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EtherCAT®

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General information

ctrlX DRIVE devices can be operated with EtherCAT® master communication. It is possible to exchange real-time and acyclic data with the EtherCAT® Master. The "Servo Drive Profile over EtherCAT® (SoE)" which is based on the profile of the Sercos II specification is supported.

> This chapter is neither intended to replace the corresponding EtherCAT® specification nor the DS301 from CiA. This section describes how and to what extent the functions, parameters, diagnostics etc. described in the standards are applied in ctrlX DRIVE devices.

We distinguish the following communication channels:

- **Cyclic data channel** (process data)
  → Data container for cyclic transmission of useful data (**process data**) in real time
- **Acyclic data channel** (service channel)
  → EtherCAT® mailbox method for acyclic transmission of useful data (**service data**)
  → Transmission of Ethernet telegrams via an EtherCAT® mailbox method [Ethernet over EtherCAT® (EoE)]

> Decoupling of the communication and application state machine is only possible for SoE.

Relevance for the user

The configuration of the process data objects (PDOs) must be parameterized by the EtherCAT® Master. Templates can be taken from the ESI, but free parameterization is also possible. The device description file (ESI) can be used for offline parameterization in advance (see ↘ "Device data sheet (ESI)"). For more information on the application of the DS402 profile, see chapter "Operation modes" or "Scaling".

When parameterizing the process data objects, observe the maximum length of the configurable MDT / AT data of 15 IDNs with a maximum of 48 bytes (+ 2 byte status/control word)

ctrlX DRIVE supports "distributed clock synchronization" (exact adjustment of distributed clocks).

The minimum EtherCAT® cycle time is 250 µs

Commissioning

The EtherCAT® master communication at ctrlX DRIVE is commissioned mainly via the EtherCAT® Master. For the drive

itself, the SoE protocol and the Servodrive application profile have to be active. Access for commissioning the ctrlX DRIVE is possible via the panel using USB-C or via EoE.

> ℹ️ When setting up an EtherCAT® network with ctrlX DRIVE, note the following:
> - Use slot XF21 as an input (ETHERCAT IN)
> - Use slot XF22 as output (ETHERCAT OUT)

Commissioning without EtherCAT Master

Due to the EtherCAT limitations regarding Ethernet communication, an engineering connection is not always possible:

Critical fields of application are:

- **Application 1:** Drive with active EtherCAT® in non-EtherCAT network
  Here the Engineering tool (ctrlX DRIVE Engineering / IndraWorks Ds) has to be connected and "EtherCAT/VARAN deactivation" has to be selected in the following dialog. After a subsequent reboot, the drive can be accessed via Ethernet.
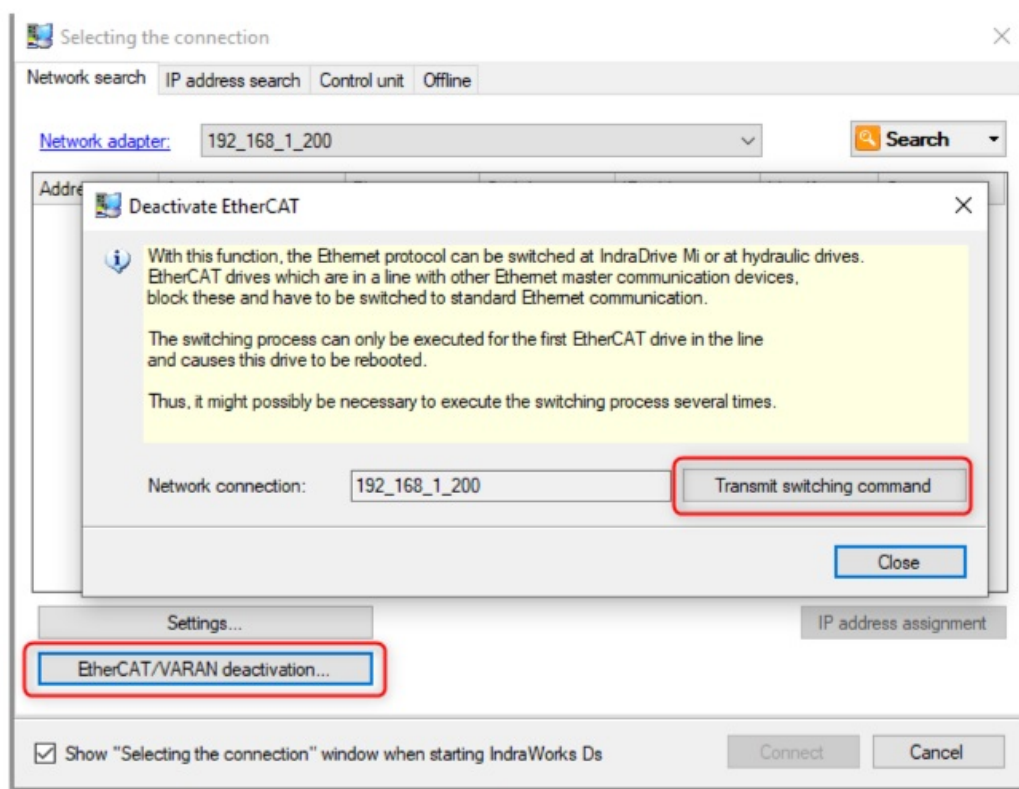

Fig. 161: Drive with active EtherCAT® in non-EtherCAT network

- **Application 2:** Drive with non-active EtherCAT® in EtherCAT network
  Connection of the engineering tool and switching of the drives to standard engineering, then setting of the EtherCAT protocol for all drives.

Additional information and details

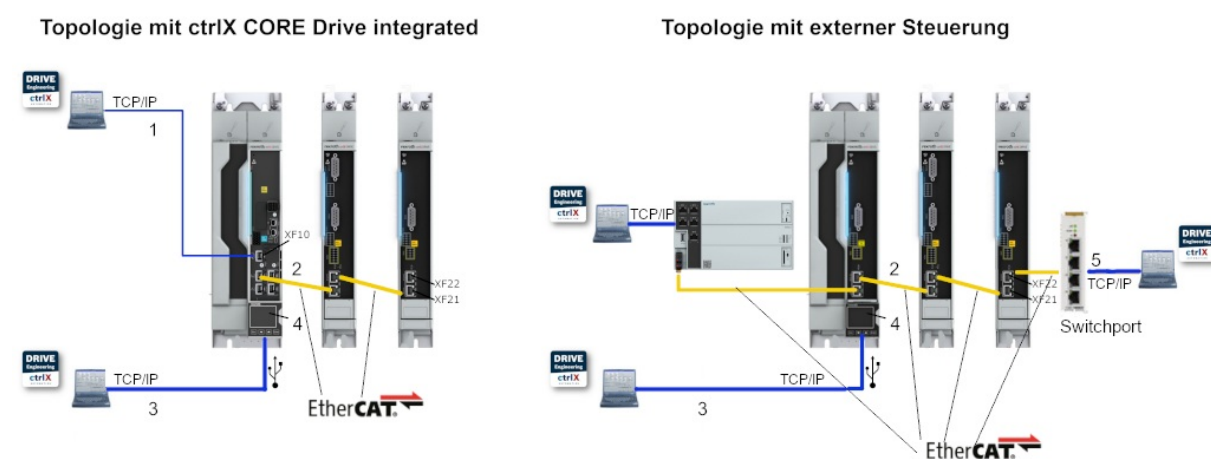## Topology

Fig. 162: Engineering options with EtherCAT®

1	ctrlX CORE HMI/Engineering port
2	IP-compatible Industrial Ethernet master communication (field bus)
3	Virtual Ethernet interface via USB to panel
4	Plug-in panel that can be taken from device to device during operation
5	Engineering (only possible via coupler or e.g. EL6601) Note: Connecting Engineering PC directly to the EtherCAT® network is not supported due to restrictions in EtherCAT®
XF21	Slot P1 as input ("IN")
XF22	Slot P2 as output ("OUT")

General features

- Transmission rate 100 Mbit/s

- Data transfer via Ethernet cable (min. CAT5e copper, CAT7 copper is recommended)
- Maximum length of Ethernet cable between two devices: 100 m
- Topology: "Line"
- Minimum cycle time: 250 µs
- SoE protocol (Servo Drive Profile over EtherCAT®) is supported
- 16-bit Sercos parameters of the drive are accessed via "SoE" protocol
- Max. length of configurable MDT / AT data of 15 IDNs with a max. of 48 bytes (+ 2 byte status/control word)
- Cyclic data exchange of command values and actual values
- Free configuration of telegram contents
- EtherCAT® mailbox method for parameterization and diagnostics
- "EtherNET over EtherCAT" (EoE) is supported
- "File transfer over EtherCAT" (FoE) is supported
- "Distributed clock synchronization" (exact adjustment of distributed clocks)
- Can be used as a distributed clock reference

Coupling of EtherCAT state machine with subdevice machine

For the coupling of state machines see ↘ "EtherCAT state machine "

Synchronization and timing

The necessary default settings are taken from the device description file (ESI) when the drive is integrated into the EtherCAT® Master. In the case of a manual configuration, certain times must be observed. The minimum EtherCAT cycle time for ctrlX DRIVE is 250 µs.

ctrlX DRIVE supports the following modes:

- **DC Mode Sync0:** Slave application synchronizes to Sync0 signal

Acyclic data channel

Object directory (online)

- All objects (corresponds to S-0-0017)
- All objects that can be mapped to an RxPDO (corresponds to S-0-0188)
- All objects that can be mapped to a TxPDO (corresponds to S-0-0187)
- All objects that need to be saved (corresponds to S-0-0192)

EtherNET over EtherCAT (EoE)

With "EtherNET over EtherCAT" (EoE), standard EtherNET telegrams are tunneled to the drive via the EtherCAT mailbox. This allows access to the drive via standard Ethernet. For the EtherCAT® Master to forward the data from Ethernet to EoE, the routing must be configured and activated.

The IP address of the slave is set in the master and then transmitted to the slave. The parameters S-0-1020, S-0-1021 and S-0-1022 must therefore not be changed (manually) in the drive. The (virtual) Mac address of the slave is displayed in the parameter S-0-1019.

The command C6100 "Activate IP settings" (S-0-1048.0.1) is started automatically in the drive to take over the IP settings changed by the master.

Comparison of ADS - EoE
Comparison of ADS - EoE

	ADS	EoE
Parameter w / r	Yes (16 bits only, alias required)	Yes
FWA update	No	Yes
Transmission rate	O	+
Openness	Beckhoff only	Yes
Parameters via control unit	Yes	Yes
Solution		As a prerequisite, the control unit has to support EoE Endpoint.
CoE / SoE	SoE only	CoE and SoE

Legend:

ADS: *Automation Device Specification by Beckhoff*

File transfer over EtherCAT (FoE)

File transfer over EtherCAT (FoE) enables the import of firmware updates via EtherCAT. The data transfer via the FoE protocol is only allowed in the "Bootstrap" state (the EtherCAT bus state machine).

If a file was transferred in the Bootstrap state and after successful download of a file the slave is switched back to Init via the master of Bootstrap, an internal reboot of the device is automatically triggered.

Servodrive Profile over EtherCAT (SoE)

Device data sheet (ESI)

The device data sheet (XML format) informs the EtherCAT® master of the type and characteristics of the respective device (Drive, IO,...).

The device data sheet should be integrated in the EtherCAT® master. An existing older version has to be replaced. The

XML files standardized by the EtherCAT® Technology Group (ETG) can be read by all EtherCAT® masters.

The device data sheets are supplied with ctrlX Drive Engineering and can be found in the installation directory under DeviceDataSheets.

> ⓘ The device data sheets must not be changed.

Parameters and diagnostics

Parameters involved

- P-0-4075, EtherCAT bus: Field bus watchdog
- S-0-0001, Application synchronization: NC cycle time
- S-0-0005, SoE protocol: Minimum feedback acquisition time (T4min)
- S-0-0097, Class 2 diagnostics: Mask
- S-0-0098, Class 3 diagnostics: Mask
- S-0-0187, MCI connection type 1: List of configurable data
- S-0-0188, MCI connection type 2: List of configurable data
- S-0-1042, MCI identification: Topology index
- S-0-0002, SoE protocol: Sercos cycle time (TScyc)
- S-0-0014, MCI diagnostics: Interface status
- S-0-0015, SoE protocol: Telegram type parameter
- S-0-0016, SoE protocol: Configuration list of AT
- S-0-0024, SoE protocol: Configuration list of MDT
- S-0-0029, SoE protocol: MDT error counter
- S-0-0134, Servodrive profile: Control word
- S-0-0135, Servodrive profile: Status word
- S-0-0185, SoE protocol: Max. length of data record in the AT
- S-0-0186, SoE protocol: Max. length of data record in the MDT

Diagnostics involved

- A0004 Initialization
- A0005 Pre-Operational
- A0006 Safe-Operational
- C0101 Invalid parameters -> S-0-0021
- C0104 Config. IDNs for MDT not configurable
- C0106 Config. IDNs for AT not configurable
- C0112 Timing setting not allowed
- C0190 EtherCAT: Invalid Watchdog Configuration
- C0191 EtherCAT: Freerun needs 3buffer mode
- C0192 EtherCAT: Sync0 Cycle Time does not fit
- E4072 EtherCAT EoE mailbox error
- F4002 Failure of a consumer connection
- F4009 Bus failure