ifm electronic

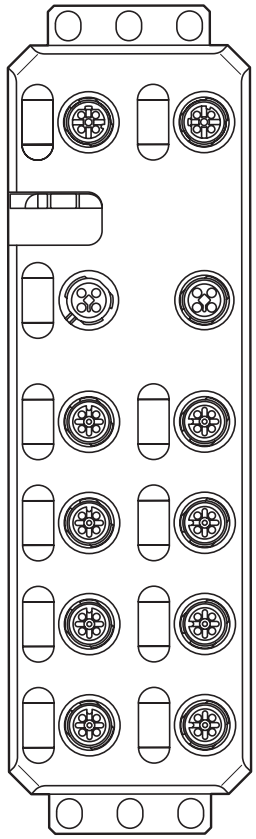
CE

Device manual
IO-Link master EtherCat

UK

ecomat300

AL1030



7391038/00 02/2016

Contents

1 Preliminary note

This document applies to devices of the type "IO-Link master EtherCat" (art. no. AL1030). These instructions are part of the device.

This document is intended for specialists. These specialists are people who are qualified by their appropriate training and their experience to see risks and to avoid possible hazards that may be caused during operation or maintenance of the device. The document contains information about the correct handling of the device.

Read this document before use to familiarise yourself with operating conditions, installation and operation. Keep this document during the entire duration of use of the device.

Adhere to the safety instructions.

Symbols

► Instruction

> Reaction, result

[…] Designation of keys, buttons or indications

→ Cross-reference

Important note
Non-compliance may result in malfunction or interference.

Information
Supplementary note

Warnings used

⚠ WARNING
Warning of serious personal injury.
Death or serious irreversible injuries may result.

⚠ CAUTION
Warning of personal injury.
Slight reversible injuries may result.

NOTICE
Warning of damage to property.

2 Safety instructions

These instructions contain texts and figures concerning the correct handling of the device and must be read before installation or use.

Observe the operating instructions. Non-observance of the instructions, operation which is not in accordance with use as prescribed below, wrong installation or incorrect handling can seriously affect the safety of operators and machinery.

- ► Prepare installation
- ► Disconnect the device
- ► Ensure that devices cannot be accidentally restarted.
- ► Verify safe isolation from the supply.
- ► Earth and short circuit.
- ► Cover or enclose adjacent units that are live.
- ► Follow the specific mounting instructions of the device.
- ► Only suitably qualified personnel in accordance with EN 50 110-1/-2 (VDC 0105 part 100) is permitted to work on this device/system.
- ► Before installation and before touching the device ensure that you are free of electrostatic charge.
- ► The functional earth (FE) must be connected to the protective earth (PE) or to the potential equalisation. The system installer is responsible for implementing this connection.
- ► Connecting cables and signal lines must be installed in such a manner that inductive or capacitive interference do not impair the automatic functions.
- ► Install automation equipment and related operating elements in such a way that they are protected against unintentional operation.
- ► Suitable safety hardware and software measures should be implemented for the I/O interface so that a line or wire breakage on the signal side does not result in undefined states in the automation device.
- ► Ensure a reliable electrical isolation of the low voltage for the 24 V supply. Only use power supplies compliant with IEC 60 364-4-41 or HD 384.4.41 S2 (VDE 0100 part 410).
- ► Fluctuations or deviations of the mains voltage from the rated value must not exceed the tolerance limits specified in the technical data; otherwise this may cause malfunction and dangerous operation.
- ► E-stop devices to IEC/EN 60 204-1 must be effective in all operating modes of the automation device. Unlatching the e-stop devices must not cause restart.

- ► Devices that are designed for mounting in housings or control cabinets must only be operated and controlled after they have been installed with the housing closed. Desktop or portable units must only be operated and controlled in enclosed housings.
- ► Measures should be taken to ensure the proper restart of programs interrupted after a voltage dip or failure. This should not cause dangerous operating states even for a short time. If necessary, an emergency stop must be carried out.
- ► Wherever faults in the automation system may cause personal injuries or damage to property, external measures must be implemented to ensure a safe operating state in the event of a fault or malfunction (e.g. by means of separate limit switches, mechanical interlocks etc.)
- ► The electrical installation must be carried out in accordance with the relevant regulations (e.g. with regard to cable cross-sections, fuses, PE).
- ► All work relating to transport, installation, commissioning and maintenance must only be carried out by qualified personnel. (IEC 60 364 or HD 384 or DIN VDE 0100 and national work safety regulations have to be observed).
- ► All shrouds and doors must be kept closed during operation.

3 Documentation

This documentation relates to the hardware and firmware status at the time of editing this manual. The features of the devices are continuously developed further and improved.

The documentation applies to firmware version v2.2.x.x or higher.

4 Functions and features

The device has been designed for use within an EtherCAT network and designed for use without a control cabinet in plant construction. It enables the operation of up to eight IO-Link sensors/actuators and is also used to acquire digital signals.

5 Product description

5.1 DI (digital input)

The digital inputs receive the digital control signals from the process level. These signals are transferred to the higher-level automation device via the network/bus. The signal status is indicated via LEDs. The sensors are connected via M12 screw connectors. The sensors are supplied from the sensor voltage U_S.

5.2 IOL (IO-Link port)

These devices have IO-Link ports for communication-capable sensors so that the automation device can make dynamic changes to the sensor parameters directly.

The IO-Link ports can be operated in the following operating modes:

- DI (behaves like a digital input supplied via U_S)
- DO (behaves like a digital output supplied via U_S)
- IO-Link (IOL sensor supplied via U_S / IOL actuator supplied via U_S and U_A)

5.3 Connections

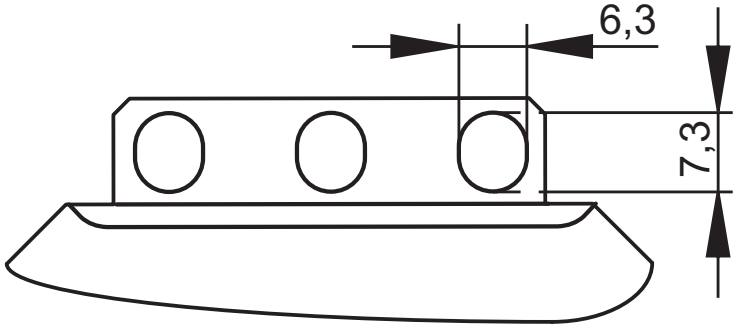
The bus, I/O devices and supply are connected via M12 screw connections. Each device is connected directly to the network/bus system.

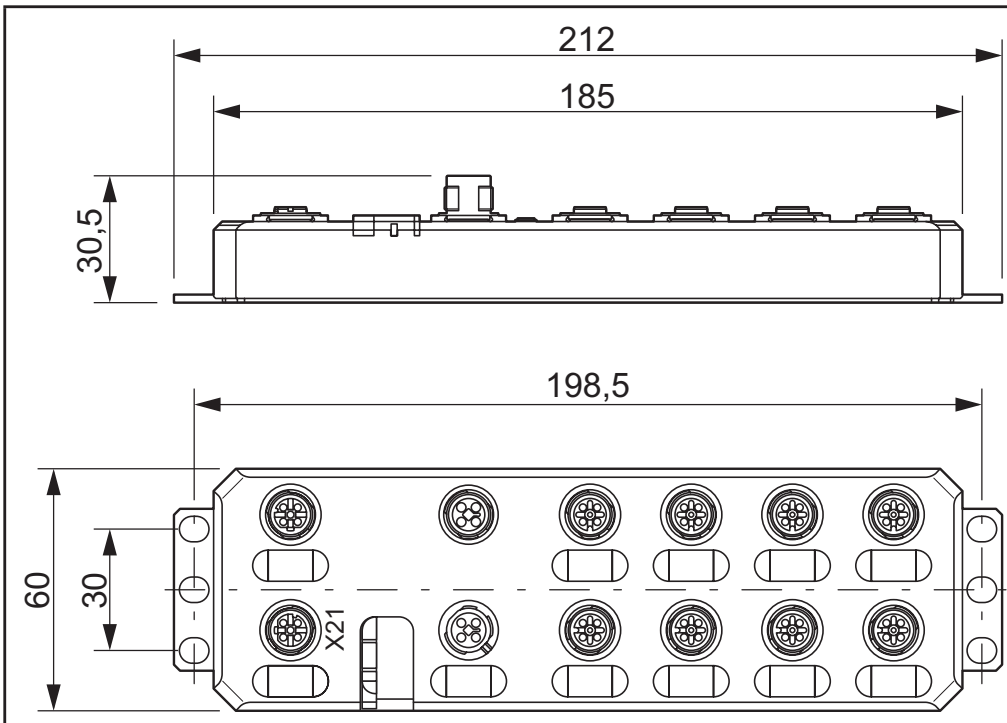
5.4 Protection rating

The devices have IP65/67 protection rating. To ensure IP65 / IP67 protection, cover unused sockets with protective caps.

6 Scale drawings

6.1 Dimensions of the screw holes in the fixing clips

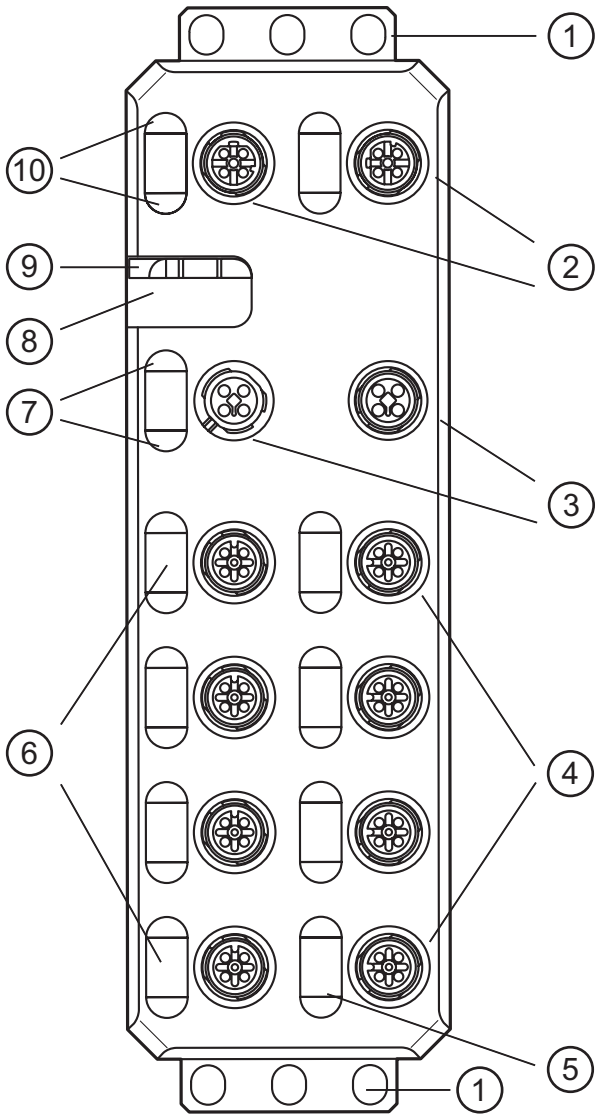




Scale drawing AL1030

The fixing clips are firmly mounted.

7 Structure of the device



1. Fixing clips (FE connection)
2. Network or bus connection (IN, OUT)
3. Connections for the supply voltages
4. Connections for inputs/outputs or IO-Link ports
5. Markers for labelling
6. Status indicators of the inputs/outputs or the IO-Link ports
7. Diagnostics and status indication for the supply voltages
8. Rotary coding switch (no function for ProfiNet)
9. Diagnostics and status indicators for the network / bus system
10. Diagnostics and status indicators for the network (not for Profibus)

8 Electrical connection

For the devices, a distinction is made between two voltages:

- U_S to supply the communications power and the sensors (always required),
- U_A for supplying the actuators, only required for devices with fixed outputs or for additional devices.

All supply voltages are connected via M12 connectors.

Damage to the electronics

► Connect both supply voltages completely (to +24 V and GND).
Do not connect several supply voltages via one GND, as this will exceed the current rating of the contacts.

8.1 Supply voltages U_S and U_A

The voltages U_S and U_A are fed in at connection X31.

Power supply U_S is required to supply the communications power of the device electronics and to supply the sensors. It must be connected to every device. If this supply voltage is disconnected, the device will not work.

► Install the power supply for the device electronics independently of the power supply for the actuators.

► Protect the power supplies independently.

> This means that the bus can continue running even if some I/O devices are switched off.

8.2 Power supply U_S

► Connect power supply Usfor the logic and sensors to socket X31.

► To supply additional devices, connect the cable for the outgoing supply voltage to socket X32.

Damage to the electronics

The current rating of the M12 connectors is 12 A per contact.
Make sure that this value is not exceeded. Please note that the connection for the outgoing supply voltage is not monitored for overload. If the permissible current rating is exceeded, this may result in damage to the connectors.

8.3 Power supply U_A

The voltage supply U_A is only required for the supply of the IO-Link actuators. IO-Link port in the operating mode DO is supplied via U_S.

Damage to the electronics

Power supplies U_S and U_A should only be supplied with SELV.

8.4 Diagnostic and status indicators

8.4.1 Diagnostics

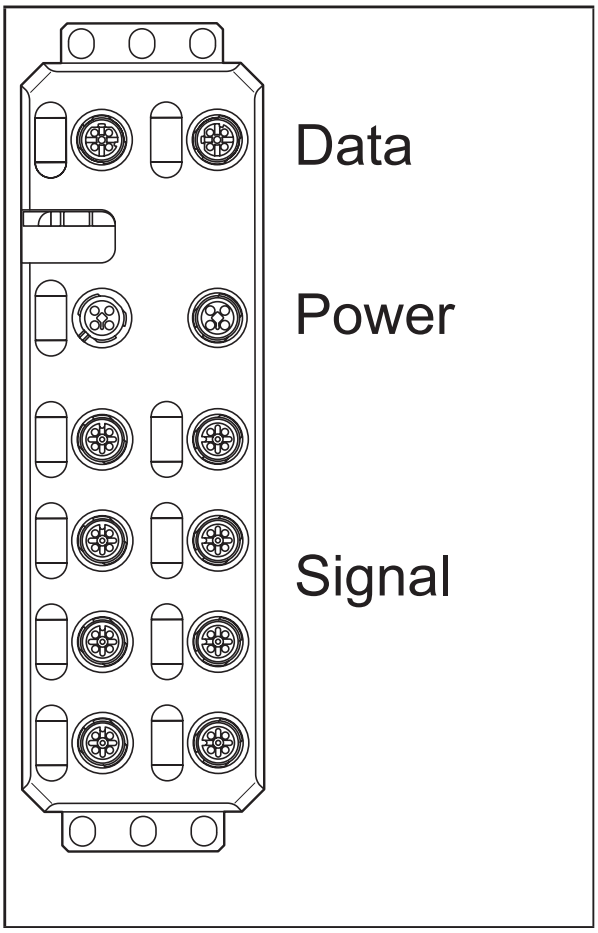
The diagnostic indicators (green/yellow/red) indicate whether an error is present or not. In case of an error, they indicate the error type and location. The device is operating correctly if all green indicators are on.

8.4.2 Status

The status indicators (yellow) indicate the signal state of the corresponding input/output or of the IO-Link port. If the yellow status indicators are on, this indicates signal state “1” of the input/output signal.

The devices have three main areas for diagnostics and status indicators.

- Indicators for the network/bus system (network/bus-specific) - Data
- Indicators for the power supplies - Power
- Indicators for the inputs and outputs and the IO-Link ports (device-specific) - Signal



9 Installation

When preparing for cable installation, the local conditions and the corresponding mounting regulations are very important. Cables can be installed, for example, in cable ducts or on cable bridges.

Data corruption and loss

A minimum distance between the cabling and possible sources of interference (e.g., machines, welding equipment, power lines) is defined in the applicable regulations and standards. During system planning and installation, these regulations and standards must be taken into account and observed.

Protect the bus cables from sources of electric/magnetic interference and mechanical strain.

Observe the following guidelines regarding “electromagnetic compatibility” (EMC) to keep mechanical risks and interference to a minimum.

9.1 Mechanical strain

- ► Choose the correct cable type for the respective application (e.g., indoor or outdoor installation, drag chains).
- ► Observe the minimum bending radius.
- ► Make sure that cables do not enter the shear area of moving machine parts.
- ► Do not install bus cables at right angles to driving routes and machine movements.
- ► Use cable ducts and cable bridges.

► Observe the specifications of the cables used.

9.2 Sources of interference

Signal cables and power supply lines should not be installed in parallel.

- ► If necessary, metal isolating segments should be placed between the power supply lines and signal cables.
- ► Only use connectors with metal housing and connect as much of the shielding as possible to the housing.
- ► For outdoor cables between buildings, make sure that grounding is carried out in accordance with “Installing network/bus cables between buildings”.
- ► During installation, all connector locking mechanisms (screws, union nuts) must be firmly tightened in order to ensure the best possible contact between shielding and ground. Before initial startup, the ground or shielding connection of cables must be checked for low-resistance continuity.

9.3 Cable routing in control cabinets

- ► Install network/bus cables in separate cable ducts or separate cable bundles.
- ► Where possible, do not install network/bus cables parallel to power supply lines.

► Install network/bus cables at least 10 cm away from power lines.

9.4 Cable routing in buildings

► Where possible, use metal cable hangers.

► Do not install network/bus cables together with or parallel to power supply lines.

► Separate network/bus cables on cable bridges or in cable ducts from power supply lines using isolating segments.

► Install network/bus cables as far away as possible from sources of interference, such as motors and welding equipment.

► For long cable connections, install an additional equipotential bonding line between the terminal points.

9.5 Cable routing outside buildings

► Install network/bus cables in metal pipes that are grounded on both sides or in concrete cable ducts with continuous reinforcement.

► For long cable connections, install an additional equipotential bonding line between the terminal points.

9.6 Installing network/bus cables between buildings

9.6.1 Causes of surge voltages

Surge voltages occur as a result of switching operations, electrostatic discharge, and lightning discharge. Surge voltages can be inductively, capacitively or galvanically coupled into electrical cables for mains supply, measured value transmission, and data transmission. In this way, surge voltages reach the power supply units and the interfaces of systems and devices.

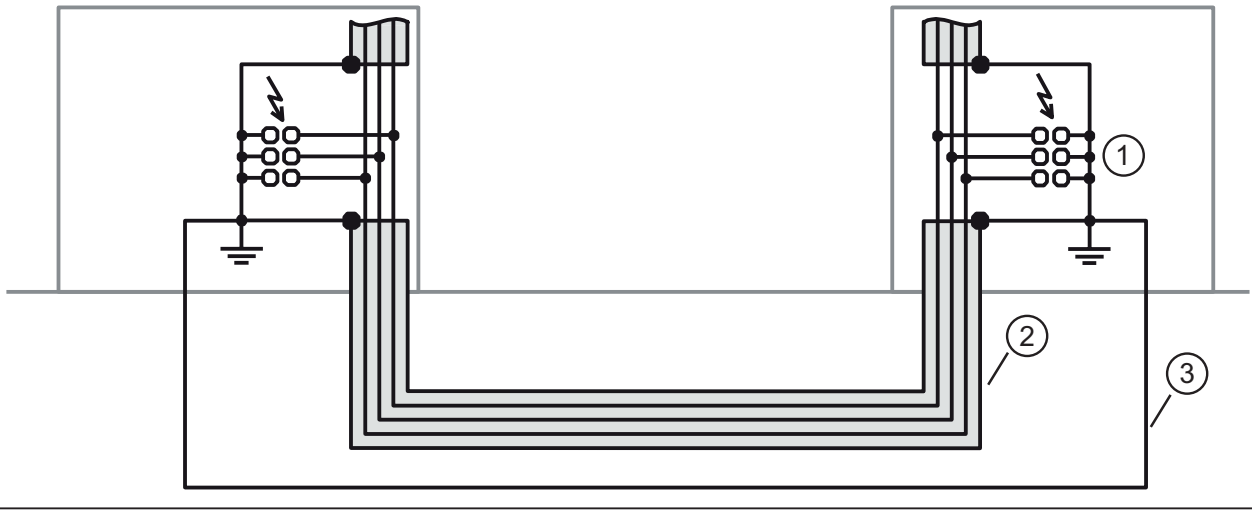
9.6.2 Equipotential bonding line

Install an additional equipotential bonding line between the grounding points of buildings, preferably in the form of

- a metal-reinforced concrete channel,
- an additional grounding cable or
- a metal pipe.

9.6.3 Surge protective devices

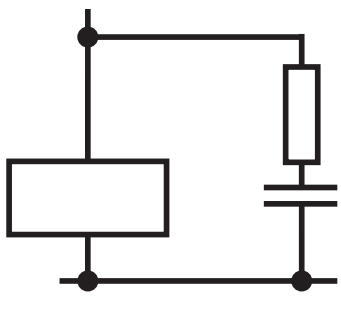
ifm recommends wiring all the wires of the cable to surge protective devices in order to protect the devices against surge voltages.
Observe all national and international regulations when installing surge protective devices.



1. Surge protective devices
2. Cable shielding
3. Equipotential bonding line

9.7 Surge protection measures

ifm recommends wiring relay coils or motor coils to an RC element in order to protect the devices against interference. Depending on the application, the delay time of the relay can be increased by approximately 1 ms.



Relay coil with RC element

For the dimensioning of the RC element, the following values are recommended:

R = 100...200 Ω /
C = 220...470 nF

9.8 Grounding concept

The devices operate in the low-level signal voltage range. In the case of low-level signal devices, interference is discharged via functional earth (FE). Functional earth (FE) is only used to discharge interference. It does not provide shock protection for people.

Functional grounding

The devices are designed to be screwed onto a flat mounting surface.

► Ground the devices by means of the mounting screws of the fixing clips.

9.9 Installation instructions

Electrostatic discharge

The device contains components that can be damaged or destroyed by electrostatic discharge. When handling the device, observe the necessary safety precautions against electrostatic discharge (ESD) according to EN 61340-5-1 and IEC 61340-5-1.

Damage to the electronics

► The device may only be installed and removed by qualified electricians in accordance with the ESD regulations.
► Implement the FE connection using mounting screws, in order to ensure immunity to interference.
► To ensure IP65/IP67 protection, cover unused connections with protective caps.
► Only supply the sensors with the voltage U_S which is provided at the terminal points.
► Avoid polarity reversal of supply voltages U_S and U_A.

Data corruption or loss

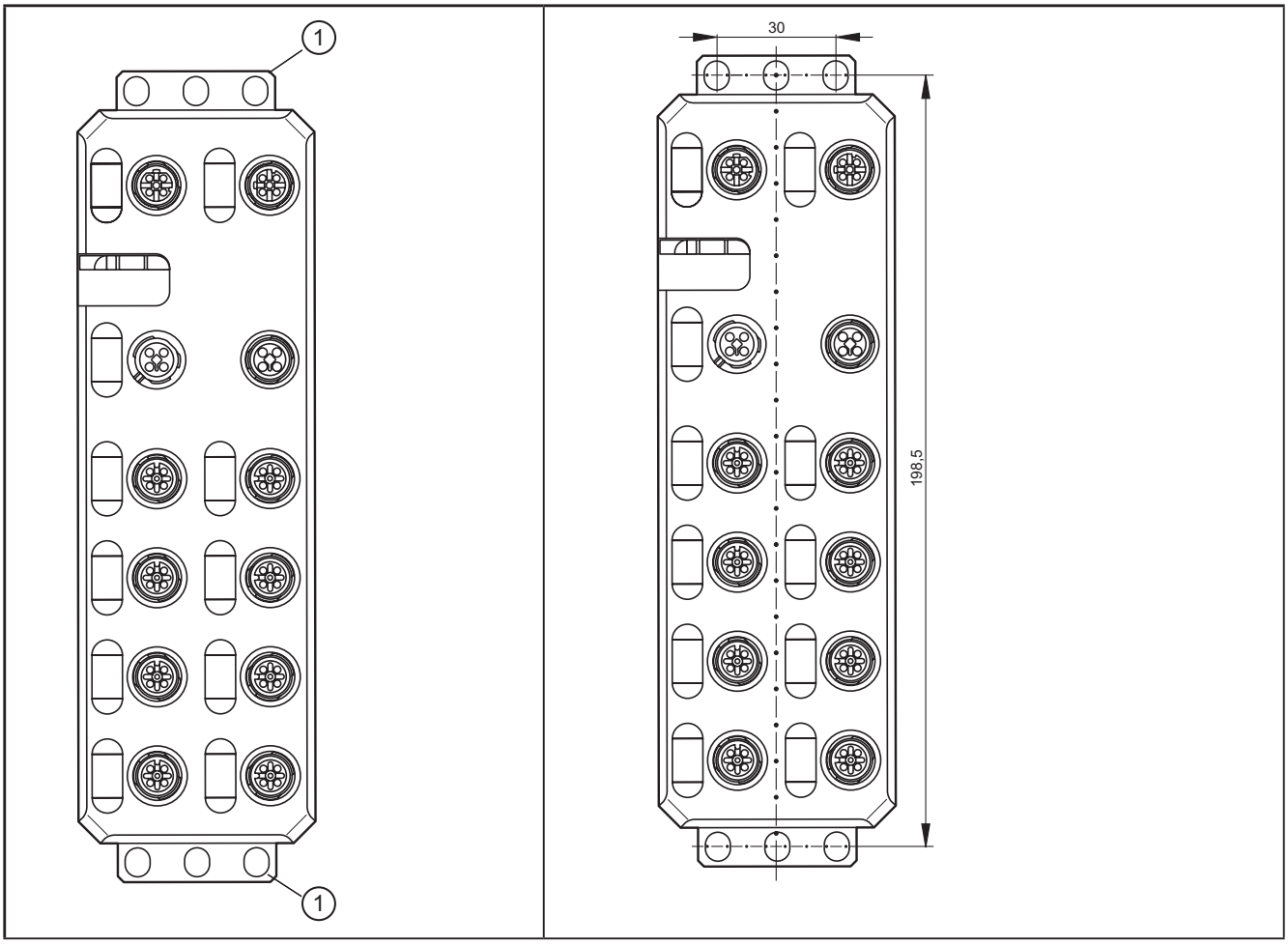
► Implement the FE connection using mounting screws, in order to ensure immunity to interference.

9.10 Mounting distances

No specific distances are required between devices or between a device and a cabinet door or cover. Mounting distances are determined solely by the plugs used and the bending radii of the cables.

9.11 Mounting dimensions

► Screw the device directly onto the flat mounting surface using the drill holes (1) of the fixing clips.



► Use standard M5 screws with toothed lock washer and self-locking nuts.
► Observe the maximum torque of the screws.

Functional grounding

► Functional grounding is crucial for interference-free operation. Ground the device by means of the mounting screws of the fixing clips.

10 Features

10.1 EtherCat characteristics

- Connection to the EtherCAT network using M12 connectors (D-coded)
- 2 Ethernet ports
- Transmission rate 100 MBit/s
- Support of the EtherCat cycle time of min. 100 µs
- Automatic addressing

- Identification
  - Encoding switch for creation of the ID for the "Explicit Device ID" mechanism
  - Configured Second Station Alias
- Hot Connect
- Acyclic data communication (mailbox protocols CoE, FoE, EoE and AoE)
- Device description through ESI
- Firmware that can be updated
- Specification: ETG.1000 V1.02, ETG.5001.3 (Annex K)
  - Represented as modular EtherCat device via Modular Device Profile (MDP)
- Integrated web server for web-based management
- Connection of four IO-Link devices with additional digital input
- Connection of four IO-Link actuators with additional voltage supply
- Connection of IO-Link ports using M12 connectors (A-coded, 5-pos.)
- Diagnostic and status indicators
- Short-circuit and overload protection of the sensor supply
- Protection rating IP65/67

10.2 IO-Link features

- Connection of eight IO-Link devices
  - 4 type A ports with an additional digital input
  - 4 type B ports with an additional voltage supply
- Connection of IO-Link ports using M12 connectors (A-coded, 5-pos.)
- Parameter setting of devices via the AoE protocol
- Parameter data on the master
- Configurable process data
- IO-Link specification v1.1

10.3 General features

- Diagnostic and status indicators
- Short-circuit and overload protection of the sensor supply
- Protection rating IP65/67

11 Technical data

General data	
Housing material	Pocan
Weight [kg]	0.48
Ambient temperature (operation) [°C]	-25 ...60
Ambient temperature (storage/transport) [°C]	-25...85
Permissible humidity (operation) [%]	5...95
Air pressure (operation) [kPa]	70...106 (up to 3000 m above sea level)
Air pressure (storage/transport) [kPa]	70...106 (up to 3000 m above sea level)
Protection rating	IP65 / IP67
Protection class	III, IEC 61140, EN 61140, VDE 0140-1
Connection data	
Connection type	M12 connector
EtherCAT interface	
Number	2
Connection type	M12 connectors, D-coded
Designation connection point	Copper cable
Number of positions	4
Transmission rate [MBits/s]	10/100 (with auto-negotiation)
Cycle time [µs]	< 100
EtherCAT	
Type of unit	EtherCat slave
Mailbox protocols	CANopen over EtherCat, File access over EtherCat
Type of addressing	Auto-increment addressing Fixed position addressing Logical addressing
Specification	ETG.1000 V1.02
Supply of the module electronics and the sensors (U_S)	
Connection type	M12 connector (T-coded)
Number of positions	4
Designation	U_S
Supply voltage [V]	24 DC
Nominal supply voltage range [V]	19...31.2 DC (including all tolerances, including ripple)
Typical current consumption [mA]	180 ±15 % (at 24 V DC)

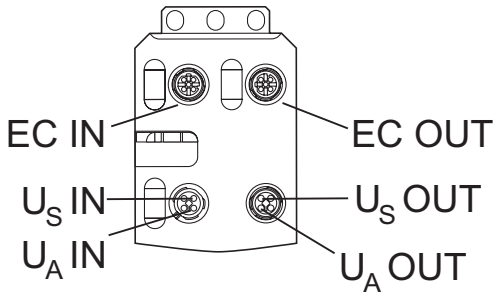
Max. current consumption [A]	12
Supply of the actuators	
Connection type	M12 connector (T-coded)
Number of positions	4
Designation	U_A
Supply voltage [V]	24 DC
Nominal supply voltage range [V]	18...31.2 DC (including all tolerances, including ripple)
Typical current consumption [mA]	28 ±15 % (at 24 V DC)
Max. current consumption [A]	12
Supply of the IO-Link ports	
Peripheral supply voltage [V]	24 DC
Nominal current for every IO-Link port [mA]	200 (short-term during start-up up to 1.6 A)
Nominal current for each device [A]	1.6
Overload protection	electronic in the unit
Permissible conductor length to the sensor [m]	< 20
IO-Link ports in the digital input mode (DI)	
Number of inputs	max. 8 (EN 61131-2 type 1)
Connection type	M12 connector, X01 ... X04 double occupancy
Connection technology	2 / 3 wires
Nominal input voltage [V]	24 DC
Nominal input current [mA]	typ. 3
Sensor current [mA]	max. 200 for each channel from L+/L-
Total current consumption [A]	max. 1.6 from L+/L-
Input voltage range "0" signal [V]	-3...5 DC
Input voltage range "1" signal [V]	15...30 DC
Input filter time [µs]	< 1000
Overload protection, short-circuit protection of sensor supply	electronic
IO-Link ports in the digital output mode (DO)	
Number of outputs	Max. 8
Connection type	M12 connector, X01 ... X04 double occupancy
Connection technology	2 / 3 wire
Nominal output voltage [V]	24 DC

Output current for each channel [mA]	200
Output current for each device [A]	1.6
Nominal load, ohmic [W]	12 (48 Ω; with nominal voltage)
inductive nominal load [VA]	12 (1.2 H; 12 Ω; with nominal voltage)
Signal delay [µs]	Max. 150 (at power on)
Signal delay [µs]	Max. 200 (at power off)
Switching frequency	max. 5500 per second (with load current)
Switching frequency	max. 1 per second (with inductive nominal load)
Limitation of the voltage induced on circuit interruption [V]	-15 DC
Output voltage when switched off [V]	max. 1
Output current when switched off [µA]	max. 300
Behaviour with overload	Switching off with automatic restart
Overload protection, short-circuit protection of the outputs	electronic
Digital inputs on pin 2 with type A ports	
Number of inputs	4 (EN 61131-2 type 1)
Connection type	M12 connector, X01 ... X04 double occupancy
Connection technology	2 / 3 wire
Nominal input voltage [V]	24 DC
Nominal input current [mA]	typ. 3
Sensor current [mA]	Max. 200 for each channel from L+/L-
Total current consumption [A]	Max. 1.6 from L+/L-
Input voltage range "0" signal [V]	-3...5 DC
Input voltage range "1" signal [V]	15...30 DC
Input filter time [µs]	< 1000
Overload protection, short-circuit protection of sensor supply	electronic
Potential isolation/isolation of the voltage ranges	**Test voltage**
24 V supply (communications power and sensor supply, IO-Link ports)/bus connection (Ethernet 1) [V]	500 AC, 50 Hz, 1 min
24 V supply (communications power and sensor supply, IO-Link ports)/bus connection (Ethernet 2) [V]	500 AC, 50 Hz, 1 min
24 V supply (communications power and sensor supply, IO-Link ports)/FE	500 AC, 50 Hz, 1 min
Bus connection (Ethernet 1) / FE [V]	500 AC, 50 Hz, 1 min
Bus connection (Ethernet 2) / FE [V]	500 AC, 50 Hz, 1 min
Bus connection (Ethernet 1) / bus connection (Ethernet 2) [V]	500 AC, 50 Hz, 1 min

24 V-supply (actuator supply) / 24 V supply (communications power and sensor supply, IO-Link ports) [V]	500 AC, 50 Hz, 1 min
24 V supply (actuator supply)/bus connection (Ethernet 1) [V]	500 AC, 50 Hz, 1 min
24 V supply (actuator supply)/bus connection (Ethernet 2) [V]	500 AC, 50 Hz, 1 min
24 V supply (actuator supply)/FE [V]	500 AC, 50 Hz, 1 min
Mechanical tests	
Vibration resistance in accordance with EN 60068-2-6/IEC 60068-2-6 [g]	5
Shock in accordance with EN 60068-2-27/IEC 60068-2-27 [g]	30, 11 ms duration, half-sine shock pulse
Continuous shock according to EN 60068-2-27/IEC 60068-2-27 [g]	10
Conformity with the EMC Directive 2004/108/EG	
Noise immunity test in accordance with EN 61000-6-2	
Electrostatic discharge (ESD) EN 61000-4-2/IEC 61000-4-2	Criterion B; 6 kV contact discharge; 8 kV air discharge
Electromagnetic fields EN 61000-4-3/IEC 61000-4-3	Criterion A; field intensity: 10 V/m
Fast transients (burst) EN 61000-4-4/IEC 61000-4-4	Criterion B, 2 kV
Transient surge voltage (surge) EN 61000-4-5/IEC 61000-4-5	Criterion B; Supply cables DC: ±0.5 kV / ±0.5 kV (symmetric / asymmetric)
Conducted interference EN 61000-4-6/IEC 61000-4-6	Criterion A; Test voltage 10 V
Noise emission test according to EN 61000-6-4	
Radio interference properties EN 55022	Class A
Approvals	at www.ifm.com

12 Connections

12.1 EtherCat and power supply connection



EC IN (X21): EtherCat IN
EC OUT (X22): EtherCat OUT
U_S IN (X31): Power supply IN (logic and sensors)
U_A IN (X31): Power supply IN (IO-Link actuators)
U_S OUT (X32): Power supply OUT (logic and sensors) for further devices)
U_A OUT (X32): Power supply OUT (actuators) for further devices

► Implement the FE connection using mounting screws.

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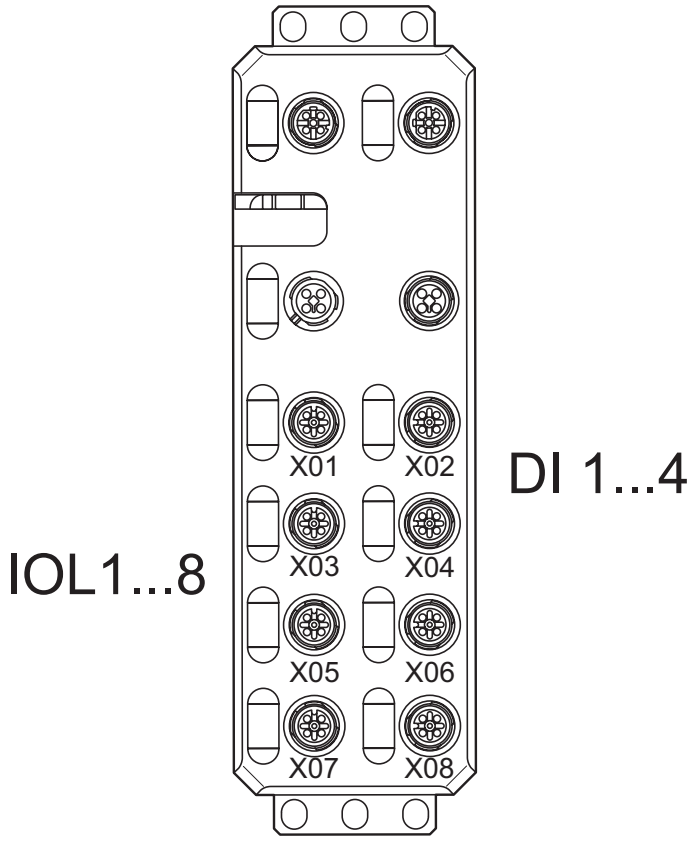
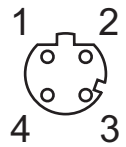
12.2 Connecting IO Link ports and digital inputs



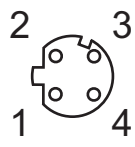
IO-Link 1...8 (X01...X08): IO-Link ports 1...8
DI1...DI4 (X01...X04): Inputs 1...4

► Implement the FE connection using mounting screws.

12.3 Pin connection EtherCat



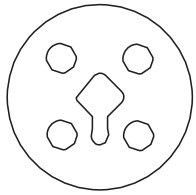
EC IN (X21)
1: TX +
2: RX +
3: TX -
4: RX -



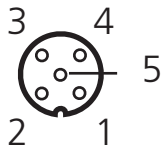
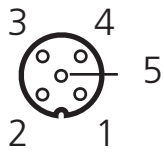
EC OUT (X22)
1: TX +
2: RX +
3: TX -
4: RX -

The shield is connected to FE in the device. The thread is used for additional shielding.

12.4 Pin connection voltage supply U_S/U_A

	IN X31 1: + 24 V DC (US) brown 2: GND (UA) white 3: GND (US) blue 4: + 24 V DC (UA) black		OUT X32 1: + 24 V DC (US) brown 2: GND (UA) white 3: GND (US) blue 4: + 24 V DC (UA) black
Pin assignment of the power supply, T-coded			

12.5 Pin connection of the inputs and IO-Link ports

	IO-Link A ports (X01...X04) 1: 24 V DC (L+) 2: DI 3: GND (L-) 4: C/Q IO-Link data transmission channel 5: not used		IO-Link B ports (X05...X08) 1: 24 V DC (L+) 2: 24 V DC (U_A) 3: GND (L-) 4: C/Q IO-Link data transmission channel 5: GND (UA)

12.5.1 Port class A (type A)

The IO-Link port according to type A is assigned an additional hardwired DI (digital input) at pin 2.

12.5.2 Port class B (type B)

The IO-Link port according to type B has an additional supply voltage via pins 2 and 5. This port is designed to connect devices with a higher current requirement.

12.6 Operating modes

The C/Q cable (pin 4) can be configured independently of the other pins. The IO-Link ports can be operated in the following operating modes:

- DI (behaves like a digital input supplied via U_S)
- DO (behaves like a digital output supplied via U_S)
- IO-Link (IOL sensor supplied via U_S / IOL actuator supplied via U_S and U_A)

12.7 Wiring information

Ensure the FE connection using mounting screws, in order to ensure immunity to interference.

To ensure IP65 / IP67 protection, cover unused sockets with protective caps.

Only supply the IO-Link master and the IO-Link devices with the voltage U_S and U_A provided at the terminal points.

Observe the correct polarity of the supply voltages U_S and U_A in order to prevent damage to the device.

When connecting the sensors and actuators, observe the assignment of the connections.

Fix the device to a level surface or to a profile. Do not use this device to bridge gaps in order to prevent forces being transmitted via the device.

Use standard M5 screws with toothed lock washer and self-locking nuts. Observe the maximum torque of the screws.

13 Identification

With EtherCat devices, there is a differentiation between address assignment and identification.

Addresses are used for direct communication between EtherCat master and the corresponding slave. In this context, each master assigns a unique 16 bit address to each slave.

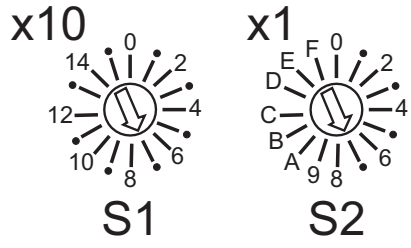
Identifications are used to clearly identify a slave in an EtherCat network.

Identifications for IO-Link masters are:

– Device Identification Value
– Configured Second Station Alias

14 Configuration via rotary encoding switch

You can configure the address assignment and other functions using rotary encoding switches.



S1 (x10)	S2 (x1)

▶ After modifying the switch position, restart the device. A modification to the switch position does not take effect during operation.

The code results from the sum of S1 x 10 plus S2 x 1. The figure shows the code 77 (7 x 10 + 7).

S1	S2	Code	Function
0...15	0...09	01...159	Device Identification Value
Others			Reserved

Switch positions 01...159

With this switch position, the EtherCAT® Explicit Device Identification is set manually.

After power-on, the device is ready for operation as soon as the LED RDY lights green. A connection to the device can, however, not be established in this switch position.

As soon as the RDY LED lights green, a new switch position can be selected on the rotary encoding switch and the device can be restarted.

14.1 Reserved/invalid switch position

The device starts with the previous settings, e.g. with the settings that were valid before the device was restarted.

14.2 Configured Second Station Alias

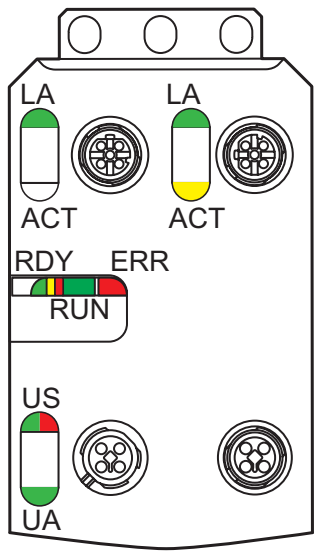
For information about the use of the "Configured Second Station Alias" identification, please refer to your project planning software.

14.3 Hot Connect

The Hot Connect functionality makes it possible to remove or add re-configured sections from the data traffic before the start or during operation. This can be done e.g. by disconnecting/connecting the communication line or by switching the participant on/off. This functionality is called "flexible topology" or "Hot Connect".

15 Local static and diagnostic displays

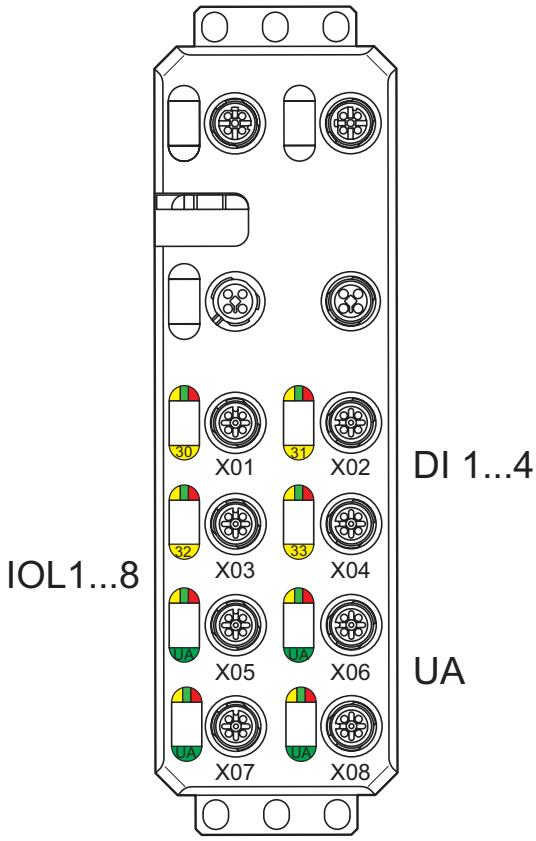
15.1 Displays for Ethernet ports and voltage supply



Description	Colour	Descrip-tion	Status	Description
L/A	green	Link / Activity	Green ON	Connection to EC IN / EC OUT established.
			Green OFF	Connection to EC IN / EC OUT not established.

Description	Colour	Descrip-tion	Status	Description
RDY	Green/ yellow/ red	Ready	Green ON	Unit is ready for operation.
			Yellow flashes	Firmware update is being performed
			Green/ yellow flashes	Overvoltage or undervoltage at U_S
				Temperature of the device is in the critical area
				Failure of the actuator supply U_A
				and U_S LED red: sensor supply overload
			Red ON	Rotary encoding switches are set to an invalid/reserved position.
			Off	Device is not ready for operation
RUN	Green	RUN	Off	Device is in the state Init
			Flashes slowly (2.5 Hz)	The device is in the pre-operational state
			Single pulse	200 ms on, 1000 ms off, device is in the safe-operational state
			Green ON	The device is in the operational state.
			Flashes (10 Hz)	Device is in the bootstrap state.
ERR	Red	Error	On	Critical error in the device
			Flashes slowly (2.5 Hz)	Configuration error, a state transition initiated by the master cannot be executed
			Single pulse	Local application error
			Double pulse	Watchdog timeout The EtherCAT® watchdog for monitoring of the process data has expired
			Off	no fault
US	Green/red	$U_{sensors}$	Green ON	Communications power/sensor voltage present.
			Off	Communications power/sensor voltage not present or too low.
			Red ON	Sensor voltage overloaded
UA	green	$U_{actuators}$	On	Actuator voltage is sufficient
			Off	Actuator voltage not present or too low

15.2 Displaying the IO-Link ports and inputs



Description	Colour	Description	Status	Description
IO-Link LED	Green / yellow / red	Status of the IO-Link ports (X01 ... X08)	Green ON	IO-Link communication is active
			Green flashes	IO-Link communication is not available
			Yellow ON	In the SIO mode, the digital input or output is set
			Red ON	In IO-Link mode IO-Link communication error
			Red ON	In IO-Link mode Overload of the L+/L- cable
			Red ON	In SIO mode Overload of the L+/L- cable
			Red ON	Overload of the C/Q cable
			Off	In the SIO mode, the digital input or output is not set.
30 ... 33	Yellow	Status of the digital inputs	Yellow ON	Input is set
			Yellow OFF	Input is not set.
UA	Green/red	Actuator supply for X05 ... X08	Green ON	Actuator voltage is sufficient
			Green OFF	Actuator voltage not present or too low
			Red ON	Short circuit between pin 2 and pin 5

The numbering of the LEDs is as follows:
the first number specifies the byte, the second number specifies the bit.

16 EtherCAT

The mailbox protocol CAN application layer over EtherCat (CoE) constitutes the foundation of the "Device Profile" and permits parameter setting of EtherCat devices via the object directory. Access to the object directory via CoE takes place through Service Data Object (SDO) Services.

For a description of the object implemented on the device, please refer to the chapter "EtherCat object directory".

17 EtherCat Modular Device Profile (MDP)

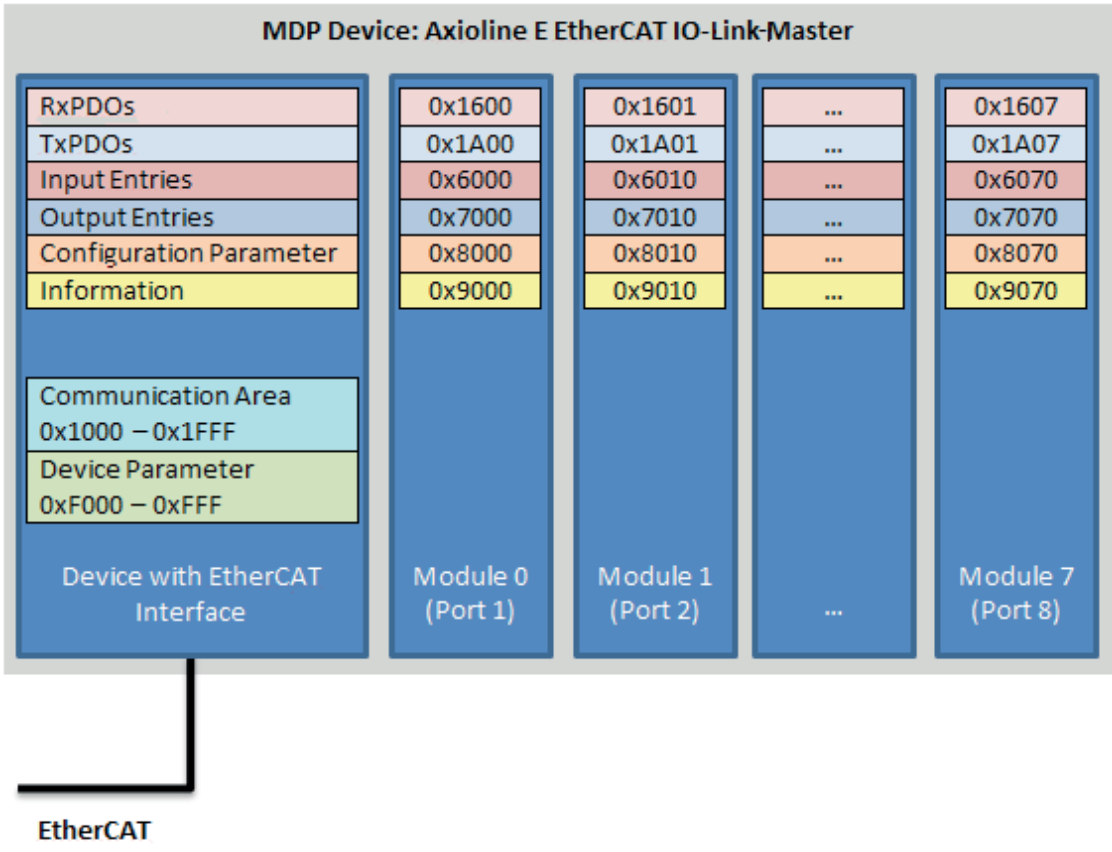
The device functions on the basis of the "Modular Device Profile" (ETG.5001) and is specified as profile implementation "5001" (Modular Device Profile).

It basically follows specification ETG.5001.3 Annex K (IO-Link master) and corresponds functionally with the "Modular Device Profile 6220".
In contrast to ETG.5001.3 Annex K, which envisages synchronisation of the status machine of the EtherCat slave with the status machine of the IO-Link master, conflicts between the states of the two status machines with the own fail-safe mechanism are absorbed with the own fail-safe mechanism (EtherCat slave is switched in PRE-OP).

The mailbox protocol "CAN application layer over EtherCat (CoE)" constitutes the foundation of the Modular Device Profile (MDP) and permits parameter setting of EtherCat devices via the object directory.

Access to the object directory via COE takes place through Service Data Object Services (SDO). The objects implemented on the device are described in chapter "EtherCat object directory".

In this context, the structural context of the device is as follows:



18 EtherCat State Machine

The device is provided with a state machine, the EtherCat State Machine (ESM). The EtherCat master sends requests about status changes to the AL Control Register of the slave. The slave shows the current state in the AL Status Register and provides continuing error codes in the AL Status Code Register.

18.1 AL Control and AL Status Register

If the master writes on the AL Control Register, the corresponding state transition is triggered by the slave in the device state machine. In this context, the AL Status Register mirrors the current status of the slave.

Index (hex)	Object name	Data type	Rights	Description/value	
0120	AL Control	UINT16	R/W	Bit 0...bit 3	State (AL status requested by master)
					01_{hex} = Init (I)
					02_{hex} = Pre-Operational (P)
					03_{hex} = Bootstrap (B)
					04_{hex} = Safe-Operational (S)
					08_{hex} = Operational (O)
				Bit 4	Acknowledge (master acknowledge bit)
					00_{hex} = Parameter Change of the AL Status Register will be unchanged.
					01_{hex} = Parameter Change of the AL Status Register will be reset.
				Bit 5...bit 7	Reserved
					00_{hex} = Shall be zero
0130	AL Status	UINT16	RO	Bit 0...Bit 3	AL Status (AL status requested by master)
					01_{hex} = Init (I)
					02_{hex} = Pre-Operational (P)
					03_{hex} = Bootstrap (B)
					04_{hex} = Safe-Operational (S)
					08_{hex} = Operational (O)
				Bit 4	Change (Error Flag, Master acknowledge bit)
					00_{hex} = Acknowledgement of state in AL Control Register
					01_{hex} = A change has happened or an error occurred.
				Bit 5...bit 7	Reserved
				Bit 8...bit 15	Application specific
					Reserved

18.2 AL Status Code Register

If the state transition required by the master is not possible, an error flag is set by the slave in the AL Status Register (bit 4) and an error code is written to the AL Status Code Register.

AL status code (hex)	Description	State or transition	Resulting state
0000	no error	Each	Current situation
0001	Unspecified error	Each	Each + E
0011	Invalid requested state change	I→S, I→O, P→O O→B, S→B	Current state + E
0012	Unknown requested state	Each	Current state + E
0015	Invalid Mailbox Configuration for Bootstrap	I→B	I + E
0017	Invalid Sync Manager Configuration	P→S, S→O	Current state + E
001B	Sync Manager Watchdog	O, S	S + E
001D	Invalid output configuration	O, S P→S	S + E P + E
001E	Invalid input configuration	O, S, P→S	P + E

19 EtherCat communication methods

The EtherCat protocol offers two methods of communication:

- Mailbox method
- Buffered method.

The mailbox method is used to send acyclic commands to slaves. If a slave receives a mailbox message, this message must first be processes before anything else can be processed.

The buffered method, however, makes it possible both for master and slave to use a shared data area. The data in this area (buffer) can be written or read by both at any time.

The Sync Managers manage the data exchange for both methods to avoid data collisions. A detailed description of all Sync Managers is available in the description "EtherCat Slave Controller" of the EtherCat user organisation (www.EtherCat.org).

20 EtherCAT synchronisation

To synchronise the application, there are two modes you can select in the engineering system.

- FreeRun
  (process data update by means of a device-internal application cycle)
- SM Synchronous (process data update in case of an SM event)

20.1 FreeRun

In this mode, the EtherCat communication system and the I/Os work asynchronously. The I/Os are in the auto run state and are running with the minimum cycle time possible for the current module configuration. This mode is set by default in the device

20.2 SM Synchronous

In this mode, the EtherCat communication system and the I/Os function asynchronously. With each Sync Manager Event (bus cycle), the IOs are exchanged between the EtherCat bus and the device.
It is possible to synchronise on the SM2 (Sync Manager for data from the master to the slave) or on the SM3 (Sync Manager for data from the slave to the master). If the device is configured for input and output data, it makes sense to use the SM2.

If only input data is configured (data from the slave to the master), synchronisation can also take place on the SM3.
The setting must be written in the PRE-Operational state into the Subobject1 of the objects $1C12_{hex}$ (SM2) and $1C13_{hex}$ (SM3).

Recommended setting: $1C12_{hex}$: 1 = 01_{hex} and $1C13_{hex}$: 1 = 22_{hex}

Detailed information about this can be found in the specification ETG1020.

In order to make sure that the parameters do not need to be set again and again in the object directory, they can be set in the start-up parameters.

21 EtherCat object directory (CoE objects)

The object directory of the device contains objects that can be addressed via the SDO services. The device supports standard objects and manufacturer-specific objects. The standard objects are described in the ETG status ETG.1000.6 (Application Layer Protocol Specification).
It supports Modular Device Profiles - specific objects that are described in the ETG standard ETG.5001.3. At the same time, manufacturer-specific objects are supported that will be described in detail in the following.

The addressing of the objects is done via a combination of index and sub-index. Sub-index 0 indicates the number of sub-indexes or the number of the highest sub-index.

The following applies to the following tables:

Length = length of the elements in bytes
RO = read only
Rights = access rights
R/W = read and write

Index (hex)	Object name	Data type	Rights
Device Identity Objects (1)			
1000	Device type	UINT32	RO
1008	Manufacturer Device Name	STRING	RO
1009	Manufacturer Hardware Version	STRING	RO
100A	Manufacturer Software Version	STRING	RO
1018	Identity	IDENTITY	RO
Diagnosis Objects			
10F3	Diagnosis History	RECORD	RO
10F8	Timestamp Object	UINT64	RO
PDO Mapping Objects			
1600...1607	RxPDO Mapping IO-L Outputs Port 1…8	PDO mapping	R/W
1608	RxPDO Mapping IOLM_Control	PDO mapping	RO
1A01...1A07	TxPDO Mapping IO-L Inputs Port 1...8	PDO mapping	RW
1A08	New Message Available	PDO mapping	RO
1A09	Timestamp	PDO mapping	RO
1A81	TxPDO Mapping IOLS_Status	PDO mapping	RO
1A82	TxPDO Mapping IOLM_Status	PDO mapping	RO
1B02	TxPDO Alignment	PDO mapping	R/W
Sync Manager Objects			
1C00	Sync Manager Communication Type	UINT8	RO
1C10	Sync Manager 0 PDO Assignment (Mail Out control register)	UINT16	RO
1C11	Sync Manager 1 PDO Assignment (Mail IN control register)	UINT16	RO
1C12	Sync Manager 2 PDO Assignment (process data output control register)	UINT16	RW
1C13	Sync Manager 3 PDO Assignment (process data output control register)	UINT16	R/W
1C32	Sync Parameter of SM2	SYNC_PAR	R/W
1C33	Sync Parameter of SM3	SYNC_PAR	R/W

Index (hex)	Object name	Data type	Rights
Device Identity Objects (2)			
2001	Component Name	STRING	RO
2002	Vendor Name	STRING	RO
2003	Vendor URL	STRING	RO
2004	Order Number	STRING	RO
2005	Manufacturing Date	STRING	RO
2006	QS Date	STRING	RO
2007	Installation Location	STRING	R/W
2008	Operational Hours	UINT32	RO
2009	Service Date	STRING	RO
200A	Equipment Ident	STRING	R/W
Safe State Objects			
2100...2170	Safe State Mode IOL-Port 1 ... 8	UINT8	R/W
2180	Safe State Mode IOLM_Control (DO)	UINT8	R/W
2182	Safe State Values IOLM_Control (DO)	UINT8	R/W
IO-Link Port Parameter Objects			
2F00	IO-Link Parameter Port 1…8	RECORD	RO
Reset Object			
2F00	Reset to Factory Settings	UINT8	R/W
IO-Link Master Status & Control Objects			
3000	IOLM_Control	UINT8	RW
3001	IOLM_Status	UINT8	RO
IO-Link Process Data Objects			
6000...6070	IO-Link Inputs Port 1…8	STRING	RO
7000...7070	IO-Link Outputs Port 1…8	STRING	RO
IO-Link Configuration Objects (Expected Configuration of the IO-Link-Devices)			
8000...8070	IO-Link Configuration Data Port 1…8	RECORD	RO
IO-Link Information Objects (Detected Configuration of the IO-Link Devices)			
9000...9070	IO-Link Information Data Port 1…8	RECORD	RO
IO-Link Device Objects			
F000	Modular Device Profile	RECORD	RO
F020	Module Address List	UINT8	RO
F030	Configured Module Ident List	UINT32	R/W
F050	Detected Module Ident List	UINT32	RO
F100	IO-Link Port Status	UINT8	RO

22 CoE: type label

The device has objects to be identified. They contain information about the manufacturer and the device and constitute the type label.

In the following, the objects constituting the type label will be described.

Index (hex)	Subindex	Object name	Data type	Rights	Description / value
1000	-	Device type	UINT32	RO	5001 (Modular Device Profile)
1008	-	Manufacturer Device Name	STRING	RO	Product name
1009	-	Manufacturer Hardware version	STRING	RO	Hardware version, version ID
100A	-	Manufacturer Software version	STRING	RO	Firmware version, version ID
1018	Identity				
	00	Number of Entries	UINT8	RO	Number of sub-indexes of the object
	01	Vendor ID	UINT32	RO	00000084_{hex} (132)
	02	Product code	UINT32	RO	Article no.
	03	Revision number	UINT32	RO	Device revision, version ID
	04	Serial number	UINT32	RO	Serial number
2001	-	Component Name	STRING	RO	EtherCat IO-Link Gateway
2002	-	Vendor Name	STRING	RO	ifm
2003	-	Vendor URL	STRING	RO	www.ifm.com
2004	-	Order Number	STRING	RO	Article no.
2005	-	Manufacturing Date	STRING	RO	yyyy-mm-dd T hh:mm:ss Z (date and time of production)
2006	-	QS Date	STRING	RO	yyyy-mm-dd T hh:mm:ss Z (Date and time of final production test)
2007	-	Installation Location	STRING	R/W	User-defined installation location of the device
2008	-	Operational Hours	UINT32	RO	Operating hours counter
2009	-	Service Date	STRING	RO	yyyy-mm-dd T hh:mm:ss Z (date and time of a service)
200A	-	Equipment Ident	STRING	R/W	User-defined device name

23 CoE: IO-Link port configuration

The device design is based on the "Modular Device Profiles" (ETG.5001). There is a differentiation between modules and slots.

A module corresponds with the configuration of an IO-Link device with fixed process data lengths. The word "module" is a synonym for an IO-Link device.

A slot is an IO-Link port of the IO-Link master; the module is put into a slot.

Exactly one module and, thus, only one Rx/TxPDO can be assigned to each port of the IO-Link master. Only one data object (6000_{hex}, 7000_{hex}) can be assigned to a Rx/TxPDO. The data object consists of individual sub-objects.

The first sub-object of each object (subindex 01) always contains the size and number of the existing sub-objects. Each object can have a maximum size of 32 sub-indexes and, hence, 32 bytes. This corresponds with the maximum IO-Link process data length.

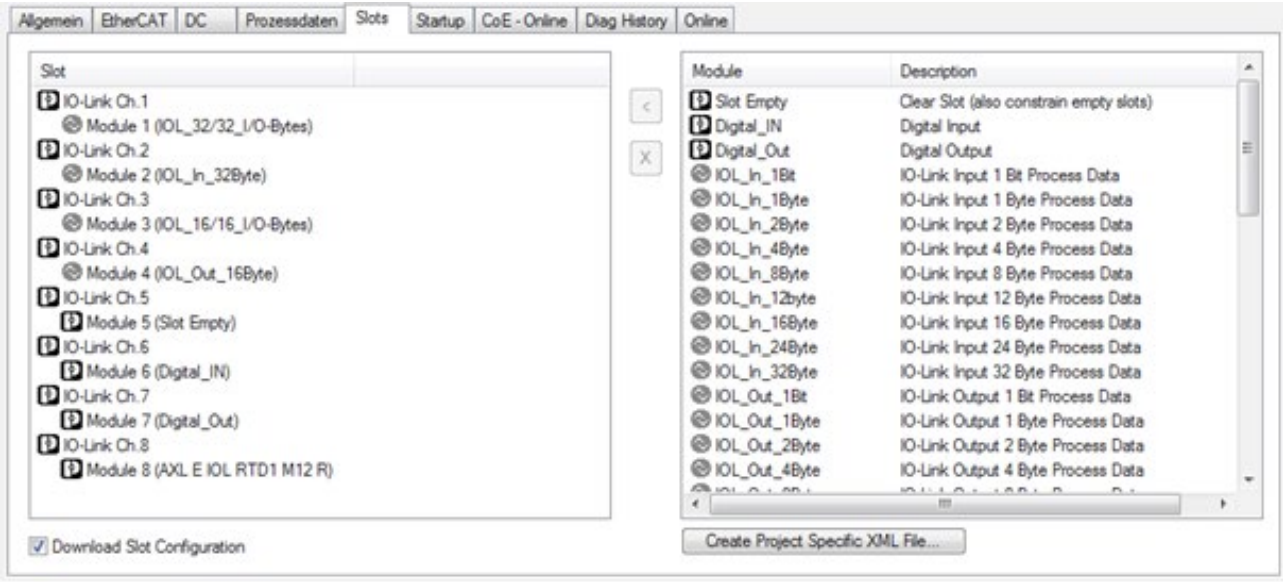
If the exact IO-Link process data length of the connected device is not available in the device description file, then select the next largest constellation.

23.1 Configuration of the operating mode

The ESI file [ifm_AL1030_Modules.xml] contains all modules supported by the device. Assigning a module to a slot is done via a configuration tool (e.g. TwinCAT). If a module is added to a slot, all corresponding start-up commands (start-up parameters) are created automatically, and necessary entries are added to the PDO list.
The following values are available as operating modes

Hex	Description
00	Deactivated
01	Digital_IN (function as digital input)
02	Digital_OUT (function as digital output)
03	IO-Link
04	DI with IO-Link (no cyclic IO-Link communication, also called SIO mode)

Depending on the slot configuration, they are entered as start-up command in the object 0x80n0:28 (Master Control). A possible port configuration in the engineering tool TwinCAT could look as follows:



For further information about the structure of the $80n0_{hex}$ objects, please consult the chapter "IO-Link device configuration (configured)".

23.2 Configuration of port parameters

The following objects describe basic start-up parameters like the "Data Storage Mechanism" of IO-Link devices. These parameters can be set for each port.

<table>
<tr><th>Index (hex)</th><th>Sub-index (hex)</th><th>Object name</th><th>Data type</th><th>Rights</th><th>Description/value</th></tr>
<tr><td rowspan="3">2800</td><td colspan="5">IO-Link parameter port 1</td></tr>
<tr><td>00</td><td>Number of entries</td><td>UINT8</td><td>RO</td><td>Number of sub-indexes of the object</td></tr>
<tr><td>01</td><td>Data storage</td><td>UINT8</td><td>R/W</td><td>The data storage mechanism allows the exchange of parameters between the master and device.
To use this function, connected devices must at least support the IO-Link specification v1.1.
<table>
<tr><th>Hex</th><th>Description</th></tr>
<tr><td>00</td><td>Deactivated (default)</td></tr>
<tr><td>01</td><td>Download only
The parameter data is sent from the IO-Link master to the device.
In the event of an inconsistency between the parameter data of the IO-Link device and the IO-Link master, the data from the IO-Link master is taken as the default.
That means that it is possible to exchange the IO-Link device. In this mode, no upload is possible.</td></tr>
<tr><td>02</td><td>Upload only
The parameter data is sent from the IO-Link device to the IO-Link master.
In the event of an inconsistency between the parameter data of the IO-Link device and the IO-Link master, the data from device is used as the default.
That means that it is possible to exchange the IO-Link master.
In this mode, no download is possible.</td></tr>
<tr><td>03</td><td>Download and upload
The parameter data is saved both in the IO-Link master and the device.
In the event of an inconsistency between the parameter data of the IO-Link device or the IO-Link master, the data from the master is used as the default.</td></tr>
<tr><td>04</td><td>Deactivated and deleted
The data storage mechanism is deactivated and the master deletes all stored parameters for the respective port.</td></tr>
</table></td></tr>
</table>

UK

Index (hex)	Sub-index (hex)	Object name	Data type	Rights	Description/value	
2800	02	Device parameters	ARRAY [0…15] OF BYTE	R/W	Direct Parameter Page 2 (DPP2) The device parameter page 2 describes the area between the IO-Link objects 10_{hex}...$1F_{hex}$. This relates to an optional manufacturer-specific area of the IO-Link device data.	
					Element	Description
					[0]	DPP2 object 10_{hex}
					[15]	DPP2 object $1F_{hex}$
	03	Analogue converter Parameter	UINT16	R/W	Special object for the IO-Link/analogue converters. The settings in this object describe the ISDU object 80_{hex} of the converter. You find the detailed structure of the object in the corresponding device data sheet.	
2810	IO-Link parameter port 2					
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
...	...	...	...	...	...	
2870	IO-Link parameter port 8					
...	...	...	...	...	...	

The respective IO-Link port must be in the IO-Link operating mode to make sure that these settings apply to the objects.

23.3 Port status

The object $F100_{hex}$ (IO-Link port status) contains status data for each port, represented by a sub-index. The IO-Link status (e.g. port inactive, Siomode Digital in, etc.) and an error code are stored, if available. The object can be read cyclically or optionally be mapped in the process data.

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
F100	IO-Link Port Status					
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
	01	IO-Link Port 1 Status	UINT8	R/W	Status byte of the first IO-Link port	
					Bit	Description

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
					0...3	IO-Link status 0 = port inactive 1 = port functions as Digital_In 2 = port functions as Digital_Out 3 = communication in OP mode 4 = communication in STOP mode
					4...7	ErrorCode 0 = no error 3 = invalid device ID 10 = no device detected
	02	IO-Link Port 2 Status	UINT8	R/W	Status byte of the second IO-Link port ...	
	...	...	...	...	...	
	08	IO-Link Port 8 Status	UINT8	R/W	Status byte of the eighth IO-Link port ...	

24 CoE: IO-Link module identification

The module identification serves to adjust the configured with the actually finished modules.

The device carries this adjustment out by verifying the vendor ID and the Device ID. The configuration data about the Vendor ID and the Device ID are in the objects 8000_{hex} to 8070_{hex} and are described during the start-up of the engineering tool. The IO-Link master provides the information about the connected modules in the objects 9000_{hex} to 9070_{hex}.

A verification is only done if the sub-objects 0x80n0:04 (Device ID) and 0x80n0:05 (Vendor ID) have been configured as unequal to zero for the corresponding port (n).

If there is no verification because no Device ID and Vendor ID were entered and if the configured data lengths of a module are not correct, then only the amount of data is transmitted that had been configured.

Example
A real IO-Link device with 16 byte input process data is connected. However, only eight bytes were configured, so only eight bytes are transmitted.

The IO-Link master is identified as MDP Profile Implementation "5001". For this reason, the objects $F030_{hex}$ (Configured Module Ident List) and $F050_{hex}$ (Detected Module Ident List) which are used for module identification in case of an MDP device must be available.

Since the IO-Link functions according to the IO-Link Master Profile Implementation "6220", these objects are not evaluated by the device since identification via Vendor ID and Device ID is sufficient. No adjustment of the module numbers is made.

The entries of object $F030_{hex}$ correspond with the entries in the sub-indexes 0x8nn0:0A of the configured IO-Link devices which (read from the ESI file) are written into the sub-object 8xx0:0A during the start-up.

The entries of object $F050_{hex}$ correspond with the entries in the sub-indexes 0x9nn0:0A of the detected IO-Link devices, both are filled with zeros.

24.1 IO-Link device setting (configured)

For each IO-Link port, the objects 8000_{hex} to 8070_{hex} contain the manually defined device-specific configuration data like Device ID, Vendor ID, process data length, etc.

The IO-Link master writes all configuration data to the IO-Link master during start-up, status change from PREOP to SAFEOP. In the OP status, they can be acyclically read or changed by the EtherCat master.

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
8000	IO-Link Configuration Data Port 1					
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
	04	Device ID	UINT32	R/W	Device ID of the IO-Link device Verification will only be carried out if the value is != 0.	
	05	Vendor ID	UINT32	R/W	Vendor ID of the IO-Link device Verification will only be carried out if the value is != 0.	
	0A	Module Ident	UINT32	R/W	Module identification number Get known numbers from the ESI data. The device does not evaluate this entry.	
	24	Process Data in length	UINT8	R/W	Number and structure of the input process data of the device	
					Bit	Description
					0...4	Process data length
					5	Reserved
					6	SIO indicator (Device supports the standard IO mode)
					7	Byte indicator (length is interpreted as byte +1)
	25	Process Data out length	UINT8	R/W	Number and structure of the output process data of the device	
					Bit	Description
					0 ... 4	Process data length
					5	Reserved
					6	SIO indicator (device supports the standard IO mode)
					7	Byte indicator (length is interpreted as byte +1)
	28	Master Control	UINT16	R/W	Operating mode of the IO-Link port	
					00	Deactivated
					01	Digital_In (function as digital input)
					02	Digital_Out (function as digital output)

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
					03	IO-Link
					04	DI with IO-Link (non cyclic IOL communication, also called SIO mode)
8010	IO-Link Configuration Data Port 2					
...	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
	04	Device ID	UINT32	R/W	Device ID of the IO-Link device	
...	...	...	...	...	...	
8070	IO-Link Configuration Data Port 8					
...	...	...	...	...	...	

24.2 IO-Link Device Information (detected)

For each IO-Link port, the objects 9000_{hex} to9070_{hex} contain the read device-specific data like Device ID, Vendor ID, process data length, etc.

During start-up of the connected device, the IO-Link master reads all necessary data and transmits it to the designated objects.

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
9000	IO-Link Configuration Data Port 1					
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
	01	Fixed Station Address	UINT16	RO	First IO-Link port	
	05	Vendor ID	UINT32	RO	Vendor ID structure signalled by the device corresponds with 0x8000:05	
	06	Product code	UINT32	RO	Product code signalled by the device	
	07	Revision number	UINT32	RO	Revision number signalled by the device	
	08	Serial number	UINT32	RO	Serial number signalled by the device	
	0A	Module Ident	UINT32	R/W	Structure corresponds with 0x8000:10	
	20	IO-Link revision	UINT8	RO	IO-Link revision signalled by the device	
					Bit	Description
					0 ... 3	Minor revision
					4 ... 7	Major revision
	22	Cycle time (ms)	UINT8	RO	Cycle time signalled by the device in milliseconds	
					Bit	Description
					0 ... 5	Multiplier
					6 ... 7	Time Base
	24	Process Data in length	UINT8	RO	Input process data length signalled by the device corresponds with 0x8000:36	
	25	Process Data out length	UINT8	R/W	Output process data length structure signalled by the device corresponds with 0x8000:37	
	28	Master Control	UINT16	R/W	Operating mode of the IO-Link port	
					Hex	Description
					00	Deactivated
					01	Digital_In (function as digital input)
					02	Digital_Out (function as digital output)
					03	IO-Link
					04	DI with IO-Link (non cyclic IOL communication, also called SIO mode)
9010	IO-Link Information Data Port 2					

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value
...	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Fixed Station Address	UINT16	RO	Second IO-Link port
...	...	...	...	...	...
9070	IO-Link Information Data Port 8				
...	...	...	...	...	...

25 CoE: IO-Link process data

25.1 PDO mapping objects

One RxPDO and one TxPDO are assigned to each port of the IO-Link master. The indexes are composed as follows:

- For RxPDO: Index = 1600_{hex} + (IOL port number – 1)
- For TxPDO: Index = $1A00_{hex}$ + (IOL port number – 1)

So, index 1600_{hex}, for example, contains the output data of the module in port 1, index 1601_{hex} contains the output data of the module in port 2, ...

The RxPDO and TxPDO each reference all entries in the corresponding 0x6000 and 0x7000 objects of the device. Which objects are associated depends on the module configuration carried out for the corresponding port (slot).

The RxPDO with number 1608_{hex} contains the object with the control data for the IO-Link master (3000_{hex}), the TxPDO with number $1A82_{hex}$ contains the object with the status data of the IO-Link master (3001_{hex}).

If a module is assigned to a port, the corresponding Rx/TxPDO and the objects do not exist.

Ports that are not used should always be occupied with the placeholder module "Empty Slot", otherwise display or even configuration errors may occur.

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value
1600	RxPDO Mapping IO-L Outputs Ports 1				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	R/W	7000ppsshex – pp: Sub-index of the RxPDO – ss: Size of the subindex of the RxPDO in bits
	02	Subindex 02	UINT32	R/W	7000ppsshex – pp: Subindex of the RxPDO – ss: Size of the subindex of the RxPDO in bits
	...	...	...	...	
	20	Subindex 32	UINT32	R/W	7000ppsshex – pp: Subindex of the RxPDO – ss: Size of the subindex of the RxPDO in bits
1601	RxPDO Mapping IO-L Outputs Ports 2				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	R/W	7010ppsshex – pp: Subindex of the RxPDO – ss: Size of the subindex of the RxPDO in bits
...	...	...	...	...	...
1607	RxPDO Mapping IO-L Outputs Port 8				
...	...	...	...	...	...
1608	RxPDO Mapping IOLM_Control				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	RO	0x3000:01 (COM Control)
	02	Subindex 02	UINT32	RO	0x3000:02 (reserved)
	03	Subindex 03	UINT32	RO	0x3000:03 (Digital Outputs C/Q)
	04	Subindex 04	UINT32	RO	0x3000:04 (reserved)
1A00	TxPDO Mapping IO-L Inputs Ports 1				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	R/W	$6000ppss_{hex}$ – pp: Subindex of the TxPDO – ss: Size of the sub-index of the TxPDO in bits, starting with the first RxPDO of this slave

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value
	02	Subindex 02	UINT32	R/W	6000ppsshex – pp: Sub-index of the TxPDO – ss: Size of the sub-index of the TxPDO in bits
	...	...	...	...	
	20	Subindex 32	UINT32	R/W	6000ppsshex – pp: Sub-index of the TxPDO – ss: Size of the sub-index of the TxPDO in bits
1A01	TxPDO Mapping IO-L Inputs Ports 2				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	R/W	$6010ppss_{hex}$ – pp: Sub-index of the TxPDO – ss: Size of the sub-index of the TxPDO in bits
...	...	...	...	...	...
1A07	TxPDO Mapping IO-L Inputs Ports 8				
...	...	...	...	...	...
1A08	New Message Available				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	R/W	0x10F3:04, 1
	02	Subindex 02	UINT32	R/W	0x1000:00, 7
1A09	Timestamp				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	RO	0x10F8:00, 64
1A81	TxPDO Mapping IOLS_Status				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT8	RO	0xF100:01 (State of IO-Link Ch.1)
	...	...	...	...	...
	01	Subindex 01	UINT8	RO	0xF100:08 (State of IO-Link Ch.8)
1A82	TxPDO Mapping IOLM_Status				
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object
	01	Subindex 01	UINT32	RO	0x3001:01, 8 (COM States)
	02	Subindex 02	UINT32	RO	0x3002:02, 8 (PD-Valid States)

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value
	03	Subindex 03	UINT32	RO	0x3003:03, 8 (Digital inputs C/Q)
	04	Subindex 04	UINT32	RO	0x3004:04, 8 (Digital inputs (Pin 2))
1B02	TxPDO Alignment				
	00	Number of entries	UINT8	R/W	Number of sub-indexes of the object
	01	Subindex 01	UINT32	RO	0x0000:00, n (whereas n can be variable); it can also happen that this sub-index does not exist if the process data is already assigned.

25.2 Control and status objects

The device has all in all 32 control and status bits. This makes it possible to set IO-Link ports in the operating mode "Digital_Out" or to read the statuses of the IO-Link ports and the ports in the operating mode "Digital_In".

The objects are always mapped as TxPDO IOLM_Status/RxPDO in the cyclic PDO data. Moreover, the object IOLM_Control can be described in the PREOP state via SDO accesses.

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
3000	IOLM_Control					
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
	01	ComControl	UINT8	R/W	Enables one or several IO-Link ports in the Digital_In operating mode to switch to the operating mode IO-Link (temporarily, as long as the corresponding bit is set).	
					Bit	Description
					0	Set port 1 to IO-Link operating mode
					...	...
					7	Set port 8 to IO-Link operating mode
	02	Reserved	UINT8	R/W	Reserved	
	03	DO	UINT8	R/W	Enables control (setting and resetting) of the IO-Link ports in the Digital_Out (DO) operating mode.	
	04	Reserved	UINT8	R/W	Reserved	

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
3001	IOLM_Status					
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
	01	COM States	UINT8	RO	Informs if the corresponding port(s) have established a communication to the IO-Link device.	
					Bit	Description
					0	Port 1 IO-Link communication established
					...	...
						Port 8 IO-Link communication established
	02	PD-Valid States	UNINT8	RO	Informs if the data of the corresponding port(s) are marked as valid or invalid.	
					Bit	Description
					0	Port 1 IO-Link input data qualifier
					...	...
						Port 8 IO-Link input data qualifier
	03	Digital inputs C/Q	UINT8	RO	Shows the status of the digital inputs (Pin 4).	
					Bit	Description
					0	Input 1 (port 1) pin 4
					...	...
					7	Input 8 (port 1) pin 4
	04	Digital inputs (pin 2)	UINT8	RO	Shows the status of the hardwired digital inputs (pin 2) of the type A ports	
					Bit	Description
					0	Input 1 (port 1) pin 4
					...	...
						Input 8 (port 1) pin 4

26 Process data objects

Objects 6000_{hex} to $6FFF_{hex}$ contain the input data, objects 7000_{hex} to $7FFF_{hex}$ contain the output data of the connected IO-Link devices. For each module (IO-Link device), exactly one object is created which can contain several sub-objects.

This results in the following object index

– For input data
  Index = 6000_{hex} + (number of the IO-Link port - 1) x 0010_{hex}

– For output data
  Index = 7000_{hex} + (number of the IO-Link port - 1) x 0010_{hex}

So, index 7000_{hex} (and its sub-indexes), for example, contains the output data of the module in port 1, index 7010_{hex} (and its sub-indexes) contains the output data of the module in port 2, …

The number of sub-objects per index depends on the executed module configuration for the respective port (slot).

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value
6000	IO-Link Input Port 1				
	00	Number of entries	UINT8	RO	Depends on the executed slot configuration (max. 32)
	01	IOL Port (1 byte in)	OCTEC STRING	RO	Represents TxPDO 1 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
	02	IOL port (2 bytes in)	OCTEC STRING	RO	Represents TxPDO 2 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
	...	...	...	...	...
	20	IOL port (32 bytes in)	OCTEC STRING	RO	Represents TxPDO 32 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
6010	IO-Link Input Port 2				
	00	Number of entries	UINT8	RO	Depends on the executed slot configuration (max. 32)
	01	IOL port (1 bytes in)	OCTEC STRING	RO	Represents RxPDO 1 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
	02	IOL port (2 bytes in)	OCTEC STRING	RO	Represents RxPDO 2 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
	...	...			
	20	IOL port (32 bytes in)	OCTEC STRING	RO	Represents RxPDO 32 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
6070	IO-Link Input Port 8				

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value
...	...	...	...	...	...
7000	IO-Link Output Port 1				
	00	Number of entries	UINT8	RO	Depends on the executed slot configuration (max. 32)
	01	IOL port (1 bytes in)	OCTEC STRING	RO	Represents RxPDO 1 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
	02	IOL port (2 bytes in)	OCTEC STRING	RO	Represents RxPDO 2 of the first IO-Link device (IO-Link node address is defined in object 0xF020:01)
	...	...	...	...	...
	20	IOL port (32 bytes in)	OCTEC STRING	RO	Represents RxPDO 32 of the first IO-Link device (IO-Link node address ist defined in object 0xF020:01)
7010	IO-Link Outputs Port 2				
	00	Number of entries	UINT8	RO	Depends on the executed slot configuration (max. 32)
	01	IOL port (1 bytes in)	OCTEC STRING	RO	Represents RxPDO 1 of the second IO-Link device (IO-Link node address ist defined in object 0xF020:01)
...	...	...	...	...	...
7070	IO-Link Outputs Port 8				
...	...	...	...	...	...

27 CoE: IO-Link substitute value behaviour

The IO-Link master monitors the cyclic communication to the controller and reacts to possible faults, for example, cancellation/failure of the communication. When the EtherCat communication fails (other EtherCat status than operational), all IO-Link ports of the device are set to the configured substitute values.

The substitute value behaviour for ports in the IO-Link operating mode is set for each port via the objects 2100_{hex} to 2170_{hex}.

The substitute value behaviour of IO-Link ports is set via the following objects in the operating mode "Digital_Out"

- 2180_{hex}: Safe State Mode IOLM_Control (DO) sets the global behaviour for all ports
- 2182_{hex}: Safe State Values IOL_Control (DO), the behaviour per port can be set via the substitute value pattern. This is only valid if "substitute values" is selected in the preceding parameter.

<table>
<tr><th>Index (hex)</th><th>Sub index (hex)</th><th>Object name</th><th>Data type</th><th>Rights</th><th>Description/value</th></tr>
<tr><td rowspan="5">2100</td><td rowspan="5">-</td><td rowspan="5">Safe State Mode IOL-Port 1</td><td rowspan="5">UINT8</td><td rowspan="5">R/W</td><td>00_{hex} = set data to "0"</td></tr>
<tr><td>01_{hex} = set data to "1"</td></tr>
<tr><td>02_{hex} = hold last value</td></tr>
<tr><td>03_{hex} = IO-Link master command (default)</td></tr>
<tr><td>The "IO-Link master command" option enables the use of IO-Link-specific mechanisms for valid/invalid OUT process data</td></tr>
<tr><td>2110</td><td>-</td><td>Safe State Mode IOL-Port 2</td><td>UINT8</td><td>R/W</td><td>see above</td></tr>
<tr><td>....</td><td>...</td><td>...</td><td>...</td><td>...</td><td>...</td></tr>
<tr><td>2170</td><td>-</td><td>Safe State Mode IOL-Port 8</td><td>UINT8</td><td>R/W</td><td>see above</td></tr>
<tr><td rowspan="5">2180</td><td rowspan="5">-</td><td rowspan="5">Safe State Mode
IOLM_Control (DO)</td><td rowspan="5">UINT8</td><td rowspan="5">R/W</td><td>00_{hex} = set all outputs to "0"</td></tr>
<tr><td>01_{hex} = set all outputs to "1"</td></tr>
<tr><td>02_{hex} = all outputs hold the last value.</td></tr>
<tr><td>03_{hex} = set substitute value pattern</td></tr>
<tr><td>This option makes sure that the substitute value pattern set in object 2182 will be adopted.</td></tr>
<tr><td rowspan="5">2182</td><td rowspan="5">-</td><td rowspan="5">Safe State Values
IOL_Control (DO)</td><td rowspan="5">UINT8</td><td rowspan="5">R/W</td><td>Example
Port 2, 5 and 8 function in the "Digital_Out" mode and are to be set in case of a fault.</td></tr>
<tr><td>
<table>
<tr><td>Port</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr>
<tr><td>Bit</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><td>Sub-stitute value</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td><td>0</td><td>0</td><td>1</td></tr>
</table>
</td></tr>
<tr><td>If you convert the bit pattern to Hex, the value 92_{hex} results. This value must be entered in this object.</td></tr>
</table>

The CoE objects to configure the substitute value behaviour can only be set in the EtherCat status "Pre-Operational".

28 CoE: IO-Link device diagnostic (events)

For the diagnostic function, the object $10F3_{hex}$ is available. Up to 64 diagnostic messages can be stored in it in a ring buffer. All events are recorded that have triggered an emergency message in the device.

They are:

- EtherCat system diagnostics that are generated by the slave stack (ESM) of the IO-Link master (Info, Warning, Error). You will find a list of all supported emergency messages in the chapter "EtherCat Emergency Messages".
- IO-Link events that are sent from the connected IO-Link device to the master.

In addition, a time stamp is left in the object $10F8_{hex}$ "Timestamp Object" for each diagnostic message. The "Diagnostic History Object" has two operating types, the overwrite and the acknowledgement mode.

In the overwrite mode, new messages overwrite the older ones, i.e. if the ring buffer is full, existing diagnostic messages are overwritten, even if they are not acknowledged.

In the acknowledgement mode, more recent messages are dismissed and are lost as soon as the ring butter is completely filled with unacknowledged messages.

The mode selection takes place via 0x10F3:SI5:Bit4.

The acknowledgement of diagnostic messages is done via 0x10F3:SI3.

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
10F3	Diagnostic History		Record		Diagnostic statistics	
	00	Number of entries	UINT8	RO	Number of sub-indexes of the object	
	01	Maximum messages	UINT8	RO	Maximum number of messages (64)	
	02	Newest message	UINT8	RO	Subindex of the most recent diagnostic message (0, 6 ... 69) 0 = no message available	
	03	Newest acknowledged message	UINT8	R/W	Most recent acknowledged message	
					In overwrite mode (SI5, Bit 4 = 0)	
					Read	
					0	Message queue overwritten
					Write	
					0	Delete all messages
					6...69	Confirm pending message. If the message is not available, an SDO-Abort Code 06090030_{hex} is sent.
					In the acknowledgement mode (SI5, Bit 4 = 1)	
					Read	
					0	So far no messages acknowledged
					!= 0	Sub-index of the last acknowledged message
					Write	
					0	Delete all acknowledged messages
					6...69	Confirm pending message. If the message is not available, an SDO-Abort Code 06090030_{hex} is sent.
	04	New message available	BIT	RO	New message available	
					In overwrite mode (SI5, Bit 4 = 0)	
					0	Most recent messages read
					1	Most recent messages not read
					In the acknowledgement mode (bit 4 = 1)	

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value	
					0	No unacknowledged messages
					1	Messages for acknowledgement available
	05	Flags	UINT16	R/W	Settings for sending and storing diagnostic messages	
					Bit	Description
					0	Send emergency messages 0 = deactivated 1 = activated (default)
					1	Info messages store / send 0 = activated (default) 1 = deactivated
					2	Store / send warning messages 0 = activated (default) 1 = deactivated
					3	Error messages store / send 0 = activated (default) 1 = deactivated
					4	Mode selection 0 = overwrite mode 1 = acknowledgement mode
					5	Overwrite information (RO) in the overwrite mode: 1 = unacknowledged messages were overwritten In the acknowledgement mode: 1 = message buffer is full of unacknowledged messages, and a new message was dismissed
					6...15	Reserved

Index (hex)	Sub index (hex)	Object name	Data type	Rights	Description/value
	6...255	Diagnostic message	OCTECT STRING	RO	The first message is stored in subindex 6, the next one in 7, etc. A soon as the buffer is full, overwriting starts again at Subindex 6. For the exact structure of the diagnostic messages, please refer to chapter "Structure of a diagnostic message".
10F8	-	Timestamp Object	UINT64	RO	The object contains the current local time of the device and is indicated in [ns].

The object $1A08_{hex}$ (New Message Available) contains a status bit when a new event occurs and can be integrated in the process data as an option. For further information, please refer to the chapter PDO Mapping Objects.

28.1 Structure of a diagnostic message

Parameters	Data type	Description		
DIAG_CODE	UINT32	Diagnostic code for clear identification of the diagnostic message		
		Bit 0 … 15	Bit 16…31	Description.
		E800	Emergency code according to specification	The device is informed about a diagnostic event.
Flags	UINT16	Bit	Description	
		0...3	Diagnosis object type 0 = Info Message 1 = Warning Message 2 = Error Message Other = reserved	
		4	Time stamp	
		5...7	Reserved	
		8...15	Number of the parameters in this diagnostic message	
Text ID	UINT16	Text ID as reference for the diagnostic text defined in the ESI file		
		Bit	Description	
		0	No text ID available	
		1...65535	Text ID as reference in the ESI file	
Time stamp	UINT64	Time stamp in [ns] from the Time Stamp Object ($10F8_{hex}$) at the point of time when the event was detected		
Parameters Flags 1	UINT16	Parameter 1 Flags:		
		0005_{hex}	Data type parameter 1: UINT8	
Parameter 1	UINT8	Port number		

Parameters	Data type	Description	
Parameters Flags 2	UINT16	Parameter 2 Flags:	
		0007_{hex}	Data type parameter 2: UINT32
Parameter 2	UINT32	Event Code; see chapter "Event Codes"	
Parameters Flags 3	UINT16	Parameter 3 Flags:	
		0005_{hex}	Data type parameter 3: UINT8
Parameter 3	UINT8	Event Qualifier Shows additional information about the Event Code	
		Bit	Description
		0...2	Instance (source of the Event) 0 = unknown 1...3 = reserved 4 = application 5...7 = reserved
		3	Source 0 = device 1 = master
		4...5	Type 0 = reserved 1 = event single shot 2 = event going 3 = event coming

28.2 Confirm diagnostic messages

In overwrite mode (SI5, Bit 4 = 0)

When the subindex of the most recent acknowledged message is written into the field [Newest Acknowledged Message] (0x10F3:SI3), all older diagnostic messages are acknowledged as well. Here, it is not verified if they have already been read (indication takes place via 0x10F3:SI5:Bit 5 = 0).

If a subindex is written that does not contain a diagnostic message, the SDO-Abort-Code 06090030_{hex} is returned.

SI	History	Status		Status
6	Message_12	read		acknowledge
7	Message_13	read		acknowledge
8	Message_14	read		acknowledge
9	Message_15	read		acknowledge
10	Message_16	read		acknowledge
11	Message_17			acknowledge
12	Message_18		write SI1 = 12	acknowledge
13	Newest_19			
14	Message_09	read		acknowledge
15	Message_10	read		acknowledge
16	Message_11	read		acknowledge

In the acknowledgement mode (SI5, Bit 4 = 1)

When the subindex of the most recent acknowledged message is written into the field [Newest Acknowledged Message] (0x10F3:SI3), all older diagnostic messages are acknowledged as well.
Here, it is not verified if they have already been read (indication takes place via 0x10F3:SI5:Bit 5 = 0).

If a subindex is written that does not contain a diagnostic message, the SDO-Abort-Code 06090030_{hex} is returned.

28.3 Delete diagnostic messages

In overwrite mode (SI5, Bit 4 = 0)

If a zero is written into the field [Newest Acknowledged Message] (0x10F3:SI3), all messages are deleted without verification.

In the acknowledgement mode (SI5, Bit 4 = 1)

If a zero is written into the field [Newest Acknowledged Message] (0x10F3:SI3), all messages that are already acknowledged are deleted.

All messages that were not yet acknowledged are transferred upward in the buffer as can be seen in the example in the following figure.

SI	History	Status		History
6	Message_12	acknowledge		Message_17
7	Message_13	acknowledge		Message_18
8	Message_14	acknowledge		Newest_19
9	Message_15	acknowledge		
10	Message_16	acknowledge		
11	Message_17	read		
12	Message_18	read	write SI3 = 0	
13	Newest_19			
14	Message_09	acknowledge		
15	Message_10	acknowledge		
16	Message_11	acknowledge		

All acknowledged messages are deleted.

28.4 Event Codes

In the following, you find an overview of the possible Event codes according to the IO-Link specification (excerpt from the document: IOL-Interface-Spec_10002_V111_Oct11).

Refer to the corresponding device documentation for the Event-Codes of the connected IO-Link device.

EventCodes (hex)	**Definition**	**Device Status Value**	**TYPE**
0000	No malfunction	0	Notification
1000	General malfunction – unknown error	4	Error
1001...17FF	Reserved		
1800...18FF	Manufacturer/ vendor specific		
1900...3FFF	Reserved		
4000	Temperature fault – Overload	4	Error
4001...420F	Reserved		
4210	Device temperature over-run – Clear source of heat	2	Warning
4211...421F	Reserved		
4220	Device temperature under-run – Insulate Device	2	Warning

EventCodes (hex)	Definition	Device Status Value	TYPE
4221...4FFF	Reserved		
5000	Device hardware fault – Device exchange	4	Error
5001...500F	Reserved		
5010	Component malfunction – Repair or exchange	4	Error
5011	Non volatile memory loss – Check batteries	4	Error
5012	Batteries low – Exchange batteries	2	Warning
5013...50FF	Reserved		
5100	General power supply fault – Check availability	4	Error
5101	Fuse blown/open – Exchange fuse	4	Error
5102...510F	Reserved		
5110	Primary supply voltage over-run – Check tolerance	2	Warning
5111	Primary supply voltage under-run – Check tolerance	2	Warning
5112	Secondary supply voltage fault (Port Class B) – Check tolerance	2	Warning
5113…5FFF	Reserved		
6000	Device software fault – Check firmware revision	4	Error
6001...631F	Reserved		
6320	Parameter error – Check data sheet and values	4	Error
6321	Parameter missing – Check data sheet	4	Error
6322...634F	Reserved		
6350	Parameter changed – Check configuration	4	Error
6351...76FF	Reserved		
7700	Wire break of a subordinate device – Check installation	4	Error
7701...770F	Wire break of subordinate device 1...15 – Check installation	4	Error
7710	Short circuit – Check installation	4	Error
7711	Ground fault – Check installation	4	Error
7712...8BFF	Reserved		
8C00	Technology specific application fault – Reset Device	4	Error
8C01	Simulation active – Check operational mode	3	Warning
8C02...8C0F	Reserved		

EventCodes (hex)	Definition	Device Status Value	TYPE
8C10	Process variable range over-run – Process Data uncertain	2	Warning
8C11...8C1F	Reserved		
8C20	Measurement range over-run – Check application	4	Error
8C21...8C2F	Reserved		
8C30	Process variable range under-run – Process Data uncertain	2	Warning
8C31...8C3F	Reserved		
8C40	Maintenance required – Cleaning	1	Notification
8C41	Maintenance required – Refill	1	Notification
8C42	Maintenance required – Exchange wear and tear parts	1	Notification
8C43...8C9F	Reserved		
8CA0...8DFF	Manufacturer/ vendor specific		
8E00...AFFF	Reserved		
B000...BFFF	Reserved for profiles		
C000...FEFF	Reserved		
FF00…FFFF	SDCI specific EventCodes		

29 AoE: IO-Link device parameter setting

With the help of the AoE protocol (ADS over EtherCat), the device enables the SDO access to the IO-Link device parameters called ISDUs (Indexed Service Data Unit).

Not every EtherCat master supports the AoE protocol. Please make sure in advance that your EtherCat-Master is suitable for this type of communication!

Communication takes place via ADS (Automation Device Specification). The device provides corresponding ADS services to read and write IO-Link device parameters (ISDU). Then, the engineering tool transfers the ADS commands to the IO-Link master via AoE (client-server principle).

The addressing absolutely requires

- an AMS NetID to clearly identify the IO-Link master
- the port number to clearly identify the IO-Link master and the port

The index group $F302_{hex}$ is used for an ADS command.

The engineering tool TwinCAT provides already predefined ADS services in the form of function blocks or function libraries. For further information, please refer to the corresponding documentation.

29.1 AMS NetID

The AMS NetID ensures clear identification of the EtherCat slave and is provided by the engineering tool.

29.2 Port number

The port number ensures clear identification of the IO_Link master and its ports. The following definition applies

Value (hex)	Description
1000	IO-Link master
1001	Port 1
...	...
1008	Port 8

29.3 AoE services

As for the CoE, the index group of an ADS command is defined with $F302_{hex}$ for the IO-Link parameter channel.

The addressing of the IO-Link ISDU object is coded with index and subindex in the AoE IndexOffset. The following table gives an overview.

CoE service	AoE service	AoE port	AoE IndexGroup	AoE IndexOffset		AoE data
SDO upload	Read	EtherCAT Slave address (NetID+PortNr)	$F302_{hex}$	Bit	Description	Response: read data
				16 ... 31	ISDU-Index	
				8	0	
				0 ... 7	ISDU-Subindex	
SDO download	Write	EtherCAT Slave address (NetID+PortNr)	$F302_{hex}$	Bit	Description	Response: data to be written
				16 ... 31	ISDU-Index	
				8	0	
					ISDU subindex	

30 EtherCat emergency messages

Emergency messages are messages that are actively sent from the device to the EtherCat master in case of certain events/problems. It is an unacknowledged service based on CoE.

The signalling takes place via messages that are specified in ETG.1000.6.

Structure of an emergency message

CoE emergency message		
2 bytes	1 bytes	5 bytes
Error code	Error register	Diagnostic data

The following emergency messages are supported by the device

Error code (hex)	Error register	Diagnostic data (hex)	Localisation	Description
1001...1008	Bit D1 is set	00, 09, 0x, 00, 00, x = 1 ... 8	Channel level	General error
1011...1018	Bit D1 is set	00, 0A, 0x, 00, 00, x = 1 ... 8	Channel level	Parameter missing
1021...1028	Bit D2 is set	00, 0B, 0x, 00, 00, x = 1 ... 8	Channel level	Parameter setting error
1031...1038	Bit D1 is set	00, 0E, 0x, 00, 00, x = 1 ... 8	Channel level	Upper limit exceeded
1041...1048	Bit D1 is set	00, 0F, 0x, 00, 00, x = 1 ... 8	Channel level	Lower limit not reached
1051...1058	Bit D1 is set	00, 11, 0x, 00, 00, x = 1 ... 8	Channel level	Simulation active
1061...1068	Bit D1 is set	00, 12, 0x, 00, 00, x = 1 ... 8	Channel level	Ground fault
2301...2308	Bit D1 is set	00, 07, 0x, 00, 00, x = 1 ... 8	Channel level	Short circuit at pin 4
3001...3008	Bit D2 is set	00, 01, 0x, 00, 00, x = 1 ... 8	Channel level	Sensor supply overload
3010	Bit D2 is set	00, 02, 00, 00, 00	Device level	Sensor supply overvoltage
3020	Bit D2 is set	00, 03, 00, 00, 00	Device level	Sensor supply undervoltage
3030	Bit D2 is set	00, 04, 00, 00, 00	Device level	Actuator supply overvoltage
3031...3038	Bit D2 is set	00, 09, 0x, 00, 00, x = 1 ... 8	Channel level	Sensor supply overvoltage
3040	Bit D2 is set	00, 05, 00, 00	Device level	Actuator supply undervoltage
3041...3048	Bit D2 is set	00, 10, 0x, 00, 00, x = 1 ... 8	Channel level	Sensor supply undervoltage
3050	Bit D2 is set	00, 0D, 00, 00, 00	Device level	Short circuit of the actuator supply
3061...3068	Bit D3 is set	00, 0C, 0x, 00, 00, x = 1 ... 8	Channel level	Supply voltage failure
4001...4008	Bit D3 is set	00, 06, 0x, 00, 00, x = 1 ... 8	Channel level	Excess temperature
5001...5008	Bit D2 is set	00, 10, 0x, 00, 00, x = 1 ... 8	Channel level	Fuse blown
8101...8108	Bit D7 is set	00, 08, 0x, 00, 00, x = 1 ... 8	Channel level	Short circuit

The device sends emergency messages in case of an ingoing or outgoing error. When the problem is solved, the slave sends an emergency message with the error code 0000_{hex} (reset error). The value of the corresponding bit in the error register is 0 if for this bit no error is imminent. The diagnostic data value does not change.

31 EtherCat SDO Abort Codes

The following table informs about possible error messages during an SDO access

Abort Code (hex)	Description
0503 0000	Toggle bit not alternated
0504 0000	SDO protocol timed out
0504 0001	Client/server command specifier not valid or unknown
0504 0005	Out of memory
0601 0000	Unsupported access to an object
0601 0001	Attempt to read to a write only object
0601 0002	Attempt to write to a read only object
0601 0003	Subindex cannot be written, SIO must be 0 for write access
0601 0004	SDO complete access not supported for objects of variable length such as ENUM object types
0601 0005	Object length exceeds mailbox size
0601 0006	Object mapped to RxPDO, SDO download blocked
0602 0000	Object does not exist in the object dictionary
0604 0041	Object cannot be mapped into the PDO
0604 0042	The number and length of the objects to be mapped would exceed PDOlength
0604 0043	General parameter incompatibility reason
0604 0047	General internal incompatibility in the device
0606 0000	Access failed due to an hardware error
0607 0010	Data type does not match, length of service parameter does not match
0607 0012	Data type does not match, length of service parameter too high
0607 0013	Data type does not match, length of service parameter too low
0609 0011	Subindex does not exist
0609 0030	Value range of parameter exceeded (only for write access)
0609 0031	Value of parameter written too high
0609 0032	Value of parameter written too low
0609 0036	Maximum value is lower than minimum value
0800 0000	General error
0800 0020	Data cannot be transferred or stored to the application
0800 0021	Data cannot be transferred or stored to the application because of local control
0800 0022	Data cannot be transferred or stored to the application because of the present device state

Abort Code (hex)	Description
0800 0023	Object dictionary dynamic generation fails or no object dictionary is present

32 Set-up

32.1 Factory setting

The device has the following remanent objects

- 2007_{hex}: Installation location
- $200A_{hex}$: Equipment identification

On delivery, these objects are empty.

32.2 Restore factory settings

In order to reset the objects to the factory setting, write the value "1" on the CoE object $2F00_{hex}$. After the next power-on, the factory settings of the device are restored.

Index (hex)	Subindex	Object name	Type	Rights	Description/value
2F00	-	Reset to factory settings	UINT8	R/W	0 = normal operation (default) 1 = reset device Other = reserved

32.3 Firmware started

Once you have connected the power, the firmware is started. After completion of the firmware boot process, the LED RDY is lit green or flashes depending on the bus status. The RUN LED informs you about the current status of the internal state machine.

32.4 Firmware update

You have the option to carry out a firmware update.

For this, the File Access mechanism is applied via EtherCat (FoE) that is provided via your engineering system. For detailed instructions about the firmware update with CODESYS, please refer to chapter 36 firmware update with CODESYS V3.5.

33 Connection monitoring/substitute value behaviour

The device executes connection monitoring of the network communication. In the event of a connection timeout, the device switches its outputs to the previously configured safe state.

For further information, please refer to chapter "Safe State Objects".

33.1 IO-Link Masters

IO-Link is an internationally standardised I/O technology (IEC 61131-9) for communicating with sensors and actuators. An IO-Link master is integrated in the EtherCat device. The IO-Link master establishes the connection between the IO-Link devices and the automation system.

The device supports IO-Link specification v1.1.

34 Web-based management (WBM)

The device has a web server which generates the required pages for web-based management and, depending on the requirements of the user, sends them to a standard web browser. Web-based management can be used to access static information (e.g. technical data, MAC address) or dynamic information (e.g., IP address, status information).

In order to access the web-based management, please use TwinCAT as follows:

► Assign an IP address to the device.

► Open the window [Extended settings] in TwinCAT on the [EtherCat] tab.

► Open [Mailbox, EoE].

► Confirm the settings with [OK].

► Reload the devices in TwinCAT.

> Now you can access the unit using the web server.

35 Device description file (ESI)

A device description file is needed in EtherCat for different configuration tools.

This file is called EtherCat Slave Information (ESI).

The device has two ESI files. The modules including their corresponding data objects are described in the ESI file [ifm_AL1030_Modules.xml] and are then referenced in the main ESI file [ifm_AL1030.xml].
Both ESI files are necessary for correct functioning.

If several versions of the configuration file are available, please make sure that you are using the version of the file that corresponds with the current firmware/ hardware version.

36 Endianness

EtherCat uses the Little Endian Format. All variables, parameters and data in this document have the Little Endian (Intel) format, i.e. LSB/MSB.

37 Firmware update with the software CODESYS V3.5

This document describes how to carry out a firmware update for AL1030 with the software CODESYS V3.5.

38 Preparation

38.1 Set up network

► Connect the device to the network card used by CODESYS by means of an Ethernet cable.

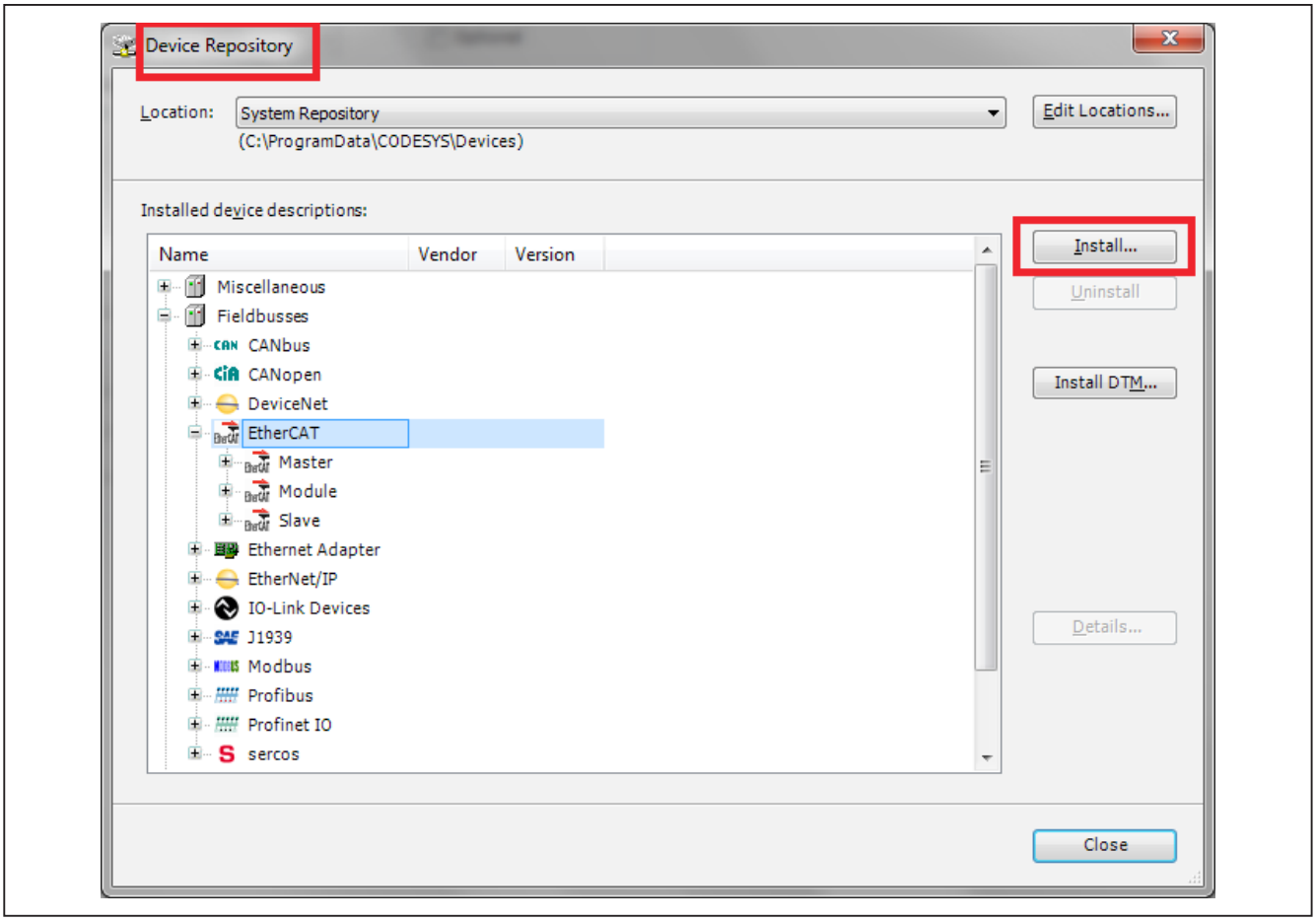
38.2 Open project

When opening CODESYS for the first time, install the device description files [ifm_AL1030.xml] and [ifm_AL1030_Modules.xml].

A device description file is also called EtherCat Slave Information File (ESI).

The device description files [ifm_AL1030.xml and ifm_AL1030_Modules.xml] saved in CODESYS must always be the files which are part of a certain firmware version or which were supplied with a certain firmware version.This means that after a firmware update the device description files [ifm_AL1030.xml] and [ifm_AL1030_Modules.xml] saved in CODESYS must also be updated.

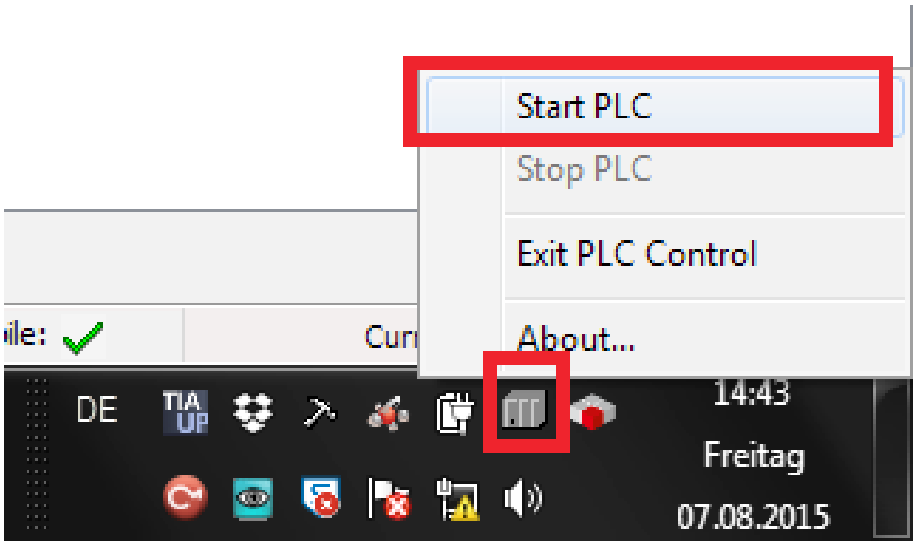
Current device description files can be found on ifm's website.



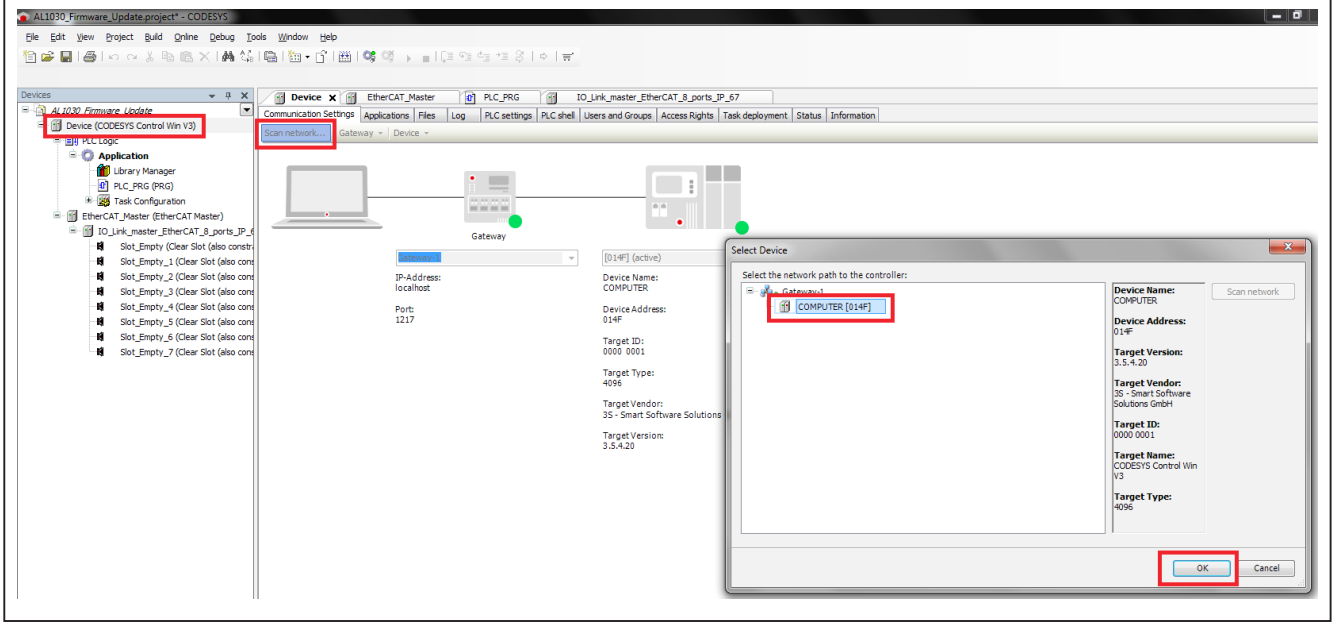
► Start CODESYS and open the CODESYS project [AL1030_Firmware_Update.project].

38.3 Set up EtherCat connection

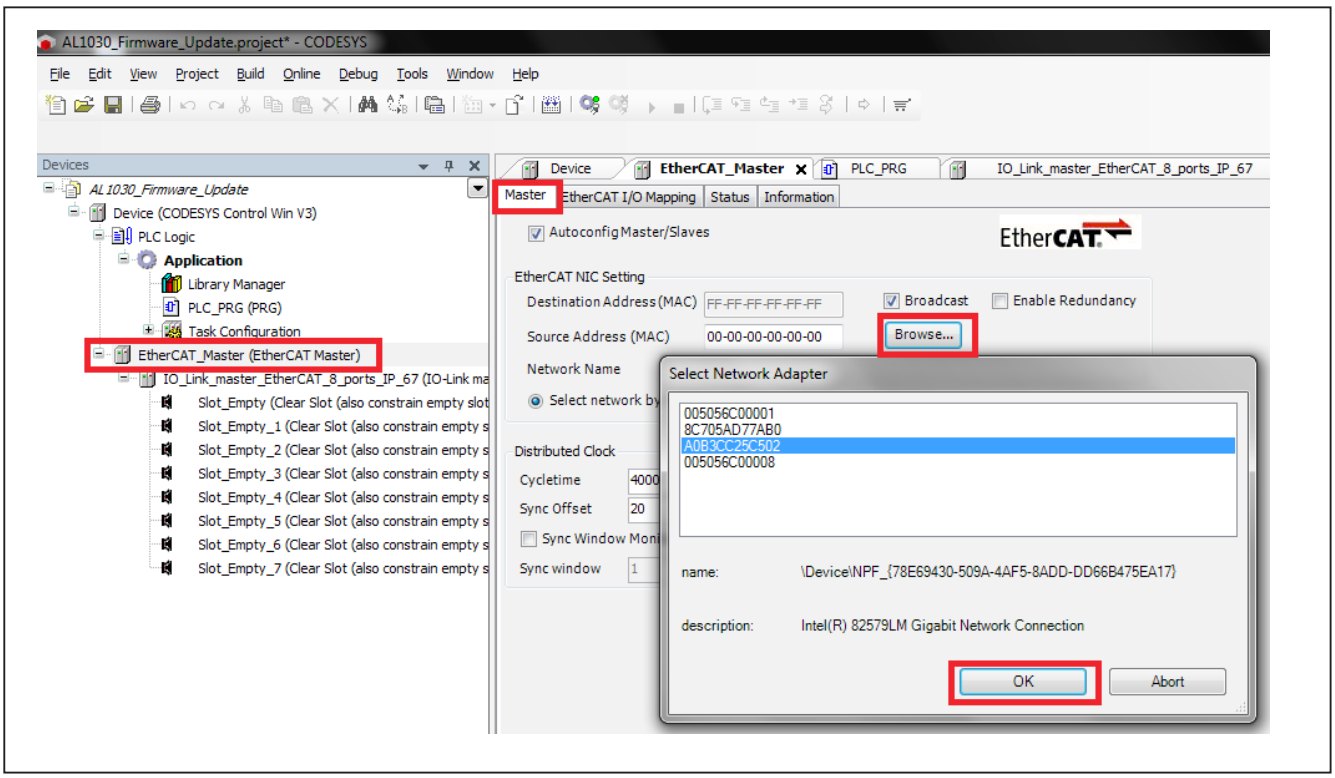
► Start SoftPLC in CODESYS.



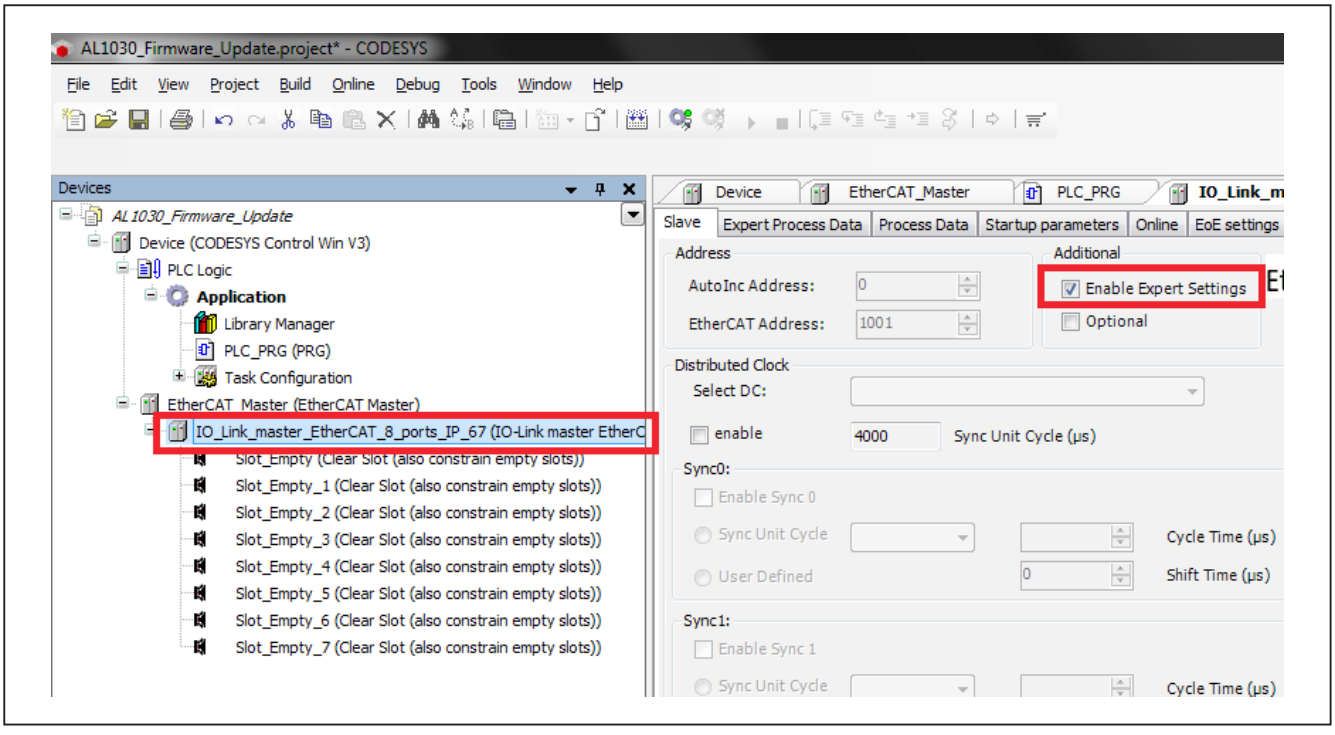
► Select SoftPLC in CODESYS.



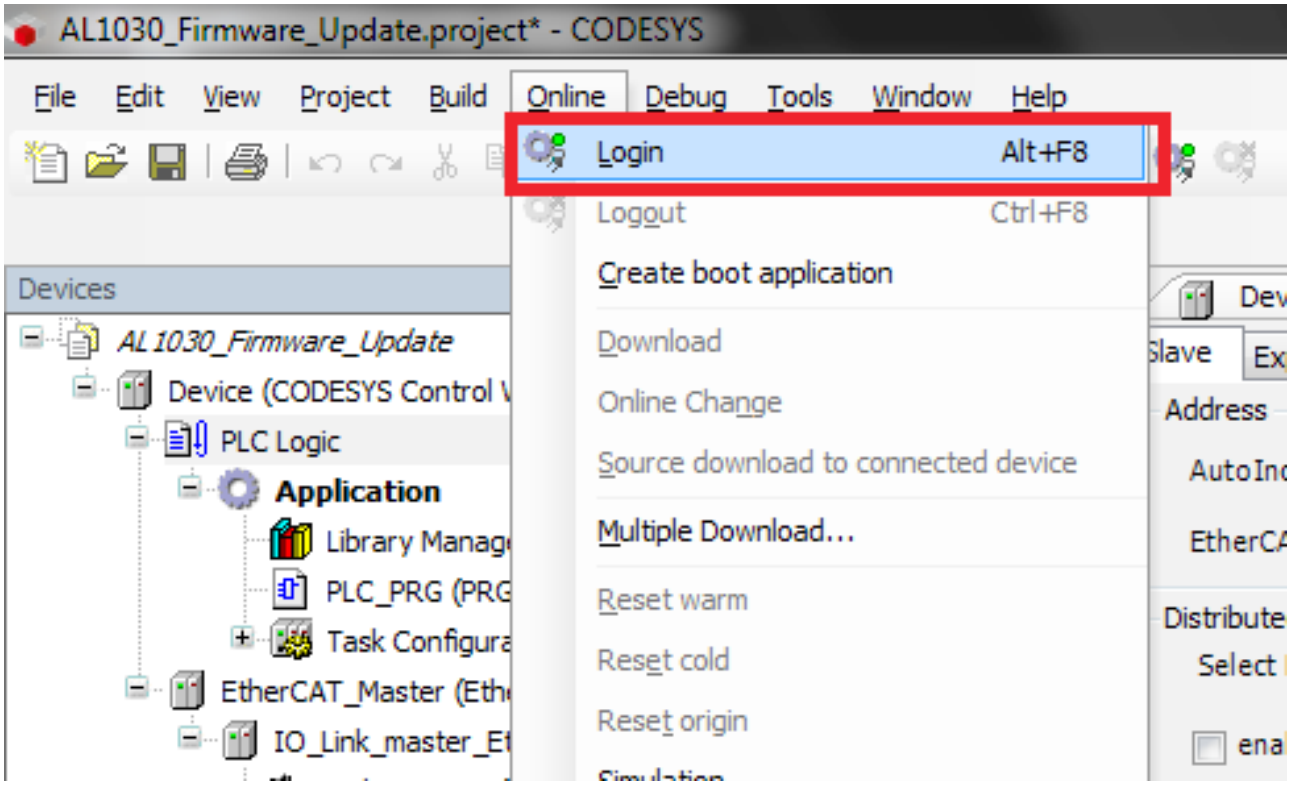
► Select MAC address of the EtherCat master.



► Enable the expert settings [Enable Expert Settings] for the EtherCat slave.



► Connect to the SoftPLC and go online.



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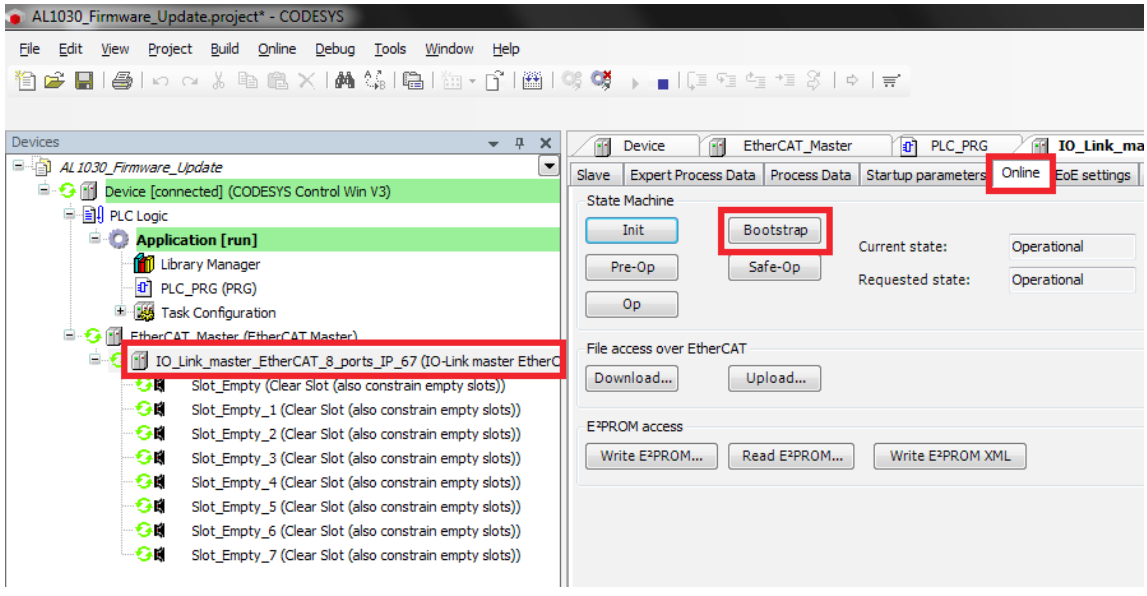
39 Firmware update (step by step)

The protocol [File Access Over EtherCat (FoE)] is always used for firmware updates.

The necessary steps for a firmware update are described below.

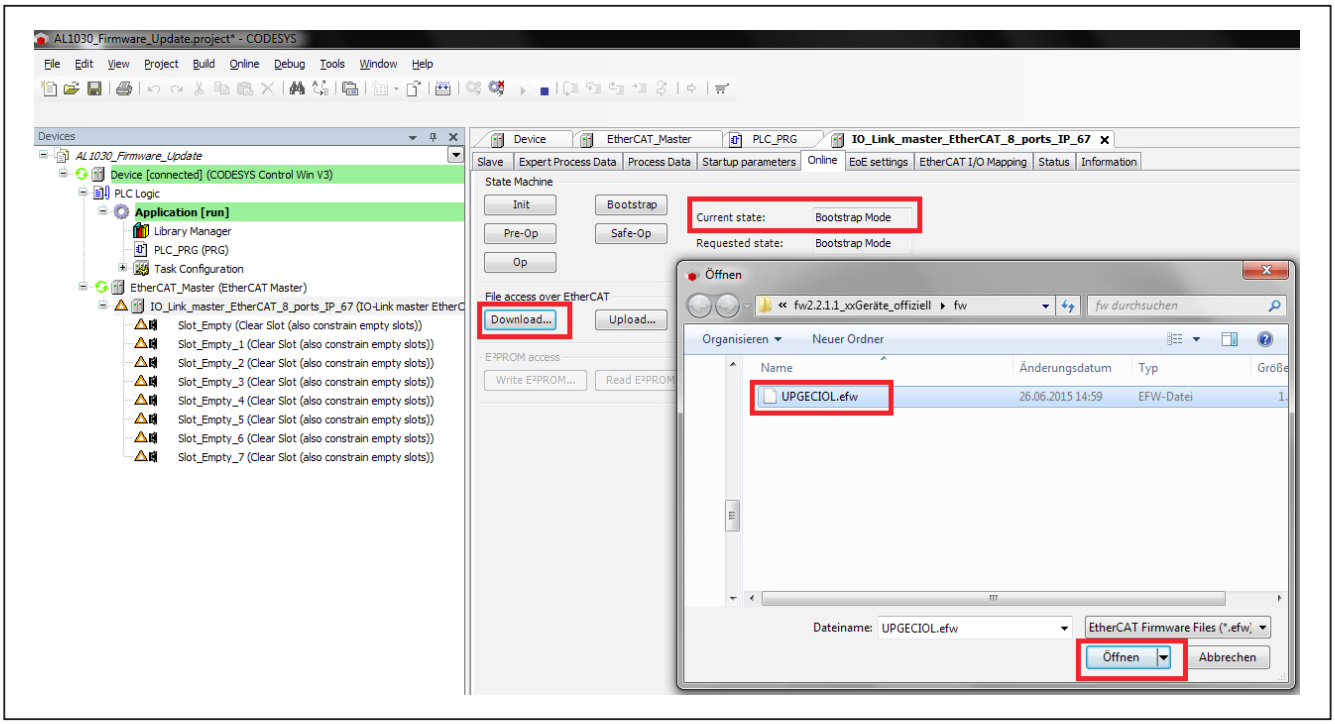
► Set the device to the EtherCat state [Bootstrap].



► Click on the tab [Online] and in the File Access over EtherCat area on [Download].

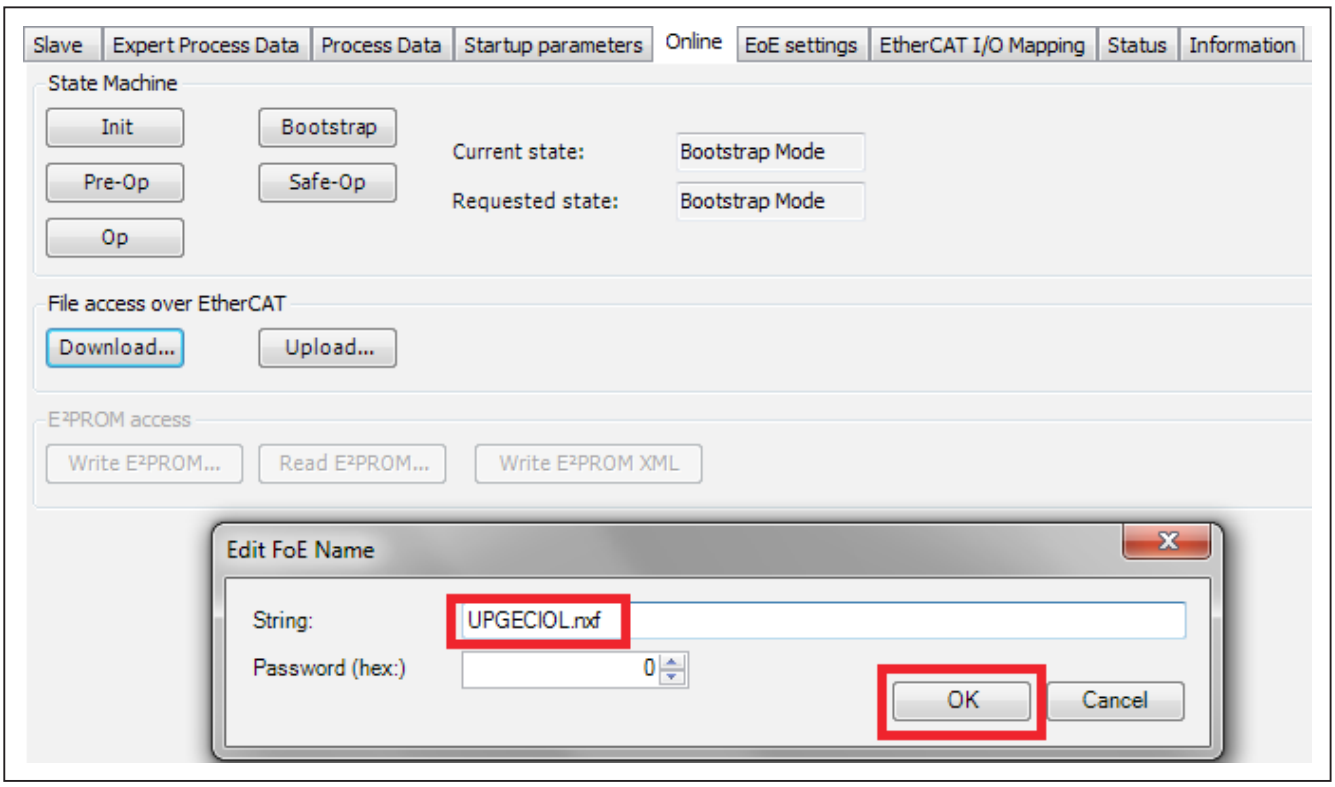
A dialogue window appears to select the firmware which is to be transferred to the device.

Firmware files for these devices have the file extension [.efw].



► Select firmware and click on [Open].

► Extend the parameter [String] by [nxf].



► Start the firmware download with [OK].

In the lower part of the screen CODESYS shows the progress of the firmware download [Downloading…].

► After the file has been transferred to the device restart the device via a power reset.

As soon as the device restarts it automatically installs the new firmware. During installation the [RDY Led] flashes orange. This can take up to 7 minutes. After installation the [RDY Led] lights green.

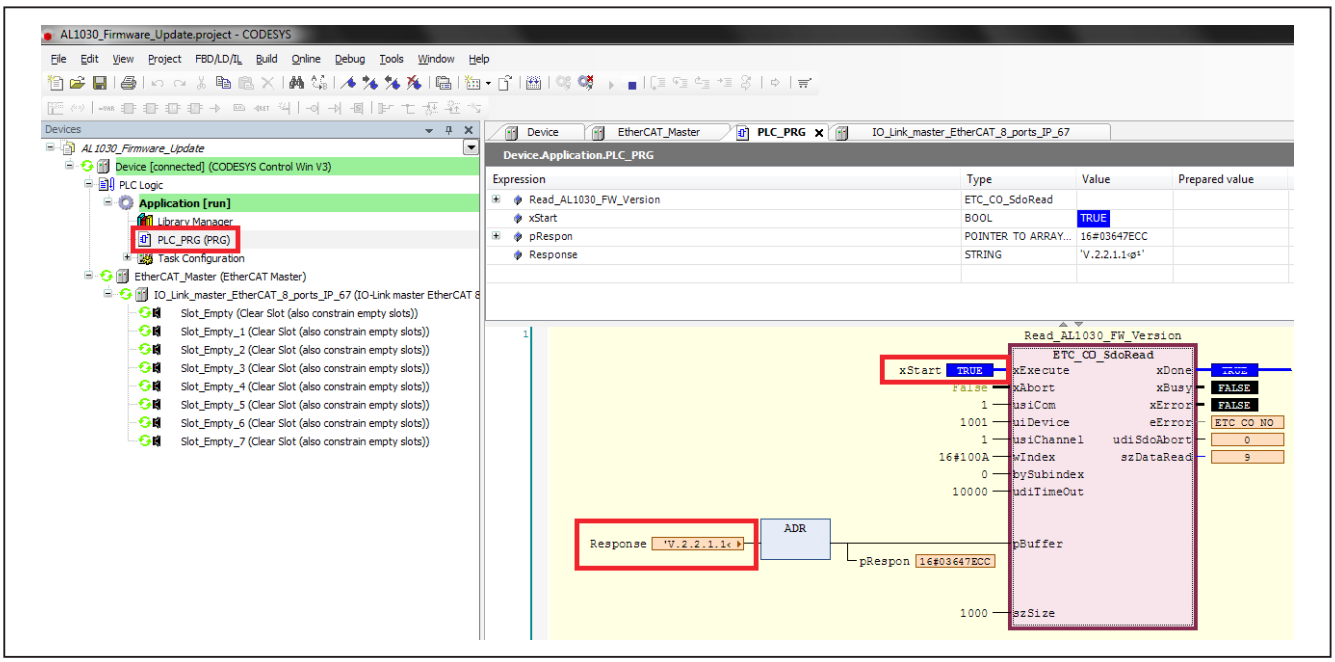
40 Check firmware version

The firmware version can be read in [CoE-Objekt 0x100A] (Manufacturer SoftwareVersion).

► Open the program [PLC_PRG] in CODESYS.

► Start the function block [ETC_CO_SdoRead] with [xExecute].

> This function block reads the software version of the device and indicates the result in [pBuffer].


AL1030_Firmware_Update.project - CODESYS
File Edit View Project FBD/LD/IL Build Online Debug Tools Window Help
Devices
AL1030_Firmware_Update
Device [connected] (CODESYS Control Win V3)
PLC Logic
Application [run]
Library Manager
PLC_PRG (PRG)
Task Configuration
EtherCAT_Master (EtherCAT Master)
IO_Link_master_EtherCAT_8_ports_IP_67 (IO-Link master EtherCAT
Slot_Empty (Clear Slot (also constrain empty slots))
Slot_Empty_1 (Clear Slot (also constrain empty slots))
Slot_Empty_2 (Clear Slot (also constrain empty slots))
Slot_Empty_3 (Clear Slot (also constrain empty slots))
Slot_Empty_4 (Clear Slot (also constrain empty slots))
Slot_Empty_5 (Clear Slot (also constrain empty slots))
Slot_Empty_6 (Clear Slot (also constrain empty slots))
Slot_Empty_7 (Clear Slot (also constrain empty slots))
Device
EtherCAT_Master
PLC_PRG
IO_Link_master_EtherCAT_8_ports_IP_67
Device.Application.PLC_PRG
Expression
Type
Value
Prepared value
Read_AL1030_FW_Version
ETC_CO_SdoRead
xStart
BOOL
TRUE
pRespon
POINTER TO ARRAY...
16#03647ECC
Response
STRING
'V.2.2.1.1<0'
Read_AL1030_FW_Version
ETC_CO_SdoRead
xStart TRUE
xExecute
xAbort
uiCom 1
uiDevice 1001
usiChannel 1
wIndex 16#100A
bySubindex 0
udiTimeOut 10000
xDone
xBusy FALSE
xError FALSE
eError ETC_CO_NO
udiSdoAbort 0
szDataRead 9
Response 'V.2.2.1.1<
ADR
pBuffer
pRespon 16#03647ECC
szSize 1000