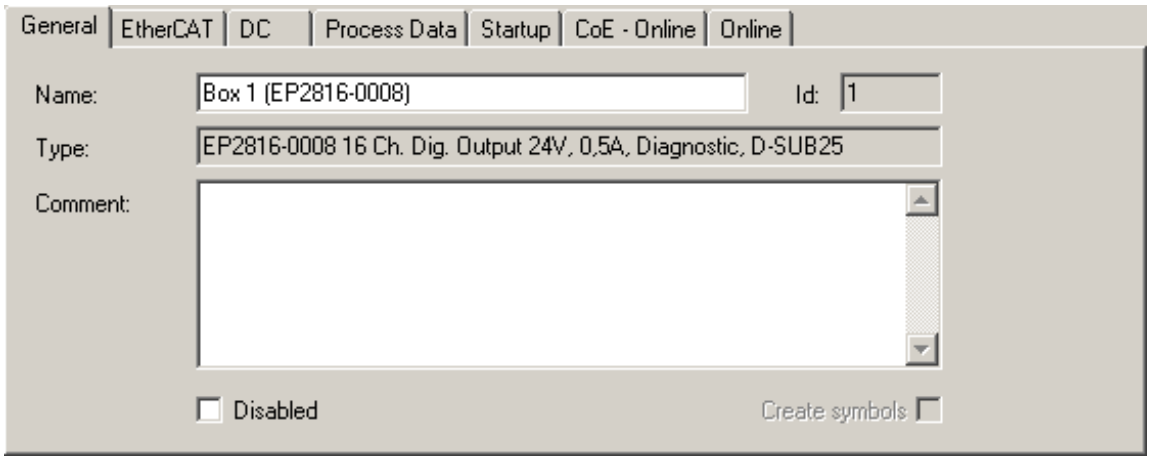


Fig. 10: General tab

Name	Name of the IO-Link master
Id	Number of the IO-Link master
Type	IO-Link master type
Comment	Here you can add a comment (e.g. regarding the system).
Disabled	Here you can deactivate the IO-Link master.
Create symbols	Access to this IO-Link master via ADS is only available if this control box is activated.

EtherCAT tab

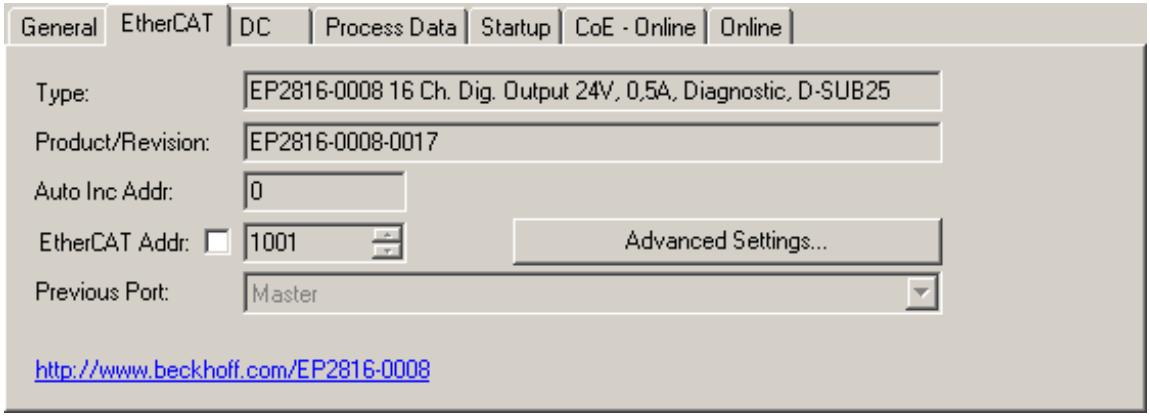


Fig. 11: EtherCAT tab

Type	IO-Link master device type
Product/Revision	Product and revision number of the IO-Link master
Auto Inc Addr.	Auto increment address of the IO-Link master. The auto increment address can be used for addressing each EtherCAT device or each IO-Link master in the communication ring through its physical position. Auto increment addressing is used during the start-up phase when the IO-Link master allocates addresses to the EtherCAT devices or IO-Link masters. With auto increment addressing the first EtherCAT device in the ring has the address 0000_{hex}. For each further slave the address is decremented by 1 ($FFFF_{hex}$, $FFFE_{hex}$ etc.).
EtherCAT Addr.	Fixed address of an EtherCAT device/IO-Link master. This address is allocated by the EtherCAT device/IO-Link master during the start-up phase. Tick the control box to the left of the input field in order to modify the default value.
Previous Port	Name and port of the EtherCAT device/IO-Link master to which this device is connected. If it is possible to connect this device with another one without changing the order of the EtherCAT devices/IO-Link masters in the communication ring, then this combination field is activated and the EtherCAT device or the IO-Link master to which this device is to be connected can be selected.
Advanced Settings	This button opens the dialogs for advanced settings.

The link at the bottom of the tab points to the product page for this IO-Link master on the web.

Process Data tab

Indicates the configuration of the process data. The input and output data of the IO-Link master are represented as CANopen process data objects (PDO). The user can select a PDO via PDO assignment and modify the content of the individual PDO via this dialog, if the IO-Link master supports this function.

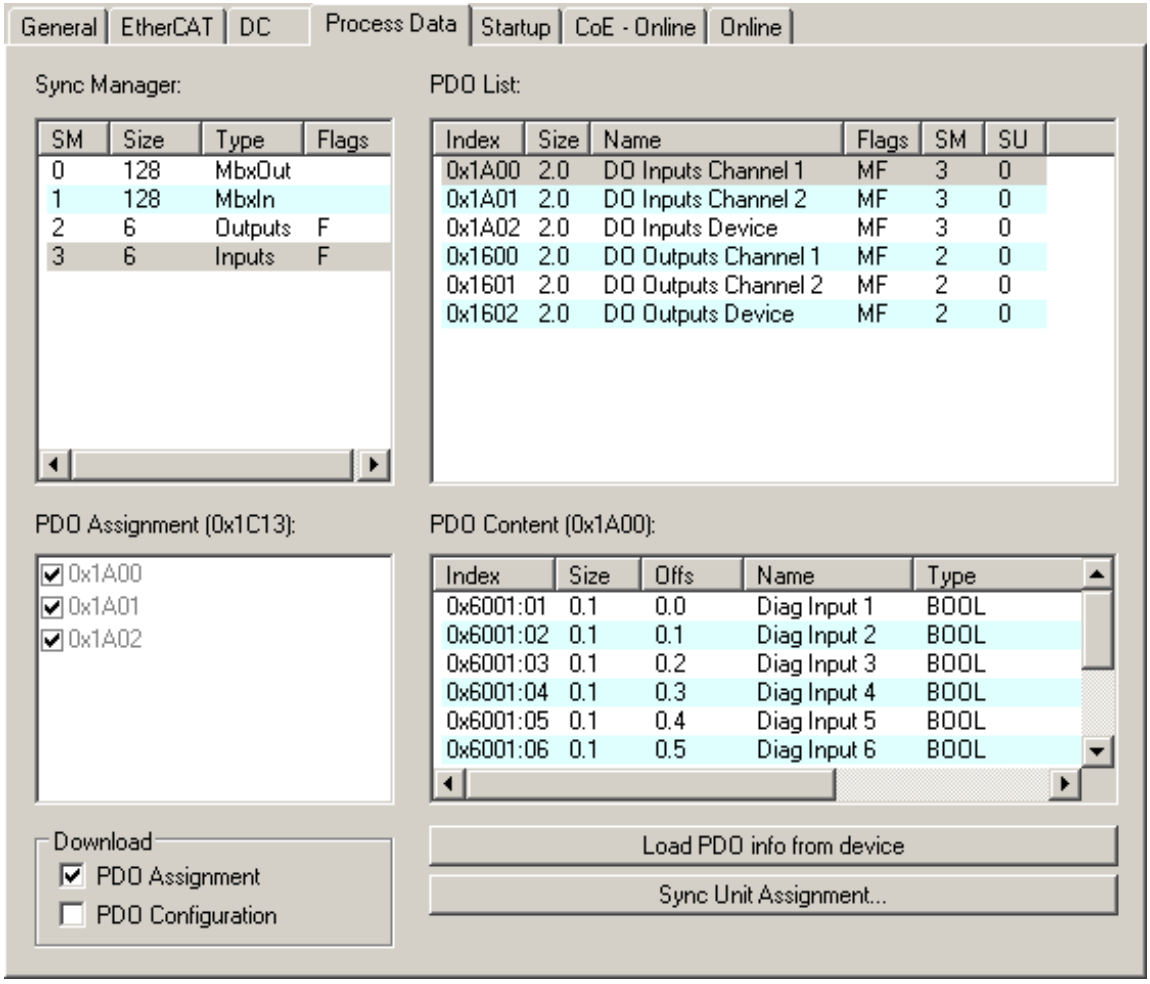


Fig. 12: Process Data tab

Sync Manager

Lists the configuration of the Sync Manager (SM).
If the IO-Link master has a mailbox, SM0 is used for the mailbox output (MbxOut) and SM1 for the mailbox input (MbxIn).
SM2 is used for the output process data (outputs) and SM3 (inputs) for the input process data.

If an input is selected, the corresponding PDO assignment is displayed in the *PDO Assignment* list below.

PDO Assignment

PDO assignment of the selected Sync Manager. All PDOs defined for this Sync Manager type are listed here:

- If the output Sync Manager (outputs) is selected in the Sync Manager list, all RxPDOs are displayed.
- If the input Sync Manager (inputs) is selected in the Sync Manager list, all TxPDOs are displayed.

The selected entries are the PDOs involved in the process data transfer. In the tree diagram of the System Manager these PDOs are displayed as variables of the IO-Link master. The name of the variable is identical to the *Name* parameter of the PDO, as displayed in the PDO list. If an entry in the PDO assignment list is deactivated (not selected and greyed out), this indicates that the input is excluded from the PDO assignment. In order to be able to select a greyed out PDO, the currently selected PDO has to be deselected first.

Activation of PDO assignment

- the IO-Link master has to run through the PS status transition cycle (from pre-operational to safe-operational) once (see Online tab [▶ 24]),
- and the System Manager has to reload the IO-Link master (button)

PDO list

List of all PDOs supported by this IO-Link master. The content of the selected PDOs is displayed in the *PDO Content* list. The PDO configuration can be modified by double-clicking on an entry.

Column	Description	
Index	PDO index.	
Size	Size of the PDO in bytes.	
Name	Name of the PDO. If this PDO is assigned to a Sync Manager, it appears as a variable of the slave with this parameter as the name.	
Flags	F	Fixed content: The content of this PDO is fixed and cannot be changed by the System Manager.
	M	Mandatory PDO. This PDO is mandatory and must therefore be assigned to a Sync Manager! Consequently, this PDO cannot be deleted from the *PDO Assignment* list
SM	Sync Manager to which this PDO is assigned. If this entry is empty, this PDO does not take part in the process data traffic.	
SU	Sync unit to which this PDO is assigned.	

PDO Content

Indicates the content of the PDO. If flag F (fixed content) of the PDO is not set the content can be modified.

Download

If the device is intelligent and has a mailbox, the configuration of the PDO and the PDO assignments can be downloaded to the device. This is an optional feature that is not supported by all IO-Link masters.

PDO Assignment

If this check box is selected, the PDO assignment that is configured in the PDO Assignment list is downloaded to the device on startup. The required commands to be sent to the device can be viewed in the Startup [▶ 20] tab.

PDO Configuration

If this check box is selected, the configuration of the respective PDOs (as shown in the PDO list and the PDO Content display) is downloaded to the IO-Link master.

Startup tab

The *Startup* tab is displayed if the IO-Link master has a mailbox and supports the *CANopen over EtherCAT* (CoE) or *Servo drive over EtherCAT* protocol. This tab indicates which download requests are sent to the mailbox during startup. It is also possible to add new mailbox requests to the list display. The download requests are sent to the master in the same order as they are shown in the list.

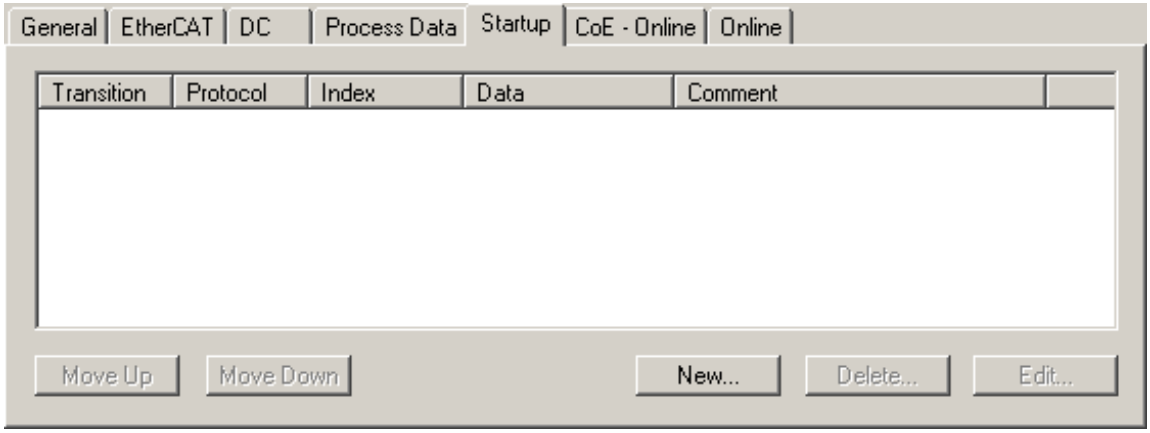


Fig. 13: Startup tab

Column	Description
Transition	Transition to which the request is sent. This can either be • the transition from pre-operational to safe-operational (PS), or • the transition from safe-operational to operational (SO). If the transition is enclosed in "<>" (e.g. <PS>), the mailbox request is fixed and cannot be modified or deleted by the user.
Protocol	Type of mailbox protocol
Index	Index of the object
Data	Date on which this object is to be downloaded.
Comment	Description of the request to be sent to the mailbox

Move Up	This button moves the selected request up by one position in the list.
Move Down	This button moves the selected request down by one position in the list.
New	This button adds a new mailbox download request to be sent during startup.
Delete	This button deletes the selected entry.
Edit	This button edits an existing request.

CoE - Online tab

The additional *CoE - Online* tab is displayed if the IO-Link master supports the *CANopen over EtherCAT* (CoE) protocol. This dialog lists the content of the object list of the slave (SDO upload) and enables the user to modify the content of an object from this list. Details for the objects of the individual IO-Link devices can be found in the device-specific object descriptions.

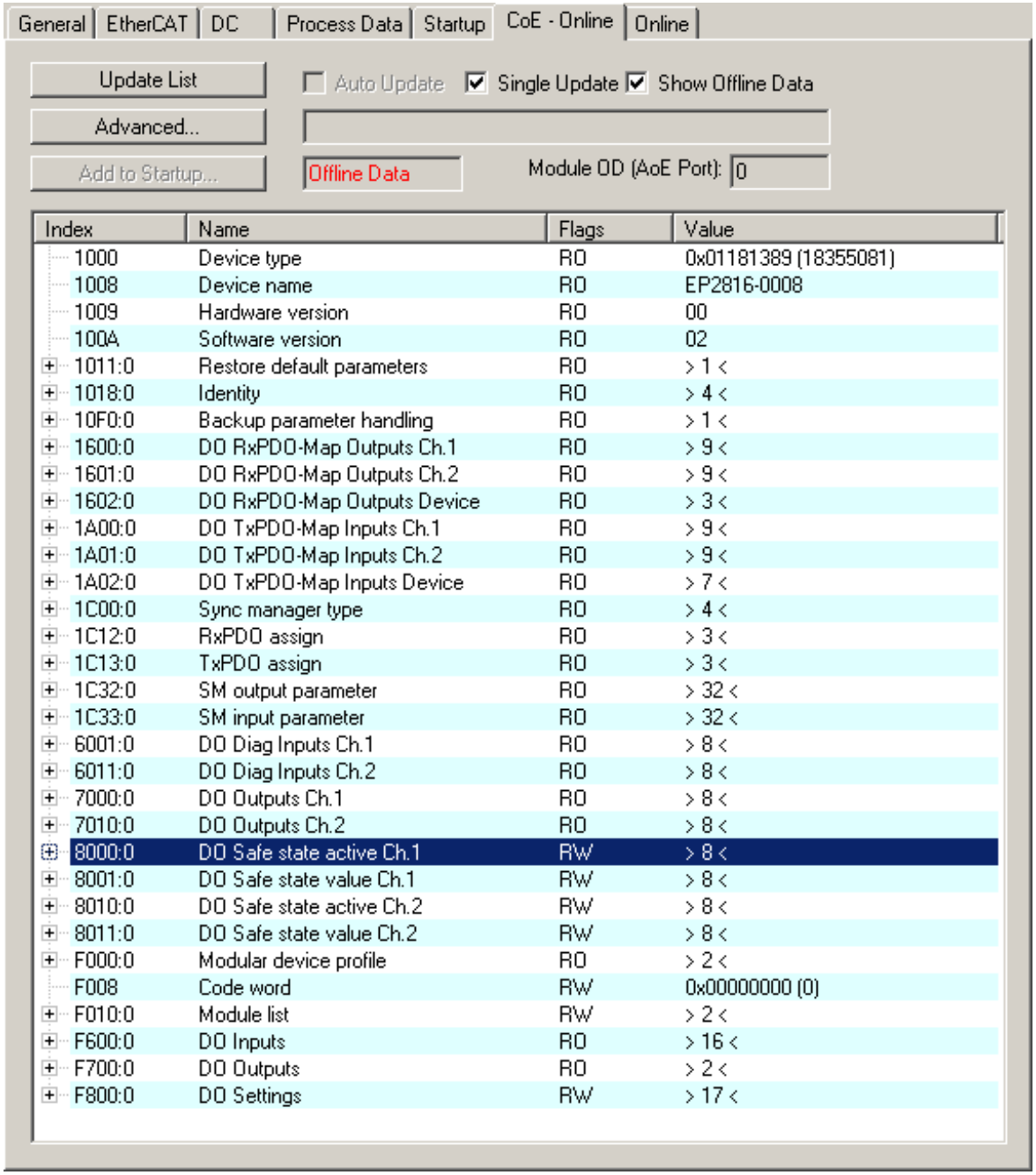


Fig. 14: CoE - Online tab

Object list display

Column	Description	
Index	Index and sub-index of the object	
Name	Name of the object	
Flags	RW	The object can be read, and data can be written to the object (read/write)
	RO	The object can be read, but no data can be written to the object (read only)
	P	An additional P identifies the object as a process data object.
Value	Value of the object	

Update List The *Update list* button updates all objects in the displayed list

Auto Update If this check box is selected, the content of the objects is updated automatically.

Advanced The *Advanced* button opens the *Advanced Settings* dialog. Here you can specify which objects are displayed in the list.

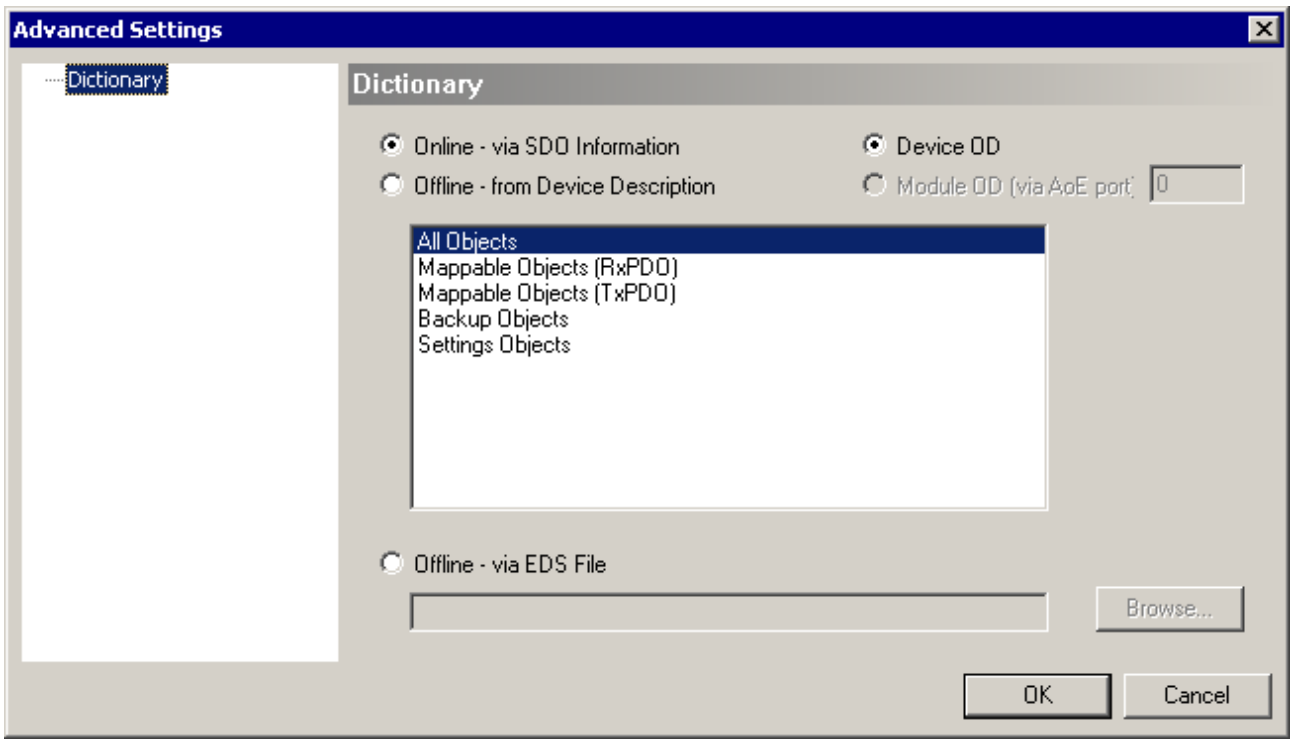


Fig. 15: Advanced Settings

Online - via SDO Information	If this option button is selected, the list of the objects included in the object list of the device is uploaded from the master via SDO information. The list below can be used to specify which object types are to be uploaded.
Offline - via EDS File	If this option button is selected, the list of the objects included in the object list is read from an EDS file provided by the user.

Diag History tab

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.

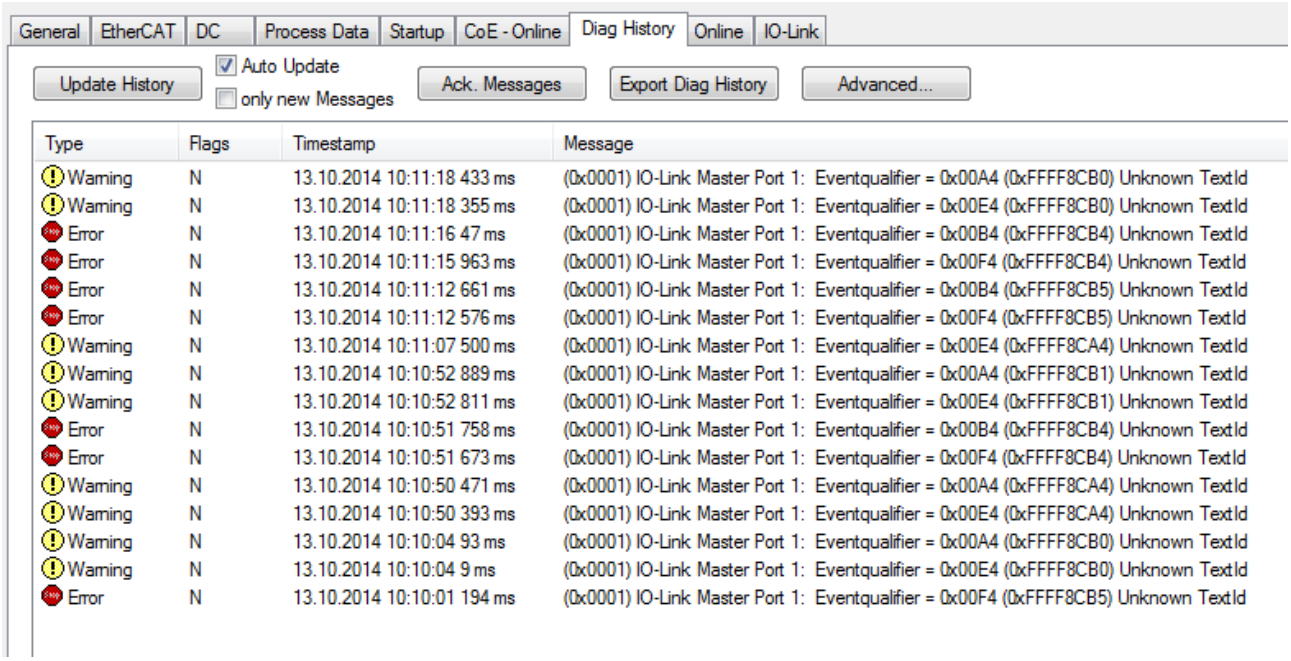


Fig. 16: DiagHistory tab

Any events that occur are categorized according to type (information, warning, error), flag (N = unconfirmed, Q = confirmed), time stamp and message (port number & event code).
The meaning of the individual messages can be taken from the vendor documentation. The IO-Link device can be directly allocated on the basis of the port number. The events occurring can be managed using the various buttons.

- **Update History:** if the "Auto Update" field is not selected, then the current events can be displayed via the "Update History" button
- **Auto Update:** if this field is selected, then the list of events occurring is automatically updated
- **Only new Messages:** if this field is selected, then only those messages that have not yet been confirmed are displayed
- **Ack. Messages:** an event is reported via the Device Diag bit (Index 0xF101:10). Confirming the message will reset the bit to 0.
- **Export Diag History:** the events that have occurred can be exported as a "txt" file and thus archived.
- **Advanced:** This field has no function for the IO-Link master terminals/boxes.

Online tab

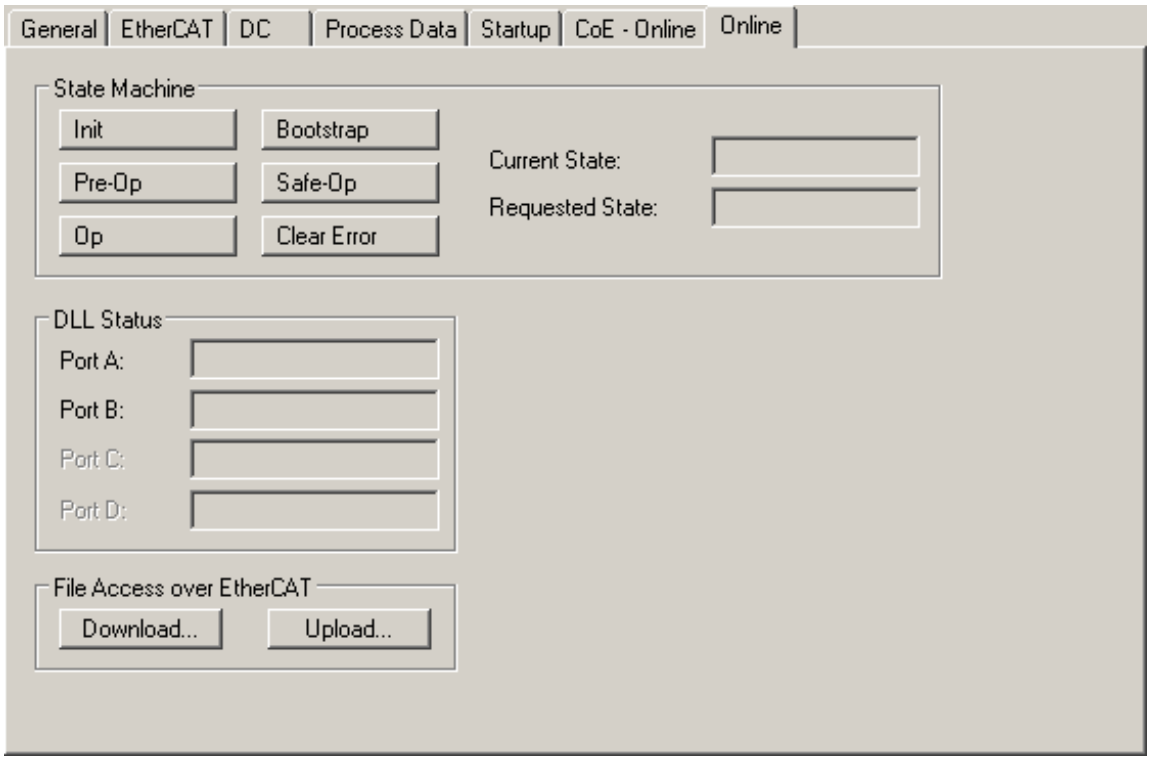


Fig. 17: Online tab

Table 1: State Machine

Init	This button attempts to set the IO-Link master to the *Init* state.
Pre-Op	This button attempts to set the IO-Link master to the *pre-operational* state.
Op	This button attempts to set the IO-Link master to the *operational* state.
Bootstrap	This button attempts to set the IO-Link master to the *Bootstrap* state.
Safe-Op	This button attempts to set the IO-Link master to the *safe-operational* state.
Clear Error	This button attempts to delete the fault display. If an IO-Link master fails during change of state it sets an error flag. Example: An IO-Link master is in PREOP state (pre-operational). The master now requests the SAFEOP state (safe-operational). If the master fails during change of state it sets the error flag. The current state is now displayed as ERR PREOP. When the *Clear Error* button is pressed the error flag is cleared, and the current state is displayed as PREOP again.
Current State	Indicates the current state of the IO-Link master.
Requested State	Indicates the state requested for the IO-Link master.

4.2 Restoring the delivery state of an EtherCAT device

To restore the delivery state for backup objects of the EP6224-xxxx (IO-Link Master), the CoE object “Restore default parameters”, “Subindex 001” can be selected in the TwinCAT System Manager (Config mode) (see following figure).

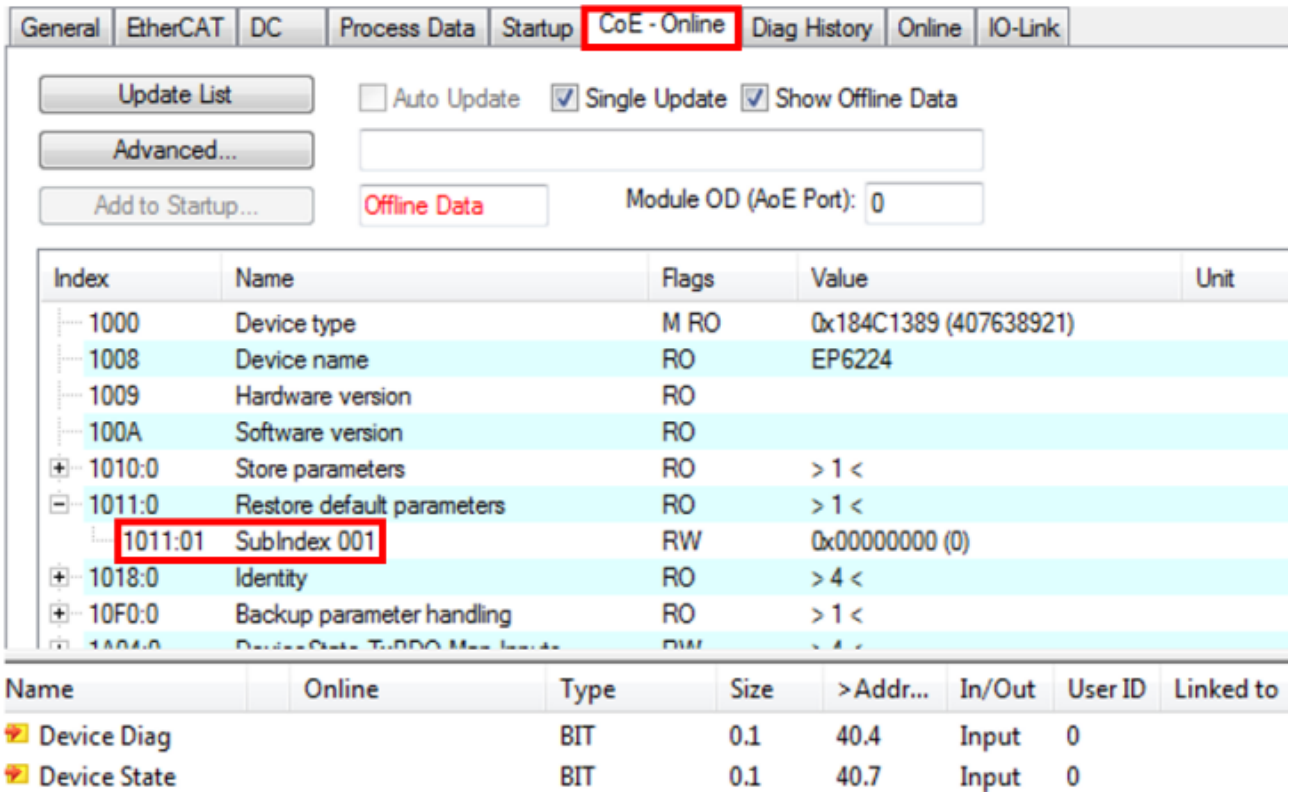


Fig. 18: Selecting the Restore default parameters PDO

Double-click on “SubIndex 001” to enter the “Set Value dialog” (see following figure). Enter the value **1684107116** in field “Dec” or the value **0x64616F6C** in field “Hex” and confirm with OK.

All backup objects are reset to the delivery state.

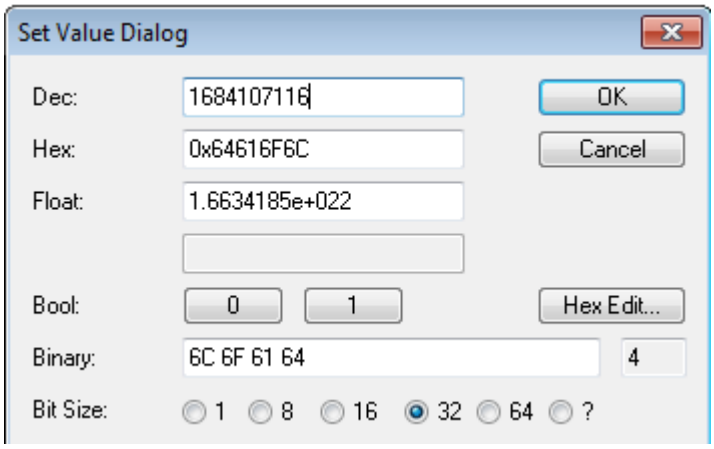


Fig. 19: Entering a restore value in the Set Value Dialog

4.3 EtherCAT State Machine

The state of the EtherCAT slave is controlled via the EtherCAT State Machine (ESM). Depending upon the state, different functions are accessible or executable in the EtherCAT slave. Specific commands must be sent by the EtherCAT master to the device in each state, particularly during the bootup of the slave.

A distinction is made between the following states:

- Init
- Pre-Operational
- Safe-Operational and
- Operational
- Boot

The regular state of each EtherCAT slave after bootup is the OP state.

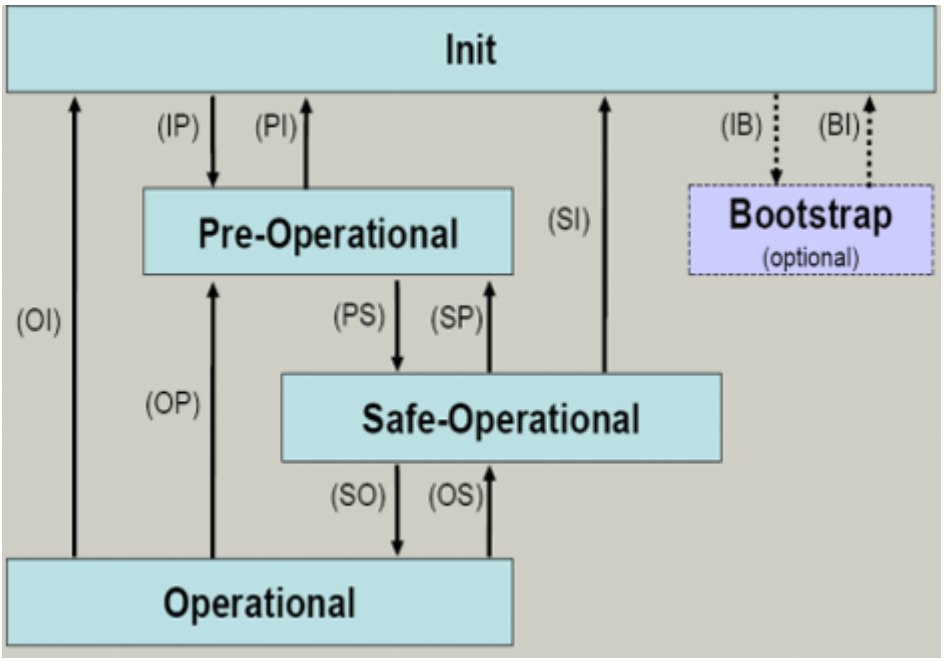


Fig. 20: EtherCAT State Machine

Init

After switch-on the EtherCAT slave in the *Init* state. No mailbox or process data communication is possible. The EtherCAT master initializes sync manager channels 0 and 1 for mailbox communication.

Pre-Operational (Pre-Op)

During the transition between *Init* and *Pre-Op* the EtherCAT slave checks whether the mailbox was initialized correctly.

In *Pre-Op* state mailbox communication is possible, but not process data communication. The EtherCAT master initializes the sync manager channels for process data (from sync manager channel 2), the FMMU channels and, if the slave supports configurable mapping, PDO mapping or the sync manager PDO assignment. In this state the settings for the process data transfer and perhaps terminal-specific parameters that may differ from the default settings are also transferred.

Safe-Operational (Safe-Op)

During transition between *Pre-Op* and *Safe-Op* the EtherCAT slave checks whether the sync manager channels for process data communication and, if required, the distributed clocks settings are correct. Before it acknowledges the change of state, the EtherCAT slave copies current input data into the associated DP-RAM areas of the EtherCAT slave controller (ECSC).

Mailbox and process data communication is possible in the *Safe-Op* state, but the slave keeps its outputs in the safe state. However, the input data are cyclically updated.

Operational (Op)

Before the EtherCAT master switches the EtherCAT slave from *Safe-Op* to *Op* it must transfer valid output data.

In the *Op* state the slave copies the output data of the masters to its outputs. Process data and mailbox communication is possible.

Boot

In the *Boot* state the slave firmware can be updated. The *Boot* state can only be reached via the *Init* state.

In the *Boot* state mailbox communication via the *file access over EtherCAT* (FoE) protocol is possible, but no other mailbox communication and no process data communication.

5 IO-Link basics

IO-Link represents a communication system for the connection of intelligent sensors and actuators to an automation system in the IEC 61131-9 standard under the designation "Single-drop digital communication interface for small sensors and actuators" (SDCI).
Both the electrical connection data and the communication protocol are standardized and summarized in the IO-Link specification.

IO-Link specification

The development of the EP6224-xxxx was subject to the IO-Link specification 1.1. At the time of the preparation of this documentation, the IO-Link specification is entering the IEC standardization and will be adopted in extended form as IEC 61131-9. The new designation SDCI will be introduced at the same time. As a member of the respective committee, Beckhoff supports the development of IO-Link and reflects changes to the specification in its products.

An IO-Link system consists of an IO-Link master, one or more IO-Link devices and sensors or actuators. The IO-Link master provides the interface to the higher-level controller and controls communication with the connected IO-Link devices. The Beckhoff EP6224-xxxx IO-Link Master module has four IO-Link ports. One IO-Link device can be connected to each of them. IO-Link is not a fieldbus, but rather a peer-to-peer connection (see following figure).

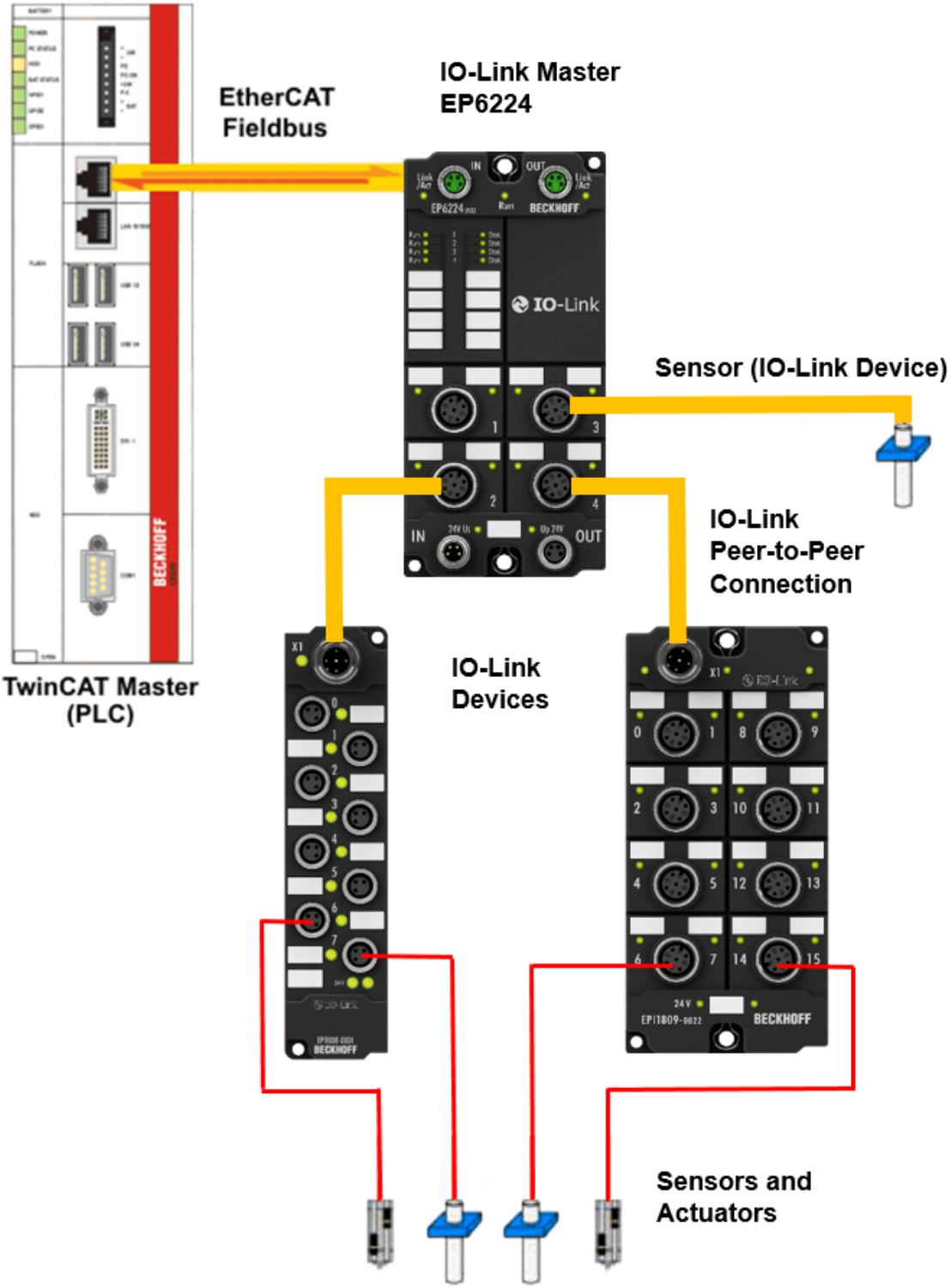


Fig. 21: IO-Link overview: Peer-to-Peer communication

The connected IO-Link devices possess individual parameter information, which is recognized during automatic scanning with TwinCAT and adopted into the System Manager. Offline can be read module specific information in form of an IO-Link Device Description (IODD) and adapted in TwinCAT.

Parameter data exchange

An intelligent IO-Link sensor/actuator can support parameterization by ISDUs (Indexed Service Data Unit). The PLC must explicitly query or, when marked as such, send these acyclic service data.

ISDU access

TwinCAT supports access via ADS and via the CoE directory.

The respective parameter is addressed via the so-called ISDU index. The following ranges are available:

Designation	Index range
System	0x00..0x0F
Identification	0x10..0x1F
Diagnostic	0x20..0x2F
Communication	0x30..0x3F
Preferred Index	0x40..0xFE
Extended Index	0x0100..0x3FFF
	The range 0x4000 to 0xFFFF is reserved

The use and implementation of these ranges is the responsibility of the sensor/actuator manufacturer. For clarification, just a few of the possible indices are listed here. Please take a look at the relevant chapter “Object description and parameterization”.

Index	Name
0010	Vendor Name
0011	Vendor Text
0012	Product Name
0013	Product ID
0015	Serial Number
0016	Hardware Revision
0017	Firmware Revision
...	...

IO-Link operating modes

The IO-Link ports on the IO-Link master can be operated in the following nine modes:

- INACTIVE: Statemachine is inaktive
- DIGINPUT: The port behaves like a digital input
- DIGOUTPUT: The port behaves like a digital output
- ESTABLISHCOMM: The IO-Link wakeup sequence is running
- INITMASTER: Readout the IO-Link device and check the communication parameters
- INITDEVICE: Initialization of the IO-Link device
- PREOPERATE: Parameter server is running
- OPERATE: The port is used for IO-Link communication
- STOP: Communication is stopped (COM-stop)

Also see about this

Object description and parameterization [▶ 66]

6 Mounting and Access

6.1 Mounting

6.1.1 Dimensions

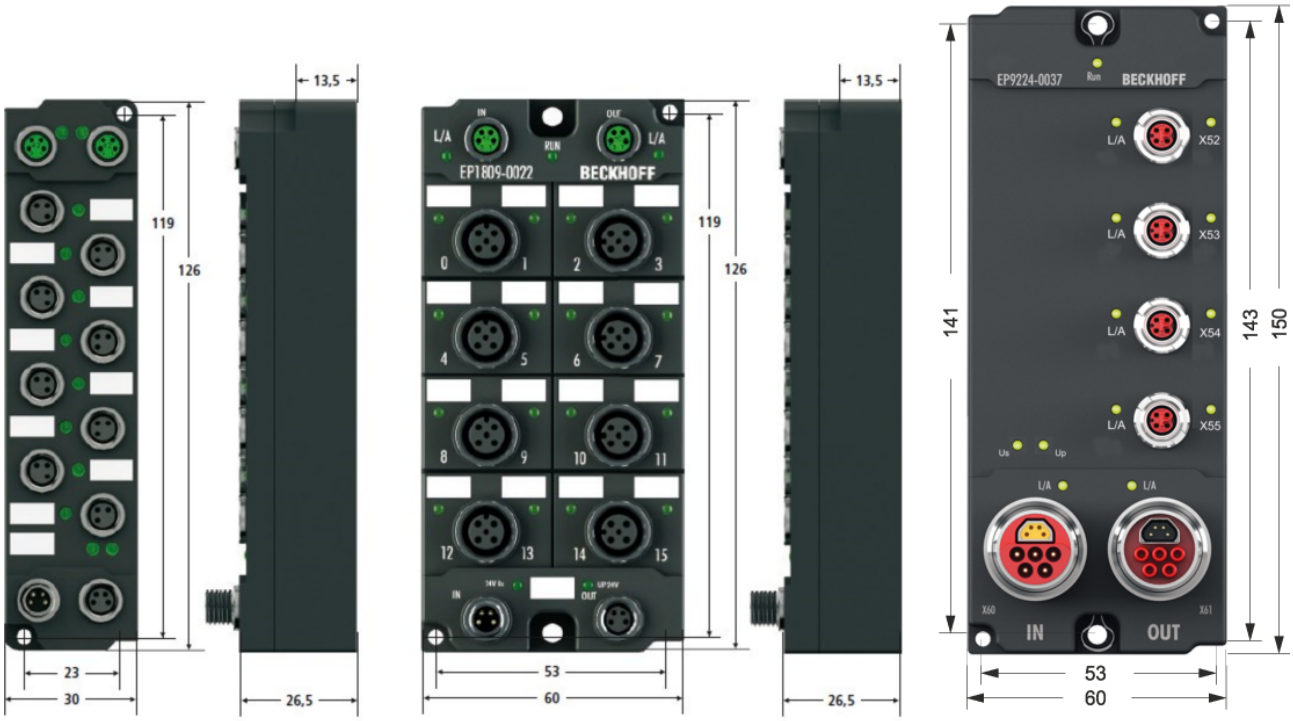


Fig. 22: Dimensions of the EtherCAT Box Modules

All dimensions are given in millimeters.

Housing properties

EtherCAT Box	lean body	wide bodies
Housing material	PA6 (polyamide)	
Casting compound	Polyurethane	
Mounting	two fastening holes Ø 3 mm for M3	two fastening holes Ø 3 mm for M3 two fastening holes Ø 4.5 mm for M4
Metal parts	Brass, nickel-plated	
Contacts	CuZn, gold-plated	
Power feed through	max. 4 A (M8) max. 16 A (7/8“) max. 15.5 A (B17 5G 1.5 mm^2)	
Installation position	variable	
Protection class	IP65, IP66, IP67 (conforms to EN 60529) when screwed together	
Dimensions (H x W x D)	app. 126 x 30 x 26.5 mm	app. 126 x 60 x 26,5 mm app. 150 x 60 x 26.5 mm (without 7/8", B17)

6.1.2 Fixing

Protection of connectors against contamination!

While mounting the modules, protect all connectors, especially the IP-Link, against contamination! Only with connected cables or plugs the protection class IP67 is guaranteed! Unused connectors have to be protected with the right plugs! See for plug sets in the catalogue.

Modules with narrow housing are mounted with two M3 bolts.
Modules with wide housing are mounted with two M3 bolts to the fixing holes located at the corners or mounted with two M4 bolts to the fixing holes located centrally.

The bolts must be longer than 15 mm. The fixing holes of the modules are not threaded.

When assembling, remember that the fieldbus connectors increases the overall height. See chapter accessories.

Mounting Rail ZS5300-0001

The mounting rail ZS5300-0001 (500 mm x 129 mm) allows the time saving assembly of modules.

The rail is made of stainless steel, 1.5 mm thick, with already pre-made M3 threads for the modules. The rail has got 5.3 mm slots to mount it via M5 screws to the machine.

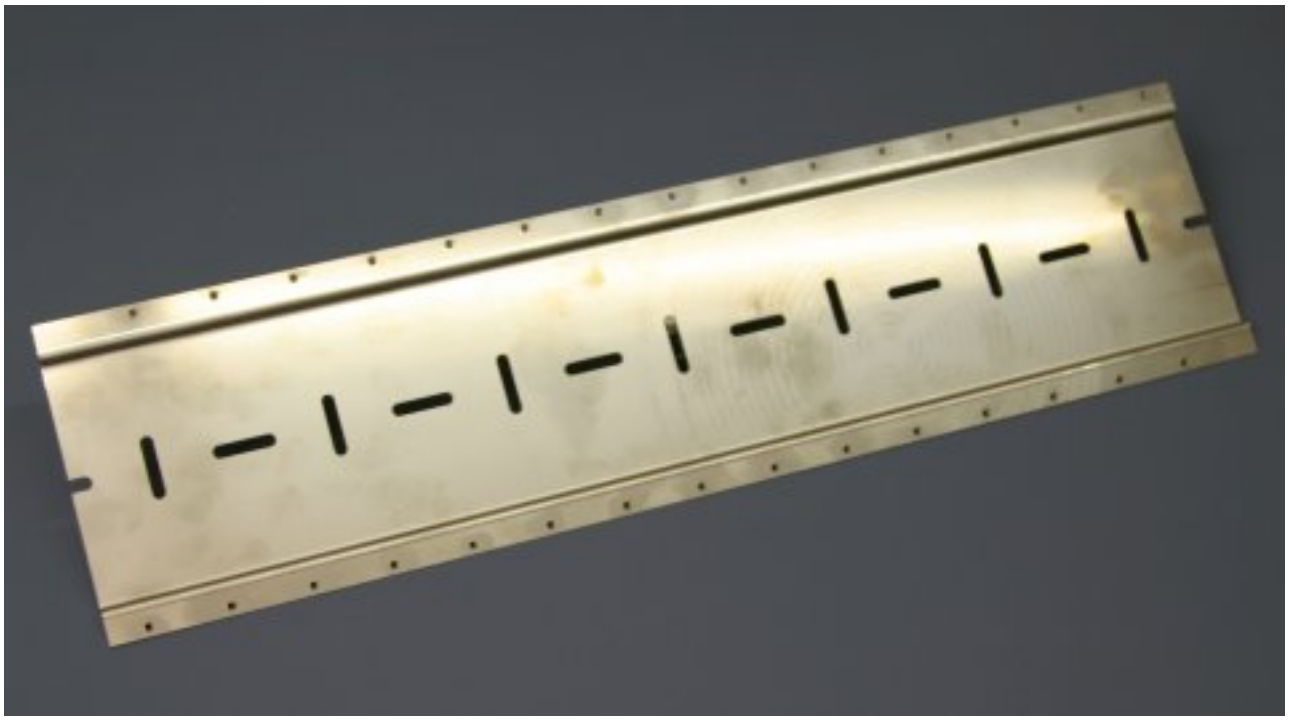


Fig. 23: Mounting Rail ZS5300-000

The mounting rail is 500 mm long, that way 15 narrow modules can be mounted with a distance of 2 mm between two modules. The rail can be cut to length for the application.

Mounting Rail ZS5300-0011

The mounting rail ZS5300-0011 (500 mm x 129 mm) has in addition to the M3 treads also pre-made M4 treads to fix 60 mm wide modules via their middle holes.

Up to 14 narrow or 7 wide modules may be mixed mounted.

6.1.3 Nut torque for connectors

M8 connectors

It is recommended to pull the M8 connectors tight with a nut torque of **0.4 Nm**. When using the torque control screwdriver ZB8800 is also a max. torque of **0.5 Nm** permissible.

Fig. 24: EtherCAT Box with M8 connectors

M12 connectors

It is recommended to pull the M12 connectors tight with a nut torque of **0.6 Nm**.

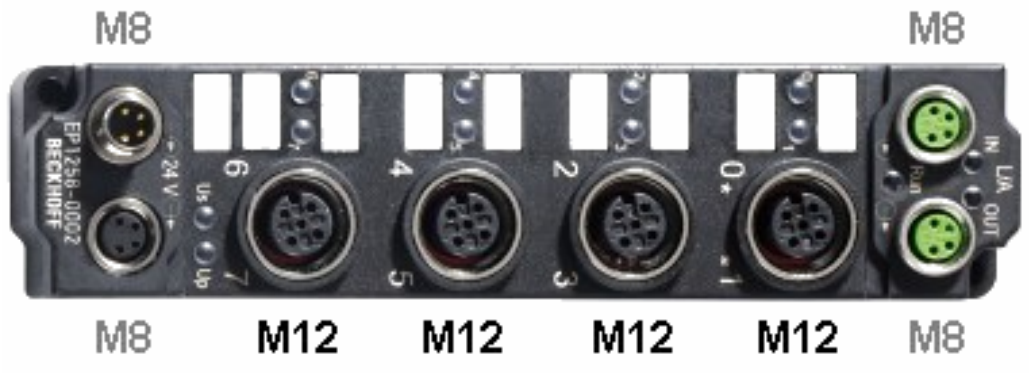


Fig. 25: EtherCAT Box with M8 and M12 connectors

7/8" plug connectors

We recommend fastening the 7/8" plug connectors with a torque of **1.5 Nm**.

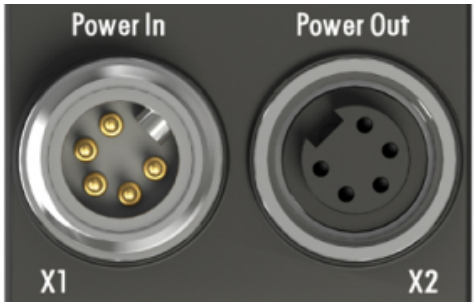


Fig. 26: 7/8" plug connectors

Torque socket wrenches

Fig. 27: ZB8801 torque socket wrench

Ensure the right torque

Use the torque socket wrenches available by Beckhoff to pull the connectors tight (ZB8800, ZB8801-0000)!

6.1.4 Additional checks

The boxes have undergone the following additional tests:

Verification	Explanation
Vibration	10 frequency runs in 3 axes
	5 Hz < f < 60 Hz displacement 0.35 mm, constant amplitude
	60.1 Hz < f < 500 Hz acceleration 5 g, constant amplitude
Shocks	1000 shocks in each direction, in 3 axes
	35 g, 11 ms

6.2 EtherCAT

6.2.1 EtherCAT connection

For the incoming and ongoing EtherCAT connection,

- the EtherCAT Box (EPxxxx) has two M8 sockets, marked in **green**
- the Coupler Box (FBB-x110) has two M12 sockets

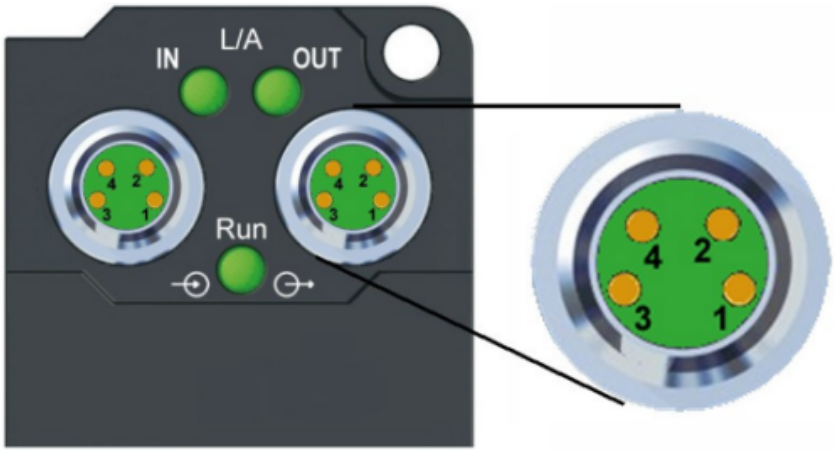


Fig. 28: EtherCAT Box: M8, 30 mm housing

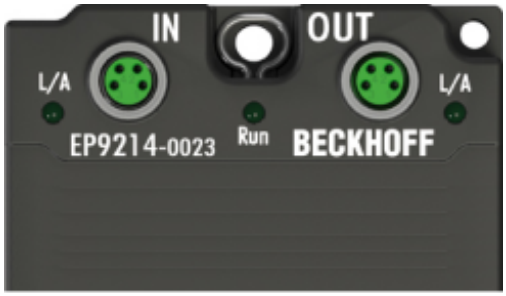


Fig. 29: EtherCAT Box: M860 mm housing (example: EP9214)

Fig. 30: Coupler Box: M12

Assignment

There are various different standards for the assignment and colors of connectors and cables for Ethernet/ EtherCAT.

Ethernet/EtherCAT		Plug connector			Cable		Standard
Signal	**Description**	**M8**	**M12**	**RJ45[1]**	**ZB9010, ZB9020, ZB9030, ZB9032, ZK1090-6292, ZK1090-3xxx-xxxx**	**ZB9031 and old versions of ZB9030, ZB9032, ZK1090-3xxx-xxxx**	**TIA-568B**
Tx +	Transmit Data+	Pin 1	Pin 1	Pin 1	yellow[2]	orange/white[3]	white/orange
Tx -	Transmit Data-	Pin 4	Pin 3	Pin 2	orange[2]	orange[3]	orange
Rx +	Receive Data+	Pin 2	Pin 2	Pin 3	white[2]	blue/white[3]	white/green
Rx -	Receive Data-	Pin 3	Pin 4	Pin 6	blue[2]	blue[3]	green
Shield	Shield	Housing		Shroud	Screen	Screen	Screen

[1]) colored markings according to EN 61918 in the four-pin RJ45 connector ZS1090-0003
[2]) wire colors according to EN 61918
[3]) wire colors

Assimilation of color coding for cable ZB9030, ZB9032 and ZK1090-3xxxx-xxxx (with M8 connectors)

For unification the prevalent cables ZB9030, ZB9032 and ZK1090-3xxx-xxxx this means the pre assembled cables with M8 connectors were changed to the colors of EN61918 (yellow, orange, white, blue).So different color coding exists. But the electrical properties are absolutely identical.

EtherCAT connector

The following connectors can be supplied for use in Beckhoff EtherCAT systems.

Name	Connector	Comment
ZS1090-0003	RJ45	four-pole, IP20, field-configurable
ZS1090-0004	M12, male	four-pin, IP67, for field assembly
ZS1090-0005	RJ45	eight-pole, IP20, field-configurable, suitable for gigabit Ethernet
ZS1090-0006	M8 plug connector	four-pole, IP67, field-configurable, for cable type ZB903x
ZS1090-0007	M8 socket	four-pole, IP67, field-configurable, for cable type ZB903x
ZS1090-1006	M8 plug connector	four-pole, IP67, field-configurable up to OD = 6.5 mm
ZS1090-1007	M8 socket	four-pole, IP67, field-configurable up to OD = 6.5 mm

6.2.2 EtherCAT - Fieldbus LEDs

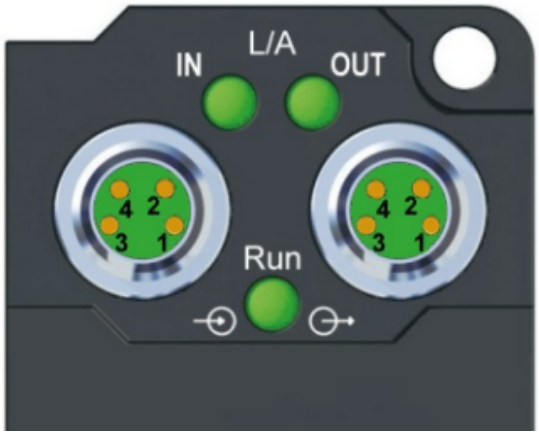


Fig. 31: EtherCAT-LEDs

LED display

LED	Display	Meaning
IN L/A	off	no connection to the preceding EtherCAT module
	Lit	LINK: connection to the preceding EtherCAT module
	flashing	ACT: Communication with the preceding EtherCAT module
OUT L/A	off	no connection to the following EtherCAT module
	Lit	LINK: connection to the following EtherCAT module
	flashing	ACT: Communication with the following EtherCAT module
Run	off	Status of the EtherCAT module is Init
	flashes quickly	Status of the EtherCAT module is pre-operational
	flashes slowly	Status of the EtherCAT module is safe-operational
	Lit	Status of the EtherCAT module is operational

EtherCAT statuses

The various statuses in which an EtherCAT module may be found are described in the Basic System Documentation for EtherCAT, which is available for download from our website (www.beckhoff.com) under Downloads.

6.3 IO-Link

6.3.1 IO-Link master connection

IO-Link interface

The IO-Link specification defines various IO-Link pin assignment, which are described in the following section.

The switching and communication line is marked with (C/Q).

Port Class A (type A): The function of pin 2 and pin 5 is not preset. The vendor can assign an additional digital channel to pin 2. Port Class B (type B): Pin 2 and Pin 5 are used for an additional power supply. The information regarding the pin assignment of your module can be found in the chapter "Introduction".

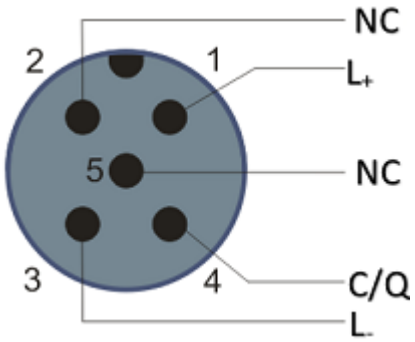


Fig. 32: Pin assignment Port Class A, Pin 2 not connected

In the case of Class A modules an additional digital input or output (I/Q) can be connected to Pin 2.

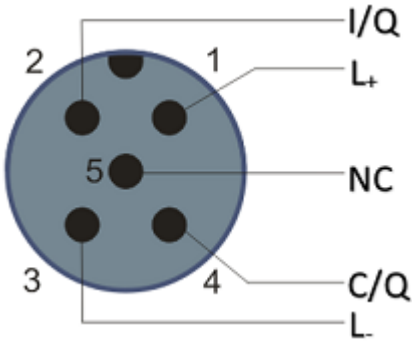


Fig. 33: Pin assignment Port Class A, Pin 2 connected

Port Class B (type B): For devices with higher current demand, an additional power supply is provided via pin 2 and pin 5.

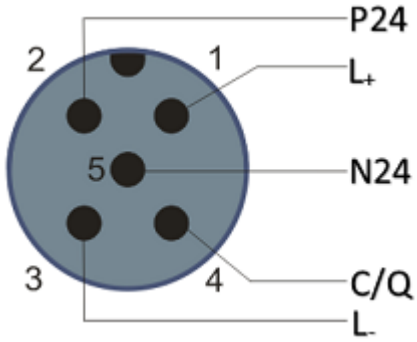


Fig. 34: Pin assignment Port Class B

The IO-Link master (EP622x-xxxx) has an A-coded M12 socket for the outgoing IO-Link connection.

Fig. 35: IO-Link connection, master

Wire colors

The wire colors of the IO-Link cable with corresponding pin assignment of the IO-Link connector:

Pin	Wire color
1	brown
2	white
3	blue
4	black
5	grey

IO-Link cable

Fig. 36: Example IO-Link cable: male to female

The cables available from Beckhoff for the IO-Link system can be found under the following link under "Accessories": https://beckhoff.de/english/fieldbus_components_accessories/m12_sensor_5w.htm?id=51657421126830456

IO-Link cable

A 3-core IO-Link cable may be sufficient for Class A masters/devices from Beckhoff. A Class B master/device requires a 5-wire IO-Link cable.

6.4 Power supply

6.4.1 Power Connection

The feeding and forwarding of supply voltages is done via two M8 connectors at the bottom end of the modules:

- IN: left M8 connector for feeding the supply voltages

- OUT: right M8 connector for forwarding the supply voltages

Fig. 37: EtherCAT Box, Connectors for power supply

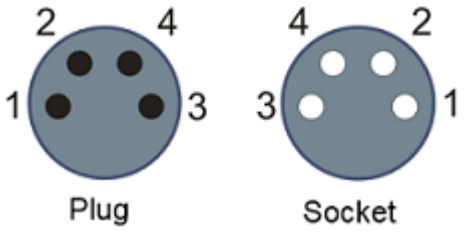


Fig. 38: Pin assignment M8, Power In and Power Out

PIN assignment

Pin	Voltage	
1	Control voltage Us, +24 V_{DC}	
2	Auxiliary voltage Up, +24 V_{DC}	
3	GNDs*	*) may be connected internally to each other depending on the module: see specific module descriptions
4	GNDp*	

The pins M8 connectors carry a maximum current of 4 A.

Two LEDs display the status of the supply voltages.

NOTE

Don't confuse the power connectors with the EtherCAT connectors!

Never connect the power cables (M8, 24 V_{DC}) with the green marked EtherCAT sockets of the EtherCAT Box Modules! This can damage the modules!

Control voltage Us: 24 V_{DC}

Power is supplied to the fieldbus, the processor logic, the inputs and the sensors from the 24 V_{DC} control voltage Us. The control voltage is electrically isolated from the fieldbus circuitry.

Auxiliary voltage Up 24 V_{DC}

The Auxiliary voltage Up supplies the digital outputs; it can be brought in separately. If the load voltage is switched off, the fieldbus functions and the power supply and functionality of the inputs are retained.

Redirection of the supply voltages

The IN and OUT power connections are bridged in the module (not IP204x-Bxxx and IE204x). The supply voltages Us and Up can thus easily be transferred from EtherCAT Box to EtherCAT Box.

NOTE

Pay attention to the maximum permissible current!

Pay attention also for the redirection of the supply voltages Us and Up, the maximum permissible current for M8 connectors of 4 A must not be exceeded!

Supply via EP92x4-0023 PowerBox modules

If the machine requires higher current or if the EtherCAT Box Modules are installed far away from the control cabinet with included power supply, the usage of four cannel power distribution modules EP9214 or EP9224 (with integrated data logging, see www.beckhoff.com/EP9224) is recommended.

With these modules intelligent power distribution concepts with up to 2 x 16 A and a maximum of 2.5 mm² cable cross-section can be realized.

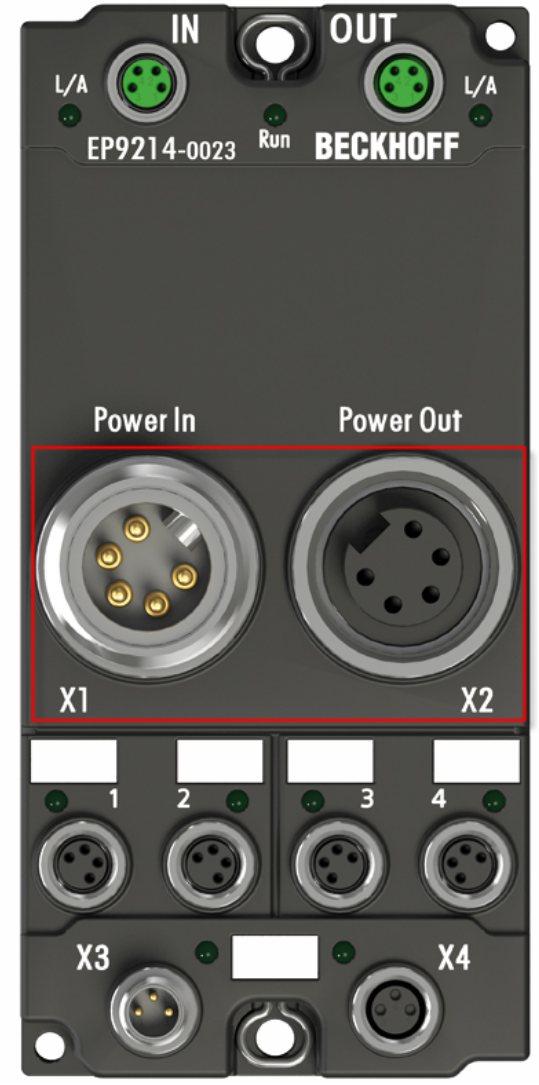


Fig. 39: EP92x4-0023, Connectors for Power In and Power Out

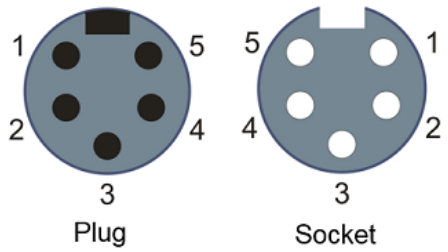


Fig. 40: Pin assignment 7/8”, Power In and Power Out

Electrical isolation

Digital modules

In the digital input/output modules, the grounds of the control voltage (GNDs) and the auxiliary voltage (GNDp) are connected to each other!

Check this at the documentation of each used EtherCAT Box.

Analog modules

In the analog input/output modules the grounds of the control voltage (GNDs) and the auxiliary voltage (GNDp) are separated from each other in order to ensure electrical isolation of the analog signals from the control voltage.

In some of the analog modules the sensors or actuators are supplied by Up - this means, for instance, that in the case of 0...10 V inputs, any reference voltage (0...30 V) may be connected to Up; this is then available to the sensors (e.g. smoothed 10 V for measuring potentiometers).

Details of the power supply may be taken from the specific module descriptions.

NOTE

Electrical isolation may be cancelled!

If digital and analog fieldbus boxes are connected directly via four-core power leads, the analog signals in the fieldbus boxes may be no longer electrically isolated from the control voltage!

6.4.2 Status LEDs for power supply

Fig. 41: Status LEDs for power supply

LED display

LED	Display	Meaning
Us (Control voltage)	off	The power supply voltage Us is not present
	green illuminated	The power supply voltage Us is present
	red illuminated	Because of overload (current > 0.5 A) the sensor supply generated from power supply voltage Us was switched off for all sensors fed from this.
Up (Auxiliary voltage)	off	The power supply voltage Up is not present
	green illuminated	The power supply voltage Up is present

6.4.3 Power cable conductor losses M8

The ZK2020-xxxx-yyyy power cables should not exceed the total length of 15 m at 4 A (with continuation). When planning the cabling, note that at 24 V nominal voltage, the functionality of the module can no longer be assured if the voltage drop reaches 6 V. Variations in the output voltage from the power supply unit must also be taken into account.

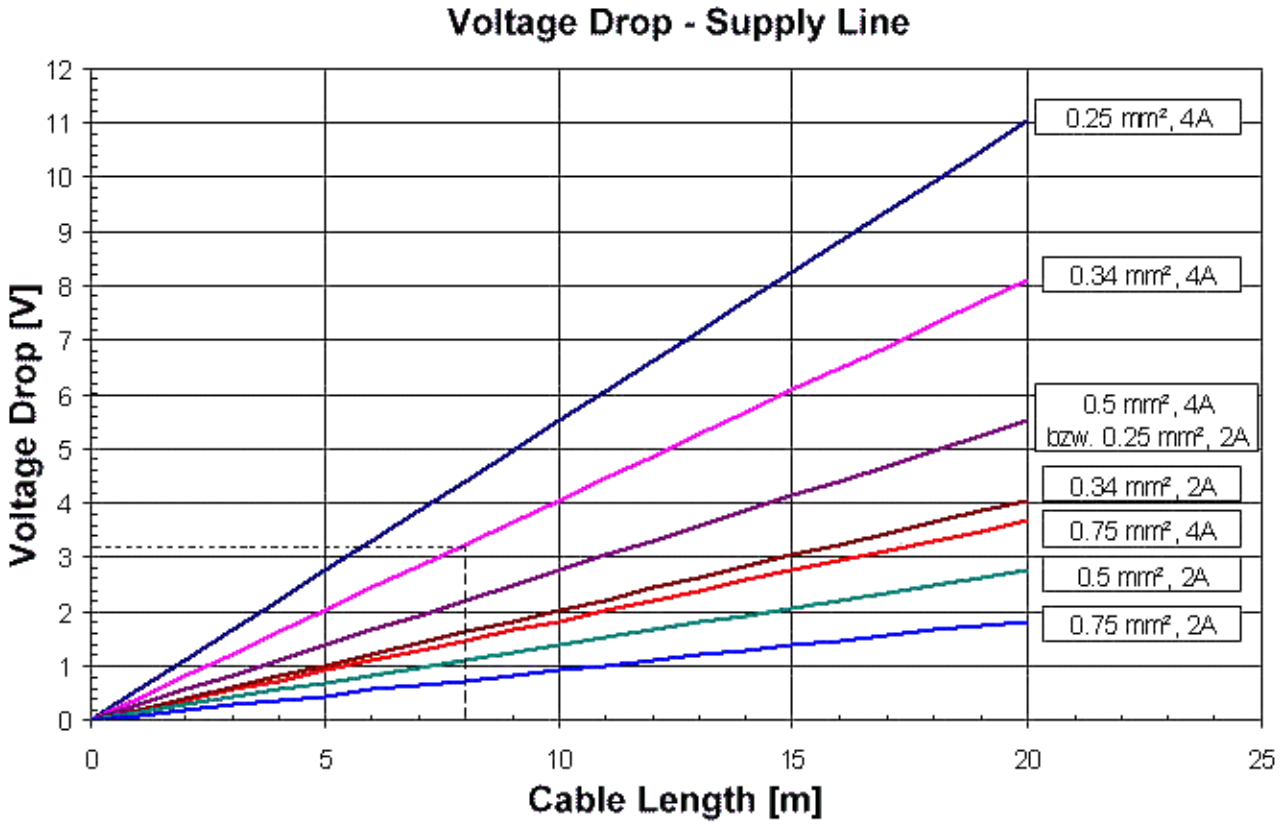


Fig. 42: Power cable conductor losses

Example

8 m power cable with 0.34 mm² cross-section has a voltage drop of 3.2 V at 4 A.

EP92x4 Power Distribution Modules

With EP9214 and EP9224 Power Distribution Modules intelligent concepts for voltage supply are available. Further information may be found under www.beckhoff.com/EP9224.

6.4.4 Conductor losses 7/8"

In the case of the power cables ZK2030-xxxx-yyy, a total length of 15 m should not be exceeded at 16 A. When wiring, note that with a rated voltage of 24 V the function of the modules can no longer be guaranteed from a voltage drop of 6 V. Variations in the output voltage from the power supply unit must also be taken into account.

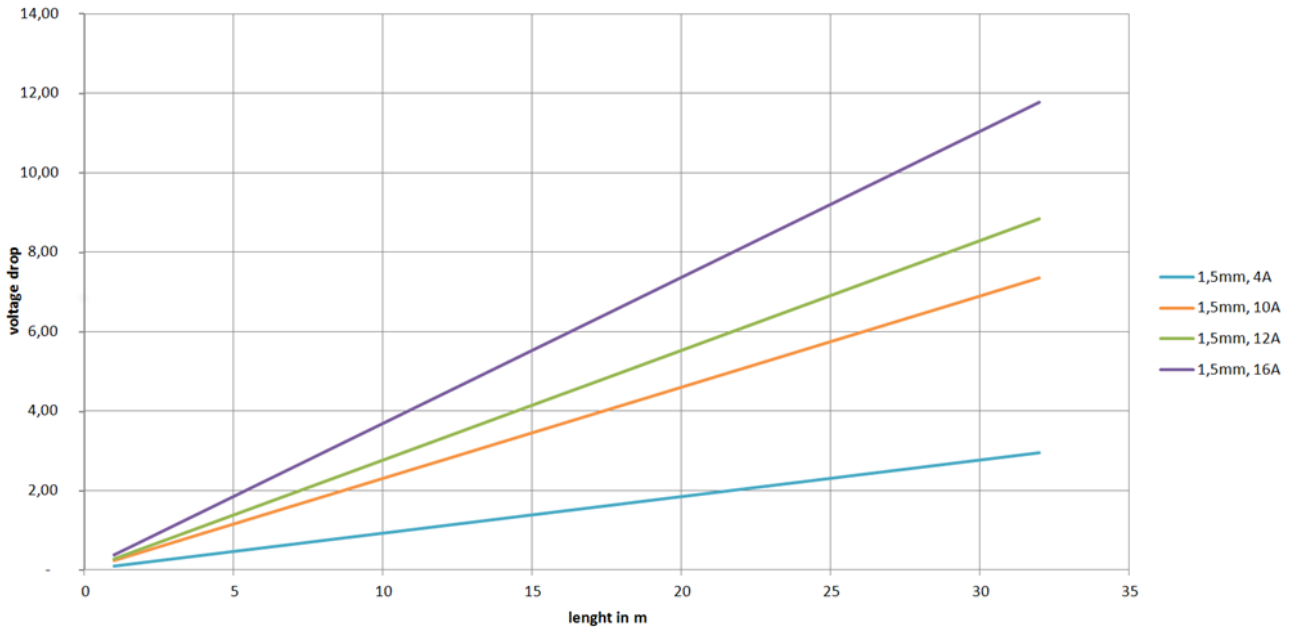


Fig. 43: ZK2030-xxxx-yyy - Conductor losses

Alternatively, larger cable cross-section can be used, e.g. 2.5 mm^2.

7 Cabling

7.1 Cabling EtherCAT

A list of the EtherCAT cable, power cable, sensor cable, Ethernet-/EtherCAT connectors and the field assembled connectors can be found at the following link: http://download.beckhoff.com/download/document/catalog/main_catalog/english/Beckhoff_EtherCAT-Box-Accessories.pdf

You can find the corresponding data sheets at the following link: http://beckhoff.de/english/fieldbus_box/data_sheets.htm?id=69033899254355

EtherCAT cable

For connecting EtherCAT devices only shielded Ethernet cables that meet the requirements of at least **category 5 (CAT5) according to EN 50173 or ISO/IEC 11801** should be used.

Recommendations about cabling

You may get detailed recommendations about cabling EtherCAT from the documentation "Recommendations for the design of the infrastructure for EtherCAT/Ethernet", that is available for download at www.Beckhoff.com.

EtherCAT uses 4 wires for signal transfer.
Due to automatic cable detection (auto-crossing) symmetric (1:1) or cross-over cables can be used between EtherCAT devices from Beckhoff.

7.2 Cabling IO-Link

A list of the EtherCAT cable, power cable, sensor cable, IO-Link cable, Ethernet-/EtherCAT connectors and the field assembled connectors can be found at the following link: http://download.beckhoff.com/download/document/catalog/main_catalog/english/Beckhoff_EtherCAT-Box-Accessories.pdf

You can find the corresponding data sheets at the following link: http://beckhoff.de/english/fieldbus_box/data_sheets.htm?id=69033899254355

IO-Link cable

The IO-Link master is connected via a unshielded, up to 20 m long, 3-wire (Type A) or 5-wire (Type B) cable with the IO-Link Device. The IO-Link Cables are in straight and angled version available. For more information on IO-Link connection, see: IO-Link master connection [▶ 39]

Fig. 44: Example IO-Link cable: male to female

Sensor cable

Fig. 45: Selection of the from Beckhoff deliverable sensor cables

8 UL Requirements

The installation of the EtherCAT Box Modules certified by UL has to meet the following requirements.

Supply voltage

⚠ CAUTION

CAUTION!

This UL requirements are valid for all supply voltages of all marked EtherCAT Box Modules!
For the compliance of the UL requirements the EtherCAT Box Modules should only be supplied

- by a 24 V_{DC} supply voltage, supplied by an isolating source and protected by means of a fuse (in accordance with UL248), rated maximum 4 Amp, or
- by a 24 V_{DC} power source, that has to satisfy *NEC class 2*.
  A *NEC class 2* power supply shall not be connected in series or parallel with another (class 2) power source!

⚠ CAUTION

CAUTION!

To meet the UL requirements, the EtherCAT Box Modules must not be connected to unlimited power sources!

Networks

⚠ CAUTION

CAUTION!

To meet the UL requirements, EtherCAT Box Modules must not be connected to telecommunication networks!

Ambient temperature range

⚠ CAUTION

CAUTION!

To meet the UL requirements, EtherCAT Box Modules has to be operated only at an ambient temperature range of 0 to 55°C!

Marking for UL

All EtherCAT Box Modules certified by UL (Underwriters Laboratories) are marked with the following label.

Fig. 46: UL label

9 ATEX notes

9.1 ATEX - Special conditions

⚠ WARNING

Observe the special conditions for the intended use of EtherCAT Box modules in potentially explosive areas – directive 94/9/EU.

- The certified components are to be installed with a BG2000-0000 or BG2000-0010 protection enclosure [▶ 51] that guarantees a protection against mechanical hazards!
- If the temperatures during rated operation are higher than 70°C at the feed-in points of cables, lines or pipes, or higher than 80°C at the wire branching points, then cables must be selected whose temperature data correspond to the actual measured temperature values!
- Observe the permissible ambient temperature range of 0 to 55°C for the use of EtherCAT Box modules in potentially explosive areas!
- Measures must be taken to protect against the rated operating voltage being exceeded by more than 40% due to short-term interference voltages!
- The connections of the certified components may only be connected or disconnected if the supply voltage has been switched off or if a non-explosive atmosphere is ensured!

Standards

The fundamental health and safety requirements are fulfilled by compliance with the following standards:

- EN 60079-0: 2006
- EN 60079-15: 2005

Marking

The EtherCAT Box modules certified for potentially explosive areas bear the following marking:

II 3 G Ex nA II T4 DEKRA 11ATEX0080 X Ta: 0 - 55°C

or

II 3 G Ex nA nC IIC T4 DEKRA 11ATEX0080 X Ta: 0 - 55°C

Batch number (D number)

The EtherCAT Box modules bear a batch number (D number) that is structured as follows:

D: WW YY FF HH

WW - week of production (calendar week)
YY - year of production
FF - firmware version
HH - hardware version

Example with batch number 29 10 02 01:

29 - week of production 29
10 - year of production 2010
02 - firmware version 02
01 - hardware version 01

9.2 BG2000 - EtherCAT Box protection enclosures

⚠ WARNING

Risk of electric shock and damage of device!

Bring the EtherCAT system into a safe, powered down state before starting installation, disassembly or wiring of the modules!

ATEX

⚠ WARNING

Mount a protection enclosure!

To fulfill the special conditions according to ATEX [▶ 50], a BG2000-0000 or BG2000-0010 protection enclosure has to be mounted over the EtherCAT Box.

Installation

Put the cables for EtherCAT, power supply and sensors/actuators through the hole of the protection enclosure.

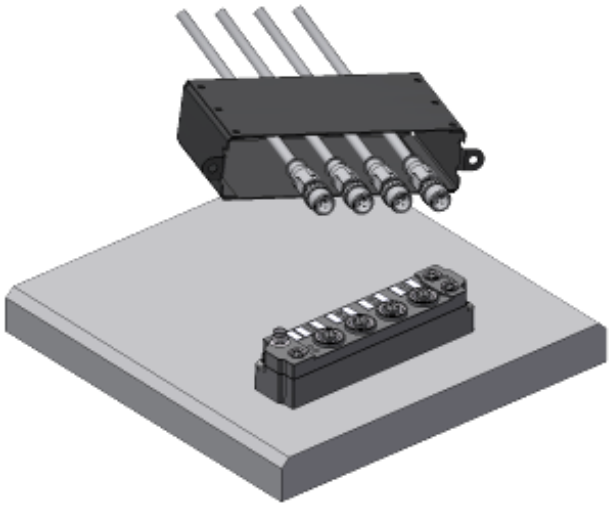


Fig. 47: BG2000 - putting the cables

Fix the wires for EtherCAT, power supply and sensors/actuators to the EtherCAT Box.

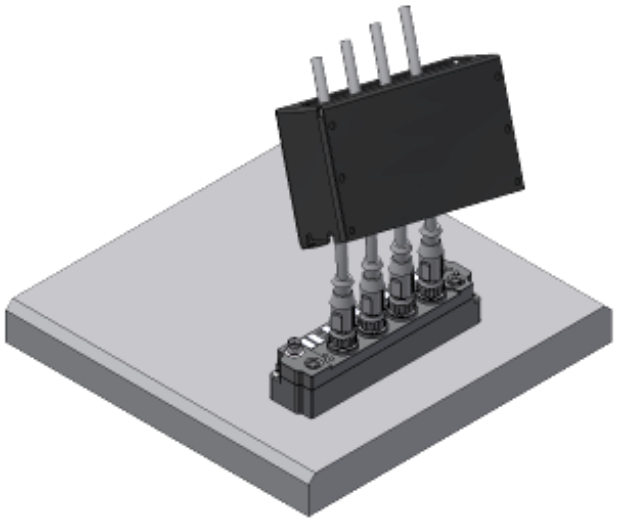


Fig. 48: BG2000 - fixing the cables

Mount the protection enclosure over the EtherCAT Box.

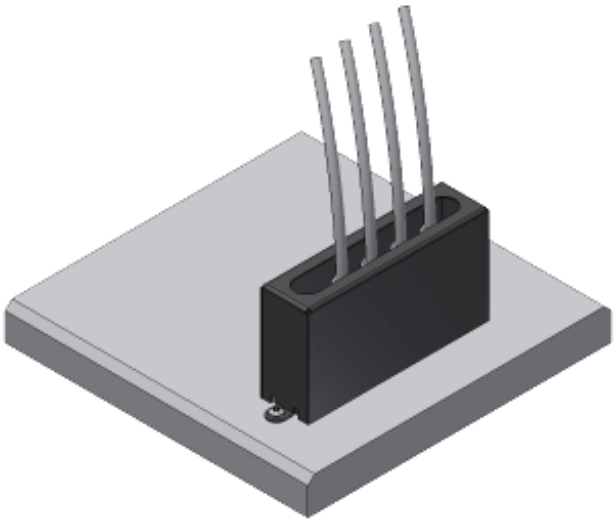


Fig. 49: BG2000 - mounting the protection enclosure

9.3 ATEX Documentation

Notes about operation of EtherCAT Box Modules (EPxxxx-xxxx) in potentially explosive areas (ATEX)

Pay also attention to the continuative documentationNotes about operation of EtherCAT Box Modules (EPxxxx-xxxx) in potentially explosive areas (ATEX) that is available in the download area of the Beckhoff homepage http:\\www.beckhoff.com!

10 Commissioning/Configuration

10.1 IO-Link master

10.1.1 Offline configuration settings - TwinCAT (master)

In this part of the documentation is the manual configuration of the IO-Link master in TwinCAT described.

Distinction between Online and Offline

The distinction between online and offline refers to the presence of the actual I/O environment (drives, terminals, box-modules).

- **Offline**
  If the configuration is to be prepared in advance of the system configuration as a programming system, e.g. on a laptop, this is only possible in “Offline configuration” mode. In this case all components have to be entered manually in the configuration, e.g. based on the electrical design (as described under 1. Importing the device description IODD).
- **Online**
  If the designed control system is already connected to the EtherCAT system and all components are energized and the infrastructure is ready for operation, the TwinCAT configuration can simply be generated through “scanning” from the runtime system. This is referred to as online configuration. In any case, during each startup the EtherCAT master/ IO-Link master checks whether the devices it finds match the configuration. This test can be parameterized in the extended device settings.

To take advantage of the current features/settings of the master, the latest version of the ESI file should always be downloaded. Therefore it is necessary to consider the following note first.

Installation of the latest ESI-XML device description

The TwinCAT System Manager needs the device description files for the devices to be used in order to generate the configuration in online or offline mode. The device description is contained in the so-called ESI files (EtherCAT Slave Information) in XML format. These files can be requested from the respective manufacturer and are made available for download. The ESI files for Beckhoff EtherCAT devices are available on the Beckhoff website. The ESI files should be saved in the TwinCAT installation directory (default: C:\TwinCAT\IO\EtherCAT). The files are read (once) when a new System Manager window is opened. A TwinCAT installation includes the set of Beckhoff ESI files that was current at the time when the TwinCAT build was created. For TwinCAT 2.11 and higher, the ESI directory can be uploaded from the System Manager, if the programming PC is connected to the internet (TwinCAT → EtherCAT-Devices → Update Device Description…) see following figure.

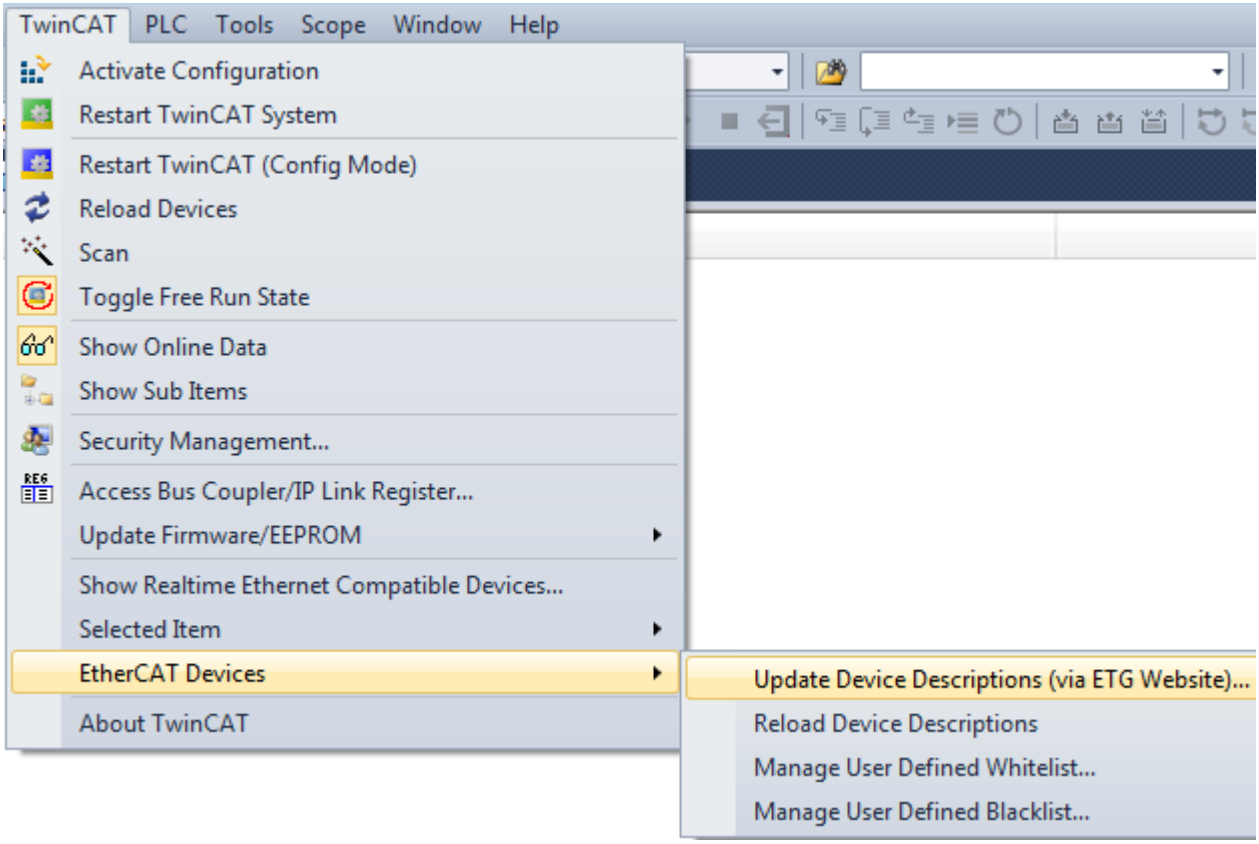


Fig. 50: Update Device Descriptions

Appending a module manually

- The EtherCAT system must be in a safe, de-energized state before the EtherCAT modules are connected to the EtherCAT network!
- Switch on the operating voltage, open the TwinCAT System Manager (Config mode)
- Append a new I/O device. In the dialog that appears select the device *EtherCAT (Direct Mode),* and confirm with *OK*.

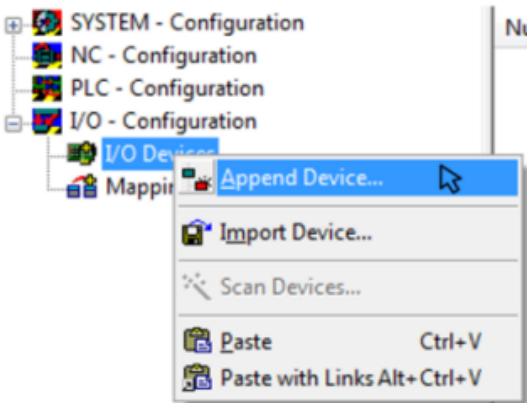


Fig. 51: Appending a new I/O device (I/O Devices -> right-click -> Append Device...)

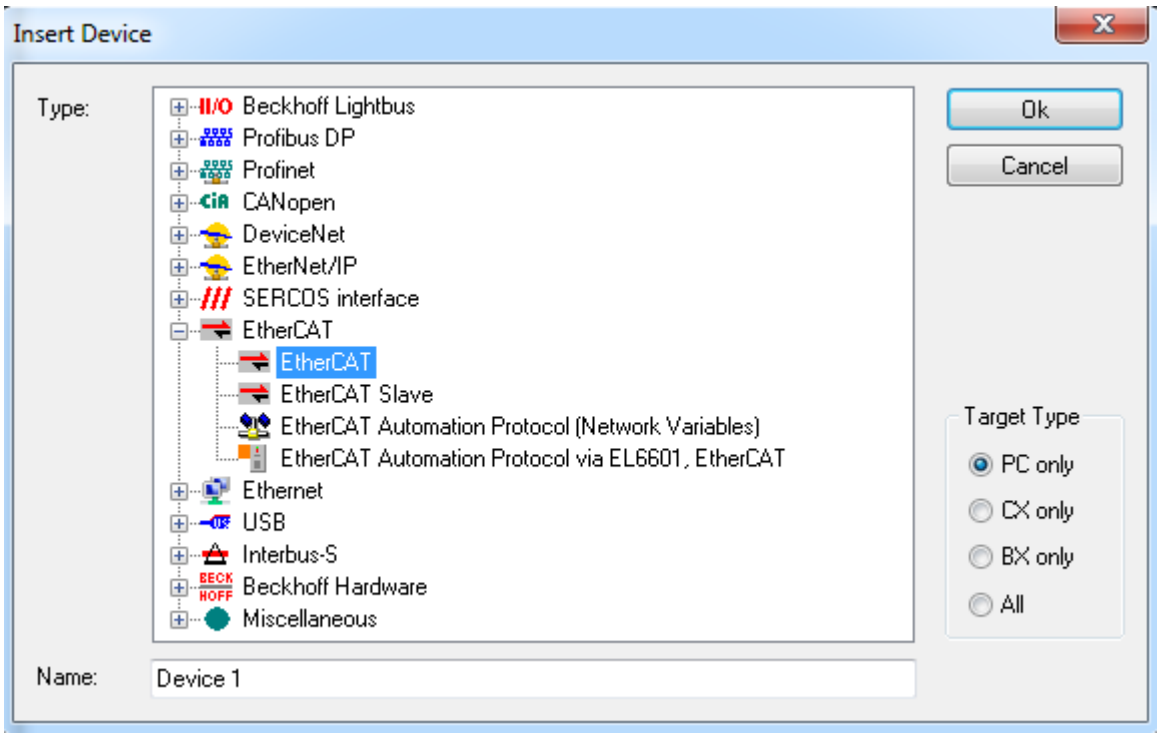


Fig. 52: Selecting the device EtherCAT

- Append a new box.

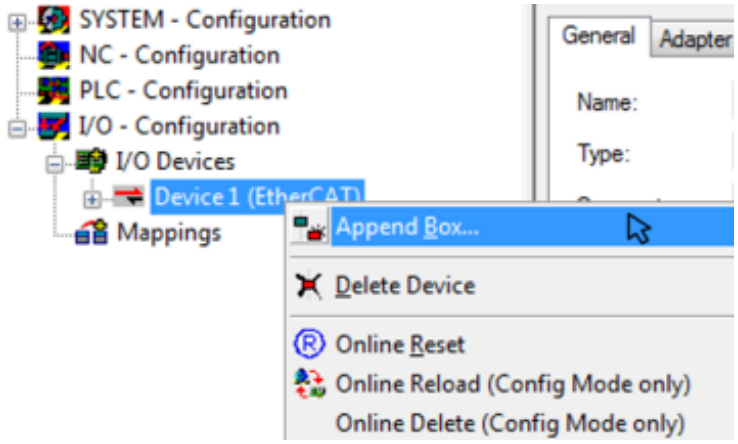


Fig. 53: Appending a new box (Device -> right-click -> Append Box...)

- In the dialog that appears select the desired box (e.g. EP6224-2022), and confirm with *OK*.

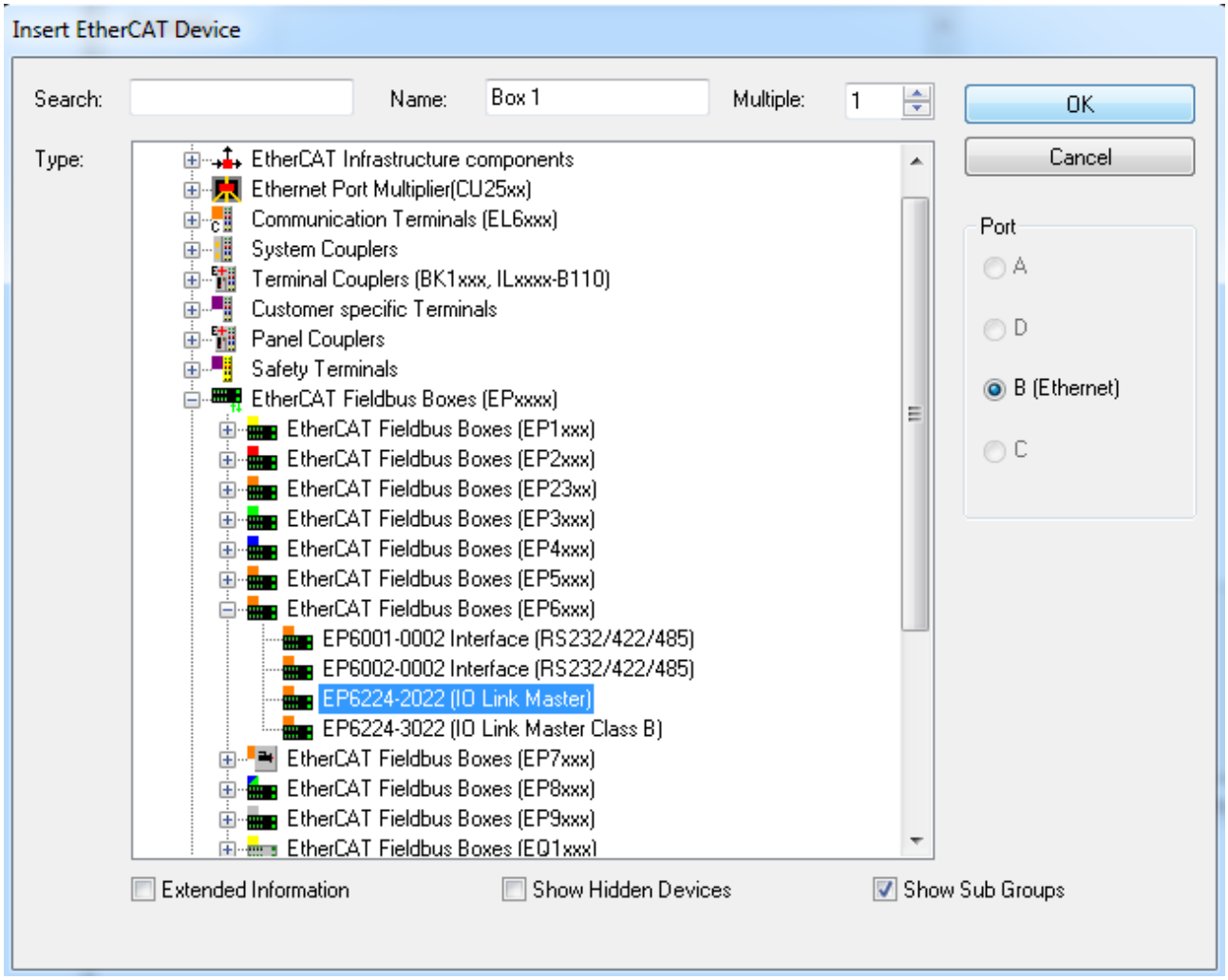


Fig. 54: Selecting a Box (e.g. EP6224-2022)

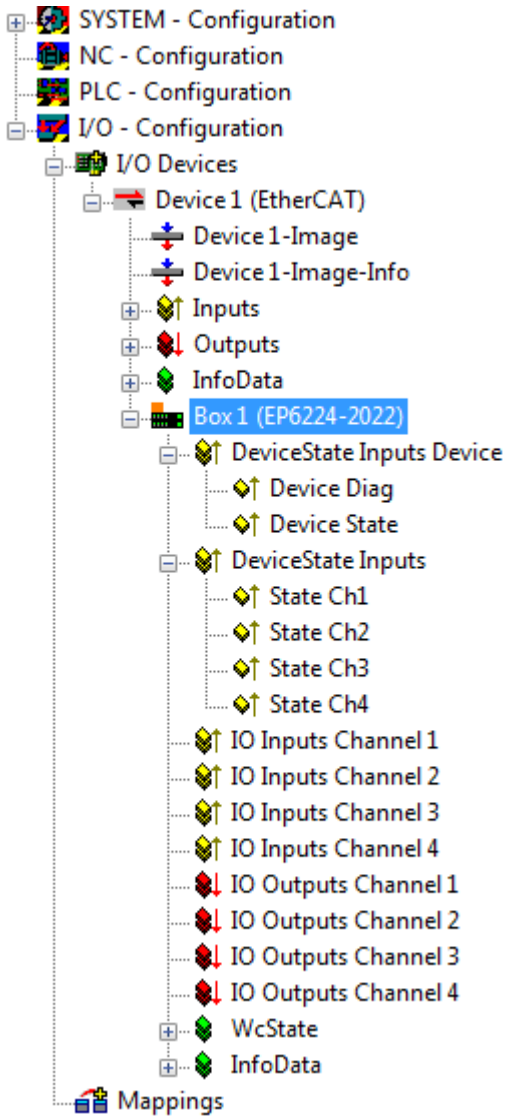


Fig. 55: Appended Box in the TwinCAT tree

In this section is described, how to configure the IO-Link master in TwinCAT and the integration of IO-Link devices.

Configuration of the IO-Link master

Configuration of the IO-Link master requires a plug-in, which is usually supplied with the TwinCAT installation. When the IO-Link master is added to the TwinCAT System Manager (see section Offline [▶ 53] / Online [▶ 59] configuration settings - TwinCAT (master)) an additional tab called IO-Link is created (see following figure). If the tab is not displayed, the associated System Manager extension is missing. You can install it separately. Please contact support.

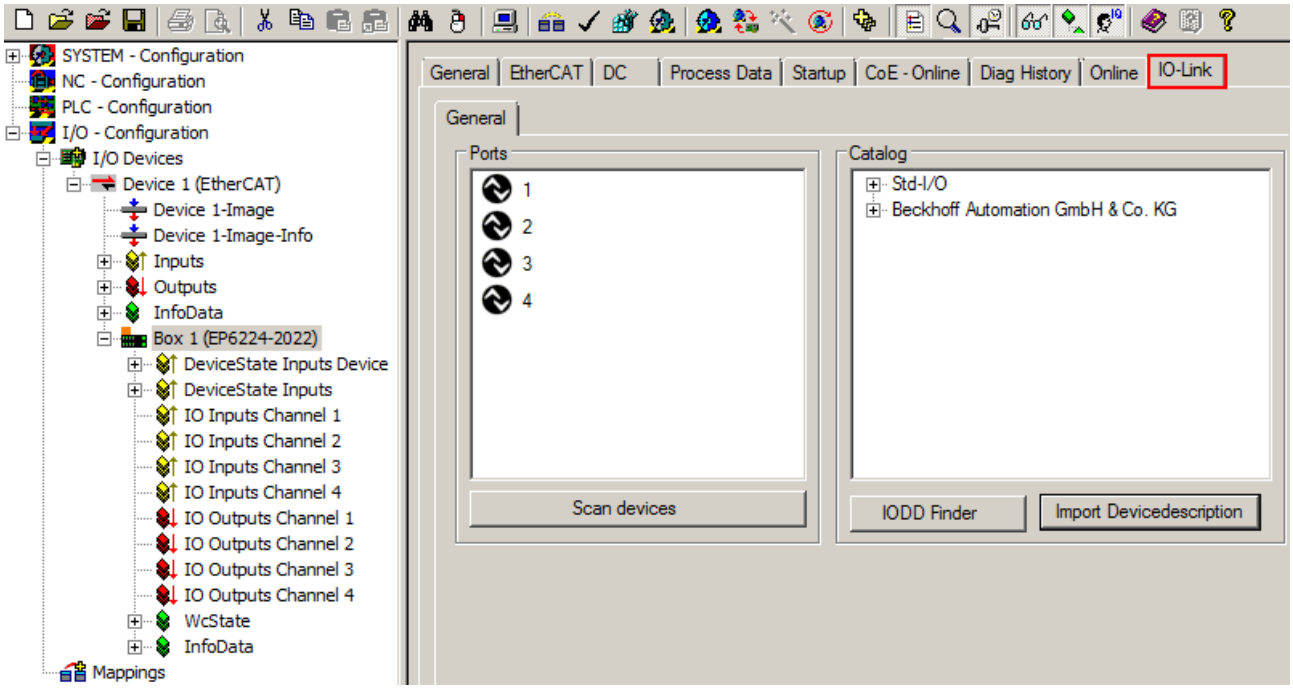


Fig. 56: "IO-Link" tab

10.1.2 Online configuration settings - TwinCAT (master)

In this part of the documentation is the configuration of a physically existing IO-Link master in TwinCAT described.

Online configuration “Scan” (TwinCAT 3.x)

Distinction between Online and Offline

The distinction between online and offline refers to the presence of the actual I/O environment (drives, terminals, box-modules).

- **Offline**
  If the configuration is to be prepared in advance of the system configuration as a programming system, e.g. on a laptop, this is only possible in “Offline configuration” mode. In this case all components have to be entered manually in the configuration, e.g. based on the electrical design (as described under 1. Importing the device description IODD).
- **Online**
  If the designed control system is already connected to the EtherCAT system and all components are energized and the infrastructure is ready for operation, the TwinCAT configuration can simply be generated through “scanning” from the runtime system. This is referred to as online configuration. In any case, during each startup the EtherCAT master/ IO-Link master checks whether the devices it finds match the configuration. This test can be parameterized in the extended device settings.

To take advantage of the current features/settings of the master, the latest version of the ESI file should always be downloaded. Therefore it is necessary to consider the following note first.

Installation of the latest ESI-XML device description

The TwinCAT System Manager needs the device description files for the devices to be used in order to generate the configuration in online or offline mode. The device description is contained in the so-called ESI files (EtherCAT Slave Information) in XML format. These files can be requested from the respective manufacturer and are made available for download. The ESI files for Beckhoff EtherCAT devices are available on the Beckhoff website. The ESI files should be saved in the TwinCAT installation directory (default: C:\TwinCAT\IO\EtherCAT). The files are read (once) when a new System Manager window is opened. A TwinCAT installation includes the set of Beckhoff ESI files that was current at the time when the TwinCAT build was created. For TwinCAT 2.11 and higher, the ESI directory can be uploaded from the System Manager, if the programming PC is connected to the internet (TwinCAT → EtherCAT-Devices → Update Device Description…) see following figure.

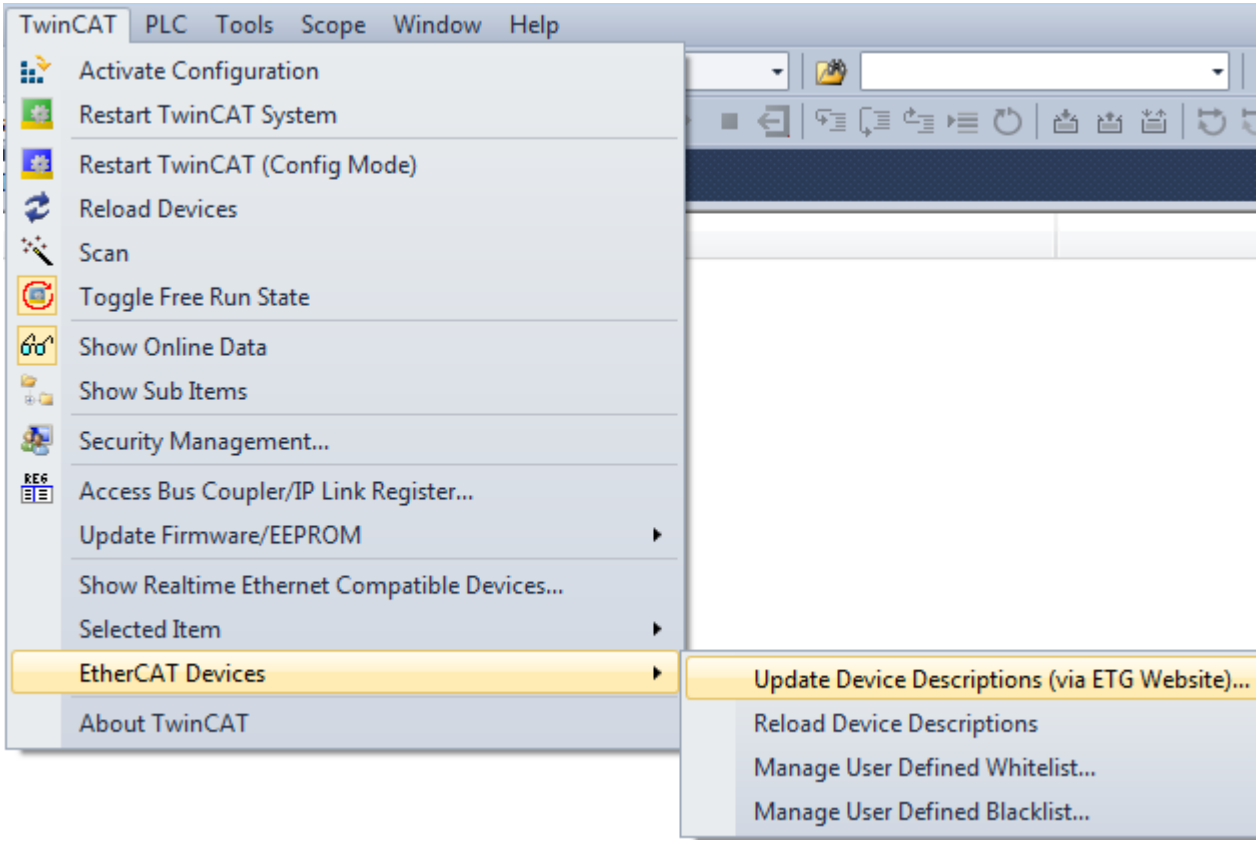


Fig. 57: Update Device Descriptions

The following conditions must be met before a configuration can be set up:

- the real EtherCAT and IO-Link hardware (devices, couplers, drives) must be present and installed
- the master/devices must be connected via EtherCAT cables and IO-Link cables in the same way as they are intended to be used later
- the devices/modules be connected to the power supply and ready for communication
- TwinCAT must be in CONFIG mode on the target system.

The online scan process consists of:

- detecting the EtherCAT device (Ethernet Port at the IPC)
- detecting the connected EtherCAT devices. This step can be carried out independent of the preceding step.
- troubleshooting

The scan with existing configuration can also be carried out for comparison.

Detecting/scanning of the EtherCAT device

The online device search can be used if the TwinCAT system is in CONFIG mode (blue TwinCAT icon or blue indication in the System Manager).

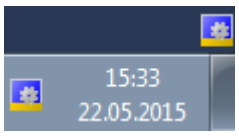


Fig. 58: TwinCAT CONFIG mode display

Online scanning in Config mode

The online search is not available in RUN mode (production operation).

Note the differentiation between TwinCAT programming system and TwinCAT target system. The TwinCAT icon next to the Windows clock always shows the TwinCAT mode of the local IPC. The System Manager window shows the TwinCAT state of the target system.

Right-clicking on “I/O Devices” in the configuration tree opens the search dialog.

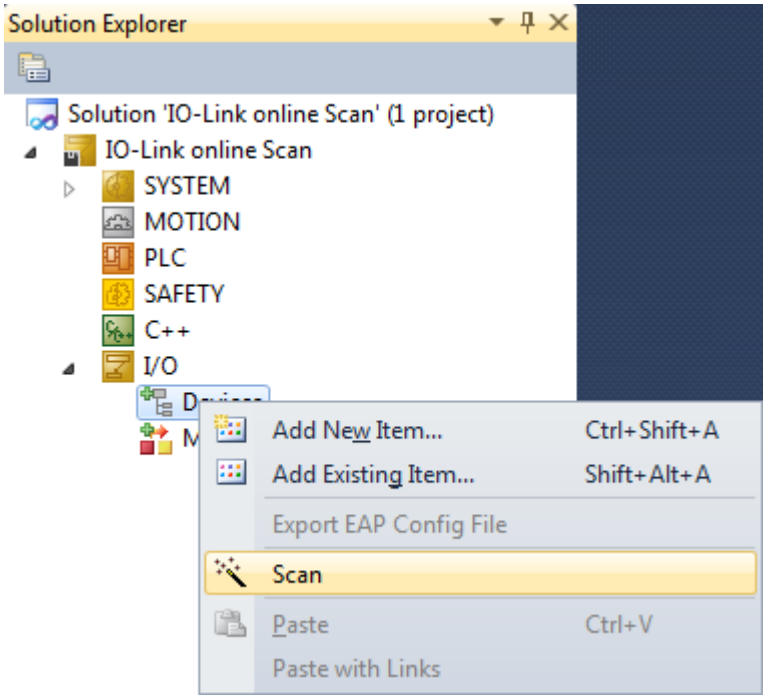


Fig. 59: Scan Devices

This scan mode not only tries to find EtherCAT devices (or Ethernet ports that can be used as such), but also NOVRAM, fieldbus cards, SMB etc. Not all devices can be found automatically.

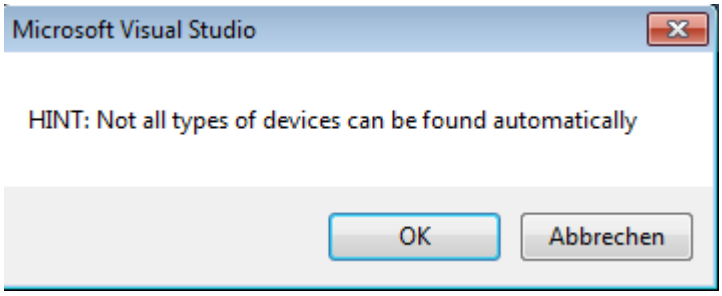


Fig. 60: note for automatic device scan

Ethernet ports with installed TwinCAT real-time driver are shown as “RT Ethernet” devices. An EtherCAT frame is sent to these ports for testing purposes. If the scan agent detects from the response that an EtherCAT slave is connected, the port is shown immediately as an “EtherCAT Device”.

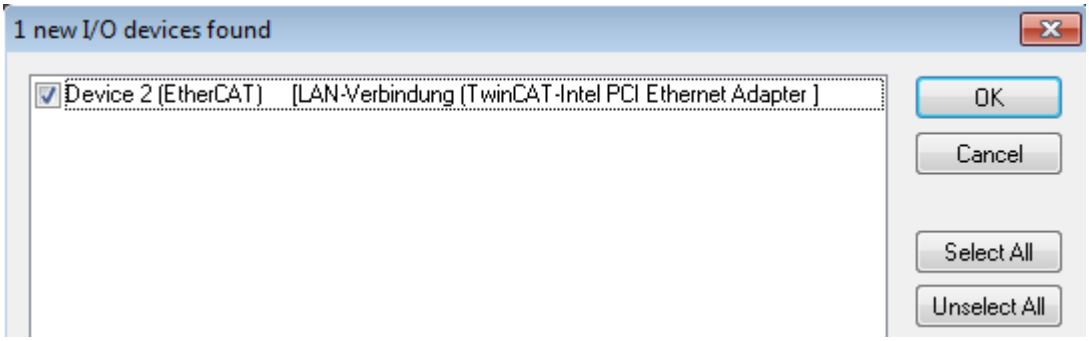


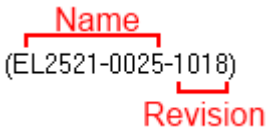
Fig. 61: detected Ethernet devices

After confirmation with “OK” a device scan is suggested for all selected devices, see following figure.

Detecting/Scanning the EtherCAT devices

Online scan functionality

During a scan the master queries the identity information of the EtherCAT slaves from the slave EEPROM. The name and revision are used for determining the type. The respective devices are located in the stored ESI data and integrated in the configuration tree in the default state defined there.



If an EtherCAT device was created in the configuration (manually or through a scan), the I/O field can be scanned for devices/slaves.

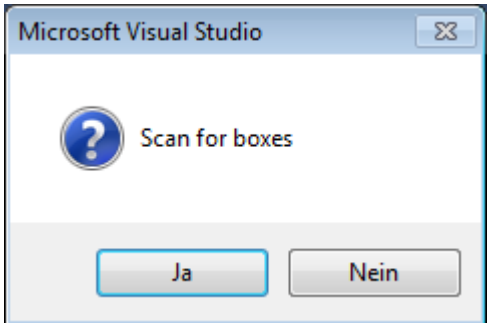


Fig. 62: scan query after automatic creation of an EtherCAT device

The configuration has been build and directly shifted into the online state (OPERATIONAL). The EtherCAT system should then be in a functional cyclic state, as shown in the following figure.

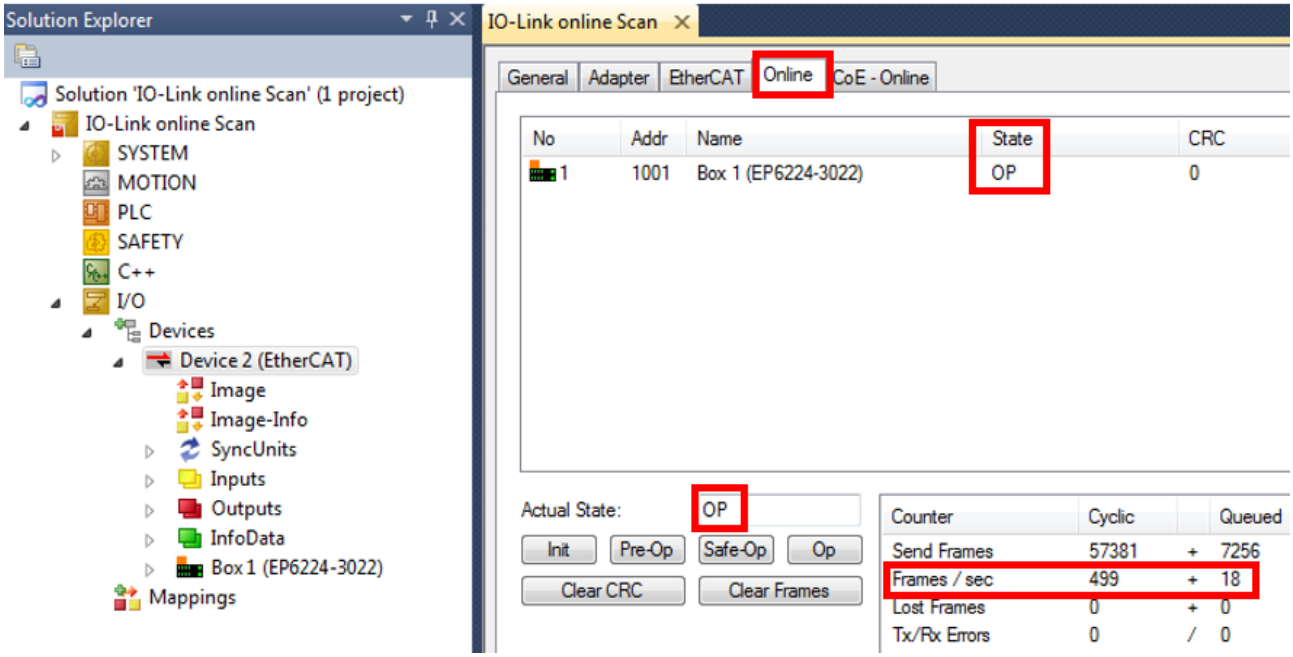


Fig. 63: online display example

Please note:

- all slaves should be in OP state
- the EtherCAT master should be in “Actual State” OP
- “frames/sec” should match the cycle time taking into account the sent number of frames
- no excessive “LostFrames” or CRC errors should occur

The configuration is now complete. It can be modified as described under the offline procedure.

The connected IO-Link master (EP6224-2022) is displayed in the TwinCAT structure as you can see in the figure below.

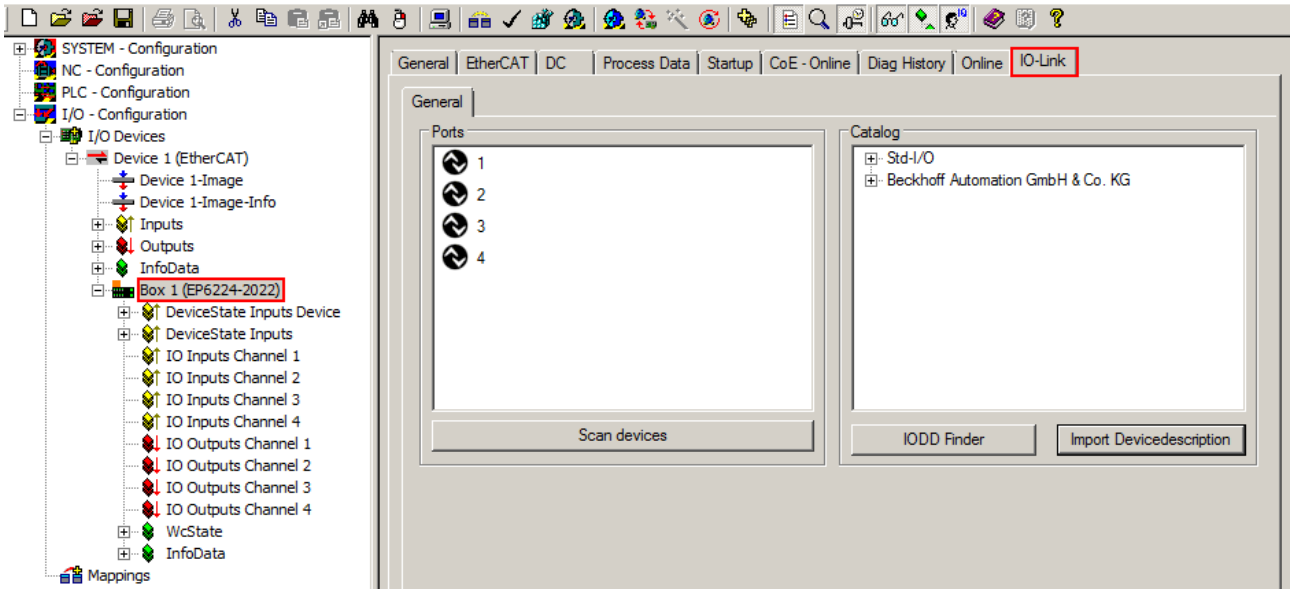


Fig. 64: Master display after scan for boxes

Troubleshooting

Various effects may occur during scanning.

- An **unknown device** is detected, i.e. an EtherCAT slave for which no ESI XML description is available. In this case the System Manager offers to read any ESI that maybe stored in the device.

- **Devices are not detected properly**
  Possible reasons include:
  - faulty data links, resulting in data loss during the scan
  - slave has invalid device description

    The connections and devices should be checked in a targeted manner, e.g. via the emergency scan.
    Then re-run the scan.

Scan over existing configuration

If a scan is initiated for an existing configuration, the actual I/O environment may match the configuration exactly or it may differ. This enables the configuration to be compared.

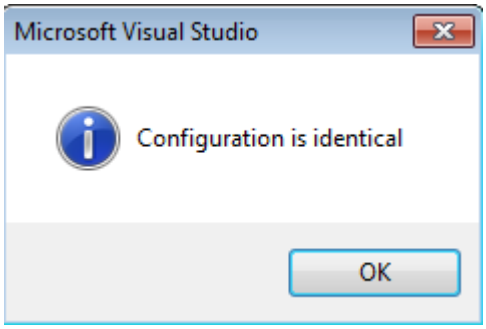


Fig. 65: identical configuration

If differences are detected, they are shown in the correction dialog, so that the user can modify the configuration as required.

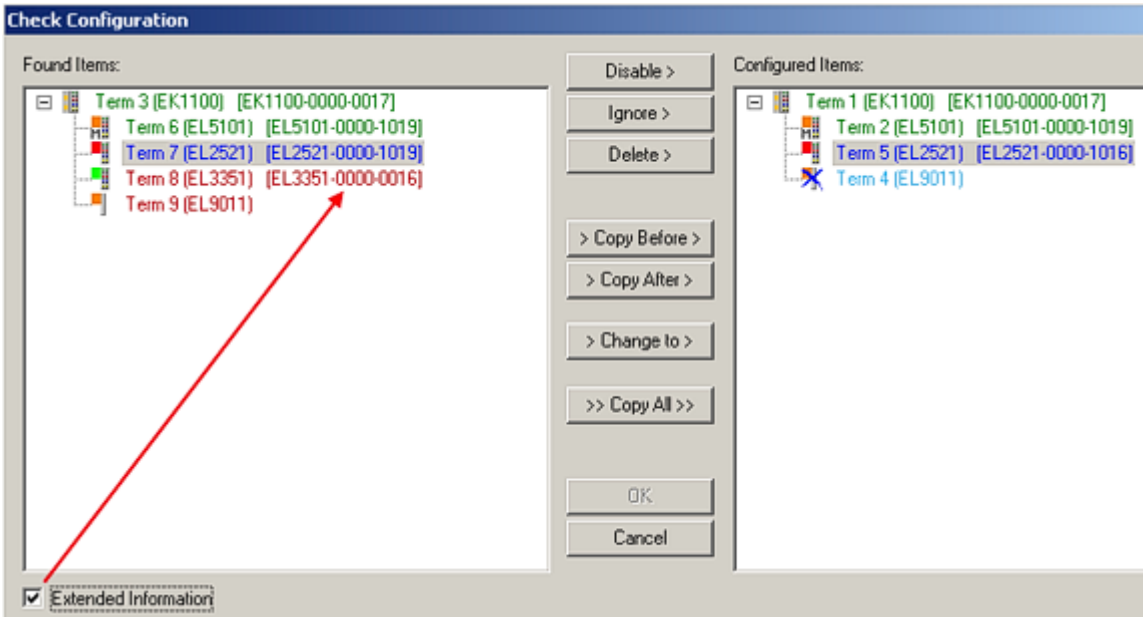


Fig. 66: correction dialog

It is advisable to tick the “Extended Information” check box to reveal differences in the revision.

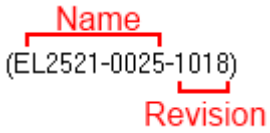
Colour	Explanation
green	This EtherCAT slave matches the entry on the other side. Both type and revision match.
blue	This EtherCAT slave is present on the other side, but in a different revision. If the found revision is higher than the configured revision, the slave maybe used provided compatibility issues are taken into account. If the found revision is lower than the configured revision, it is likely that the slave cannot be used. The found device may not support all functions that the master expects based on the higher revision number.
light blue	This EtherCAT slave is ignored („Ignore“ button).
red	This EtherCAT slave is not present on the other side.

Device selection based on revision, compatibility

The ESI description also defines the process image, the communication type between master and slave/device and the device functions, if applicable. The physical device (firmware, if available) has to support the communication queries/settings of the master. This is backward compatible, i.e. newer devices (higher revision) should be supported if the EtherCAT master addresses them as an older revision. The following compatibility rule of thumb is to be assumed for Beckhoff EtherCAT Terminals/Boxes:

device revision in the system >= device revision in the configuration

This also enables subsequent replacement of devices without changing the configuration (different specifications are possible for drives). Example: If an EL2521-0025-**1018** is specified in the configuration, an EL2521-0025-**1019** or higher (-**1020**, -**1021**) can be used in practice.



If current ESI descriptions are available in the TwinCAT system, the last revision offered in the selection dialog matches the Beckhoff state of production. It is recommended to use the last device revision when creating a new configuration, if current Beckhoff devices are used in the real application. Older revisions should only be used if older devices from stock are to be used in the application.

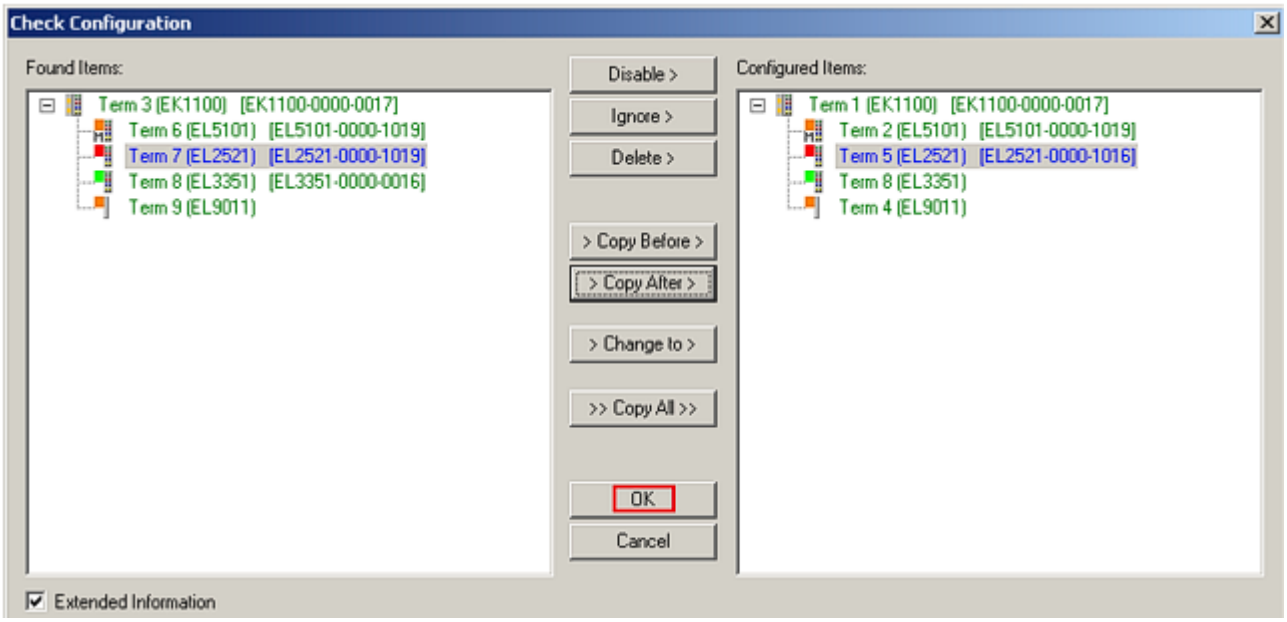


Fig. 67: correction dialog with modifications

Once all modifications have been saved or accepted, click “OK” to transfer them to the real *.tsm configuration.

10.2 Object description and parameterization

EtherCAT XML Device Description

The display matches that of the CoE objects from the EtherCAT XML Device Description. We recommend downloading the latest XML file from the download area of the Beckhoff website and installing it according to installation instructions.

Parameterization via the CoE list (CAN over EtherCAT)

The EtherCAT device is parameterized via the CoE - Online tab [▶ 21] (double-click on the respective object) or via the Process Data tab [▶ 18] (allocation of PDOs). Please note the following general CoE notes when using/manipulating the CoE parameters:
- Keep a startup list if components have to be replaced
- Differentiation between online/offline dictionary, existence of current XML description
- use “CoE reload” for resetting changes

Introduction

The CoE overview contains objects for different intended applications:

- Objects required for parameterization during commissioning.
- Objects intended for regular operation, e.g. through ADS access.
- Objects for indicating internal settings (may be fixed).
- Profile specific objects, for exposition the status of the inputs and outputs.

The following section first describes the objects require for normal operation, followed by a complete overview of other objects.

10.2.1 Objects for commissioning

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1_{dec})
1011:01	SubIndex 001	If this object is set to "**0x64616F6C**" in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0_{dec})

Index 80n0 IO Settings Ch.1 - 4 (for 0 ≤ n ≤ 3)

<table>
<tr><th>Index (hex)</th><th>Name</th><th>Meaning</th><th>Data type</th><th>Flags</th><th>Default</th></tr>
<tr><td>80n0:0</td><td>IO Settings Ch.1- 4</td><td>IO Settings Channel x</td><td>UINT8</td><td>RW</td><td>0x28 (40_{dez})</td></tr>
<tr><td>80n0:04</td><td>Device ID</td><td>The device ID is used for validating the IO link device.</td><td>UINT32</td><td>RW</td><td>0x00000000 (0_{dez})</td></tr>
<tr><td>80n0:05</td><td>VendorID</td><td>The vendor ID is used for validating the manufacturer of the IO link device.</td><td>UINT32</td><td>RW</td><td>0x00000000 (0_{dez})</td></tr>
<tr><td>80n0:20</td><td>IO-Link Revision</td><td>ID of the specification version based on which the IO link device communicates.

Bit 0-3: MinorRev
Bit 4-7: MajorRev</td><td>UINT8</td><td>RW</td><td>0x00 (0_{dez})</td></tr>
<tr><td>80n0:21</td><td>Frame capability</td><td>The Frame capability indicates certain functionalities of the IO link device (e.g. SPDU supported).

Bit 0: SPDU
Bit 1: Type1
Bit 7: PHY1</td><td>UINT8</td><td>RW</td><td>0x00 (0_{dez})</td></tr>
<tr><td>80n0:22</td><td>Min cycle time</td><td>The cycle time refers to the communication between the IO link master and the IO link device.
This value is transferred in the IO link format for Min Cycle Time.

Bit 6 und 7: Time Base
Bit 0 to 5: Multiplier

0x00: The IO-Link master automatically uses the smallest possible update time of the IO-Link device.

<table><tr><th>Time Base</th><th>Meaning Time base</th><th>Calculation</th><th>Min. Cycle Time</th></tr><tr><td>00_{bin}</td><td>0.1ms</td><td>Multiplier x Time Base</td><td>0.4- 6.3 ms</td></tr><tr><td>01_{bin}</td><td>0.4ms</td><td>6.4 ms + Multiplier x Time Base</td><td>6.4- 31.6 ms</td></tr><tr><td>10_{bin}</td><td>1.6ms</td><td>32.0 ms + Multiplier x Time Base</td><td>32.0 - 132.8 ms</td></tr><tr><td>11_{bin}</td><td>6.4 ms</td><td>134.4 ms + Multiplier x Time Base</td><td>134.4- 537.6 ms</td></tr></table></td><td>UINT8</td><td>RW</td><td>0x00 (0_{dez})</td></tr>
<tr><td>80n0:23</td><td>Offset time</td><td>reserved</td><td>UINT8</td><td>RW</td><td>0x00 (0_{dez})</td></tr>
<tr><td>80n0:24</td><td>Process data in length</td><td>These parameters are transferred in the IO link format for "Process data in length".

Bit 7:
BYTE
(indicates whether the value in LENGTH interpreted as bit length [bit not set] or as byte length + 1 [bit set]

Bit 6:
SIO
(indicates whether the device supports the standard IO mode [bit set])

Bit 0 to 4:
LENGTH
(length of the process data)</td><td>UINT8</td><td>RW</td><td>0x00 (0_{dez})</td></tr>
</table>

Index (hex)	Name	Meaning	Data type	Flags	Default
80n0:25	Process data out length	These parameters are transferred in the IO link format for "Process data out length". Bit 7: BYTE (indicates whether the value in LENGTH interpreted as bit length [bit not set] or as byte length + 1 [bit set] Bit 6: SIO (indicates whether the device supports the standard IO mode [bit set]) Bit 0 to 4: LENGTH (length of the process data)	UINT8	RW	0x00 (0_{dez})
80n0:26	Compatible ID	reserved	UINT16	RW	0x0000 (0_{dez})
80n0:27	Reserved	reserved	UINT16	RW	0x0000 (0_{dez})
80n0:28	Master Control	0: IO link port inactive 1: IO link port as digital input port 2: IO link port as digital output port 3: IO link port in communication via the IO link protocol 4:IO link port in communication via the IO link protocol. IO link state is ComStop (none cyclic communication, data are exchanged on demand).	UINT16	RW	0x0000 (0_{dez})

10.2.2 Objects for regular operation

In normal functional range the EL6224 has no such objects.

Complete overview

10.2.3 Standard objects (0x1000-0x1FFF)

The standard objects of all EtherCAT slaves have the same meaning.

Index 1000 Device type

Index (hex)	Name	Meaning	Data type	Flags	Default
1000:0	Device type	Device Type of the EtherCAT slave: The Lo-Word contains the supported CoE Profile (5001). The Hi-Word contains the Module Profile corresponding to the Modular Device Profile.	UINT32	RO	0x184C1389 (407638921_{dez})

Index 1008 Device name

Index (hex)	Name	Meaning	Data type	Flags	Default
1008:0	Device name	Device name of the EtherCAT slave	STRING	RO	EP6224

Index 1009 Hardware version

Index (hex)	Name	Meaning	Data type	Flags	Default
1009:0	Hardware version	Hardware version of the EtherCAT slaves	STRING	RO	01

Index 100A Software version

Index (hex)	Name	Meaning	Data type	Flags	Default
100A:0	Software version	Firmware version of the EtherCAT slaves	STRING	RO	01

Index 1018 Identity

Index (hex)	Name	Meaning	Data type	Flags	Default
1018:0	Identity	contains informations to identify the EtherCAT slave	UINT8	RO	0x04 (4_{dez})
1018:01	Vendor ID	Vendor ID of the EtherCAT slave	UINT32	RO	0x00000002 (2_{dez})
1018:02	Product code	Product code of the EtherCAT slave	UINT32	RO	0x18503052 (407908434_{dez})
1018:03	Revision	Revision number of the EtherCAT-Slave, the Lo-Word (Bit 0-15) indicates the special functions terminal number; the Hi-Word (Bit 16-31) refers to the device description.	UINT32	RO	0x00100000 (1048576_{dez})
1018:04	Serial number	Serial number of the EtherCAT-Slave, the Lo-Byte (Bit 0-7) of the Lo-Word contains the year of manufacturing, the Hi-Byte (Bit 8-15) of the Lo-Word contains the week of manufacturing, the Hi-Word (Bit 16-31) is 0 .	UINT32	RO	0x00000000 (0_{dez})

Index 10F0 Backup parameter handling

Index (hex)	Name	Meaning	Data type	Flags	Default
10F0:0	Backup parameter handling	contains informations for the standardized Upload and Download of the Backup Entries	UINT8	RO	0x01 (1_{dez})
10F0:01	Checksum	Checksum over all backup entries	UINT32	RO	0x00000000 (0_{dez})

Index 1600 IO RxPDOPDO-Map Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
1600:0	IO RxPDOPDO-Map Ch.1	PDO Mapping RxPDO 1	UINT8	RW	0x01 (1_{dez})
1600:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1601 IO RxPDOPDO-Map Ch.2

Index (hex)	Name	Meaning	Data type	Flags	Default
1601:0	IO RxPDOPDO-Map Ch.2	PDO Mapping RxPDO 2	UINT8	RW	0x01 (1_{dez})
1601:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1602 IO RxPDOPDO-Map Ch.3

Index (hex)	Name	Meaning	Data type	Flags	Default
1602:0	IO RxPDOPDO-Map Ch.3	PDO Mapping RxPDO 3	UINT8	RW	0x01 (1_{dez})
1602:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1603 IO RxPDOPDO-Map Ch.4

Index (hex)	Name	Meaning	Data type	Flags	Default
1603:0	IO RxPDOPDO-Map Ch.4	PDO Mapping RxPDO 4	UINT8	RW	0x01 (1_{dez})
1603:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1A00 IO TxPDOPDO-Map Ch.1

Index (hex)	Name	Meaning	Data type	Flags	Default
1A00:0	IO TxPDOPDO-Map Ch.1	PDO Mapping TxPDO 1	UINT8	RW	0x01 (1_{dez})
1A00:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1A01 IO TxPDOPDO-Map Ch.2

Index (hex)	Name	Meaning	Data type	Flags	Default
1A01:0	IO TxPDOPDO-Map Ch.2	PDO Mapping TxPDO 2	UINT8	RW	0x01 (1_{dez})
1A01:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1A02 IO TxPDOPDO-Map Ch.3

Index (hex)	Name	Meaning	Data type	Flags	Default
1A02:0	IO TxPDOPDO-Map Ch.3	PDO Mapping TxPDO 3	UINT8	RW	0x01 (1_{dez})
1A02:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1A03 IO TxPDOPDO-Map Ch.4

Index (hex)	Name	Meaning	Data type	Flags	Default
1A03:0	IO TxPDOPDO-Map Ch.4	PDO Mapping TxPDO 4	UINT8	RW	0x01 (1_{dez})
1A03:01	SubIndex 001	1. PDO Mapping entry (8 bits align)	UINT32	RW	0x0000:00, 8

Index 1A04 TxPDOeState TxPDO-Map Device

Index (hex)	Name	Meaning	Data type	Flags	Default
1A04:0	TxPDOeState TxPDO-Map Device	PDO Mapping TxPDO 5	UINT8	RW	0x04 (4_{dez})
1A04:01	SubIndex 001	1. PDO Mapping entry (object 0xF100 (Diagnosis Status data), entry 0x01 (State Ch1))	UINT32	RW	0xF100:01, 8
1A04:02	SubIndex 002	2. PDO Mapping entry (object 0xF100 (Diagnosis Status data), entry 0x02 (State Ch2))	UINT32	RW	0xF100:02, 8
1A04:03	SubIndex 003	3. PDO Mapping entry (object 0xF100 (Diagnosis Status data), entry 0x03 (State Ch3))	UINT32	RW	0xF100:03, 8
1A04:04	SubIndex 004	4. PDO Mapping entry (object 0xF100 (Diagnosis Status data), entry 0x04 (State Ch4))	UINT32	RW	0xF100:04, 8

Index 1C00Sync manager type

Index (hex)	Name	Meaning	Data type	Flags	Default
1C00:0	Sync manager type	Usage of the Sync Manager channels	UINT8	RO	0x04 (4_{dez})
1C00:01	SubIndex 001	Sync-Manager Type Channel 1: Mailbox Write	UINT8	RO	0x01 (1_{dez})
1C00:02	SubIndex 002	Sync-Manager Type Channel 2: Mailbox Read	UINT8	RO	0x02 (2_{dez})
1C00:03	SubIndex 003	Sync-Manager Type Channel 3: Process Data Write (Outputs)	UINT8	RO	0x03 (3_{dez})
1C00:04	SubIndex 004	Sync-Manager Type Channel 4: Process Data Read (Inputs)	UINT8	RO	0x04 (4_{dez})

Index 1C12 RxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C12:0	RxPDO assign	PDO Assign Outputs	UINT8	RW	0x04 (4_{dez})
1C12:01	SubIndex 001	1. assigned RxPDO (contains the index of the corresponding RxPDO Mapping object)	UINT16	RW	0x1600 (5632_{dez})
1C12:02	SubIndex 002	2. assigned RxPDO (contains the index of the corresponding RxPDO Mapping object)	UINT16	RW	0x1601 (5633_{dez})
1C12:03	SubIndex 003	3. assigned RxPDO (contains the index of the corresponding RxPDO Mapping object)	UINT16	RW	0x1602 (5634_{dez})
1C12:04	SubIndex 004	4. assigned RxPDO (contains the index of the corresponding RxPDO Mapping object)	UINT16	RW	0x1603 (5635_{dez})

Index 1C13 TxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C13:0	TxPDO assign	PDO Assign Inputs	UINT8	RW	0x05 (5_{dez})
1C13:01	SubIndex 001	1. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object)	UINT16	RW	0x1A00 (6656_{dez})
1C13:02	SubIndex 002	2. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object)	UINT16	RW	0x1A01 (6657_{dez})
1C13:03	SubIndex 003	3. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object)	UINT16	RW	0x1A02 (6658_{dez})
1C13:04	SubIndex 004	4. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object)	UINT16	RW	0x1A03 (6659_{dez})
1C13:05	SubIndex 005	5. assigned TxPDO (contains the index of the corresponding TxPDO Mapping object))	UINT16	RW	0x1A04 (6660_{dez})

Index 1C32 SM output parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C32:0	SM output parameter	Synchronization parameter of the outputs	UINT8	RO	0x20 (32_{dez})
1C32:01	Sync mode	actual synchronization mode: 0: Free Run 1: Synchron with SM 2 Event 2: DC-Mode - Synchron with SYNC0 Event 3: DC-Mode - Synchron with SYNC1 Event	UINT16	RW	0x0000 (0_{dez})
1C32:02	Cycle time	Cycle time (in ns): Free Run: cycle time of the local timer Synchron with SM 2 Event: Cycle time of the master DC-Mode: SYNC0/SYNC1 Cycle time	UINT32	RW	0x000186A0 (100000_{dez})
1C32:03	Shift time	Time between SYNC0 Event and Outputs Valid (in ns, only in DC-Mode)	UINT32	RO	0x00000000 (0_{dez})
1C32:04	Sync modes supported	Supported synchronization modes: Bit 0 = 1: Free Run is supported Bit 1 = 1: Synchron with SM 2 Event is supported Bit 2-3 = 01: DC-Mode is supported Bit 4-5 = 10: Output Shift with SYNC1 Event (only DC-Mode) Bit 14 = 1: dynamic times (could be measured Messen by writing 1C32:08)	UINT16	RO	0xC007 (49159_{dez})
1C32:05	Minimum cycle time	Minimum cycle time supported (in ns)	UINT32	RO	0x000186A0 (100000_{dez})
1C32:06	Calc and copy time	Minimal time between SYNC0 and SYNC1 Event (in ns, only in DC-Mode)	UINT32	RO	0x00000000 (0_{dez})
1C32:08	Command	0: Measurement of the times will be stopped 1: Measurement of the times will be started The Entries 1C32:03, 1C32:05, 1C32:06, 1C32:09, 1C33:03, 1C33:06, 1C33:09 will be updated with the maximum measured values.	UINT16	RW	0x0000 (0_{dez})
1C32:09	Delay time	Time between SYNC1 Event and Outputs Valid (in ns, only in DC-Mode)	UINT32	RO	0x00000000 (0_{dez})
1C32:0B	SM event missed counter	Number of the missed SM-Events in state OPERATIONAL (only in DC Mode)	UINT16	RO	0x0000 (0_{dez})
1C32:0C	Cycle exceeded counter	Number of the exceeded cycles in state OPERATIONAL	UINT16	RO	0x0000 (0_{dez})
1C32:0D	Shift too short counter	Number of the too short distances between SYNC0 and SYNC1 Event (only in DC Mode)	UINT16	RO	0x0000 (0_{dez})
1C32:20	Sync error	TRUE: In the last cycle the synchronization was not correct (only in DC Mode)	BOOLEAN	RO	0x00 (0_{dez})

Index 1C33 SM input parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C33:0	SM input parameter	Synchronization parameter of the inputs	UINT8	RO	0x20 (32_{dez})
1C33:01	Sync mode	actual synchronization mode: 0: Free Run 1: Synchron with SM 3 Event (no Outputs available) 2: DC - Synchron with SYNC0 Event 3: DC - Synchron with SYNC1 Event 34: Synchron with SM 2 Event (Outputs available)	UINT16	RW	0x0000 (0_{dez})
1C33:02	Cycle time	same as 1C32:02	UINT32	RW	0x000186A0 (100000_{dez})
1C33:03	Shift time	time between SYNC0-Event and Input Latch (in ns, only in DC-Mode)	UINT32	RO	0x00000000 (0_{dez})
1C33:04	Sync modes supported	Supported synchronization modes: Bit 0: Free Run is supported Bit 1: Synchron with SM 2 Event is supported (Outputs available) Bit 1: Synchron with SM 3 Event is supported (no Outputs available) Bit 2-3 = 01: DC-Mode is supported Bit 4-5 = 01: Input Shift with local event (Outputs available) Bit 4-5 = 10: Input Shift with SYNC1 Event (no Outputs available) Bit 14 = 1: dynamic times (could be measured Messen by writing 1C32:08 or 1C33:08)	UINT16	RO	0xC007 (49159_{dez})
1C33:05	Minimum cycle time	same as 1C32:05	UINT32	RO	0x000186A0 (100000_{dez})
1C33:06	Calc and copy time	time between Input Latch and the availability of the inputs for the master (in ns, only in DC-Mode)	UINT32	RO	0x00000000 (0_{dez})
1C33:08	Command	same as 1C32:08	UINT16	RW	0x0000 (0_{dez})
1C33:09	Delay time	time between SYNC1-Event and Input Latch (in ns, only in DC-Mode)	UINT32	RO	0x00000000 (0_{dez})
1C33:0B	SM event missed counter	same as 1C32:11	UINT16	RO	0x0000 (0_{dez})
1C33:0C	Cycle exceeded counter	same as 1C32:12	UINT16	RO	0x0000 (0_{dez})
1C33:0D	Shift too short counter	same as 1C32:13	UINT16	RO	0x0000 (0_{dez})
1C33:20	Sync error	same as 1C32:32	BOOLEAN	RO	0x00 (0_{dez})

10.2.4 Profile specific objects (0x6000-0xFFFF)

The profile specific objects have the same meaning for all EtherCAT Slaves which support the profile 5001.

Index 60n0 IO Inputs Ch.1 - 4 (for 0 ≤ n ≤ 3)

Index (hex)	Name	Meaning	Data type	Flags	Default
60n0:0	IO Inputs Ch.1 - 4	Max. Subindex	UINT8	RO	0x00 (0_{dez})
60n0:01	Subindex 001	IO-Link input process data			
...	...	...			
60n0:10	Subindex 016	IO-Link input process data			

Index 70n0 IO Outputs Ch.1 - 4 (for 0 ≤ n ≤ 3)

Index (hex)	Name	Meaning	Data type	Flags	Default
70n0:0	IO Outputs Ch.1 - 4	Max. Subindex	UINT8	RO	0x00 (0_{dez})
70n0:01	Subindex 001	IO-Link output process data			
...	...	...			
70n0:10	Subindex 016	IO-Link output process data			

Index 90n0 IO Info data Ch.1 - 4 (for 0 ≤ n ≤ 3)

<table>
<tr><th>Index (hex)</th><th>Name</th><th>Meaning</th><th>Data type</th><th>Flags</th><th>Default</th></tr>
<tr><td>90n0:0</td><td>IO Info data Ch.1 - 4</td><td>Max. Subindex</td><td>UINT8</td><td>RO</td><td>0x27 (39_{dez})</td></tr>
<tr><td>90n0:04</td><td>Device ID</td><td>The device ID is used for validating the IO link device.</td><td>UINT32</td><td>RO</td><td>0x00000000 (0_{dez})</td></tr>
<tr><td>90n0:05</td><td>VendorID</td><td>The vendor ID is used for validating the manufacturer of the IO link device.</td><td>UINT32</td><td>RO</td><td>0x00000000 (0_{dez})</td></tr>
<tr><td>90n0:07</td><td>IO-Link revision</td><td>ID of the specification version based on which the IO link device communicates.

Bit 0-3: MinorRev
Bit 4-7: MajorRev</td><td>UINT8</td><td>RO</td><td>0x00 (0_{dez})</td></tr>
<tr><td>90n0:20</td><td>FrameCapability</td><td>The Frame Capability indicates certain functionalities of the IO link device (e.g. SPDU supported).

Bit 0: SPDU
Bit 1: Type1
Bit 7: PHY1</td><td>UINT8</td><td>RO</td><td>0x00 (0</td></tr>
<tr><td>90n0:21</td><td>Min cycle time</td><td>The cycle time refers to the communication between the IO link master and the IO link device.
This value is transferred in the IO link format for Min Cycle Time.

Bit 6 und 7: Time Base
Bit 0 to 5: Multiplier

<table><tr><th>Time Base</th><th>Meaning Time base</th><th>Calculation</th><th>Min. Cycle Time</th></tr><tr><td>00b</td><td>0,100 ms</td><td>Multiplier x Time Base</td><td>0,000 - 6,300 ms</td></tr><tr><td>01b</td><td>0,400 ms</td><td>6,400 ms + Multiplier x Time Base</td><td>6,400 - 31,600 ms</td></tr><tr><td>10b</td><td>1,600 ms</td><td>32,000 ms + Multiplier x Time Base</td><td>32,000 - 132,800 ms</td></tr><tr><td>11b</td><td>6,400 ms</td><td>134,400 ms + Multiplier x Time Base</td><td>134,400 - 537,600 ms</td></tr></table></td><td>UINT8</td><td>RO</td><td>0x00 (0_{dez})</td></tr>
<tr><td>90n0:22</td><td>Offset time</td><td>reserved</td><td>UINT8</td><td>RO</td><td>0x00 (0_{dez})</td></tr>
<tr><td>90n0:23</td><td>Process data in length</td><td>These parameters are transferred in the IO link format for "Process data in length".

Bit 7:
BYTE
(indicates whether the value in LENGTH interpreted as bit length [bit not set] or as byte length + 1 [bit set]

Bit 6:
SIO
(indicates whether the device supports the standard IO mode [bit set])

Bit 0 bis 4:
LENGTH
(length of the process data)</td><td>UINT8</td><td>RO</td><td>0x00 (0_{dez})</td></tr>
<tr><td>90n0:24</td><td>Process data out length</td><td>These parameters are transferred in the IO link format for "Process data out length".

Bit 7:
BYTE
(indicates whether the value in LENGTH interpreted as bit length [bit not set] or as byte length + 1 [bit set]

Bit 6:
SIO
(indicates whether the device supports the standard IO mode [bit set])

Bit 0 bis 4:
LENGTH
(length of the process data)</td><td>UINT8</td><td>RO</td><td>0x00 (0_{dez})</td></tr>
<tr><td>90n0:26</td><td>Reserved</td><td>reserved</td><td>UINT16</td><td>RO</td><td>0x0000 (0_{dez})</td></tr>
<tr><td>90n0:27</td><td>Reserved2</td><td>reserved</td><td>UINT16</td><td>RO</td><td>0x0000 (0_{dez})</td></tr>
</table>

Index A0n0 IO Diag data Ch.1 - 4 (for 0 ≤ n ≤ 3)

Index (hex)	Name	Meaning	Data type	Flags	Default
A0n0:0	IO Diag data Ch.1 - 4	Max. Subindex	UINT8	RO	0x02 (2_{dez})
A0n0:01	IO-Link State	The value of the IO link state corresponds to a state from the IO link master state machine 0: INACTIVE 1: DIGINPUT 2: DIGOUTPUT 3: ESTABLISHCOMM 4: INITMASTER 5: INITDEVICE 7: PREOPERATE 8: OPERATE 9: STOP	UINT8	RO	0x00 (0_{dez})
A0n0:02	Lost Frames	This parameter counts the number of lost IO link telegrams. This value is deleted whenever IO link starts up, otherwise it is incremented continuously.	UINT8	RO	0x00 (0_{dez})

Index F000 Modular device profile

Index (hex)	Name	Meaning	Data type	Flags	Default
F000:0	Modular device profile	General information about the Modular Device Profile	UINT8	RO	0x02 (2_{dez})
F000:01	Module index distance	Index distance between the objects of two channels	UINT16	RO	0x0010 (16_{dez})
F000:02	Maximum number of modules	Number of channels	UINT16	RO	0x0004 (4_{dez})

Index F008 Code word

Index (hex)	Name	Meaning	Data type	Flags	Default
F008:0	Code word	reserved	UINT32	RW	0x00000000 (0_{dez})

Index F010 Module list

Index (hex)	Name	Meaning	Data type	Flags	Default
F010:0	Module list	Max. Subindex	UINT8	RW	0x04 (4_{dez})
F010:01	SubIndex 001	-	UINT32	RW	0x0000184C (6220_{dez})
F010:02	SubIndex 002	-	UINT32	RW	0x0000184C (6220_{dez})
F010:03	SubIndex 003	-	UINT32	RW	0x0000184C (6220_{dez})
F010:04	SubIndex 004	-	UINT32	RW	0x0000184C (6220_{dez})

Index F100 Diagnosis Status data

Index (hex)	Name	Meaning	Data type	Flags	Default
F100:0	Diagnosis Status data	Max. Subindex	UINT8	RO	0x04 (4_{dez})
F100:01	State Ch1	Statusbyte Ch. 1	UINT8	RO	0x00 (0_{dez})
F100:02	State Ch2	Statusbyte Ch. 2	UINT8	RO	0x00 (0_{dez})
F100:03	State Ch3	Statusbyte Ch. 3	UINT8	RO	0x00 (0_{dez})
F100:04	State Ch4	Statusbyte Ch. 4	UINT8	RO	0x00 (0_{dez})

Index F900 Info data

Index (hex)	Name	Meaning	Data type	Flags	Default
F900:0	Info data	Max. Subindex	UINT8	RO	0x09 (9_{dez})
F900:01	IO-Link Version	-	UINT8	RO	0x10 (16_{dez})

11 Error handling and diagnosis

11.1 Ex6224 - ADS Error Codes

Error codes are generated in the event of an error during ADS access to an IO-Link device.
The error code contains information about the error category, origin and instance. The possible error codes are listed in table „Error Codes“.
Additional information about a certain error (S_APP_DEV) is listed in table „Additional Code“:

Example of an AdsReturnCode

AdsReturnCode 0x**80110700**

80: Device Application Error (IO-Link Spec),
11: Index not Available (IO-Link Spec),
0700: General ADS Error

Error Codes (IO-Link Spec)

Type	Origin	Name	Category	Mode	Instance	Value (Hi Byte, hex)	Comment
PDU buffer overflow	remote	S_PDU_BUFFER	ERROR	SiNGLE SHOT	DL	52	Device buffer is too small for storing the complete PDU
PDU checksum error (master)	local	M_PDU_CHECK	ERROR	SiNGLE SHOT	DL	56	Calculated PDU checksum in master does not match actual received SPDU
PDU checksum error (device)	remote	S_PDU_CHECK	ERROR	SiNGLE SHOT	DL	56	Calculated PDU checksum in device does not match actual received SPDU
PDU flow control error	remote	S_PDU_FLOW	ERROR	SiNGLE SHOT	DL	56	Violation of flow control rule during transfer of SPDU between master and device
Illegal PDU service primitive (master)	local	M_PDU_ILLEGAL	ERROR	SiNGLE SHOT	AL	57	Unknown service primitive or wrong response e.g. Read Response on Write Request
Illegal PDU service primitive (device)	local / remote	S_PDU_ILLEGAL	ERROR	SiNGLE SHOT	AL	58	Unknown service primitive e.g. different protocol revision
Communication error	remote	COM_ERR		SiNGLE SHOT	unknown	10	Negative service response initiated by a communication error, e.g.. IO-Link connection interrupted
Device application error	remote	S_APP_DEV**	ERROR	SiNGLE SHOT	APP	80	Service PDU transferred, but not processed due to device error. See error details in Additional Code**

Additional Code (IO-Link Spec)

Type	Value (Lo Byte, hex)	Comment
No details	00	Device buffer is too small for storing the complete PDU
Index not available	11	Calculated PDU checksum in master does not match actual received SPDU
Subindex not available	12	Calculated PDU checksum in device does not match actual received SPDU
Service temporarily not available	20	Violation of flow control rule during transfer of SPDU between master and device
Service temporarily not available, local control	21	Unknown service primitive or wrong response e.g. Read Response on Write Request
Service temporarily not available, device control	22	Unknown service primitive e.g. different protocol revision
Access denied	23	Negative service response initiated by a communication error, eg. IO-Link connection interrupted
Parameter value out of range	30	Service PDU transferred, but not processed due to device error. See error details in Additional Code
Parameter value above limit	31	Service PDU transferred, but not processed due to device error. See error details in Additional Code
Parameter value below limit	32	Service PDU transferred, but not processed due to device error. See error details in Additional Code
Interfering parameter	40	Service PDU transferred, but not processed due to device error. See error details in Additional Code
Application failure	81	Service PDU transferred, but not processed due to device error. See error details in Additional Code
Application not ready	82	Service PDU transferred, but not processed due to device error. See error details in Additional Code

12 Appendix

12.1 General operating conditions

Protection degrees (IP-Code)

The standard IEC 60529 (DIN EN 60529) defines the degrees of protection in different classes.

1. Number: dust protection and touch guard	Definition
0	Non-protected
1	Protected against access to hazardous parts with the back of a hand. Protected against solid foreign objects of Ø 50 mm
2	Protected against access to hazardous parts with a finger. Protected against solid foreign objects of Ø 12.5 mm.
3	Protected against access to hazardous parts with a tool. Protected against solid foreign objects Ø 2.5 mm.
4	Protected against access to hazardous parts with a wire. Protected against solid foreign objects Ø 1 mm.
5	Protected against access to hazardous parts with a wire. Dust-protected. Intrusion of dust is not totally prevented, but dust shall not penetrate in a quantity to interfere with satisfactory operation of the device or to impair safety.
6	Protected against access to hazardous parts with a wire. Dust-tight. No intrusion of dust.

2. Number: water* protection	Definition
0	Non-protected
1	Protected against water drops
2	Protected against water drops when enclosure tilted up to 15°.
3	Protected against spraying water. Water sprayed at an angle up to 60° on either side of the vertical shall have no harmful effects.
4	Protected against splashing water. Water splashed against the disclosure from any direction shall have no harmful effects
5	Protected against water jets
6	Protected against powerful water jets
7	Protected against the effects of temporary immersion in water. Intrusion of water in quantities causing harmful effects shall not be possible when the enclosure is temporarily immersed in water for 30 min. in 1 m depth.

*) These protection classes define only protection against water!

Chemical Resistance

The Resistance relates to the Housing of the Fieldbus/EtherCAT Box and the used metal parts. In the table below you will find some typical resistance.

Character	Resistance
Steam	at temperatures >100°C: not resistant
Sodium base liquor (ph-Value > 12)	at room temperature: resistant > 40°C: not resistant
Acetic acid	not resistant
Argon (technical clean)	resistant

Key

- resistant: Lifetime several months
- non inherently resistant: Lifetime several weeks
- not resistant: Lifetime several hours resp. early decomposition

12.2 IP67 Box - Accessories

Fixing

Ordering information	Description
ZS5300-0001	Mounting rail (500 mm x 129 mm)

Marking material, plugs

Ordering information	Description
ZS5000-0000	Fieldbus Box set M8 (contact labels, plugs)
ZS5000-0002	Fieldbus Box set M12 (contact labels, plugs)
ZS5000-0010	plugs M8, IP67 (50 pieces)
ZS5000-0020	plugs M12, IP67 (50 pieces)
ZS5100-0000	marking labels, not printed, 4 stripes at 10 pieces
ZS5100-xxxx	printed marking labels, on request

Tools

Ordering information	Description
ZB8800	torque socket wrench with ratchet wrench for M8 connectors (over molded)
ZB8800-0001	ratchet wrench for M8 connectors (field assembly)
ZB8800-0002	ratchet wrench for M12 connectors (over molded)
ZB8801	torque wrench adjustable for M8 and M12 connectors
ZB8801-0001	ratched wrench for M8 connectors (over molded)
ZB8801-0002	ratched wrench for M8 connectors (field assembly) and M12 connectors (over molded)
ZB8801-0003	ratched wrench for M12 connectors (field assembly)

Further accessories

Further accessories may be found at the price list for Beckhoff fieldbus components and at the internet under http://www.beckhoff.de/english/fieldbus_box/data_sheets.htm?id=69033899254355.

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