EtherCAT – SB6

Manual

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1 Foreword

The SB6 series drive controllers are available with the Ethernet-based EtherCAT fieldbus system as standard.

This documentation describes a combination of a drive controller (EtherCAT SubDevice) and controller (EtherCAT MainDevice), as well as the associated automation software.

The drive controllers of the SB6 series successfully passed the EtherCAT and Fail Safe over EtherCAT (FSoE) conformance tests. This means that the communication interface was tested to ensure the reliability and function of the lower-level communication regardless of vendor.

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2 User information

This documentation assists you in commissioning 6th generation STOBER drive controllers (EtherCAT SubDevice) in combination with a higher-level controller (EtherCAT MainDevice) over an EtherCAT network.

Technical knowledge

Operating an EtherCAT network requires having familiarity with the basics of the EtherCAT network technology.

Technical requirements

Before you begin operating your EtherCAT network, you need to wire the drive controllers and initially check that they are functioning correctly. To do this, follow the instructions in the manual for the relevant drive controller.

2.1 Storage and transfer

As this documentation contains important information for handling the product safely and efficiently, it must be stored in the immediate vicinity of the product until product disposal and be accessible to qualified personnel at all times.

Also pass on this documentation if the product is transferred or sold to a third party.

2.2 Described product

This documentation is mandatory for SB6 series drive controllers in conjunction with the DriveControlSuite software (DS6) in V 6.7-A or later and associated firmware in V 6.7-A-EC or later.

2.3 Directives and standards

Refer to the drive controller documentation for the European directives and standards relevant to the drive controller and accessories.

2.4 Timeliness

Check whether this document is the latest version of the documentation. We make the latest document versions for our products available for download on our website:
http://www.stoeber.de/en/downloads/.

2.5 Original language

The original language of this documentation is German; all other language versions are derived from the original language.

2.6 Limitation of liability

This documentation was created taking into account the applicable standards and regulations as well as the current state of technology.

No warranty or liability claims for damage shall result from failure to comply with the documentation or from use that deviates from the intended use of the product. This is especially true for damage caused by individual technical modifications to the product or the project configuration and operation of the product by unqualified personnel.

2.7 Formatting conventions

Orientation guides in the form of signal words, symbols and special text markups are used to emphasize specific information so that you are able identify it in this documentation quickly.

2.7.1 Display of warning messages and information

Warning messages are identified with symbols. They indicate special risks when handling the product and are accompanied by relevant signal words that express the extent of the risk. Furthermore, useful tips and recommendations for efficient, error-free operation are specially highlighted.

ATTENTION!

Attention

This indicates that damage to property may occur

- if the stated precautionary measures are not taken.

⚠ CAUTION!

Caution

This word with a warning triangle indicates that minor personal injury may occur

- if the stated precautionary measures are not taken.

⚠ WARNING!

Warning

This word with a warning triangle means there may be a considerable risk of fatal injury

- if the stated precautionary measures are not taken.

⚠ DANGER!

Danger

This word with a warning triangle indicates that there is a considerable risk of fatal injury

- if the stated precautionary measures are not taken.

Information

Information indicates important information about the product or serves to emphasize a section in the documentation that deserves special attention from the reader.

2.7.2 Markup of text elements

Certain elements of the continuous text are distinguished as follows.

Important information	Words or expressions with a special meaning
Interpolated position mode	Optional: File or product name or other name
Detailed information	Internal cross-reference
http://www.samplelink.com	External cross-reference

Software and other displays

The following formatting is used to identify the various information content of elements referenced by the software interface or a drive controller display, as well as any user entries.

Main menu Settings	Window names, dialog box names, page names or buttons, combined proper nouns, functions referenced by the interface
Select `Referencing method A`	Predefined entry
Save your `<own IP address>`	User-defined entry
EVENT 52: COMMUNICATION	Displays (status, messages, warnings, faults)

Keyboard shortcuts and command sequences or paths are represented as follows.

[Ctrl], [Ctrl] + [S]	Key, key combination
Table > Insert table	Navigation to menus/submenus (path specification)

Operating buttons

The buttons of the drive controller are depicted as follows in the continuous text.

[OK]	Button on the operating unit of the drive controller

2.7.3 Mathematics and formulas

The following signs are used to represent mathematical relationships and formulas.

−	Subtraction
+	Addition
×	Multiplication
÷	Division
| |	Absolute value

2.8 Trademarks

The following names used in connection with the device, its optional equipment and its accessories are trademarks or registered trademarks of other companies:

CANopen®, CiA®	CANopen® and CiA® are registered trademarks of CAN in AUTOMATION e.V., Germany, the international user and manufacturer association.
CODESYS®	CODESYS® is a registered trademark of CODESYS GmbH, Germany.
EtherCAT®, Safety over EtherCAT®	EtherCAT® and TwinCAT® are registered trademarks and patented technologies, licensed by Beckhoff Automation GmbH, Germany.
TwinCAT®	TwinCAT® is a registered and licensed trademark of Beckhoff Automation GmbH, Germany.
Windows®, Windows® 7, Windows® 10, Windows® 11	Windows®, the Windows® logo, Windows® XP, Windows® 7, Windows® 10, and Windows® 11 are registered trademarks of Microsoft Corporation in the United States and/or other countries.

All other trademarks not listed here are the property of their respective owners.

Products that are registered as trademarks are not specially indicated in this documentation. Existing property rights (patents, trademarks, protection of utility models) are to be observed.

3 Safety notes

⚠ WARNING!

Risk of fatal injury if safety notes and residual risks are not observed!

Failure to observe the safety notes and residual risks in the drive controller documentation may result in accidents causing serious injury or death.

- Observe the safety notes in the drive controller documentation.
- Consider the residual risks in the risk assessment for the machine or system.

⚠ WARNING!

Malfunction of the machine due to incorrect or modified parameterization!

In the event of incorrect or modified parameterization, malfunctions can occur on machines or systems which can lead to serious injuries or death.

- Observe the security notes in the drive controller documentation.
- Protect the parameterization, e.g. from unauthorized access.
- Take appropriate measures for possible malfunctions (e.g. emergency off or emergency stop).

4 Network structure

An EtherCAT network normally consists of an EtherCAT MainDevice (controller) and EtherCAT SubDevices, i.e. drive controllers from the SB6 series.

The EtherCAT network structure is generally optimized for a line topology. Each EtherCAT SubDevice has an incoming and continuing bus connection.

Overall network expansion is virtually unlimited because a maximum of 65535 EtherCAT nodes can be connected together.

You can configure and parameterize the drive controllers using the DriveControlSuite commissioning software and the entire EtherCAT network using the automation software of the controller.

The following graphic provides a generalized depiction of an EtherCAT network with an EtherCAT MainDevice and EtherCAT SubDevices.

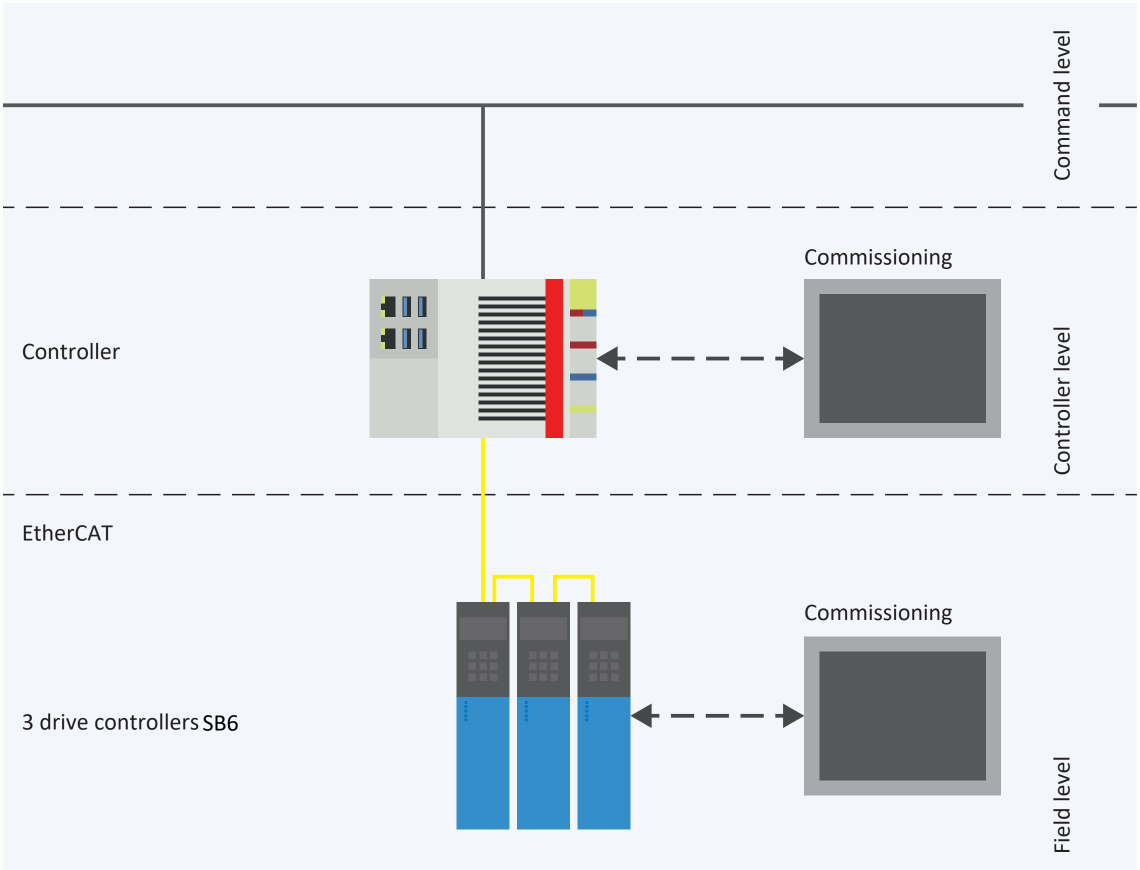


Fig. 1: EtherCAT: Network structure

5 Connection

To connect the drive controllers to other EtherCAT nodes, the top of each device features two RJ-45 sockets.

5.1 Selecting suitable cables

EtherCAT is an Ethernet-based communications technology optimized for automation technology.

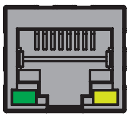
Ethernet patch cables or crossover cables meeting the CAT 5e quality level are the ideal cables. The Fast Ethernet technology allows a maximum cable length of 100 m between two nodes.

Information

Ensure that you only use shielded cables with an SF/FTP, S/FTP or SF/UTP design.

5.2 X200, X201: Fieldbus connection

The drive controllers have both RJ-45 sockets X200 and X201. The sockets are located on top of the device. The associated pin assignment and color coding correspond to the EIA/TIA-T568B standard.

Socket	Pin	Designation	Function
1|2| ... |7|8 	1	Tx+	Communication
	2	Tx–	
	3	Rx+	
	4	—	—
	5	—	—
	6	Rx–	Communication
	7	—	—
	8	—	—

Tab. 1: X200 and X201 connection description

6 What you should know before commissioning

The following chapters provide a quick introduction to the structure of the program interface and accompanying window designations as well as relevant information about parameters and generally saving your project configuration.

6.1 Program interfaces

The following chapters include an overview of the program interfaces for the described software components.

6.1.1 DS6 program interface

Using the graphical interface of the DriveControlSuite commissioning software (DS6), you can project, parameterize and commission your drive project quickly and efficiently. In case of service, you can evaluate diagnostic information such as operating states, fault memories and fault counters of your drive project using DriveControlSuite.

Information

The program interface of DriveControlSuite is available in German, English and French. To change the language of the program interface, select Settings > Language.

Information

The DriveControlSuite help in the menu bar can be reached via Help > Help for DS6 or via the [F1] key on your keyboard. When you press [F1] in an area of the program, the corresponding help topic opens.

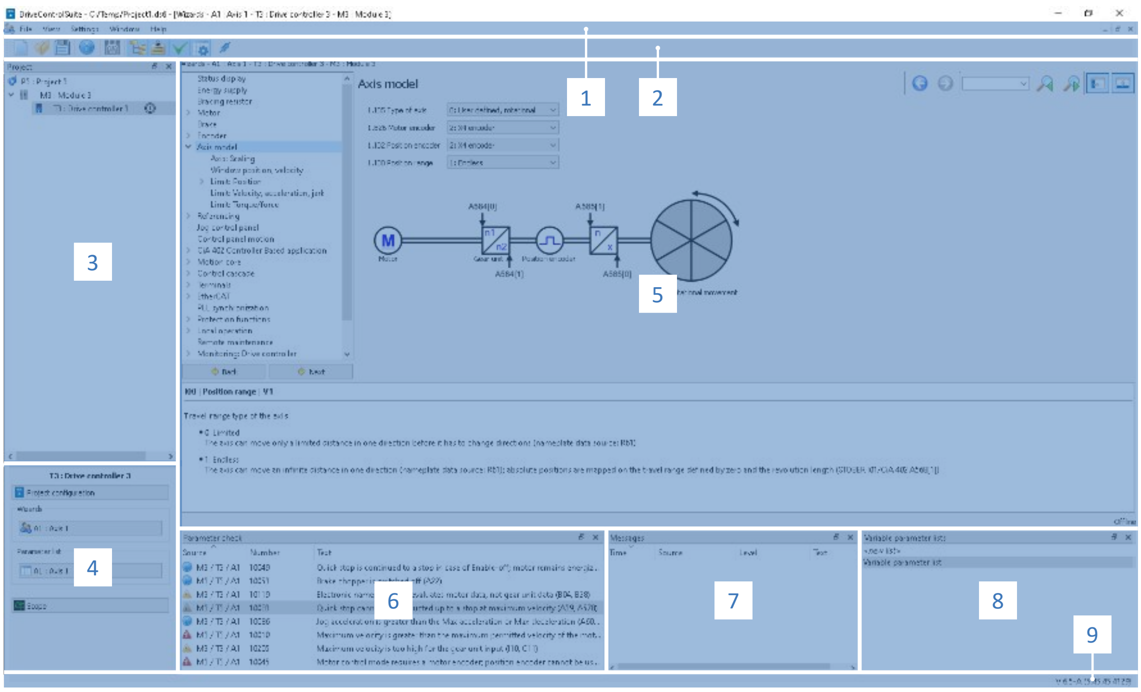


Fig. 2: DS6: Program interface

No.	Area	Description
1	Menu bar	Using the File, View, Settings and Window menus, you can open and save projects, display and hide program windows, select the interface language and access level and change between different windows in the workspace.
2	Toolbar	The toolbar enables quick access to frequently needed functions, like opening and saving projects and hiding and displaying windows in the program interface.
3	Project tree	The project tree forms the structure of your drive project in the form of modules and drive controllers. Select an element using the project tree first in order to edit it using the project menu.
4	Project menu	The project menu offers you various functions for editing the project, module and drive controller. The project menu adapts to the element that you selected in the project tree.
5	Workspace	The different windows which can be used to edit your drive project, such as the configuration dialog, wizards, the parameter list or the scope analysis tool, open in the workspace.
6	Parameter check	The parameter check points out irregularities and inconsistencies that were detected in the plausibility check of calculable parameters.
7	Messages	The entries in the messages log the connection and communication status of the drive controllers, incorrect inputs caught by the system, errors when opening a project or rule violations in the graphical programming.
8	Variable parameter lists	You can use variable parameter lists to compile any parameters in individual parameter lists for a quick overview.
9	Status bar	In the status bar, you can find the specifications of the software version and get additional information about the project file, the devices and the progress of the process during processes such as loading projects.

6.1.1.1 Configuring the view

In DriveControlSuite, you can change the visibility and arrangement of areas and windows, such as to optimize the available space in the workspace when working with smaller screens.

Showing/hiding areas

Use the icons in the toolbar or the items in the View menu to show or hide specific areas in DriveControlSuite as needed.

Icon	Item	Description
–	Reset	Resets the view to factory settings.
	Project	Shows/hides the Project window (project tree, project menu).
	Messages	Shows/hides the Messages window.
	Parameter check	Shows/hides the Parameter check window.
	Variable parameter lists	Shows/hides the Variable parameter lists window.

Arrange and group areas

You can undock and rearrange the individual areas via drag and drop. If you drag an undocked window to the edge of DriveControlSuite, you can release it there in a color-highlighted area either next to or on top of another window to redock it.

When you release the window onto another window, the two areas are merged into one window where you can use tabs to switch between the areas.

6.1.1.2 Navigation using sensitive circuit diagrams

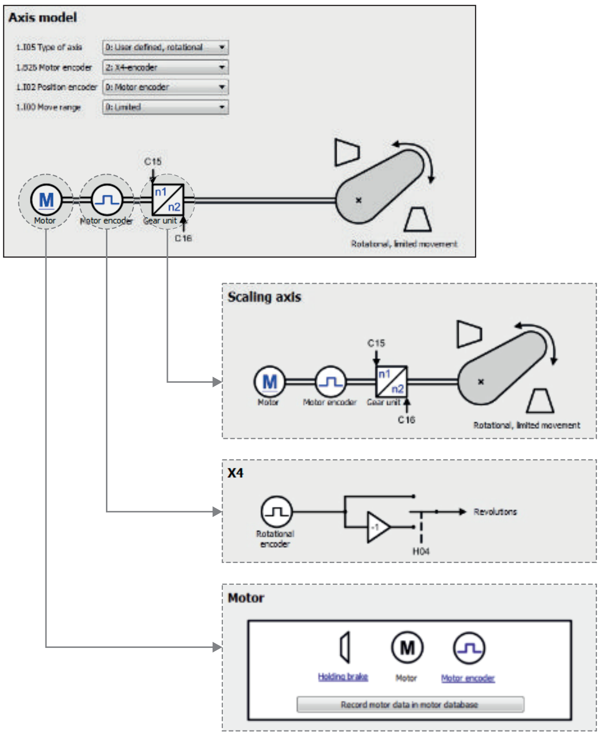


Fig. 3: DriveControlSuite: Navigation using text links and symbols

In order to graphically illustrate the processing sequence of actual and set values, the use of signals or the arrangement of drive components and to make configuring the accompanying parameters easier, they are displayed on the respective wizard pages of the workspace in the form of circuit diagrams.

Blue text links or clickable icons indicate links within the program. These refer to the corresponding wizard pages and, as a result, allow you to reach additional helpful detail pages with a click.

6.1.2 TwinCAT 3 program interface

In TwinCAT 3, you commission your EtherCAT system via the TwinCAT 3 Engineering development environment. The following graphic shows the interface elements relevant to this documentation.

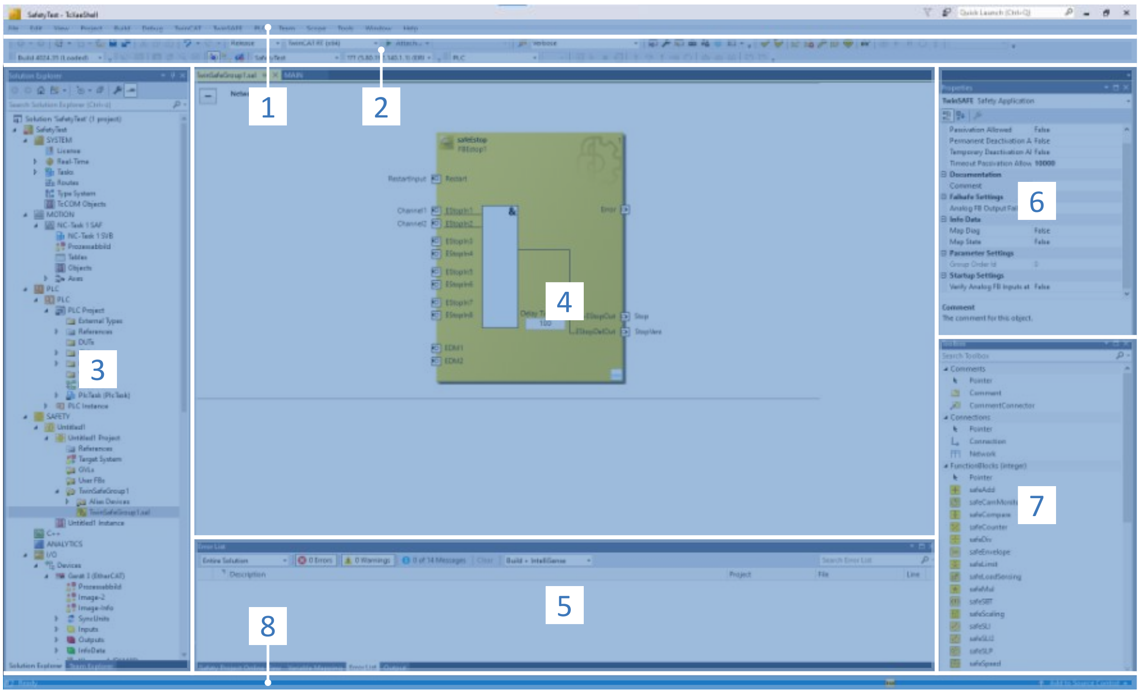


Fig. 4: TwinCAT 3 Engineering: Program interface

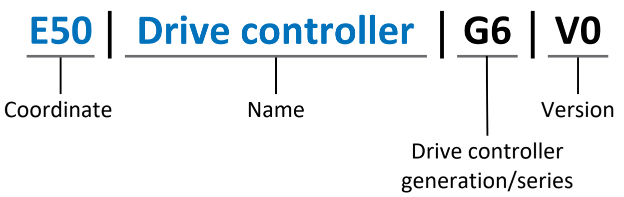
No.	Area	Description
1	Menu bar	The menu bar shows the menus set by default. Editor-specific menus appear only when the corresponding editor is open. Using the Tools menu, you can configure the programming interface and add to existing menus or define new ones, for example.
2	Toolbar	The toolbar enables quick access to frequently used functions, such as opening and saving projects.
3	Solution explorer	The solution explorer maps the structure of your project with the project elements it contains. First select an element using the solution explorer to edit it in the editor.
4	Main window (editor)	In the editor, you define and edit objects, e.g. graphical programming elements.
5	Message window	The Messages window informs you of any errors or warnings currently present. You also receive messages about the syntax check, compilation process, etc.
6	Properties window	The properties window shows the properties of the element selected in the solution explorer.
7	Toolbox	The toolbox displays the tools available for the active editor, such as graphical programming elements.
8	Information and status bar	The information and status bar informs you about the state of the system (Config, Run, Stop or Exception mode). In online operation, you can see the current status of the program. If an editor window is active, the current position of the cursor and the set editing mode may also be displayed.

6.2 Meaning of parameters

You can use parameters to adapt the function of the drive controller to your individual application. In addition, parameters visualize the current actual values (actual velocity, actual torque, etc.) and trigger actions such as Save values, Test phase, etc.

Interpretation of parameter identification

Parameter identification consists of the following elements, where short forms are also possible, i.e. only specifying a coordinate or the combination of coordinate and name.



6.2.1 Parameter groups

Parameters are assigned to individual groups by topic. The drive controllers differentiate between the following parameter groups.

Group	Topic
A	Drive controllers, communication, cycle times
B	Motor
C	Machine, velocity, torque/force, comparators
D	Set value
E	Display
F	Terminals, analog and digital inputs and outputs, brake
G	Technology – Part 1 (application-dependent)
H	Encoder
I	Motion (all motion settings)
J	Motion blocks
K	Control panel
L	Technology – Part 2 (application-dependent)
M	Profiles (application-dependent)
N	Additional functions (application-dependent; e.g. extended cam control unit)
P	Customer-specific parameters (programming)
Q	Customer-specific parameters, instance-dependent (programming)
R	Production data for the drive controller, motor, brakes, motor adapter, gearbox and geared motor
S	Safety (safety technology)
T	Scope
U	Protection functions
Z	Fault counter

Tab. 2: Parameter groups

6.2.2 Parameter types and data types

In addition to topic-based sorting in individual groups, all parameters belong to a certain data type and parameter type. The data type of a parameter is displayed in the parameter list, properties table. The connections between parameter types, data types and their value range can be found in the following table.

Data type	Parameter type	Length	Value range (decimal)
INT8	Integer or selection	1 byte (signed)	-128 – 127
INT16	Integer	2 bytes (1 word, signed)	-32768 – 32767
INT32	Integer or position	4 bytes (1 double word, signed)	-2 147 483 648 – 2 147 483 647
BOOL	Binary number	1 bit (internal: LSB in 1 byte)	0, 1
BYTE	Binary number	1 byte (unsigned)	0 – 255
WORD	Binary number	2 bytes (1 word, unsigned)	0 – 65535
DWORD	Binary number or parameter address	4 bytes (1 double word, unsigned)	0 – 4 294 967 295
REAL32 (single type according to IEE754)	Floating-point number	4 bytes (1 double word, signed)	-3.40282×10^{38} – 3.40282×10^{38}
STR8	Text	8 characters	—
STR16	Text	16 characters	—
STR80	Text	80 characters	—

Tab. 3: Parameters: Data types, parameter types, possible values

Parameter types: Use

- Integer, floating-point number
  For general computing processes
  Example: Set and actual values
- Selection
  Numeric value to which a direct meaning is assigned
  Example: Sources for signals or set values
- Binary number
  Bit-oriented parameter information that is collected in binary
  Example: Control and status words
- Position
  Integer combined with associated units and decimal places
  Example: Actual and set values of positions
- Velocity, acceleration, deceleration, jerk
  Floating-point number combined with associated units
  Example: Actual and set values for velocity, acceleration, deceleration, jerk
- Parameter address
  Referencing of a parameter
  Example: In F40 AO1 source, for example, E08 n-motor filtered can be parameterized
- Text
  Outputs or messages

6.2.3 Parameter types

The following types of parameters are differentiated.

Parameter type	Description	Example
Simple parameters	Consist of one group and one line with a defined value.	A21 Brake resistor R: Value = 100 ohms
Array parameters	Consist of a group, a line and multiple sequential (listed) elements, which have the same properties but different values.	A10 Access level ▪ A10[0] access level: Value = Access level via operating unit ▪ A10[2] access level: Value = Access level via CANopen and EtherCAT ▪ A10[4] access level: Value = Access level via PROFINET
Record parameters	Consist of a group, a line and multiple sequential (listed) elements, which can have different properties and different values.	A00 Save values ▪ A00[0] Start: Value = Start action ▪ A00[1] Progress: Value = Display action progress ▪ A00[2] Result: Value = Display action result

Tab. 4: Parameter types

6.2.4 Parameter structure

Every parameter has specific coordinates with the following structure.

1. E200 [0]

Line

Group Element

Axis

- Axis (optional)
  Axis to which an axis-specific parameter is assigned; not applicable for global parameters (value range: 1 - 4).
- Group
  The thematic group to which a parameter belongs (value range: A – Z).
- Line
  Distinguishes the parameters within a parameter group (value range: 0 – 999).
- Element (optional)
  Elements of an array or record parameter (value range: 0 – 16000).

6.2.5 Parameter visibility

The visibility of a parameter is controlled by the access level you set in DriveControlSuite and by the properties you project for the respective drive controller (e.g. hardware, firmware and application). A parameter can also be shown or hidden depending on other parameters or settings. For example, the parameters of an additional function are only shown as soon as you activate the relevant additional function.

Access level

The access options for the individual software parameters are ranked hierarchically and divided into individual levels. This means that parameters can be hidden for a specific purpose and, relatedly, their configuration options can be locked starting from a specific level.

Each parameter has one access level for read access (visibility) and one access level for write access (editability). The following levels are present:

- Level 0
  Elementary parameters
- Level 1
  Important parameters of an application
- Level 2
  Important parameters for service with extensive diagnostic options
- Level 3
  All parameters needed for commissioning and optimizing an application

The parameter A10 Access level controls general access to parameters:

- Over the drive controller display (A10[0])
- Over CANopen or EtherCAT (A10[2])
- Over PROFINET (A10[3])

Hardware

Which parameters are available to you in DriveControlSuite is determined by which series you select in the configuration dialog for the drive controller, for example, or whether you project an option module. Basically, the only parameters that are displayed are the ones you need to parameterize the configured hardware.

For example, a drive controller can evaluate an encoder using terminal X120, provided that a corresponding terminal module has been installed. The accompanying evaluation is activated using parameter H120. However, this parameter is visible only if the terminal module was initially selected during the drive project configuration.

Firmware

Due to the further development and updating of functions for the drive controllers, new parameters and also new versions of existing parameters are continuously being implemented in DriveControlSuite and in the firmware. The parameters are displayed in the software according to the DriveControlSuite version used and the configured firmware version of the respective drive controller.

Applications

Applications generally differ in terms of functions and their control. For this reason, different parameters are available with each application.

Information

If a parameter exists in the configuration due to the projected properties of the drive controller (e.g. hardware, firmware, application), it is generally available for fieldbus communication. The visibility of a generally available parameter has no effect on its availability for fieldbus communication (e.g. through access level or parameter selection).

6.3 Signal sources

Drive controllers are controlled either by a fieldbus, by terminals or by mixed operation consisting of a fieldbus system and terminals. You can use the corresponding selection parameters, referred to as signal sources, to configure in DriveControlSuite whether the control signals and set values of the application are obtained over a fieldbus or using terminals.

In case of activation by using terminals, the respective analog or digital inputs are specified directly as the source. In case of activation by fieldbus, parameters are selected as sources for control signals and set values, which must be part of the process data mapping between the controller and drive controller so that the controller can write to them via fieldbus.

6.4 Non-volatile memory

All project configurations, parameterizations and related changes to parameter values are in effect after transmission to the drive controller, but are only stored in volatile memory.

Saving to a drive controller

To save the configuration in non-volatile memory on a drive controller, you have the following options:

- Saving the configuration using the Save values wizard:
  Project menu > Wizards area > Projected axis > Save values wizard:
  Select the Save values action
- Saving the configuration using the parameter list:
  Project menu > Parameter list area > Projected axis > Group A: Drive controller > A00 Save values:
  Set the parameter A00[0] to the value 1: Active
- Saving the configuration using the S1 operating button:
  Press and hold the operating button for 3 s
- Saving the configuration using the operating unit:
  Press the save button for 3 s

Saving to all drive controllers within a project

To save the configuration in non-volatile memory on several drive controllers, you have the following options:

- Saving the configuration using the toolbar:
  Toolbar > Save values icon: Click the Save values icon
- Saving the configuration using the Online functions window:
  Project menu > Online connection button > Online functions window: Click on Save values (A00)

Information

Do not shut off the drive controller while saving. If the supply voltage to the control unit is interrupted while saving, the drive controller will start with the last correct configuration that was saved and with fault 40: Invalid data the next time it is switched on. In order to acknowledge the fault and successfully complete the saving process, the configuration must be stored again in non-volatile memory and the action must be completed.

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7 Commissioning

Are you looking to operate drive controllers with a controller over an EtherCAT network?

The following chapters describe commissioning using DriveControlSuite in combination with the TwinCAT 3 Engineering automation software.

We assume the following system environment as an example so that you can follow the individual commissioning steps exactly:

- Drive controllers of the SB6 series in firmware version 6.7-A-EC or later
- DriveControlSuite commissioning software version 6.7-A or later

in combination with

- Beckhoff controller
- Beckhoff TwinCAT 3 Engineering automation software

Commissioning is divided into the following steps:

1. DriveControlSuite
   Project all of the drive controllers, i.e. application type, device control systems, process data for fieldbus communication and mechanical axis model in DriveControlSuite.
   Depending on the selected application (CiA 402 or CiA 402 HiRes Motion), scale your axis models on the drive controller side or the controller side.
   In both cases, transfer your configuration to the drive controllers of the system network.
2. Automation software
   Scale your axis model if necessary and then map your entire hardware environment in the respective software.
   Synchronize the operation of the distributed clocks in all EtherCAT nodes and configure the communication of individual nodes over the EoE protocol.
   Finally, transfer the entire configuration to the controller and then start up your EtherCAT system.

7.1 DS6: Configuring the drive controller

Project and configure all drive controllers for your drive system in DriveControlSuite (see also DS6 program interface [▶ 13]).

Information

Since a system environment with a controller is assumed for commissioning, the following steps are described on the basis of the CiA 402 and CiA 402 HiRes Motion applications in combination with the CiA 402 device control. Operation of EtherCAT with drive-based applications like Drive Based, Drive Based Synchronous and Drive Based Center Winder is also possible.

Information

Always perform the steps described below in the specified order!

Some parameters are interdependent and do not become accessible to you until you have first configured certain settings. Follow the steps in the specified sequence so that you can finish the parameterization completely.

7.1.1 Initiating the project

In order to be able to configure all drive controllers and axes of your drive system using DriveControlSuite, you must record them as part of a project.

7.1.1.1 Projecting the drive controller and axis

Create a new project and project the first drive controller along with the accompanying axis.

Information

Make sure that you project the correct series in the Drive controller tab. The projected series cannot be changed afterwards.

Creating a new project

1. Start DriveControlSuite.
2. On the start screen, click Create new project.
   - ⇨ The new project is created and the configuration dialog for the first drive controller opens.
   - ⇨ The Drive controller button is active.

Projecting the drive controller

1. Properties tab:
   Establish the relationship between your circuit diagram and the drive controller to be projected in DriveControlSuite.
   1.1. Reference:
   Define the reference code (equipment code) of the drive controller.
   1.2. Designation:
   Give the drive controller a unique name.
   1.3. Version:
   Version your project configuration.
   1.4. Description:
   If necessary, save additional supporting information (e.g., the change history).
2. Drive controller tab:
   Select the series, device type and firmware version of the drive controller.
   2.1. Firmware:
   Select the EtherCAT version 6.x -**EC**.
3. Option modules tab:
   Project the option modules of the drive controller.
4. Device control tab:
   Project the basic control of the drive controller.
   4.1. Device control:
   Select CiA 402 device control.
   4.2. Process data Rx, Process data Tx:
   Select EtherCAT Rx or EtherCAT Rx SDO Info and EtherCAT Tx for transmitting the EtherCAT process data.
   4.3. If you are working with hardware and software products from Beckhoff and are using the SDO Info service, select EtherCAT Rx SDO Info and EtherCAT Tx for the transmission of the EtherCAT process data. You set up the SDO Info service in TwinCAT 3 (see SDO Info service [▶ 89]).
   4.4. If you are working with a CODESYS SoftMotion controller and the CODESYS V3 automation software, select EtherCAT Rx and EtherCAT Tx for transmitting the EtherCAT process data.

ATTENTION!

Change of addressing when changing the template

If you change the template from EtherCAT Rx to EtherCAT Rx SDO Info, the addressing of the elements of array and record parameters also changes. Note this in particular for existing configurations. For the templates, various ESI files are created. When changing the template, you must create a new ESI file using the wizards in DriveControlSuite and provide it to TwinCAT 3. A template change also causes a change to the revision number of the drive controller. Therefore, restart the drive controller after changing the template.

Projecting the axis

1. Click Axis A.
2. Properties tab:
   Establish the relationship between your circuit diagram and the axis to be projected in DriveControlSuite.
   2.1. Reference:
   Define the reference code (equipment code) of the axis.
   2.2. Designation:
   Give the axis a unique name.
   2.3. Version:
   Version your project configuration.
   2.4. Description:
   If necessary, save additional supporting information (e.g., the change history).
3. Application tab:
   Select the desired controller-based application CiA 402 or CiA 402 HiRes Motion.
   3.1. If you are working with hardware and software products from Beckhoff, we recommend CiA 402 (incremental version).
   3.2. If you are working with a CODESYS SoftMotion controller and the CODESYS V3 automation software, we recommend CiA 402 HiRes Motion (version with user-defined units of measure).
4. Motor tab:
   Select the type of motor you operate with this axis. If you are working with motors from third-party suppliers, enter the accompanying motor data later.
5. Confirm with OK.

7.1.1.2 Configuring safety technology

If the drive controller is part of a safety circuit, you must configure the safety technology in accordance with the commissioning steps outlined in the corresponding manual in the next step (see Detailed information [▸ 105]).

7.1.1.3 Creating other drive controllers and modules

In DriveControlSuite, all drive controllers within a project are grouped using modules. If you add a new drive controller to your project, be sure to always assign it to an existing module. Group drive controllers in a module if, for example, they are located in the same control cabinet or work together to operate the same machine part.

Creating a drive controller

1. In the project tree, select your project P1 > module M1 > context menu Create new drive controller.
   ⇨ The drive controller is created in the project tree and the configuration dialog opens.
2. Project the drive controller as described in Projecting the drive controller and axis.
3. Repeat the steps for all other drive controllers that you want to project.

Creating a module

1. In the project tree, select your project P1 > context menu Create new module.
   ⇨ The module is created in the project tree.
2. Project the module as described in Projecting the module [▸ 27].
3. Repeat the steps for all other modules that you want to project.

7.1.1.4 Projecting the module

Give your module a unique name, enter the reference code and, as an option, store additional information like the version and change history of the module.

1. Select the module in the project tree and click on Project configuration in the project menu.
   - ⇨ The configuration dialog for the module opens.
2. Establish the relationship between your circuit diagram and the module in DriveControlSuite.
   - 2.1. Reference:
     Define the reference code (equipment code) of the module.
   - 2.2. Designation:
     Give the module a unique name.
   - 2.3. Version:
     Version the module.
   - 2.4. Description:
     If necessary, save additional supporting information (e.g., the change history).
3. Confirm with OK.

7.1.1.5 Projecting the project

Give your project a unique name, enter the reference code and, as an option, store additional information like the version and change history of the project.

1. Select the project in the project tree and click on Project configuration in the project menu.
   - ⇨ The configuration dialog for the project opens.
2. Establish the relationship between your circuit diagram and the project in DriveControlSuite.
   - 2.1. Reference:
     Define the reference code (equipment code) of the project.
   - 2.2. Designation:
     Give the project a unique name.
   - 2.3. Version:
     Version the project.
   - 2.4. Description:
     If necessary, save additional supporting information (e.g., the change history).
3. Confirm with OK.

7.1.2 Mapping the mechanical axis model

To be able to put your real drive train with one or more drive controllers into operation, you must map your complete mechanical environment in DriveControlSuite.

The 6th generation of STOBER drive controllers are specially developed for communication between the drive controller and controller on the basis of the actual variables at the output (° or mm of real axis movement). The scaling of the axis model is calculated by the drive controller's firmware independently of the encoder model, without any rounding errors or drift.

Information

The scaling of the axis depends on whether you have configured the CiA 402 or CiA 402 HiRes Motion application: For the CiA 402 HiRes Motion application, scale the axis for the drive controller in the DriveControlSuite; for the incremental version CiA 402, scale the axis in the controller.

When scaling the axis, follow the instructions for the application you are projecting.

7.1.2.1 Parameterizing the motor

You have projected one of the following motors:

Synchronous servo motor with EnDat 2.2 digital encoder or EnDat 3 (with optional brake)

When the project is configured for the corresponding motor, limiting values for currents and torques as well as associated temperature data are automatically transferred to the respective parameters of the individual wizards. All additional data on the brake and encoder is transferred at the same time.

Lean motor without encoder (with optional brake)

When the project is configured for the corresponding motor, limiting values for currents and torques as well as associated temperature data are automatically transferred to the respective parameters of the individual wizards. You only have to parameterize the cable length in use and the mass inertia ratio of the load to the motor. Even the brake purging and engaging times are already stored. You just have to activate the brake.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the Motor wizard.
3. B101 Cable length:
   Select the cable length of the power cable in use.
4. Select the Control cascade wizard > Control mode.
5. C30 J-Last / J-Motor:
   Parameterize the mass inertia ratio of the load to the motor.

Then activate the brake.

1. Select the relevant drive controller in the project tree and click on the first projected axis in the Project menu > Wizard area.
2. Select the Brake wizard.
3. F00 Brake:
   Select 1: Active.

7.1.2.2 Parameterizing the axis model

Parameterize the setup of your drive in this order:

- Define the axis model
- Scale the axis
- Parameterize the position and velocity window
- Limit the axis (optional)
  - Limit the position
  - Limit the velocity, acceleration and jerk
  - Limit the torque and force

7.1.2.2.1 Defining the axis model

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the Axis model wizard.
3. I05 Type of axis:
   Define whether the axis type is rotational or translational.
   3.1. If you have projected the CiA 402 application, or if you would like to configure the units of measure and the number of decimal places for the CiA 402 HiRes Motion application individually for specifying and displaying positions, velocities, accelerations and jerk, select 0: User defined, rotational or 1: User defined, translational.
   3.2. If you have projected the CiA 402 HiRes Motion application and the units of measure and the number of decimal places for specifying and displaying positions, velocities, accelerations and jerk are to be fixed, select 2: Rotational or 3: Translational.
4. B26 Motor encoder:
   Select the interface to which the motor encoder is connected.
5. I02 Position encoder:
   Select the interface to which the position encoder is connected.
6. I00 Position range:
   Select whether the travel range of the axis is limited or endless (modulo). The CiA 402 application requires the 0: Limited selection; the 1: Endless selection is only possible for the CiA 402 HiRes Motion application.

Information

When you parameterize I05 Type of axis, you can either use selection 0: User defined, rotational or 1: User defined, translational to configure units of measure and the number of decimal places for the axis model individually or use selections 2: Rotational and 3: Translational to revert to preset values.

Selection 0: User defined, rotational and selection 1: User defined, translational let you configure the unit of measure (I09) and the decimal places (I06) individually. Velocity, acceleration and jerk are represented as the derivative of the unit of measure with respect to time.

Selection 2: Rotational sets the following units of measure for the axis model: position in °, velocity in rpm, acceleration in rad/s^2, jerk in rad/s^3.

Selection 3: Translational sets the following units of measure for the axis model: position in mm, velocity in m/s, acceleration in m/s^2, jerk in m/s^3.

Information

If you do not parameterize it differently for I02 Position encoder, B26 Motor encoder is used for position control as standard.

7.1.2.2.2 CiA 402: Scaling an axis

If you have projected CiA 402, you mainly scale the axis in the control software and only define the polarity of the axis in DriveControlSuite (parameter: A571).

✓ You have projected CiA 402 (incremental version).

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the Axis model wizard > Axis: Scaling.
3. A585[0] Feed constant. Feed[1], A585[1] Feed constant.Shaft revolutions[2]:
   Leave the preset A585[0] at 1048576 inc (= 20 bits = 2^{20}) and A585[1] at 1 U and adjust the corresponding value in the control software.
4. I06 Decimal places position:
   Leave the default value at 0.
5. A571 Polarity:
   Use the polarity to define the direction of interpretation between the axis movement and motor movement.

Information

Parameter I297 Maximum speed position encoder must be parameterized according to your application case. If I297 is set too low, the permitted maximum speed is exceeded even at normal operating speeds. On the other hand, if I297 is set too high, measuring errors of the encoder can be overlooked.

I297 depends on the following parameters: I05 Type of axis, I06 Decimal places position, I09 Measure unit as well as I07 Distance factor numerator position and I08 Distance factor denominator position or A585 Feed constant for CiA 402. If you have made changes to one of the parameters listed, select I297 accordingly as well.

[1] Corresponds to object 6092 hex, subindex 1 hex
[2] Corresponds to object 6092 hex, subindex 2 hex

7.1.2.2.3 CiA 402 HiRes Motion: Scaling an axis

If you have projected CiA 402 HiRes Motion, you mainly scale the axis in DriveControlSuite and only enter the number of decimal places in the control software (parameter: I06).

✓ You have projected CiA 402 HiRes Motion.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the Axis model wizard > Axis: Scaling.
3. A584[0] Gear ratio.Motor revolutions, A584[1] Gear ratio.Shaft revolutions:
   Define the gear ratio (gearbox input revolutions per gearbox output revolutions).
4. A585[1] Feed constant.Shaft revolutions, A585[0] Feed constant. Feed:
   Define the feed (feed distance per gearbox output revolutions).
5. I06 Decimal places position:
   If you selected 0: User defined, rotational or 1: User defined, translational for I05, define the number of decimal places for positions. A change to I06 moves the decimal separator for all position values.
6. I09 Measure unit:
   If you selected 0: User defined, rotational or 1: User defined, translational for I05, define the unit of measure.
7. A571 Polarity:
   Use the polarity to define the direction of interpretation between the axis movement and motor movement.
8. A568 Position range limit:
   If you selected 1: Endless for I00, enter the revolution length of the axis.

Information

Parameter I297 Maximum speed position encoder must be parameterized according to your application case. If I297 is set too low, the permitted maximum speed is exceeded even at normal operating speeds. On the other hand, if I297 is set too high, measuring errors of the encoder can be overlooked.

I297 depends on the following parameters: I05 Type of axis, I06 Decimal places position, I09 Measure unit as well as I07 Distance factor numerator position and I08 Distance factor denominator position or A585 Feed constant for CiA 402. If you have made changes to one of the parameters listed, select I297 accordingly as well.

7.1.2.2.4 Parameterizing the position and velocity window

Enter position limits and velocity zones for set values. To do so, parameterize boundary values for reaching a position or velocity.

1. Select the Axis model wizard > Window position, velocity.
2. C40 Velocity window:
   Parameterize a tolerance window for velocity tests.
3. I22 Target window:
   Parameterize a tolerance window for position tests.
4. I87 Actual position in window time:
   Parameterize how long a drive must stay in the specified position window before a corresponding status message is output.
5. A546 Following error window:
   Parameterize a tolerance window for lag tests.

7.1.2.2.5 Limiting the axis

As an option, you can limit the maximum permitted motion variables of position, velocity, acceleration, jerk and torque/ force according to your application.

Information

To simplify the scaling and limiting of the axis, the Axis model wizard > Axis: Scaling provides you with the **Conversion of position, velocities, accelerations, torque/force** scaling calculator, which calculates the effects of changed motion variables on the entire system. You can use the scaling calculator to enter values for motion variables of the motor, gearbox output and axis in order to convert the values to all other locations in the axis model.

Limiting the position

To secure the travel range of the axis, you have the option to limit the permitted positions using a software or hardware limit switch.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the Axis model wizard > Limit: Position.
3. I101 Source positive /limit switch, I102 Source negative /limit switch:
   To limit the travel range of the axis in the positive or negative direction of motion via hardware limit switches, select the source of the digital signal that is used to evaluate a limit switch at the positive or negative end of the travel range.
   3.1. If bit 1 or bit 2 of the control word I210 of the application is the source, select 2: Parameter.
   3.2. If a digital input (direct or inverted) acts as the source, select the corresponding input.
4. I50 Software stop positive, I51 Software stop negative:
   If you selected 0: Limited for I00 and would like to limit the travel range of the axis via software limit switches, define the largest or smallest permitted position for software position limiting.

ATTENTION!

Material damage due to leaving the permitted travel range

When a limit switch is overshot, the axis at the end of the permitted travel range will go into a fault condition, either with or without a quick stop depending on the parameterization of the device control, so it may come to a standstill past the limit switch and outside the permitted travel range.

- Allow sufficient space past the limit switch for your application to bring the axis to a standstill.

Limiting velocity, acceleration, jerk

As an option, you can limit the motion variables of velocity, acceleration and jerk and define the quick stop deceleration according to your application. The default values are designed for slow velocities without gearboxes.

1. Select the Motor wizard.
2. B83 v-max motor:
   Determine the maximum permitted velocity of the motor.
3. Select the Axis model wizard > Axis: Scaling.
4. Conversion of positions, velocities, accelerations, torque/force area:
   Use the scaling calculator to determine the maximum permitted velocity of the motor and the maximum permitted velocity of the output as a reference value.
5. Select the Axis model wizard > Limit: Velocity, acceleration, jerk.
6. I10 Maximal speed:
   Define the maximum permitted velocity of the output according to your application (taking into account the previously determined reference value).
7. I11 Maximal acceleration:
   Define the maximum permitted acceleration for the output.
8. I16 Maximal jerk:
   Define the maximum permitted jerk for the output.
9. I17 Quickstop deceleration:
   Define the desired quick stop deceleration for the output.

Limiting the torque/force

As an option, you can limit the torque/force according to your application. The default values take into account the rated operation together with the overload reserves.

1. Select the Axis model wizard > Limit: Torque/force.
2. C03 Maximum positive torque/force, C05 Maximum negative torque/force:
   Define the maximum permitted set torque/maximum permitted set force.
3. C08 Maximum torque/force for quick stop:
   Define the maximum permitted set torque/maximum permitted set force in case of a quick stop and in case of drive-controlled emergency stop SS1, SS1 and SS2.

7.1.3 Parameterizing general EtherCAT settings

✓ You have projected a device control with the process data as part of drive controller and axis projecting.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard.
3. Fieldbus scaling A213:
   Leave the preset at 1: Native (values are passed unchanged).
4. A258 EtherCAT PDO-Timeout:
   To allow detection of a communication failure, define the tolerated failure time for monitoring the receive PDO (value range: 0 – 65535 ms). For more information, refer to the parameter description of A258.
5. Optional: If you would like to use the SDO Info service, define which objects the controller can read out via SDO Info using A268.

7.1.4 Configuring PDO transmission

PDO channels provide real-time transmission of control and status information, as well as actual and set values, from an EtherCAT MainDevice to EtherCAT SubDevices and vice versa.

PDO communication allows for simultaneous operation of one PDO channel per transmission and sending direction. Each channel contains a PDO with a defined sequence of up to 24 parameters to be transmitted. These are free to be configured in any way. One channel is reserved for FSoE communication and is parameterized automatically.

In order to guarantee error-free communication between the controller and the drive controller, STOBER offers application-dependent pre-assignment of the process data channels, which you can adapt to your specific application. Further information on standard mapping can be found in the manual for the respective application.

If you make changes to the process data mapping, you must make these both on the drive controller in the DriveControlSuite and in the control software.

7.1.4.1 Adapting RxPDO

✓ You have configured the global EtherCAT settings.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Received process data RxPDO.
3. Check the preset process data and configure it according to your requirements if necessary.

7.1.4.2 Adapting TxPDO

✓ You have configured the global EtherCAT settings.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Transmitted process data TxPDO.
3. Check the preset process data and configure it according to your requirements if necessary.

7.1.5 Synchronizing EtherCAT nodes

Precise synchronization of the EtherCAT nodes is absolutely required for spatially distributed processes that require simultaneous actions (path interpolation). EtherCAT provides the distributed clocks (DC-Sync) method for this. Synchronization using distributed clocks is more precise than SyncManager event synchronization (SM-Sync) because it is subject to fewer fluctuations. For this reason, DC-Sync is preconfigured in EtherCAT MainDevice and SubDevices.

PLL synchronization wizard

Leave the presets in the first step and optimize them if necessary once you have commissioned the EtherCAT network and can assess and evaluate the quality of communication.

For more information on synchronization, and how to adjust it after the fact, see Synchronization [▶ 71].

7.1.6 Creating an ESI file

If you are working with TwinCAT 3, create an ESI file for the controller for each series of the drive controller as described below. The ESI file contains all the relevant data of an EtherCAT SubDevice that must be read into the EtherCAT MainDevice to configure the EtherCAT system with TwinCAT 3.

TwinCAT 3 can only read in one ESI file per series of the drive controller, i.e. if you use different applications or PDO transmissions for the same series, you must extend your ESI file accordingly.

If you make changes to the project configuration or the PDO transmission in the meantime, you must generate a new ESI file and make it available to TwinCAT 3.

For more information on ESI files, see ESI files [▶ 84].

✓ You have completed the configuration of PDO transmission.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard.
3. Click on Create new ESI.
   ⇨ The Write ESI dialog box opens.
4. Save the ESI file (*.xml) in the directory where the controller will read it from (TwinCAT 3 Engineering default installation: C:\TwinCAT\3.1\Config\IO\EtherCAT).

⇨ The ESI file is imported the next time TwinCAT 3 Engineering is started.

7.1.7 Transmitting and saving the configuration

In order to transmit and save the configuration to one or more drive controllers, you must connect your PC and the drive controllers over the network.

⚠ WARNING!

Injury to persons and material damage due to axis movement!

If there is an online connection between DriveControlSuite and the drive controller, changes to the configuration can lead to unexpected axis movements.

- Only change the configuration if you have visual contact with the axis.
- Make sure that no people or objects are within the travel range.
- For access via remote maintenance, there must be a communication link between you and a person on site with eye contact to the axis.

Information

During the search, all drive controllers within the broadcast domain are found via IPv4 limited broadcast.

Requirements for finding a drive controller in the network:

- Network supports IPv4 limited broadcast
- All drive controllers and the PC are in the same subnet (broadcast domain)

✓ The drive controllers are switched on and can be found in the network.

1. In the project tree, select the module under which you have recorded your drive controller and click Online connection in the project menu.
   ⇨ The Add connection dialog box opens. All drive controllers found via IPv4 limited broadcast are displayed.
2. Direct connection tab, IP address column:
   Activate the IP addresses in question and confirm your selection with OK.
   ⇨ The Online functions window opens. All drive controllers connected through the selected IP addresses are displayed.
3. Select the module and the drive controller to which you would like to transfer the configuration. Change the selection of transmission type from Read to Send.
4. Change the selection Create new drive controller:
   Select the configuration that you would like to transfer to the drive controller.
5. Repeat steps 3 and 4 for all other drive controllers to which you would like to transfer your configuration.
6. Online tab:
   Click Establish online connections.

⇨ The configurations are transferred to the drive controllers.

Saving a configuration

✓ You have successfully transferred the configuration.

1. Online functions window, Online tab, Actions for drive controller in online operation area:
   Click Save values (A00).

   ⇨ The Save values (A00) window opens.

2. Select on which drive controllers you want to save the configuration.

3. Click Start action.

   ⇨ The configuration is stored on the drive controllers in non-volatile memory.

4. Close the Save values (A00) window.

Information

For the configuration to take effect on the drive controller, a restart may be required in certain cases, such as after the configuration is saved on the drive controller for the first time or when changes are made to the firmware or process data mapping.

Restarting a drive controller

✓ You have stored the configuration on the drive controller in non-volatile memory.

1. Online functions window, Online tab:
   Click Restart (A09).

   ⇨ The Restart (A09) window opens.

2. Select which of the connected drive controllers you want to restart.

3. Click Start action.

4. Confirm the safety note with OK.

   ⇨ The Restart (A09) window closes.

⇨ The fieldbus communication and connection between DriveControlSuite and drive controllers are interrupted.

⇨ The selected drive controllers restart.

7.1.8 Testing the configuration

After you have transferred the configuration to the drive controller, first check your projected axis model and the parameterized electrical and mechanical data for plausibility before continuing with the parameterization.

You can test the configuration quickly and easily via DriveControlSuite or, as an alternative, directly via the operating unit of the drive controller. For further information, refer to the corresponding manual of the drive controller.

Information

Make sure that the values of the control panel are compatible with your projected axis model in order to obtain useful test results that you can use to optimize your configuration for the respective axis.

The scaling calculator is available under the Axis model wizard > Axis: Scaling to recalculate the values for the control panel according to your projected axis model.

⚠ WARNING!

Injury to persons and material damage due to axis movement!

When you activate the control panel, DriveControlSuite gives you sole control of the motions of the axis. If you are using a controller, it no longer monitors the axis movements after the control panel is activated. The controller cannot intervene to prevent collisions. The controller takes over control again when the control panel is deactivated, which can cause unexpected axis movements.

- Do not switch to other windows when the control panel is active.
- Only use the control panel if you have visual contact with the axis.
- Make sure that no people or objects are within the travel range.
- For access via remote maintenance, there must be a communication link between you and a person on site with eye contact to the axis.

Testing the configuration using the jog control panel

✓ There is an online connection between DriveControlSuite and the drive controller.

✓ You have successfully stored the configuration on the drive controller.

✓ No safety function is active.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the Jog control panel wizard.
3. Click Control panel on and then Enable.
   ⇨ The axis is monitored via the active control panel.
4. Check the default values of the control panel and adjust them to your projected axis model if necessary.
5. To test the configuration of your projected axis for direction of motion, velocity, etc., move the axis gradually using the Jog+, Jog-, Jog step+ and Jog step- buttons.
6. Use your test results to optimize your configuration as necessary.
7. To deactivate the control panel, click on Control panel off.

Information

Jog+ and Jog– cause a continual manual movement in the positive or negative direction. Jog step+ and Jog step- move the axis relative to the current actual position by the increment specified in I14.

Jog+ and Jog– have a higher priority than Jog step+ and Jog step–.

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7.2 TwinCAT 3: Putting the EtherCAT system into operation

TwinCAT 3 automation software gives you the option to map the hardware environment of your EtherCAT system and to configure and parameterize all necessary bus parameters including data exchange via MainDevice and SubDevices (also see TwinCAT 3 program interface [▶ 17]).

Note that all system nodes have to be networked physically before commissioning. In addition, you have projected the drive controllers in question in advance, i.e. EtherCAT SubDevices in DriveControlSuite, and transmitted the configuration to those drive controllers.

Information

For the following description, we require that you have projected the CiA 402 application.

Information

Always perform the steps described below in the specified order!

Some parameters are interdependent and do not become accessible to you until you have first configured certain settings. Follow the steps in the specified sequence so that you can finish the parameterization completely.

7.2.1 EtherCAT MainDevice: Activating Config-Modus

To be able to configure the EtherCAT MainDevice online, first create a TwinCAT project, add a connection between TwinCAT System Manager and EtherCAT MainDevice if necessary and activate Config mode.

Creating a TwinCAT project

✓ You have saved the ESI file generated from the DriveControlSuite in the specified directory (C:\TwinCAT\3.1\Config\IO\EtherCAT).

1. Start TwinCAT 3 Engineering.
   - ⇨ TwinCAT 3 Engineering opens; the Start Page tab is active.
   - ⇨ The stored ESI file is read in upon program start.
2. Select File > New > Project....
   - ⇨ The New Project window opens.
3. Select Installed > Templates > TwinCAT Projects > TwinCAT XAE Project (XML format).
4. Name, Location, Solution name:
   Label the project and enter a save location and an internal project name.
5. Confirm with OK.

EtherCAT MainDevice: Adding routing

If Run-Time (EtherCAT MainDevice) is installed on a different PC than TwinCAT System Manager, first establish a connection by adding a route to the EtherCAT MainDevice.

✓ The EtherCAT MainDevice is connected to the network, all system components are energized and the infrastructure is ready for operation.

1. In TwinCAT 3 Engineering, click on the <Local> list field in the toolbar and select Choose Target System....
   ⇨ The Choose Target System window opens.
2. Click on Search (Ethernet)....
   ⇨ The Add Route Dialog window opens.
3. Click on Broadcast Search.
   ⇨ The Select Adapter(s) window opens.
4. Select the adapter that is connected to your EtherCAT MainDevice and confirm with OK.
   ⇨ All available controllers are listed.
5. Select the desired EtherCAT MainDevice and confirm with Add Route.
   ⇨ The Add Remote Route window opens.
6. Under Remote User Credentials, enter the following data:
   User name: `Administrator`
   Password: `1`
7. Confirm with OK.
   ⇨ The connection to the EtherCAT MainDevice is added.
   ⇨ The EtherCAT MainDevice is available as a target system for Config mode.
8. Close the Add Route Dialog and Choose Target System windows.

EtherCAT MainDevice: Activating Config-Modus

If necessary, select the EtherCAT MainDevice as the target system and activate Config mode so you can configure the EtherCAT system online.

✓ The EtherCAT MainDevice is connected to the network, all system components are energized and the infrastructure is ready for operation.

✓ You have added the routing to the EtherCAT MainDevice, if necessary.

1. If Run-Time (EtherCAT MainDevice) and TwinCAT System Manager are installed on different PCs, click on the <Local> list field in the TwinCAT 3 Engineering toolbar and select the desired EtherCAT MainDevice.
   ⇨ The EtherCAT MainDevice is saved as the target system.
2. To activate the configuration mode (Config Mode), select Menu TWINCAT > Restart TwinCAT (Config Mode).
   ⇨ The Restart TwinCAT System in Config Mode dialog box opens.
3. Confirm with OK.

⇨ TwinCAT 3 Engineering is in Config mode for the selected EtherCAT MainDevice.

7.2.2 Scanning the hardware environment

If all system components are connected to the EtherCAT network and the network is energized, it is possible to scan for connected devices automatically. In this scenario, TwinCAT 3 Engineering searches for connected devices and terminals and integrates them into the existing project in accordance with their configuration entries in the accompanying ESI files.

If the actual EtherCAT infrastructure is not available, i.e. you are configuring in offline mode, you must map and project all connected devices manually in TwinCAT 3 Engineering. You can find more detailed information on this in the online help tool of the TwinCAT 3 Engineering software.

✓ You have activated Config mode.

1. In the solution explorer, navigate to I/O > Devices > Scan context menu.
2. Confirm the HINT: Not all types of devices can be found automatically dialog box with OK.
   - ⇨ TwinCAT 3 Engineering scans the EtherCAT system for the EtherCAT MainDevice.
   - ⇨ The ... new I/O devices found dialog box opens.
3. Activate the relevant EtherCAT MainDevice and confirm with OK.
   - ⇨ The EtherCAT MainDevice is created in the solution explorer under I/O > Devices as a device (EtherCAT).
   - ⇨ The Scan for boxes? dialog box opens.
4. Confirm with Yes.
   - ⇨ TwinCAT 3 Engineering scans the EtherCAT system for the EtherCAT SubDevices.
   - ⇨ The EtherCAT drive(s) added dialog box opens.
5. Append linked axis to:
   If you are using controller-based operation for the drive controller, select the desired option and confirm with OK in order to activate the NC or CNC function. For drive-based control, you prevent the creation of an axis using Cancel.
   - ⇨ The EtherCAT SubDevices are created in the solution explorer.
     The Activate Free Run dialog box opens.
6. In order to shift the system components during configuration into free run mode and thereby enable verification of the signal exchange, confirm with Yes.

⇨ EtherCAT MainDevice and SubDevices are created in TwinCAT 3 Engineering.

7.2.3 Expanding the startup list

With the help of the startup list, you can change the values of objects during startup of the EtherCAT state machine via the CoE protocol. You can add objects from the object directory of the ESI file to the startup list. If you are using the SDO Info service, additional objects are also available. The objects are accessed in the order in which they appear in the startup list.

Selecting and adding an object from the list

Objects that are either contained in the object directory of the ESI file or have previously been read from the drive controller via SDO Info are available for selection from a list in TwinCAT 3 Engineering.

✓ EtherCAT MainDevice and SubDevices are created in TwinCAT 3 Engineering.

1. In the solution explorer, navigate to the EtherCAT SubDevice for which you want to add an object to the startup list.
2. Double-click on the EtherCAT SubDevice.
   ⇨ The settings open in the main window.
3. In the main window, switch to the Startup tab.
   ⇨ The current startup list is displayed.
4. Click New....
   ⇨ The Edit CANopen Startup Entry window opens.
   ⇨ All available objects are listed.
5. In the list, double-click on the object that you want to add to the startup list.
   ⇨ The Set Value Dialog window opens.
6. Dec, Hex, Enum:
   Enter the value to be written to the object in the field corresponding to the desired data format (decimal specification, hexadecimal specification or selection from list).
7. Confirm the value with OK.
8. Transition:
   In the Edit CANopen Startup Entry window, activate the state change upon which the object is to be written:
   8.1. I -> P: State change from Init to Pre-Operational
   8.2. P -> S: State change from Pre-Operational to Safe-Operational
   8.3. S -> O: State change from Safe-Operational to Operational
   8.4. O -> S: State change from Operational to Safe-Operational
   8.5. S -> P: State change from Safe-Operational to Pre-Operational
9. Comment:
   If required, store a comment that will be displayed in the startup list for the object.
10. Confirm with OK.

⇨ The object is added to the startup list.

Adding an object via index and subindex

Alternatively, you can add objects to the startup list by their index and subindex.

For manufacturer-specific parameters, calculate the index and subindex of the object from the parameter coordinate in advance (see Manufacturer-specific parameters: 2000 hex – 53FF hex [▶ 98]).

✓ EtherCAT MainDevice and SubDevices are created in TwinCAT 3 Engineering.

1. In the solution explorer, navigate to the EtherCAT SubDevice for which you want to add an object to the startup list.
2. Double-click on the EtherCAT SubDevice.
   ⇨ The settings open in the main window.
3. In the main window, switch to the Startup tab.
   ⇨ The current startup list is displayed.
4. Click New....
   ⇨ The Edit CANopen Startup Entry window opens.
5. Transition:
   Activate the state change upon which the object is to be written:
   5.1. I -> P: State change from Init to Pre-Operational
   5.2. P -> S: State change from Pre-Operational to Safe-Operational
   5.3. S -> O: State change from Safe-Operational to Operational
   5.4. O -> S: State change from Operational to Safe-Operational
   5.5. S -> P: State change from Safe-Operational to Pre-Operational
6. Index (hex):
   Enter the index of the object (hexadecimal specification).
7. Sub-index (dec):
   Enter the subindex of the object (decimal specification).
8. Data (hexbin):
   Enter the value to be written to the object.
9. Comment:
   If required, store a comment that will be displayed in the startup list for the object.
10. Confirm with OK.

⇨ The object is added to the startup list.

7.2.4 Configuring synchronization using distributed clocks

As the more precise of the two sync methods, synchronization using distributed clocks (DC-Sync) is pre-configured in the EtherCAT SubDevices. Check the associated settings for EtherCAT MainDevice and SubDevices.

✓ You have fully configured the associated axis model in the DriveControlSuite.

1. Navigate to the EtherCAT MainDevice in the solution explorer.
2. Double-click on the EtherCAT MainDevice.
   ⇨ The settings open in the main window.
3. In the main window, switch to the EtherCAT tab and click Advanced Settings....
   ⇨ The Advanced Settings window opens.
4. In the tree view, select Distributed Clocks.
5. Automatic DC Mode Selection:
   This option must be activated.
6. Close the window.
7. Navigate to the first EtherCAT SubDevice in the solution explorer.
8. In the main window, switch to the DC tab and click Advanced Settings....
   ⇨ The Advanced Settings window opens.
9. Enable:
   This option must be activated.
10. DC enabled (multiplier = 1):
    This list entry must be selected.
11. Sync Unit Cycle (μs):
    Check the default value for the cycle time of the controller and change it if necessary.
12. Enable SYNC 0:
    This option must be activated.
13. Close the window.
14. Repeat steps 7 – 13 for each additional SubDevice in your EtherCAT network.

⇨ The EtherCAT MainDevice and SubDevices will now be synchronized with the first EtherCAT SubDevice that has the distributed clocks option enabled.

7.2.5 Configuring synchronization via SyncManager event

Synchronization using distributed clocks (DC-Sync) is pre-configured in the EtherCAT SubDevices. You have the option of switching the synchronization for one or more EtherCAT SubDevices manually to synchronization via SyncManager event (SM-Sync).

1. In the solution explorer, navigate to the EtherCAT SubDevice for which you want to change the synchronization to SM-Sync.
2. Double-click on the EtherCAT SubDevice.
   ⇨ The settings open in the main window.
3. In the main window, switch to the DC tab.
4. Operation Mode:
   Select the SM Synchronous list entry from the picklist.
   ⇨ You have changed the synchronization for the EtherCAT SubDevice.
5. Repeat the steps for each additional SubDevice of your EtherCAT network for which you want to switch the synchronization to SM-Sync.

7.2.6 CiA 402: Controller-based axis control

In order to control one or more drive controllers with controller-based operation when using the CiA 402 application (incremental version), start by parameterizing the axes and then program your control.

7.2.6.1 Parameterizing an axis

1. In the solution explorer, navigate to Motion > NC-Task 1 SAF > Axes > Axis 1.
2. Double-click the axis.
   ⇨ The settings open in the main window.
3. In the main window, switch to the Settings tab.
4. Unit:
   Select degrees (°) as the unit.
5. Switch to the Parameters tab.
6. Open the Maximum Dynamics parameter list.
7. Parameterize associated limit values for velocity, acceleration and deceleration.
8. Open the Limit Switches parameter list.
9. Soft Position Limit Minimum Monitoring:
   If you want to put a lower negative limit on position values, select the True list entry and enter the associated value in Minimum Position.
10. Soft Position Limit Maximum Monitoring:
    If you want to put an upper positive limit on position values, select the True list entry and enter the associated value in Maximum Position.
11. In the solution explorer, navigate to Axis > Enc.
12. In the main window, switch to the Parameters tab.
13. Open the Encoder Evaluation parameter list.
14. Scaling Factor Numerator:
    Specify the value `0.000343322` (360 ÷ 1048576) – in accordance with the parameterization of A585[0] = 1048576 inc for the feed factor in DriveControlSuite.
15. Repeat the steps for each additional axis.

⇨ The axes are parameterized.

7.2.6.2 Programming axis control

You can program control of the axes in TwinCAT 3 using the MC_POWER block.

In order to control the drive controller with controller-based operation, the following operating modes are available in parameter A541 Modes of operation:

- -1: Jog
- 6: Homing mode
- 7: Interpolated position mode or
- 8: Cyclic synchronous position mode
- 9: Cyclic synchronous velocity mode
- 10: Cyclic synchronous torque mode

The axes are controlled using control word A515. The device state machine has to receive certain commands for starting operation and the associated state transitions. These commands are the result of a bit combination in the control word. The order of the commands is specified by the device state machine in accordance with CiA 402.

Gravity-loaded axis with brake

Information

If you are using a gravity-loaded axis and a brake, always use a quick stop to switch the drive (state transition 11 in accordance with the device state machine). This prevents the load from dropping until the brake is fully engaged.

In the MC_POWER block, start by deactivating the Enable_Positive and Enable_Negative bits and then the Enable bit on a delay in order to bring the drive to a standstill as defined.

For more detailed information on the operating modes, device control and standard mapping, please refer to the manual for the CiA 402 application.

7.2.7 CiA 402 HiRes Motion: Drive-based axis control

Drive-based axis control in the CiA 402 HiRes Motion application requires manual programming in the automation software. The following operating modes are available to you in the parameter A541 Modes of operation:

- -1: Jog
- 1: Profile position mode
- 2: Velocity mode
- 3: Profile velocity mode
- 4: Profile torque mode
- 6: Homing mode

The axes are controlled using control word A515. The device state machine has to receive certain commands for starting operation and the associated state transitions. These commands are the result of a bit combination in the control word; the order of commands is specified by the device state machine in accordance with CiA 402.

Gravity-loaded axis with brake

Information

If you are using a gravity-loaded axis and a brake, always use a quick stop to switch the drive (state transition 11 in accordance with the device state machine). This prevents the load from dropping until the brake is fully engaged.

For more detailed information on the operating modes, device control and standard mapping, please refer to the manual for the CiA 402 application.

7.2.8 Configuring EoE communication

1. Navigate to the EtherCAT MainDevice in the solution explorer.
2. Double-click on the EtherCAT MainDevice.
   ⇨ The settings open in the main window.
3. In the main window, switch to the EtherCAT tab and click Advanced Settings....
   ⇨ The Advanced Settings window opens.
4. Select EoE Support from the tree view on the left.
5. Virtual Ethernet Switch > Enable:
   This option must be activated.
6. Close the window.
7. Navigate to the first EtherCAT SubDevice in the solution explorer.
8. In the main window, switch to the EtherCAT tab and click Advanced Settings....
   ⇨ The Advanced Settings window opens.
9. In the tree view on the left, navigate to Mailbox > EoE.
10. Virtual Ethernet Port:
    This option must be activated.
11. IP Port:
    Activate this option.
12. Define the type of address assignment:
    12.1. Activate the DHCP option if an IP address is to be assigned to the EtherCAT SubDevice automatically via DHCP.
    12.2. Activate the IP Address option in order to assign a fixed IP address to the EtherCAT SubDevice in accordance with the subnet of your EoE device group. When assigning a fixed IP address for EoE, note that the first and last host address in a subnet must not be used. If one of these addresses is configured in TwinCAT 3, it is not accepted by the drive controller.
13. Default gateway:
    When assigning a fixed IP address, the IP address of the EtherCAT network interface of the EtherCAT MainDevice must be specified as the default gateway.
14. Close the window.
15. Repeat steps 7 – 14 for each additional SubDevice in your EtherCAT system.

⇨ EoE communication is enabled for EtherCAT MainDevice and SubDevices.

Information

Depending on your EoE network structure, you may have to set the routing on your EtherCAT MainDevice PC manually in order to connect the Ethernet and EtherCAT networks (see EoE: Application cases with STOBER devices [▶ 59]).

Information

Address assignment via DHCP is possible via either a DHCP server or DriveControlSuite. This requires the DHCP server or DriveControlSuite to be installed directly on the controller PC (see Topology 1: EtherCAT MainDevice and DS6 on one PC [▶ 59]). Furthermore, the IP address reference must be correctly defined in the drive controller (A166 = 2: DHCP + DS6, default value).

The correct assignment of the drive controllers in DriveControlSuite is ensured for TwinCAT 3 by the STOBER_BoxName function block (see Function blocks for TwinCAT 3 [▶ 93]).

7.2.9 Configuring a Station Alias

You have the option of assigning an EtherCAT Station Alias to each EtherCAT SubDevice. This address is stored in the EEPROM of the respective drive controller. The drive controller can thus be connected to any open port within the network and identified using the Station Alias.

1. In the solution explorer, navigate to the EtherCAT SubDevice to which you want to assign a Station Alias.
2. Double-click on the EtherCAT SubDevice.
   ⇨ The settings open in the main window.
3. In the main window, switch to the EtherCAT tab and click Advanced Settings....
   ⇨ The Advanced Settings window opens.
4. In the tree view on the left of the Advanced Settings window, navigate to ESC Access > E2PROM > Configured Station: New Value: Enter the value you want to write as the Station Alias into the EEPROM.
5. Click Write to E2PROM to write the value to EEPROM.
6. Confirm the Function succeeded! dialog box with OK.
7. Close the Advanced Settings window with OK.
8. Repeat the steps for each additional SubDevice in your EtherCAT system to which you want to assign a Station Alias.

⇨ The configuration of the Station Alias is complete.

⇨ The change of addresses will take effect upon the next start of TwinCAT 3.

Information

In DriveControlSuite, the Station Alias can be read out via parameter A254.

7.2.10 Transmitting the configuration

Transfer the configuration to the EtherCAT MainDevice.

1. Select the menu TWINCAT > Activate Configuration.
2. Confirm the transfer of the project configuration to the EtherCAT MainDevice with OK.
   ⇨ The Restart TwinCAT System in Run Mode dialog box opens.
3. Confirm with OK.

⇨ The configuration was transferred to the EtherCAT MainDevice.

7.2.11 Checking the functionality of the axes

Check the functionality of the axes before operation in production.

Information

Ensure that a suitable safety application that ensures safe shut-off of the axis (emergency off, safety switch, etc.) exists before the start of testing.

Information

In order to be able to check the function of the axes, the **A541 Modes of operation** parameter of the respective axis must be set to the value **8** (default value).

1. In the solution explorer, navigate to Motion > NC-Task 1 SAF > Axes > Axis 1.
2. Double-click the axis.
   ⇨ The settings open in the main window.
3. In the main window, switch to the Online tab.
4. In the Enabling area, click Set.
   ⇨ The Set Enabling window opens.
5. Enable the Controller, Feed Fw and Feed Bw options.
6. Override:
   Specify a value for the override (e.g. 100).
7. Confirm with OK.
   ⇨ The axis is monitored via the active control panel.
8. F1 – F4:
   Move the axis step-by-step and test the movement direction, velocity, etc. using the corresponding buttons.
9. To deactivate the enable signal, click on Set Enabling and deactivate the options Controller, Feed Fw, Feed Bw.
10. Repeat the steps for each additional axis of your system.

8 Monitoring and diagnostics

For monitoring purposes and in the event of a fault, the various monitoring and diagnostic options described below are available.

8.1 Connection monitoring

In order to be able to detect a communication failure, activate the watchdog function. This means that you monitor the arrival of cyclical process data by defining a PDO timeout in A258 (see Parameterizing general EtherCAT settings [▶ 34]).

In the Operational operating state, an activated watchdog triggers fault 52: Communication with the cause 6: EtherCAT PDO-Timeout – if a new PDO is not received within the specified timeout.

Monitoring is not triggered if the EtherCAT MainDevice ends communication as intended by leaving the Operational state.

8.2 LED display

The drive controllers feature diagnostic LEDs that visualize the state of fieldbus communication and the states of the physical connection.

8.2.1 EtherCAT state

The 2 LEDs on the front of the drive controller provide information about the connection between the controller (EtherCAT MainDevice) and drive controller (EtherCAT SubDevice) and the state of the data exchange. This information can also be read out in parameter A255.

If the drive controller includes the SY6 safety module, the safety functions are controlled using EtherCAT FSoE. In this case, an additional LED on the front of the device provides information about the FSoE state.

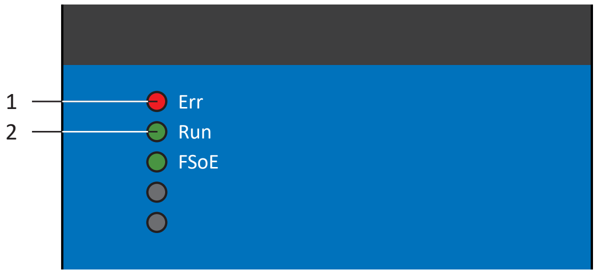

Fig. 5: LEDs for the EtherCAT state

1 Red: Error

2 Green: Run

Red LED	Conduct	Error	Description
	Off	No Error	No error
	Flashing	Invalid Configuration	Invalid configuration
	Single flash	Unsolicited State Change	The EtherCAT SubDevice changed operating states by itself
	Double flash	Application Watchdog Timeout	The EtherCAT SubDevice did not receive new PDO data during the configured watchdog timeout
	On	Application controller failure	Internal device communication error; switch device off and on again

Tab. 5: Meaning of the red LED (error)

Green LED	Conduct	Operating state	Description
	Off	Init	No communication between the EtherCAT MainDevice and SubDevice; the configuration starts, saved values are loaded
	Flashing	Pre-operational	No PDO communication; the EtherCAT MainDevice and SubDevice exchange application-specific parameters via SDOs
	Single flash	Safe-operational	The EtherCAT SubDevice sends the current actual values to the EtherCAT MainDevice, ignores its set values and refers to internal default values
	On	Operational	Normal operation: The EtherCAT MainDevice and SubDevice exchange set and actual values

Tab. 6: Meaning of the green LED (Run)

8.2.2 EtherCAT network connection

The LEDs LA $_{EC}$IN and LA $_{EC}$OUT at X200 and X201 on the top of the device indicate the state of the EtherCAT network connection.

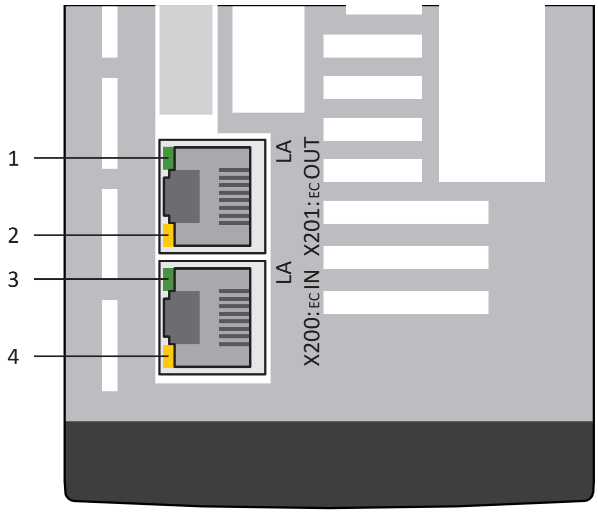

Fig. 6: LEDs for the state of the EtherCAT network connection

1 Green: LA $_{EC}$OUT at X201

2 Yellow: No function

3 Green: LA $_{EC}$IN at X200

4 Yellow: No function

Green LED	Conduct	Description
	Off	No network connection
	Flashing	Active data exchange with other EtherCAT nodes
	On	Network connection exists

Tab. 7: Meaning of the green LEDs (LA)

8.3 Events

The drive controller has a self-monitoring system that uses test rules to protect the drive system from damage. Violating the test rules triggers a corresponding event. There is no possible way for you as the user to intervene in some events, such as the Short/ground event. In others, you can influence the effects and responses.

Possible effects include:

- **Message**: Information that can be evaluated by the controller
- **Warning**: Information that can be evaluated by the controller and becomes a fault after a defined time span has elapsed without the cause being resolved
- **Fault**: Immediate drive controller response; the power unit is disabled and axis movement is no longer controlled by the drive controller or the axis is brought to a standstill by a quick stop or emergency braking

Depending on the event, there are various measures you can take to rectify the cause. As soon as the cause has been successfully rectified, you can usually acknowledge the event immediately. If the drive controller has to be restarted, a corresponding note can be found in the measures.

ATTENTION!

Damage to property due to interruption of a quick stop or emergency braking!

If, when executing a quick stop or emergency braking, a fault occurs or STO is active, the quick stop or emergency braking is interrupted. In this case, the machine can be damaged by the uncontrolled axis movement.

Information

To make it easier for control programmers to set up the human-machine interface (HMI), a list of events and their causes can be found in the STOBER download center at http://www.stoeber.de/en/downloads/ by searching for `Events`.

8.3.1 Event 52: Communication

The drive controller has a **fault** if:

- A29 = 0: Inactive for Drive Based device controller
  or
- A540 = 0: Disable drive motor coasting for CiA 402 device controller

Response:

- The power unit is disabled and axis movement is no longer controlled by the drive controller
- The brakes engage

The drive controller has a **fault with a quick stop** if:

- A29 = 1: Active for Drive Based device controller
  or
- A540 = 2: Slow down on quick stop ramp for CiA 402 device controller

Response:

- The axis is stopped by a quick stop
- During the quick stop, the brakes remain released
- At the end of the quick stop, the power unit is disabled and axis movement is no longer controlled by the drive controller
- The brakes engage

Information

A rising edge for the release override signal (source: F06) is expected in the Switch on disabled, Ready to switch on, and Switched on states (E48) so that the brake is released.

Cause		Check and action
6: EtherCAT PDO-Timeout	Missing process data	Check the task cycle time in the EtherCAT MainDevice and the timeout time in the drive controller and correct them if necessary (A258)
7: Reserved	Synchronization error	Check the synchronization settings in the EtherCAT MainDevice and correct them if necessary
	Connection error	Check the connection and shielding and correct them if necessary
15: Wrong firmware for applicataion	Projected fieldbus identification and that of the drive controller do not match	Check the projected fieldbus identification and the fieldbus identification of the drive controller and change the fieldbus if necessary (E59[2], E52[3])

Tab. 8: Event 52 – Causes and actions

8.4 Parameters

The following parameters are available for diagnostics of communication via EtherCAT.

- A254 EtherCAT Station Alias
- A255 EtherCAT Device State
- A256 EtherCAT address
- A257 EtherCAT diagnosis
- A259 EtherCAT SM-Watchdog
- A261 Sync-Diagnostics

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9 Looking for more information about EtherCAT?

The following chapters summarize the key terms, services and relationships relating to EtherCAT.

9.1 EtherCAT

EtherCAT (Ethernet for Control Automation Technology) is an industrial Ethernet technology for real-time requirements in automation technology. EtherCAT is focused on short cycle times, low jitter and precise synchronization.
EtherCAT was invented by Beckhoff Automation GmbH & Co. KG and is currently supported by the international EtherCAT Technology Group (ETG) organization. EtherCAT is an open technology that has been standardized in the IEC 61158 standard since 2005.

MainDevice/SubDevice principle and data exchange

EtherCAT follows the MainDevice/SubDevice principle. A MainDevice sends standard Ethernet frames that pass every SubDevice. The frames are processed as they pass through. More specifically, each EtherCAT SubDevice has an EtherCAT SubDevice controller (ESC) integrated into its hardware which takes the receive data addressed to the respective SubDevice as the frame passes by and attaches the SubDevice's transmit data on the fly. This means any delays are due to the hardware processing time. The last SubDevice in the network sends the frame back to the MainDevice.

The EtherCAT MainDevice is the only network node that actively sends frames; the EtherCAT SubDevices simply pass the frame on. This principle avoids potential delays and ensures real-time capability. The order of the data does not depend on the physical order of the SubDevices in the network.

9.2 Communication protocols

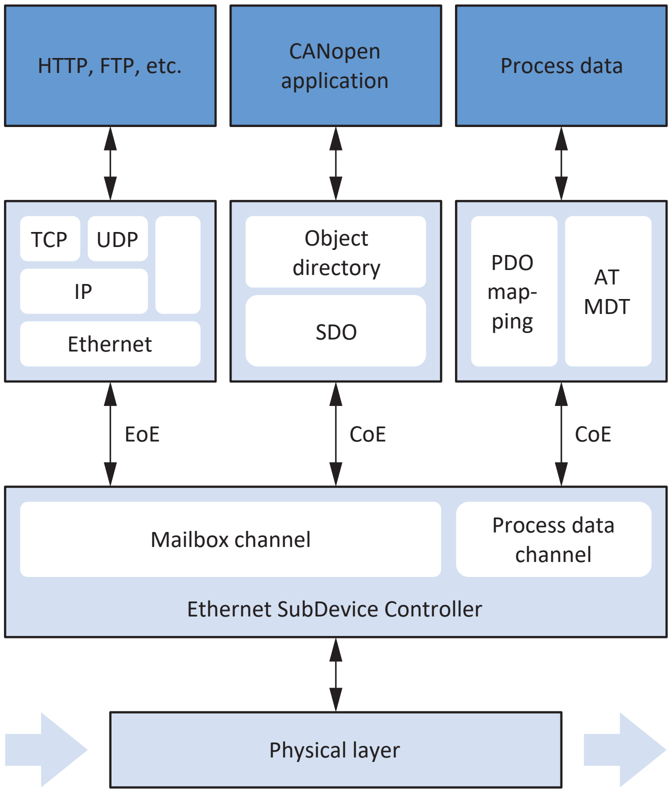

Fig. 7: EtherCAT: Communication protocols

EtherCAT uses standard Ethernet frames containing EtherCAT payloads. Communication normally takes place over a mailbox or process data channel.

Only data that is not time-critical, i.e. service data objects (SDO), are exchanged using the mailbox channel; time-critical process data objects (PDO) are, like in CANopen, transferred using the process data channel.

STOBER drive controllers of the 6th generation support the CoE and EoE EtherCAT protocols.

9.2.1 CoE: CANopen over EtherCAT

EtherCAT, together with the CoE protocol, provides CANopen-compliant communication mechanisms, enabling the use of the entire CANopen profile family over EtherCAT, thereby also allowing full use of the CiA 402 drive profile.

In terms of the respective state machines, CANopen and EtherCAT differ only in that the EtherCAT state machine (see EtherCAT state machine [▶ 69]) also has the Safe-Operational state.

9.2.2 EoE: Ethernet over EtherCAT

Using EoE, it is possible to transport any Ethernet data traffic between EoE-capable nodes in an EtherCAT network. In this process, Ethernet frames are tunneled through the EtherCAT protocol, as is typical for Internet protocols. The EtherCAT MainDevice is used as a gateway to the Ethernet network.

EoE is an acyclical protocol, meaning that the EtherCAT real-time properties (process data communication) remain unaffected.
Acyclical frames can be exchanged starting in the Pre-Operational state of the EtherCAT state machine.

The IP address, subnet mask and gateway of the EoE-capable SubDevices are stored in the EtherCAT MainDevice.

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9.2.3 EoE: Application cases with STOBER devices

STOBER uses EoE to connect the DriveControlSuite to STOBER drive controllers of the 6th generation in combination with an EtherCAT MainDevice. A distinction is made between two topologies:

- Topology 1
  The EtherCAT MainDevice and DriveControlSuite are operated on one PC; only the EtherCAT network is used
- Topology 2
  The EtherCAT MainDevice and DriveControlSuite are operated on different PCs; transmission takes place between the EtherCAT network and Ethernet

9.2.3.1 Topology 1: EtherCAT MainDevice and DS6 on one PC

If the EtherCAT MainDevice and DriveControlSuite are installed on one PC, the Ethernet subnet where the drive controllers are operated is automatically known to DriveControlSuite through the MainDevice's gateway function. DriveControlSuite detects the drive controllers; no additional manual configurations are needed.

The following graphic shows the associated network overview together with pre-assigned network addresses on the system end.

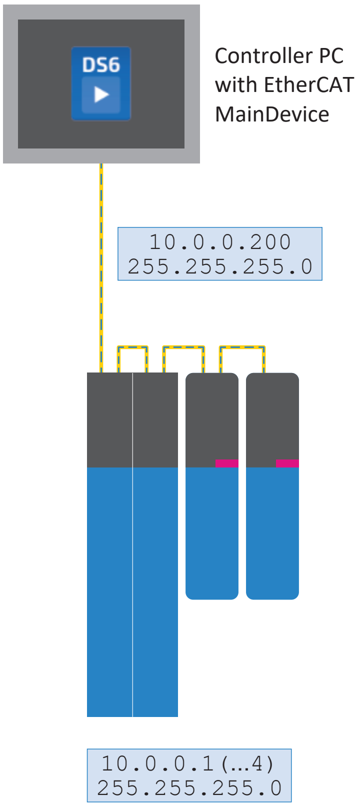

Fig. 8: Network overview: Topology 1

9.2.3.2 Topology 2: EtherCAT MainDevice and DS6 on different PCs

If the EtherCAT MainDevice and DriveControlSuite are installed on different PCs, the drive controllers are in an Ethernet subnet that is initially unknown to DriveControlSuite. In this case, the address of the MainDevice must be manually configured as the gateway for the route, i.e. the route on the service PC of the DriveControlSuite must be added.

Information

The broadcast-based drive controller search does not work due to the routing, so you must establish the direct connection in DriveControlSuite using either the Direct connection tab (Additional IP addresses context menu) or the Direct connection (manual) tab. Further information on a direct connection can be found in the manual for the respective drive controller and in the online help DS6.

The following graphic shows the associated network overview together with pre-assigned network addresses on the system end.

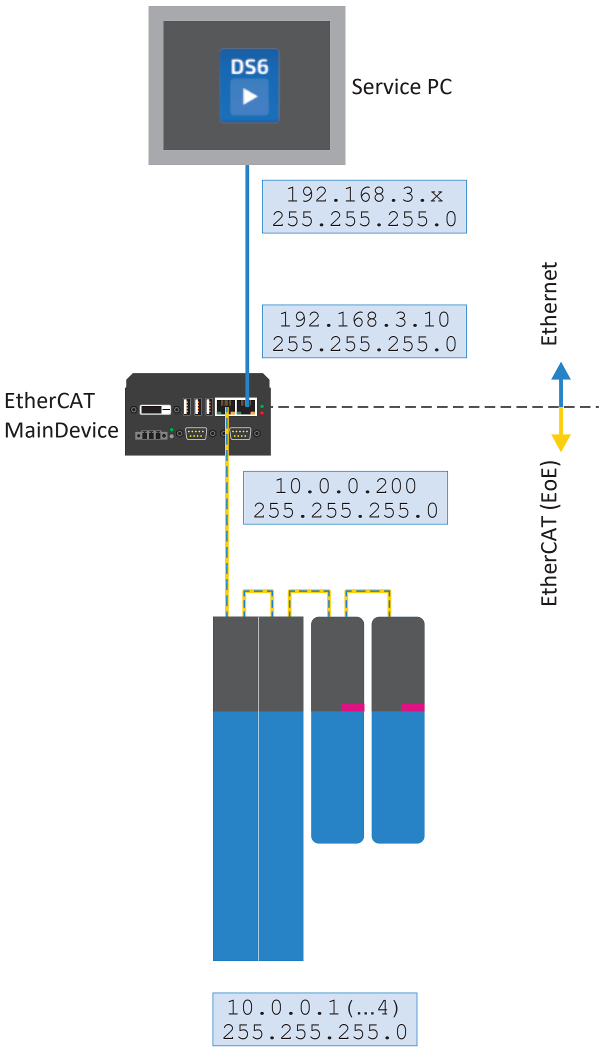

Fig. 9: Network overview: Topology 2

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EtherCAT service PC: Setting the route of an Ethernet subnet

In order to make the Ethernet subnet of the drive controllers known to DriveControlSuite, you have to configure a corresponding route on the service PC. The route allows an IP configuration packet to be forwarded to the drive controllers in question via the EtherCAT MainDevice, which acts as a gateway.
Note that the operating system of the EtherCAT MainDevice only connects the subnets known to it if IP routing is permitted there.

✓ The following information (network of the drive controllers to be triggered, subnet mask, gateway address of the MainDevice) is adapted to the STOBER presets and must be replaced by the addresses that correspond to the system environment.

1. To set the Ethernet route using the command line, open the Windows console cmd.exe.
2. Enter the following command:
   `route add 10.0.0.0 mask 255.255.255.0 192.168.3.10`

⇨ You have now successfully set the route.

Information

In TwinCAT 3, you must enable this function on the MainDevice using EtherCAT > Advanced Settings > EoE Support > Windows Network area > Windows IP Routing > IP Enable Router. Restart the PC to apply the configuration.

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9.3 Communication objects

Based on CANopen, the following communication objects are of key importance for data transmission in an EtherCAT network:

- Process Data Objects (PDO)
  ... for the transmission of real-time data of the nodes (actual and set values)
- Service Data Objects (SDOs)
  ... for access to the object directory of the nodes for device configuration
- Emergency Objects (EMCY)
  ... for monitoring the device states of the nodes

Information

If a parameter exists in the configuration due to the projected properties of the drive controller (e.g. hardware, firmware, application), it is generally available for fieldbus communication. The visibility of a generally available parameter has no effect on its availability for fieldbus communication (e.g. through access level or parameter selection).

9.3.1 Process data objects – PDO

Process Data Objects are peer-to-peer objects that are used to transmit time-critical real-time data of the nodes, such as set and actual values or control and status information such as set positions, travel velocities, or acceleration specifications.

PDOs allow simultaneous access to several communication parameters defined via the object directory of the respective node. Objects are not addressed with PDO transmission. Instead, the values of the communication parameters are transmitted directly to the respective node.

The process data mapping (PDO mapping) defines which communication parameters are sent and received. With process data mapping, which communication parameters are sent or received in which PDO can be freely selected.

PDOs are generally transmitted via process data channels (PDO channels) with high priority. From the perspective of the respective node, receive PDOs (RxPDO) are differentiated from transmit PDOs (TxPDO).

For further information on scaling the process data, see Fieldbus scaling [▸ 88].

9.3.1.1 PDO mapping

The process data mapping (PDO mapping) defines which communication parameters are sent and received. The communication parameters from the object directory of a node are mapped to the respective PDO channels for this purpose.

PDO communication enables simultaneous operation of up to 4 independent PDO channels per transmission direction (RxPDO, TxPDO), each of which can transmit 1 PDO with up to 24 communication parameters. Channel 4 is reserved for safety communication, while the remaining PDO channels are freely configurable.

In order to guarantee error-free communication between the controller and drive controller, STOBER offers application-dependent pre-assignment of the process data channels which can be changed at any time.

9.3.2 Service data objects – SDO

Service Data Objects are peer-to-peer objects that are used to transfer non-time-critical data and provide access to entries in a node's object directory in order to configure its device properties.

From the perspective of the drive controller, an SDO transmission always consists of at least one RxSDO message and one TxSDO message. In the RxSDO message, the controller selects an entry from the object directory of the drive controller via index and subindex in order to configure the device properties. The drive controller then acknowledges access to the object directory with a TxSDO message.

SDO messages are transmitted over the mailbox channel acyclically during ongoing cyclical EtherCAT operation, without impairing PDO communication.

Parameters are addressed via SDO in accordance with the access rules described in the appendix (see Manufacturer-specific parameters: 2000 hex – 53FF hex [▶ 98]).

Depending on the transmission type, SDOs can generally be used for transmitting data of any length:

- Expedited transfer
  ... for transmission of up to 4 bytes in a single message
- Segmented transfer
  ... for transmission of more than 4 bytes distributed over several messages

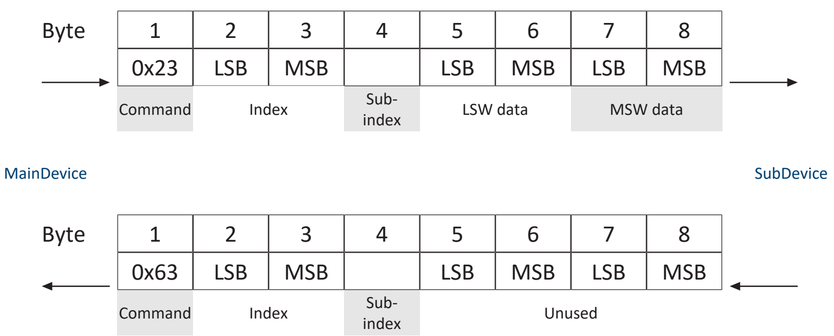
For further information on scaling the process data, see Fieldbus scaling [▶ 88].

9.3.2.1 Expedited transfer

SDO transmission via expedited transfer enables up to 4 bytes of data to be transmitted in a single message. The data is arranged in accordance with the Intel format (little-endian), meaning that the byte with the smallest value is saved at the starting address and transmitted first (compare with big-endian or Motorola format, where the highest-value component is sent first).

Writing parameters (Initiate Domain Download Request)

The controller (MainDevice) uses an Initiate Domain Download Request to initiate a write process for a communication parameter. The request receives a positive acknowledgement from an Initiate Domain Download Response of the drive controller (SubDevice).



Reading parameters (Initiate Domain Upload Request)

The controller (MainDevice) uses an Initiate Domain Upload Request to initiate a read process for a communication parameter. The request receives a positive acknowledgement from an Initiate Domain Upload Response of the drive controller (SubDevice).

Byte	1	2	3	4	5	6	7	8
→	0x40	LSB	MSB		LSB	MSB	LSB	MSB
	Command	Index		Sub-index	Reserved			

MainDevice SubDevice

Byte	1	2	3	4	5	6	7	8
←	0x42	LSB	MSB		LSB	MSB	LSB	MSB
	Command	Index		Sub-index	LSW data		MSW data	

Error message (Abort Domain Transfer)

A drive controller (SubDevice) provides a negative response to the write parameter or read parameter requests using an Abort Domain Transfer (see SDO transmission: Error codes [▶ 100]).

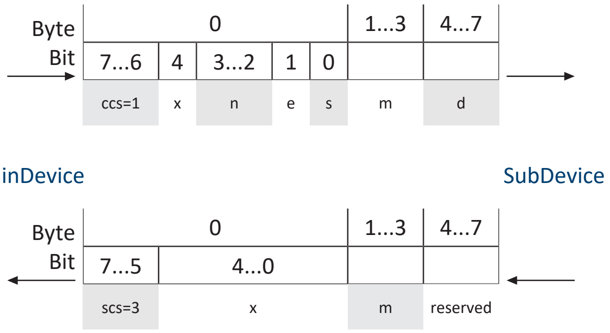
Byte	1	2	3	4	5	6	7	8
←	0x80	LSB	MSB		LSB	MSB	LSB	MSB
MainDevice	Command	Index		Sub-index	Additional code		Error code	Error class

SubDevice

9.3.2.2 Segmented transfer

With SDO transmission via segmented transfer, more than 4 bytes of data can be transmitted distributed over several messages. The total number of bytes to be transmitted are sent in a first initiate message (Initiate SDO Download); this is followed by the segments (Download SDO Segment), each with 1 byte of control and protocol information and up to 7 bytes of payload.

Initiate SDO Download Protocol



ccs	Client command specifier	1 = Initiate download request
scs	Server command specifier	3 = Initiate download response
n	Number of bytes	Number of bytes in "Data" that contain no usable data. If e = 0 , s = 1, then n = valid, otherwise n = 0
e	Transfer type	▪ 0 = Normal transfer ▪ 1 = Expedited transfer
s	Size indicator	▪ 0 = Not displayed ▪ 1 = Displayed
m	Multiplexor	= Index + subindex
d	Data	▪ If e = 0, s = 0, then d = reserved ▪ If e = 0, s = 1, then d = number of bytes to be transmitted ▪ If e = 1, s = 1, then d = 4-n
x	Unused	x = 0

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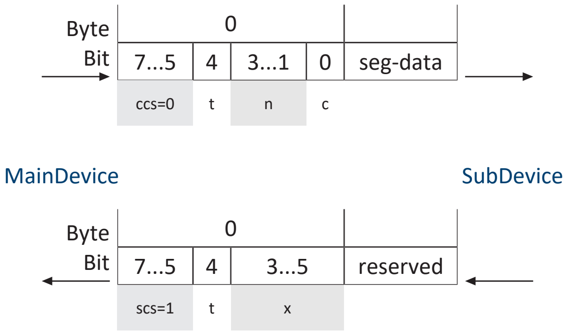
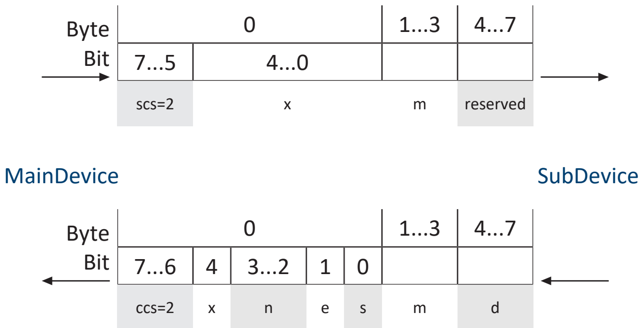
Download SDO Segment Protocol



ccs	Client command specifier	0 = Download segment request
scs	Server command specifier	1 = Download segment response
n	Number of bytes	Number of bytes in "Segment data" that contain no usable data. n = 0: No information about unused data
seg-data	Segment data	7 bytes of usable data
c	Continue	▪ 0 = More segments follow ▪ 1 = Last segment
t	Toggle bit	t = 0 for segment 1; must change for each segment. Identical values for request and response.
x	Unused	x = 0

Initiate SDO Upload Protocol



ccs	Client command specifier	2 = Initiate upload request
scs	Server command specifier	2 = Initiate upload response
n	Number of bytes	Number of bytes in "Data" that contain no usable data. If e = 0 , s = 1, then n = valid, otherwise n = 0
e	Transfer type	▪ 0 = Normal transfer ▪ 1 = Expedited transfer
s	Size indicator	▪ 0 = Not displayed ▪ 1 = Displayed
m	Multiplexor	= Index + subindex
d	Data	▪ If e = 0, s = 0, then d = reserved ▪ If e = 0, s = 1, then d = number of bytes to be transmitted ▪ If e = 1, s = 1, then d = 4-n
x	Unused	x = 0

Upload SDO Segment Protocol

Byte	0			1...7
Bit	7...5	4	3...0	reserved
	ccs=3	t	x	

MainDevice → SubDevice

Byte	0				1...7
Bit	7...5	4	3...1	0	
	scs=0	t	n	c	

MainDevice ← SubDevice

ccs	Client command specifier	3 = Upload segment request
scs	Server command specifier	0 = Upload segment response
n	Number of bytes	Number of bytes in "Segment data" that contain no usable data. n = 0: No information about unused data
seg-data	Segment data	7 bytes of usable data
c	Continue	▪ 0 = More segments follow ▪ 1 = Last segment
t	Toggle bit	t = 0 for segment 1; must change for each segment. Identical values for request and response.
x	Unused	x = 0

Examples

Segment download with 16 bytes of data; contents: 01, 02, 03 ... 10 hex

Client: IDDReq:	21	idx	x	10 00 00 00	(ccs = 1, e = 0 = normal, s = 1 -> data = no. of bytes)
Server: IDDRes:	60	idx	x	00 00 00 00	
Client: DSegReq:	00	01 02 03 04 05 06 07			(ccs = 0, t = 0, n = 0, c = 0 -> all data bytes are used)
Server: DSegRes:	20	00 00 00 00 00 00 00			
Client: DSegReq:	10	08 09 0A 0B 0C 0D 0E			(ccs = 0, t = 1, n = 0, c = 0 -> all data bytes are used)
Server: DSegRes:	30	00 00 00 00 00 00 00			
Client: DSegReq:	0b	0F 10 00 00 00 00 00			(ccs = 0, t = 0, n = 5, c = 1 -> 5 data bytes are unused)
Server: DSegRes:	20	00 00 00 00 00 00 00			

Segment upload with 16 bytes of data; contents: 01, 02, 03 ... 10 hex

Client: IDUReq:	40	idx	x	00 00 00 00	(ccs = 2, rest = 0)
Server: IDURes:	41	idx	x	10 00 00 00	(scs = 2, x = 0, e = 0, s = 1 -> data contains no. of bytes to be uploaded)
Client: USegReq:	60	00 00 00 00 00 00 00			(ccs = 3, t = 0)
Server: USegRes:	00	01 02 03 04 05 06 07			(scs = 0, t = 0, n = 0, c = 0 -> all data bytes are used)
Client: USegReq:	70	00 00 00 00 00 00 00			(ccs = 3, t = 1)
Server: USegRes:	10	08 09 0A 0B 0C 0D 0E			(scs = 0, t = 1, n = 0, c = 0 -> all data bytes are used)
Client: USegReq:	60	00 00 00 00 00 00 00			(ccs = 3, t = 0)
Server: USegRes:	0b	0F 10 00 00 00 00 00			(scs = 0, t = 0, n = 5, c = 1 -> 5 data bytes are unused)

9.3.3 Emergency objects – EMCY

Emergency Objects are peer-to-peer objects that are used to monitor the device states of the nodes in the network and are triggered in the event of internal device errors or faults.

If the EMCY service is active and a drive controller changes to the Fault device state, it sends an EMCY message to the controller. The EMCY message contains an error code that uniquely identifies the fault. As soon as the fault has been corrected and the drive controller leaves the corresponding device state, it sends another EMCY message with error code 0 hex (NO ERROR).

This mechanism automatically notifies the controller of when a drive controller enters and leaves the fault state and of the associated cause for the fault.

Specifically, the drive controller sends EMCY messages in the event of an incorrect parameterization of the SyncManager during EtherCAT system startup, an incorrect state change within the EtherCAT state machine, or a change to or from the Fault device state. EMCY messages are transmitted to the EtherCAT MainDevice via the mailbox channel.

EMCY message: Switch to the fault state

The following graphic shows an example of the structure of an EMCY message when switching to the Fault device state.

Byte	1	2	3	4	5	6	7	8	
←	43	0x10	0x01	0x29	0	0	0	0	←
MainDevice	EMCY error code		Error register	E82	E43	Free			SubDevice

Bytes 1 – 3 contain the error code and error register, bytes 4 – 5 contain the values of the parameters E82 Event type and E43 Event cause.

A table with the possible error codes of an EMCY message can be found at EMCY message: Device fault error codes [▶ 102].

EMCY message: Exiting the fault state

The following graphic shows an example of the structure of an EMCY message when leaving the Fault device state.

Byte	1	2	3	4	5	6	7	8	
←	00	00	00	0x1E	0	0	0	0	←
MainDevice	EMCY error code		Error register	E82	E43	Free			SubDevice

Bytes 1 – 3 contain the error code 0 hex (NO ERROR); byte 4 contains the value 1E hex for parameter E82 = 30: Inactive.

EMCY message: Incorrect state transitions

If an error occurs during the state transitions within the EtherCAT state machine, the EtherCAT SubDevice sends a corresponding EMCY message with the associated error code to the EtherCAT MainDevice. In accordance with the CANopen standard, an EMCY message is structured as follows in the event of a state change.

Byte	1	2	3	4	5	6	7	8	
←	0xA0	0x00	0x01	0x02	0	0	0	0	←
MainDevice	EMCY error code		Error register	Diag code	Diag data 1, 2				SubDevice

Diag data diagnostic data refers to dynamic parameters that are also provided by the firmware. This data is important for diagnostic purposes in the case of support.

You can find a table with the potential encodings for an EMCY message in the appendix (see EMCY message: Incorrect state transition error codes [▶ 101]).

9.4 EtherCAT state machine

The EtherCAT state machine (ESM) describes the different states of an EtherCAT SubDevice along with any potential state change. Different functions can be executed in the EtherCAT SubDevices depending on the individual states.

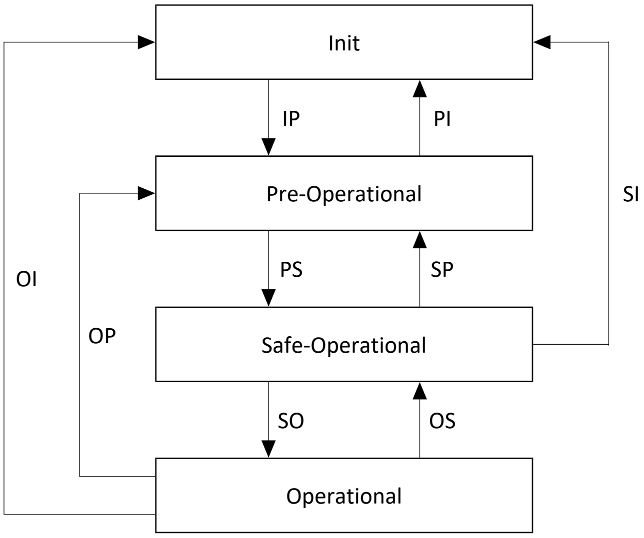


Fig. 10: EtherCAT state machine: States and state changes

States

State	Description
Init	State after an EtherCAT SubDevice is switched on. The configuration starts; saved values are loaded. Neither SDO nor PDO communication is possible using the mailbox and process data channels, i.e. the MainDevice and SubDevices do not communicate directly.
Pre-operational	The mailbox channel is active; the MainDevice and SubDevices exchange application-specific parameters using SDO communication.
Safe-operational	The mailbox and process data channels are active. All network nodes are shifted into a safe state. The SubDevices send current actual values to the MainDevice, but they ignore the MainDevice's set values and instead refer to internal default values.
Operational	The mailbox and process data channels are active. This state characterizes normal operation, i.e. the MainDevice and SubDevices exchange set and actual values.

State change

State change	Description
IP: Start Mailbox Communication	Start of SDO communication over the mailbox channel.
PI: Stop Mailbox Communication	Stop of SDO communication over the mailbox channel.
PS: Start Input UpdateStart Input Update	Start of PDO communication over the process data channel.
SP: Stop Input Update	Stop of PDO communication over the process data channel; the SubDevices do not send any actual values.
SO: Start Output Update	The SubDevices evaluate the current set value specifications of the MainDevice.
OS: Stop Output Update	The SubDevices ignore the set values of the MainDevice and refer to internal default values.
OP: Stop Output Update, Stop Input Update	Stop of PDO communication over the process data channel; neither the MainDevice nor the SubDevices send actual or set values.
SI: Stop Input Update, Stop Mailbox Communication	Stop of PDO and SDO communication over the corresponding channels; neither the MainDevice nor the SubDevices send actual or set values.
OI: Stop Output Update, Stop Input Update, Stop Mailbox Communication	Stop of PDO and SDO communication over the corresponding channels; neither the MainDevice nor the SubDevices send actual or set values.

9.5 Synchronization

For spatially distributed processes that require simultaneous actions, the EtherCAT MainDevice and SubDevices absolutely must work in synchronization with each other in the same cycle. EtherCAT provides two different methods for synchronizing the MainDevice and SubDevices: a SyncManager event (SM-Sync) and distributed clocks (DC-Sync). If the MainDevice and SubDevices are not synchronized, they are in the FreeRun state.

Each EtherCAT SubDevice Controller has a SyncManager that manages the memory units of a SubDevice. It indicates incoming process data with an interrupt signal that is used to synchronize individual EtherCAT SubDevices for SM-Sync; an additional interrupt signal is responsible for synchronization for DC-Sync.

9.5.1 SM-Sync: Synchronization using SyncManager event

In the case of synchronization via a SyncManager event, the EtherCAT SubDevices synchronize using the incoming data as the event (receive process data).

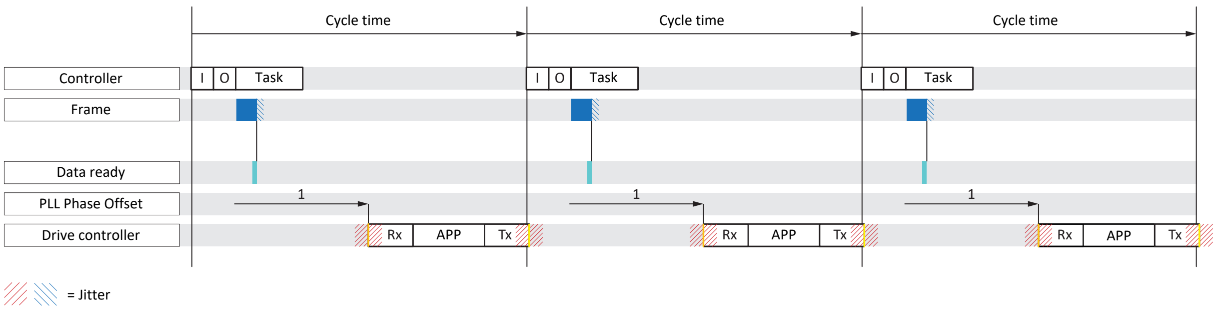


Fig. 11: SM-Sync: Synchronization using SyncManager event

Blue	Frame	Duration of the frame (control → drive controller)
Light blue	Data ready	Receive process data (control commands and set values) were completely stored in the ESC (EtherCAT SubDevice Controller) of the drive controller
Orange	Rx	Start of the application; drive controller reads receive process data (control commands and set values) from the ESC and executes the application
Yellow	Tx	End of the application; drive controller provides calculated transmit process data (status information and actual values) of the application via the ESC

SM-Sync: Settings

Arrow	Setting	Description
1	PLL Phase Offset	Time offset between provision of the process data by the controller (start of frame) and the start of process data processing (start of application) (setting: drive controller, A292)
–	MainDevice cycle time	Time within which a MainDevice task is continuously called up and processed
–	SubDevice cycle time	Time within which a SubDevice task is continuously called up and processed (parameter: A150)

The quality of synchronization using SM-Sync suffers in the case of delays in the PDO from controller to drive controller. Because the jitter of the controller has a direct effect on the drive controllers, such synchronization via a SyncManager event leads to a worse result than synchronization via distributed clocks.

9.5.2 DC-Sync: Synchronization using distributed clocks

Synchronization using the distributed clocks method allows the same time to be maintained for all nodes of an EtherCAT network.

Each EtherCAT SubDevice with distributed clocks functionality has a local clock. Normally, the time from the first DC-Sync-capable EtherCAT SubDevice downstream of the MainDevice in the network serves as the reference time. Both the MainDevice and the SubDevices synchronize to this reference clock.

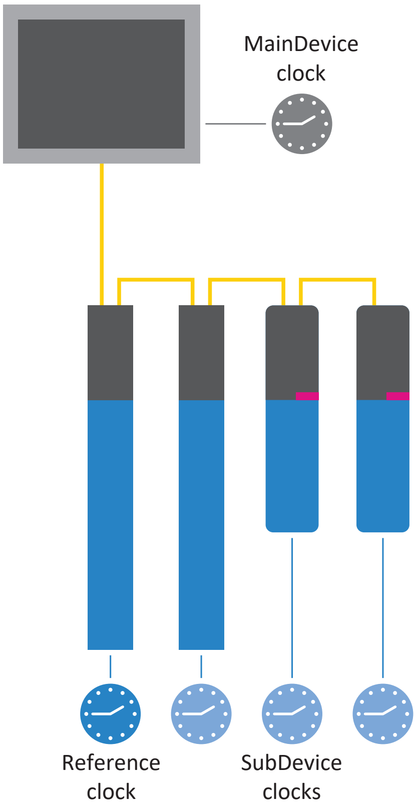


Fig. 12: EtherCAT: Distributed clocks

The EtherCAT SubDevice automatically and continuously initiates the time coordination and synchronization.
At specified intervals, it sends a frame into which the reference SubDevice enters its current time. All other SubDevices and the MainDevice read this time from the circulating frame.
Because each SubDevice experiences a certain delay when reading in the reference time due to the transmission path, the respective run times between the reference clock and the SubDevice clocks must be taken into account. For this reason, an individual offset value is measured, calculated and parameterized for each SubDevice.

The synchronous operation of all distributed MainDevice and SubDevice clocks in the network allows for highly precise, relative time information.
Moreover, this method has a high level of tolerance for fault-induced delays in the communication system thanks to the clock distribution.

9.5.2.1 TwinCAT 3: Synchronization using DC-Sync

The event associated with a synchronization application is referred to as the SYNC 0 signal in TwinCAT 3. Each SubDevice generates it own SYNC 0 signal cyclically using the respective SyncManager.

9.5.2.1.1 DC-Sync: Settings

The following diagram shows stable synchronization via distributed clocks when TwinCAT 3 is used. Both the drive controller utilization and the set times show a stable system, since the jitter of the frame (controller) and the jitter of the writing of the transmit process data (Tx) to the ESC(EtherCAT SubDevice Controller) of the drive controller are separated in time, i.e. there are no time overlaps when receiving and sending process data.

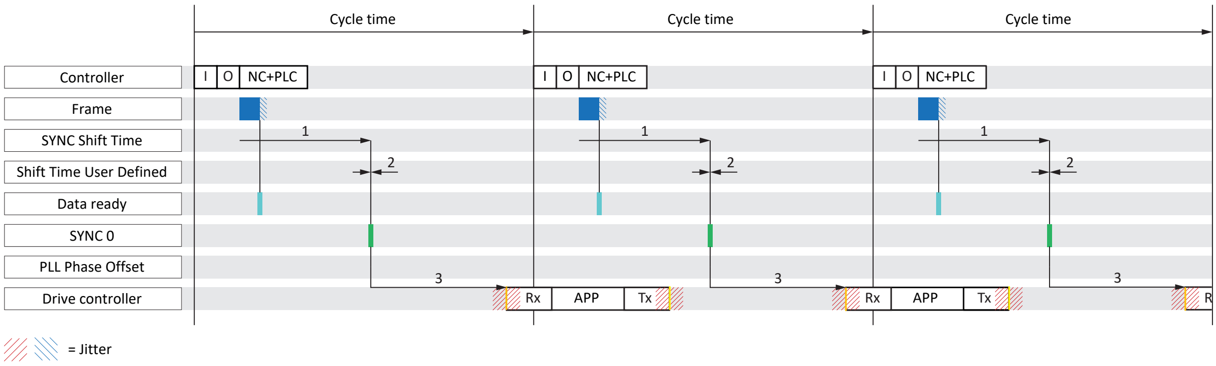


Fig. 13: TwinCAT 3: DC-Sync – settings

Blue	Frame	Duration of the frame (control → drive controller)
Light blue	Data ready	Received process data (control commands and set values) were stored completely in the ESC of the drive controller
Green	SYNC 0	Drive controller generates SYNC 0 signal for DC synchronization
Orange	Rx	Start of the application; drive controller reads receive process data (control commands and set values) from the ESC and executes the application
Yellow	Tx	End of the application; drive controller provides calculated transmit process data (status information and actual values) of the application via the ESC

DC-Sync: Settings

Arrow	Setting	Description
1	SYNC Shift Time	Time offset between the provision of the process data by the controller (frame start) and the SYNC 0 signal of the drive controller for the entire network (setting: controller)
2	Shift Time User Defined	Individual time offset in addition to the SYNC Shift Time for each drive controller (setting: controller)
3	PLL Phase Offset	Time offset between the SYNC 0 signal and the start of process data processing (start of application) (setting: drive controller, A292); A292 can only shift the start of processing within the cycle time of the drive controller; a negative value shifts the start of processing to after the synchronization signal
–	Sync Unit Cycle	The permitted cycle times for a SYNC 0 signal must be integer multiples of the drive controller cycle time A150 and must not exceed 8 ms; if the times are not permitted, a drive controller does not switch from Pre-Operational to Safe-Operational status (setting: control)

Conditions for stable synchronization

If the cycle times of the controller and drive controller are the same, the following condition applies for stable synchronization:

- SYNC Shift Time (1) + Shift Time User Defined (2) − PLL Phase Offset (3) + (Rx + APP + Tx) + jitter < cycle time

If the cycle time of the controller is a multiple of the cycle time of the drive controller, the following condition also applies:

- SYNC Shift Time (1) + Shift Time User Defined (2) − PLL Phase Offset (3) < drive controller cycle time

Checking settings

If you want to check your settings, take the following values into consideration for the drive controller and jitter:

- Runtime utilization (drive controller): E191
- Frame jitter (controller): ± 5 µs
- Application jitter (drive controller): ± 10 µs

9.5.2.1.1.1 DC-Sync: Cycle time < 1 ms

With cycle times < 1 ms, quality defects can occur in EtherCAT communication if there are time overlaps when receiving and sending process data. The following graphic shows unstable synchronization via distributed clocks when using TwinCAT 3. The synchronization is unstable because the jitter of the frame (controller) and the jitter of the writing of the transmit process data (Tx) to the ESC of the drive controller overlap.

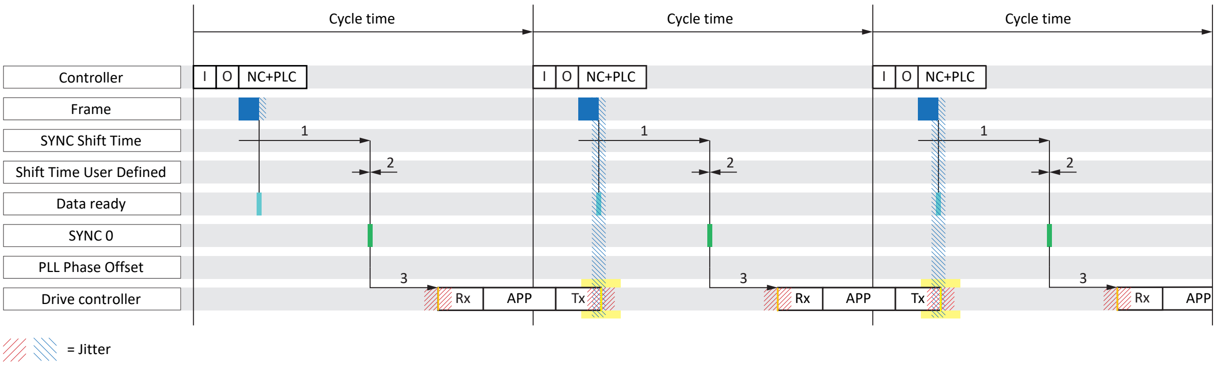


Fig. 14: TwinCAT 3: DC-Sync – unstable synchronization, cycle time < 1 ms

In the example, the data transfer (I/O) of the controller is set to task start in the EtherCAT configuration. For the application cycle sequence, the order is defined in the drive controller as RxPDO, graphical programming, TxPDO (A149 = 0). If A149 = 0, the status information and actual values for the **current** cycle are calculated and are provided and sent in the ESC of the drive controller in the same cycle.

Changing the cycle sequence

To optimize synchronization for applications with cycle times < 1 ms, change the cycle sequence to RxPDO, TxPDO, graphical programming (A149 = 1). If A149 = 1, the status information and actual values from the **previous** cycle are sent first, then the status information and actual values are calculated using the current control commands and set values for the **subsequent** cycle and provided in the ESC of the drive controller.

The following graphic shows synchronization with a modified cycle sequence. The jitter of the frame (controller) and of the writing of the process data (Tx) in the ESC of the drive controller are separated from each other in time and synchronization is stable.

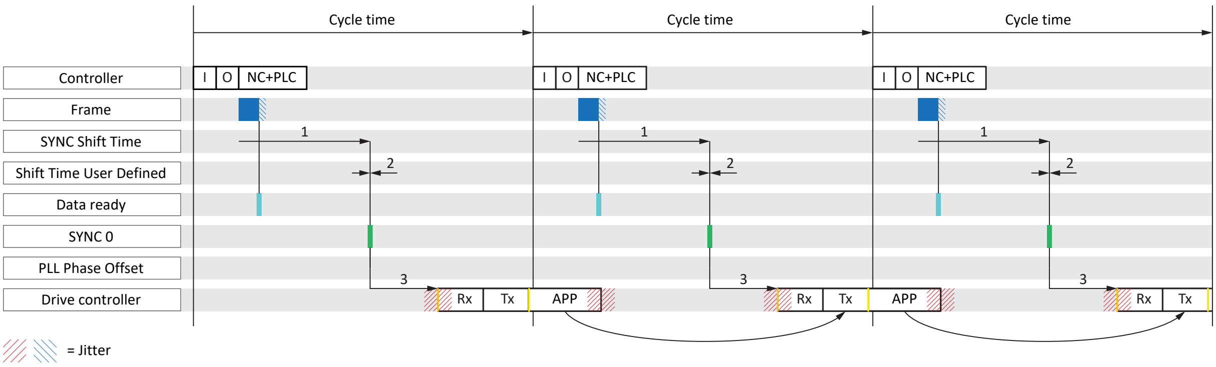


Fig. 15: TwinCAT 3: DC-Sync – stable synchronization, cycle time < 1 ms

9.5.2.1.1.2 Optimizing DC-Sync

Optimize DC synchronization using DriveControlSuite by checking and optimizing your settings for cycle time, cycle sequence and PLL phase offset (parameters: A149, A150, A292). The Optimize DC-Sync wizard suggests a suitable value range for the PLL phase offset.

✓ You are in DriveControlSuite.

✓ There is an online connection between DriveControlSuite and drive controllers.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Optimize DC-Sync.
   ⇨ The current settings for cycle sequence A149, cycle time A150 and PLL phase offset A292 are displayed.
3. A149 Cycle sequence:
   For cycle times A150 < 1 ms, select 1: RxPDO-TxPDO-Graphical Program for the cycle sequence.
4. Click on Start measurement.
   ⇨ The Start of Frame, End of Frame, Rx, Tx and Sync signals are measured
   (measurement duration: approx. 1000 × cycle time).
   ⇨ The measured values for Start of Frame, End of Frame, Rx, Tx and Sync are visualized as a diagram.
   ⇨ The measured values for End of Frame to Sync, frame duration and Sync to Rx are displayed.
   ⇨ The measured values are used to calculate a minimum and maximum value for the PLL phase offset.
5. A292 PLL phase offset:
   Define the PLL phase offset freely within the calculated value range or click on Apply mean value.

⇨ The optimization of DC synchronization is concluded.

Information

DC synchronization is considered stable if neither Rx nor Tx overlap in time with the frame of the controller (including jitter). You can achieve this by using the PLL phase offset A292 to shift the start of application Rx in the drive controller and, if necessary, changing the cycle sequence using A149.

You can determine a suitable value for the PLL phase offset by using the A287 DC-Sync optimization parameter. If the action is successful (result A287[2] = 7 or 8), A287 provides a suitable minimum and maximum value for the PLL phase offset. If the action is unsuccessful (result A287[2] < 7), A287 displays the current actual value of A292. In this case, check your settings, optimize the cycle time A150 if necessary and restart the measurement.

Meaning of the measured values

- End of Frame to Sync: Time difference between frame end and synchronization signal
- Frame duration: Maximum duration of the frame, including jitter, which contains the process data for these drive controllers
- Sync to Rx: Time difference between the synchronization signal and the start of the application in the drive controller

9.5.2.1.2 Optimize values and correct problems

You have commissioned your EtherCAT network. If you need to optimize synchronization using distributed clocks after the fact due to insufficient EtherCAT communication quality, we recommend the following measures.

9.5.2.1.2.1 EtherCAT MainDevice: DC-Sync configured for EtherCAT SubDevices?

Check whether DC-Sync is configured for all EtherCAT SubDevices on the MainDevice's end; see Configuring synchronization using distributed clocks [▶ 44].

9.5.2.1.2.2 EtherCAT SubDevice: Check control

Check the status of control for all EtherCAT SubDevices and take one of the described measures if necessary.

✓ You are in DriveControlSuite.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the PLL synchronization wizard.
   ⇨ A298 shows the status of the synchronization between the controller and the drive controller in question.
3. Bit 0 – 1: PLL engaged
   If one or both of the two associated LEDs lights up, the control range is working at ≥ 50% capacity (frequency too high or too low).
   In this case, adjust the cycle time of the Sync 0 signal on the MainDevice's end. Note that the cycle time of the Sync 0 signal must be an integer multiple of the cycle time A150 and must not exceed 8 ms.
4. Bit 2: Cycle time extended
   If the associated LED lights up, the PLL has performed an extending control intervention on the task system.
5. Bit 3: Maximum control range reached
   If the associated LED lights up, check whether the cycle times of the MainDevice and drive controller agree. Adjust these to each other if necessary.
6. Bit 4: The cycle time for the synchronization signals is greater than the specification (A296 > A291)
   If the associated LED lights up, check whether the cycle times of the MainDevice and drive controller agree. Adjust these to each other if necessary.
7. Bit 5: Control/synchronization deactivated
   If the associated LED lights up, set A290 to 1: Active.

9.5.2.1.2.3 EtherCAT SubDevice: Synchronization – reading out diagnostic parameters

You can get information about the status of the EtherCAT synchronization using the A261 diagnostic parameter. This checks whether a frame arrives at an EtherCAT SubDevice within a certain time period based on the Sync 0 signal.

✓ You are in DriveControlSuite.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Diagnostics.
   ⇨ A261[0] – [3] shows the state of the EtherCAT synchronization.
3. A261[0]:
   Display of the error code.
4. A261[1]:
   Display of the time difference between the data provision and the Sync 0 signal (unit: µs).
5. A261[2]:
   Display of the error counter. The error counter is incremented if the SubDevice has received the process data from the MainDevice after the Sync 0 signal or if the time difference between process data receipt and the Sync 0 signal is greater than half the cycle time (A261[1] > A150 × 0.5).

9.5.2.2 CODESYS V3: Synchronization using DC-Sync

The event for a synchronization operation is referred to as the Sync 0 signal in CODESYS V3. Each SubDevice generates it own Sync 0 signal cyclically using the respective SyncManager.

9.5.2.2.1 DC-Sync: Settings

The following graphic shows stable synchronization using distributed clocks when using CODESYS V3. Both the drive controller utilization and the set times show a stable system, since the jitter of the frame (controller) and the jitter of the writing of the transmit process data (Tx) to the ESC(EtherCAT SubDevice Controller) of the drive controller are separated in time, i.e. there are no time overlaps between receiving and sending process data.

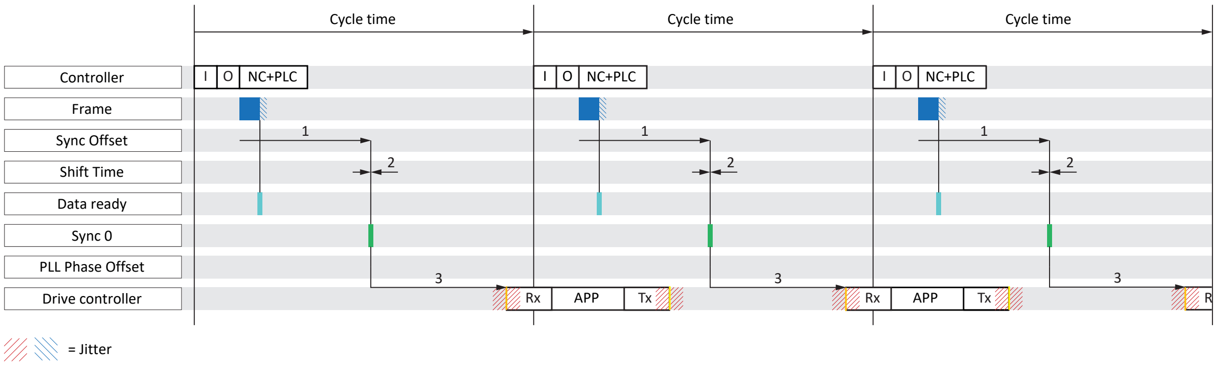


Fig. 16: CODESYS V3: DC-Sync – settings

Blue	Frame	Duration of the frame (control → drive controller)
Light blue	Data ready	Received process data (control commands and set values) were stored completely in the ESC of the drive controller
Green	Sync 0	Drive controller generates Sync 0 signal for DC synchronization
Orange	Rx	Start of the application; drive controller reads receive process data (control commands and set values) from the ESC and executes the application
Yellow	Tx	End of the application; drive controller provides calculated transmit process data (status information and actual values) of the application via the ESC

DC-Sync: Settings

Arrow	Setting	Description
1	Sync Offset	Time offset between the provision of the process data by the controller (frame start) and the Sync 0 signal of the drive controller for the entire network (setting: controller)
2	Shift Time	Individual time offset in addition to the SYNC Offset for each drive controller (setting: controller)
3	PLL Phase Offset	Time offset between the Sync 0 signal and the start of process data processing (start of application) (setting: drive controller, A292); A292 can only shift the start of processing within the cycle time of the drive controller; a negative value shifts the start of processing to after the synchronization signal
–	Sync Unit Cycle	Permitted cycle times for a Sync 0 signal must be an integer multiple of the drive controller cycle time A150 and must not exceed 8 ms; if the times are not permitted, a drive controller does not switch from Pre-Operational to Safe-Operational state (setting: controller)

Conditions for stable synchronization

If the cycle times of the controller and drive controller are the same, the following condition applies for stable synchronization:

- Sync Offset (1) + Shift Time (2) − PLL Phase Offset (3) + (Rx + APP + Tx) + jitter < cycle time

If the cycle time of the controller is a multiple of the cycle time of the drive controller, the following condition also applies:

- Sync Offset (1) + Shift Time (2) − PLL Phase Offset (3) < drive controller cycle time

Checking settings

If you want to check your settings, take the following values into consideration for the drive controller and jitter:

- Runtime utilization (drive controller): E191
- Frame jitter (controller): ± 5 µs
- Application jitter (drive controller): ± 10 µs

9.5.2.2.1.1 DC-Sync: Cycle time < 1 ms

With cycle times < 1 ms, quality defects can occur in EtherCAT communication if there are time overlaps when receiving and sending process data. The following graphic shows unstable synchronization via distributed clocks when CODESYS V3 is used. The synchronization is unstable because the jitter of the frame (controller) and the jitter of the writing of the transmit process data (Tx) to the ESC of the drive controller overlap.

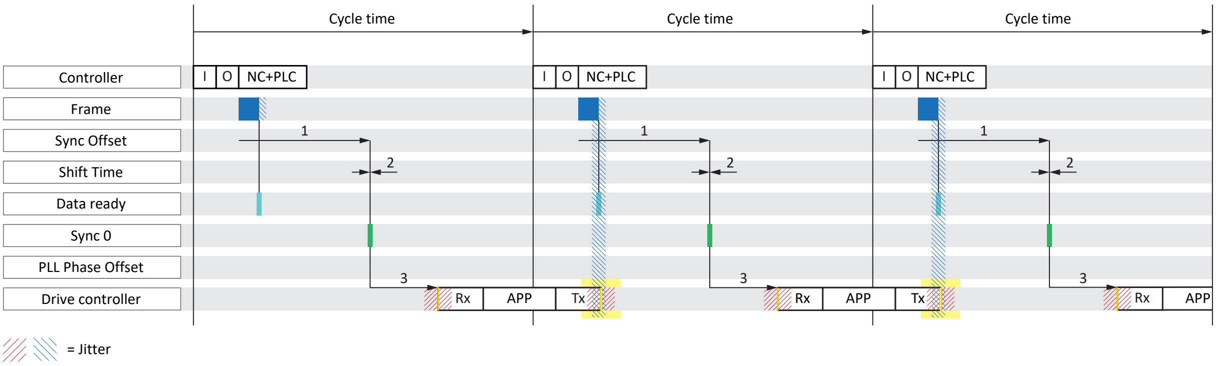


Fig. 17: CODESYS V3: DC-Sync – unstable synchronization, cycle time < 1 ms

In the example, the data transfer (I/O) of the controller is set to task start in the EtherCAT configuration. For the application cycle sequence, the order is defined in the drive controller as RxPDO, graphical programming, TxPDO (A149 = 0). If A149 = 0, the status information and actual values for the **current** cycle are calculated and are provided and sent in the ESC of the drive controller in the same cycle.

Changing the cycle sequence

To optimize synchronization for applications with cycle times < 1 ms, change the cycle sequence to RxPDO, TxPDO, graphical programming (A149 = 1). If A149 = 1, the status information and actual values from the **previous** cycle are sent first, then the status information and actual values are calculated using the current control commands and set values for the **subsequent** cycle and provided in the ESC of the drive controller.

The following graphic shows synchronization with a modified cycle sequence. The jitter of the frame (controller) and of the writing of the process data (Tx) in the ESC of the drive controller are separated from each other in time and synchronization is stable.

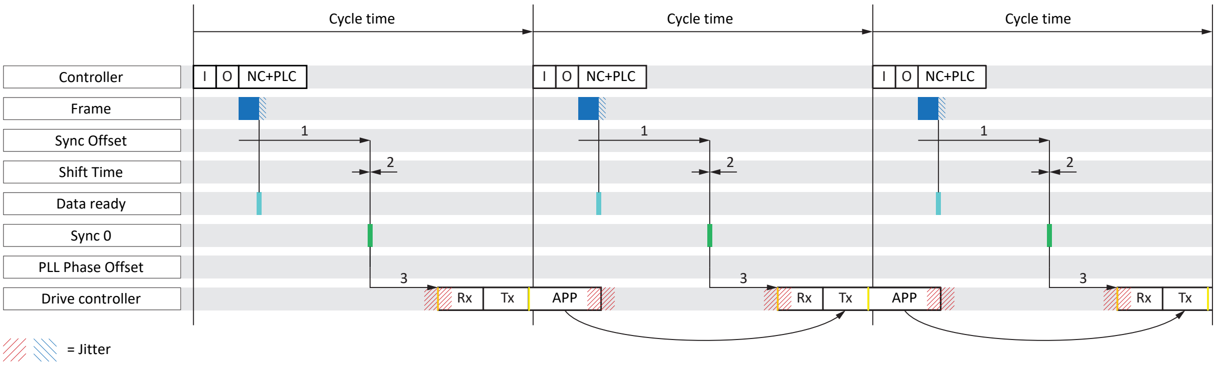


Fig. 18: CODESYS V3: DC-Sync – stable synchronization, cycle time < 1 ms

9.5.2.2.1.2 Optimizing DC-Sync

Optimize DC synchronization using DriveControlSuite by checking and optimizing your settings for cycle time, cycle sequence and PLL phase offset (parameters: A149, A150, A292). The Optimize DC-Sync wizard suggests a suitable value range for the PLL phase offset.

✓ You are in DriveControlSuite.

✓ There is an online connection between DriveControlSuite and drive controllers.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Optimize DC-Sync.
   ⇨ The current settings for cycle sequence A149, cycle time A150 and PLL phase offset A292 are displayed.
3. A149 Cycle sequence:
   For cycle times A150 < 1 ms, select 1: RxPDO-TxPDO-Graphical Program for the cycle sequence.
4. Click on Start measurement.
   ⇨ The Start of Frame, End of Frame, Rx, Tx and Sync signals are measured
   (measurement duration: approx. 1000 × cycle time).
   ⇨ The measured values for Start of Frame, End of Frame, Rx, Tx and Sync are visualized as a diagram.
   ⇨ The measured values for End of Frame to Sync, frame duration and Sync to Rx are displayed.
   ⇨ The measured values are used to calculate a minimum and maximum value for the PLL phase offset.
5. A292 PLL phase offset:
   Define the PLL phase offset freely within the calculated value range or click on Apply mean value.

⇨ The optimization of DC synchronization is concluded.

Information

DC synchronization is considered stable if neither Rx nor Tx overlap in time with the frame of the controller (including jitter). You can achieve this by using the PLL phase offset A292 to shift the start of application Rx in the drive controller and, if necessary, changing the cycle sequence using A149.

You can determine a suitable value for the PLL phase offset by using the A287 DC-Sync optimization parameter. If the action is successful (result A287[2] = 7 or 8), A287 provides a suitable minimum and maximum value for the PLL phase offset. If the action is unsuccessful (result A287[2] < 7), A287 displays the current actual value of A292. In this case, check your settings, optimize the cycle time A150 if necessary and restart the measurement.

Meaning of the measured values

- End of Frame to Sync: Time difference between frame end and synchronization signal
- Frame duration: Maximum duration of the frame, including jitter, which contains the process data for these drive controllers
- Sync to Rx: Time difference between the synchronization signal and the start of the application in the drive controller

9.5.2.2.2 Optimize values and correct problems

You have commissioned your EtherCAT network. If you need to optimize synchronization using distributed clocks after the fact due to insufficient EtherCAT communication quality, we recommend the following measures.

9.5.2.2.2.1 EtherCAT MainDevice: DC-Sync configured for EtherCAT SubDevices?

Check whether DC-Sync is configured for all EtherCAT SubDevices on the MainDevice's end. If this is not the case, change the configuration as described below.

✓ You are in CODESYS V3.

1. Navigate to the first of the added drive controllers in the device tree and double click to open it.
2. Distributed Clock:
   Select DC: The list entry DC enabled (multiplier = 1) must be selected.
   Sync 0: The option Enable Sync 0 must be activated.
   Cycle Time and Sync Offset: Make sure that the presets match the corresponding values of A291 PLC Cycle time and A293 PLL gain in DriveControlSuite.
3. If you would like to change the presets, activate the option Additional > Enable Expert Settings and adjust the settings accordingly.
4. Repeat steps 2 and 3 for all of the SubDevices in your EtherCAT network.

9.5.2.2.2.2 EtherCAT SubDevice: Check control

Check the status of control for all EtherCAT SubDevices and take one of the described measures if necessary.

✓ You are in DriveControlSuite.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the PLL synchronization wizard.
   ⇨ A298 shows the status of the synchronization between the controller and the drive controller in question.
3. Bit 0 – 1: PLL engaged
   If one or both of the two associated LEDs lights up, the control range is working at ≥ 50% capacity (frequency too high or too low).
   In this case, adjust the cycle time of the Sync 0 signal on the MainDevice's end. Note that the cycle time of the Sync 0 signal must be an integer multiple of the cycle time A150 and must not exceed 8 ms.
4. Bit 2: Cycle time extended
   If the associated LED lights up, the PLL has performed an extending control intervention on the task system.
5. Bit 3: Maximum control range reached
   If the associated LED lights up, check whether the cycle times of the MainDevice and drive controller agree. Adjust these to each other if necessary.
6. Bit 4: The cycle time for the synchronization signals is greater than the specification (A296 > A291)
   If the associated LED lights up, check whether the cycle times of the MainDevice and drive controller agree. Adjust these to each other if necessary.
7. Bit 5: Control/synchronization deactivated
   If the associated LED lights up, set A290 to 1: Active.

9.5.2.2.2.3 EtherCAT SubDevice: Synchronization – reading out diagnostic parameters

You can get information about the status of the EtherCAT synchronization using the A261 diagnostic parameter. This checks whether a frame arrives at an EtherCAT SubDevice within a certain time period based on the Sync 0 signal.

✓ You are in DriveControlSuite.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Diagnostics.
   ⇨ A261[0] – [3] shows the state of the EtherCAT synchronization.
3. A261[0]:
   Display of the error code.
4. A261[1]:
   Display of the time difference between the data provision and the Sync 0 signal (unit: µs).
5. A261[2]:
   Display of the error counter. The error counter is incremented if the SubDevice has received the process data from the MainDevice after the Sync 0 signal or if the time difference between process data receipt and the Sync 0 signal is greater than half the cycle time (A261[1] > A150 × 0.5).

9.6 ESI files

An ESI file (EtherCAT SubDevice Information) is a device description file that is made available to the EtherCAT MainDevice, i.e. a controller, for the configuration of the EtherCAT network. Each controller accepts a maximum of one ESI file per drive controller series for configuring the corresponding EtherCAT network.

In order to guarantee maximum flexibility regarding PDO transmission options, STOBER ESI files have a modular structure.

A STOBER ESI file contains specified configurations for PDO transmission for every application in the form of default modules. You can add to the standard configurations of any application or configured PDO transmission freely as desired and add your STOBER ESI file as a new module. The number of expandable modules is unlimited.

9.6.1 Adding module to ESI file

✓ You have expanded the configuration for the RxPDO and/or TxPDO transmission specified on the system side.
In order to make this available to the controller, add a new module that contains your configuration to the ESI file.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard.
3. E72 User configuration identification:
   Give the new module a descriptive name.
4. Click on Edit ESI.
   ⇨ The Add to ESI file dialog box opens.
5. Navigate to the location where you saved the ESI file, highlight the file and click Open.
   ⇨ The EsiModuleEdit dialog box opens.
   In addition to standard modules (Modules of the ESI file column), the ESI contains the module previously created by you (New modules column).
6. New modules column:
   In order to add the new module to the ESI file, click on the green arrow and confirm with OK.
   ⇨ The Edit ESI dialog box opens.
7. Save the addition to the ESI file by clicking on Yes.
8. Repeat the steps for each additional module that you would like to add to the ESI in question.

⇨ You have added your individual PDO configuration to the ESI file.

9.6.2 Deleting a module from the ESI file

You can delete a configuration of the PDO transmission you have added, i.e. the associated module, from an existing ESI file.

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard.
3. Click on Edit ESI.
   ⇨ The Add to ESI file dialog box opens.
4. Navigate to the location where you saved the ESI file in question, highlight the file and click Open.
   ⇨ The EsiModuleEdit dialog box opens.
5. Modules of the ESI file column:
   Click on the red cross for the module that you would like to delete and confirm with OK.
   ⇨ The Edit ESI dialog box opens.
6. Save the modified ESI file by clicking on Yes.

⇨ The module is deleted from the ESI file.

9.7 Cycle times

Possible cycle times can be found in the following table.

Type	Cycle times	Relevant parameters
EtherCAT fieldbus, cyclical communication	250 µs, 500 µs, 1 ms, 2 ms, 4 ms, 8 ms	Adjustable in TwinCAT 3 or CODESYS

Tab. 9: Cycle times

9.8 Activating and executing actions

To be able to activate and execute actions via fieldbus, you must first enable action activation in DriveControlSuite and extend the process data by the control byte and status word for actions.

Enabling action activation

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the CiA 402 application wizard > Additional functions.
3. Enable the Action activation option.

Adjusting receive process data

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Received process data RxPDO.

Adjusting transmit process data

1. Select the relevant drive controller in the project tree and click on the desired projected axis in the Project menu > Wizard area.
2. Select the EtherCAT wizard > Transmitted process data TxPDO.
3. A233[0] – A233[23], A234[0] – A234[23]:
   Add A69, the status word for activating actions, to the transmit process data.

Executing an action

Then execute the desired action. Here, take into account any prerequisites with regard to the device state as well as any further measures required after the start of the action. All prerequisites as well as more detailed information on the individual actions can be found in the corresponding parameter descriptions in DriveControlSuite.

Selecting an action	Establishing the device state	Starting an action	Executing the next step	Completing an action (by progress = 100%)
0001 bin = Save values (A00)	—	Execute (A75, bit 0 =1)	—	Undo execute (A75, bit 0 = 0)
0011 bin = Reset memorized values (A37)				
0111 bin = Clear reference (I38)				
1000 bin = Delete limit switch memory (I52)				
0010 bin = Restart (A09)	E48 ≠ 4: Enabled + E48 ≠ 7: Quick stop	Execute (A75, bit 0 =1)	—	Undo execute (A75, bit 0 = 0)
1101 bin = Test winding (B43)	E48 = 2: Ready for switch-on	Execute (A75, bit 0 =1)	—	Undo execute (A75, bit 0 = 0)
1010 bin = Test phase (B40)	E48 = 2: Ready for switch-on	Execute (A75, bit 0 =1)	Enable drive controller (E48 = 4: Enabled)	Undo execute (A75, bit 0 = 0) + Undo enable
1011 bin = Calibrate motor (B41)				
1100 bin = Optimize current controller (B42)				
1110 bin = Optimize current controller (standstill) (B49)				
0100 bin = Test brake (B300)				
0101 bin = Grind brake (B301)				
0110 bin = Brake 2 grind (B302)				
1001 bin = Test brake (S18)				

Tab. 10: Selecting and executing an action

9.9 Fieldbus scaling

Using parameter A213, you define the scaling for both cyclical transmission of process data objects as well as acyclical transmission of service data objects in the network in the DriveControlSuite commissioning software. The values are either converted and represented as an integer or transmitted as a raw value without scaling according to their data types.

Regardless of the settings selected in parameter A213, the configuration as well as the firmware both work exclusively with raw values. The following graphic shows an overview of fieldbus scaling.

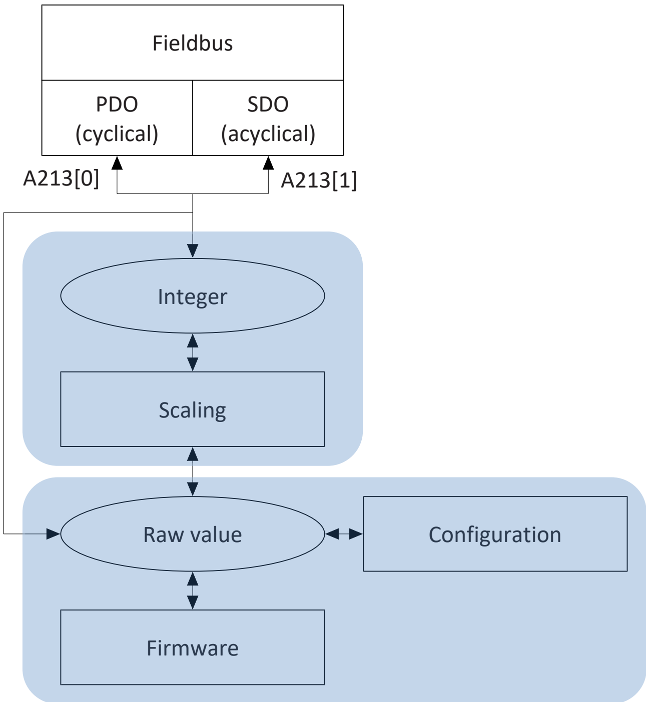


Fig. 19: Overview of fieldbus scaling

For transmission as an integer, the number of decimal places can be defined for all parameters that affect positions, velocities, accelerations, decelerations and jerk. For all other parameters, the number of decimal places is fixed. The values for scaling are output in DriveControlSuite with the properties of a parameter. The following table lists the parameters which you can use to define the number of decimal places for scaled transmission.

Scaling	Axis model	Master axis model
Position	I06	G46
Velocity (DB)	I66	G66
Velocity (CiA)	A310	—
Acceleration, deceleration, jerk (DB)	I67	G67
Acceleration, deceleration, jerk (CiA)	A311	—

Tab. 11: Fieldbus scaling for integer: Parameters for defining the decimal places

9.10 SDO Info service

Using the SDO Info service, the EtherCAT controller can read out the objects from the drive controller. During the read-out, all relevant object properties, such as data type, write and read access rights as well as mapping capabilities, are transmitted to the controller. You can define which objects are transmitted using the service in DriveControlSuite using parameter A268. The service is only supported if you have selected the EtherCAT Rx SDO Info template when creating the project in DriveControlSuite.

ATTENTION!

Change of addressing when changing the template

If you change the template from EtherCAT Rx to EtherCAT Rx SDO Info, the addressing of the elements of array and record parameters also changes. Note this in particular for existing configurations. For the templates, various ESI files are created. When changing the template, you must create a new ESI file using the wizards in DriveControlSuite and provide it to TwinCAT 3. A template change also causes a change to the revision number of the drive controller. Therefore, restart the drive controller after changing the template.

9.10.1 Setting SDO Info service in TwinCAT 3

- ✓ You have configured the drive controller in DriveControlSuite with the EtherCAT Rx SDO Info template.
- ✓ The state of the drive controller in the EtherCAT network is Pre-Operational, Safe-Operational or Operational (display: A255).
- ✓ The drive controller has already been created in the TwinCAT project.

1. Navigate to the drive controller from which the objects are to be read out in the solution explorer.
2. Double-click on the drive controller.
   ⇨ The settings open in the main window.
3. In the main window, switch to the CoE – Online tab and click Advanced....
   ⇨ The Advanced Settings window opens.
4. Select Dictionary from the tree view on the left.
5. Online - via SDO Information:
   Activate this option and select the All Objects option from the list if all objects are to be read out.
   As an alternative, you can define that only Rx- or Tx-mapping-capable objects are to be read out.
   The Backup Objects and Settings Objects options are not supported.
6. Confirm the settings with OK.

⇨ Reading out objects starts.

⇨ After completing the read-out, the Advanced Settings window closes and all read-out objects are listed.

9.10.2 Access to objects

In the DriveControlSuite commissioning software, use parameter A268 to define the scope of the communication object list that is read out. By selecting the object groups, you define whether only the index area of standardized objects, only the index area of manufacturer-specific parameters or the entire index area is read out. Furthermore, you can define whether or not each parameter group from A to Z is part of the list in the manufacturer-specific parameters.

Using parameter A10[2], you define the access level. Only objects with an access level ≤ the set access level are read out.

Note that, in addition to EtherCAT objects, only those objects are read out that are available through the configuration of the drive controller or depending on the application.

To enable changes to the values of objects in the solution explorer of TwinCAT 3 directly using the CoE - Online tab, set parameter A213[1] to 1: Native.

9.10.3 Check for conformity

In TwinCAT 3, the revision numbers are used to check whether the configuration in the drive controller and ESI file match. Therefore, in case of changes to the configuration of the drive controller, create a new ESI file using the wizard in DriveControlSuite and provide it to TwinCAT 3.

Information

The check for conformity happens only for ESI files that were created in DriveControlSuite commissioning software in version 6.5-D or later.

During the check, the revision numbers in the drive controller and ESI file are checked. If these do not match, you receive one of the error messages described below.

Error message when scanning the hardware environment

It is not possible to add a drive controller to the project. In TwinCAT XAE, you receive the error message New device type found.

Error message when starting project configuration

After you have added a drive controller manually as a SubDevice, or if you change the template in the drive controller in an existing TwinCAT project configuration, you receive the error message Check revision number. Comparison failed. The drive controller switches to the Init state.

9.11 Diagnosis History

With the help of the Diagnosis History object (10F3 hex), the EtherCAT diagnostic memory of the drive controller can be read out by the EtherCAT MainDevice. Up to 20 messages can be stored in the diagnostic memory of the drive controller. When the maximum number of 20 messages is reached, the oldest messages are overwritten. Diagnostic messages are stored in volatile memory. Each time the drive controller is restarted, the messages are deleted. A diagnostic message can be an Info, Warning or Error type. In addition, the time at which the event occurred in the drive controller is transmitted in the message. If A250 is added to the process data mapping in the DriveControlSuite of the parameters (EtherCAT wizard > Transmitted process data TxPDO), the automation software of the controller is able to determine that a new diagnostic message can be read out from the drive controller.

9.11.1 Reading out the Diagnosis History in TwinCAT 3

Diagnostic messages are displayed in TwinCAT 3 in the German, English or French language. The decisive factor is the language that you have set in TwinCAT XAE.

If you want to read out the Diagnosis History, proceed as follows:

1. Start TwinCAT XAE.
2. In the solution explorer, navigate to the drive controller whose diagnosis history you want to read out.
3. In the main window, switch to the Diag History tab.
4. Click Update History.

⇨ The Diagnosis History is read out from the drive controller and displayed in the main window.

Information

If you enable the Auto Update option, new messages will be read out automatically. It is not necessary to click the Update History button. Activate the Only New Messages option if you want to hide already acknowledged messages. You can send messages via the button Ack. Acknowledge messages. In the Flags column, you can see which messages are new (N) and which have already been acknowledged (Q).

If required, in the advanced settings you can specify which messages should be stored in the Diagnosis History.

1. On the Diag History tab, click Advanced....
   ⇨ The Advanced Settings window opens.
2. In the section Message Types, define which messages should be stored in the Diagnosis History.
   ⇨ Deactivated message types are no longer stored in the Diagnosis History.
3. Confirm your selection with OK.

Information

Do not change the settings in the sections Emergency and Overwrite/Acknowledge Mode. Disabling these options will be ignored.

9.11.2 Determination of the system time

The system time in the drive controller can be determined in different ways:

Distributed Clocks

If the EtherCAT network is synchronized via Distributed Clocks, the current system time of the EtherCAT network is used as the time stamp of the diagnostic message.

SNTP server

If the EtherCAT network does not synchronize or if synchronization is done via SM-Sync, an SNTP server can be used to determine the current time stamp (see Simple Network Time Protocol (SNTP) [▶ 103]).

Without time stamp

If the current time stamp cannot be determined via Distributed Clocks or an SNTP server, the value 0 is transmitted as the time stamp. This value is also transmitted if an event occurs before the distributed clocks are synchronized or before the current timestamp is determined via an SNTP server.

9.12 Function blocks for TwinCAT 3

STOBER function blocks are small, functional software units that support you during commissioning of your drive controllers and in case of service. You can reuse the function blocks in TwinCAT 3 in different projects.

The available function blocks can be found in packed form at http://www.stoeber.de/en/downloads/.
Enter `TwinCAT 3 blocks` into the search field.

The following table provides an overview of the available function blocks.

Function block	Description	Software version	Library version
STOBER_BoxName	Write the name of the EtherCAT SubDevice to parameter A251 of the drive controller	V 3.1.4022.22 and later	V 3.1.0.0 and later
STOBER_Backup_Restore_Initiator	Determine possible services for the STOBER_Backup_Restore function block	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_Backup_Restore	Load project configurations from TwinCAT 3 into the drive controllers	V 3.1.4022.22 and later	V 3.1.1.0 and later
STOBER_MC_HOME	Control drive controller-guided referencing of the CiA 402 and CiA 402 HiRes Motion applications (with transfer of an NC axis)	V 3.1.4022.22 and later	V 3.1.0.0 and later
STOBER_MC_HOME_REF	Control drive controller-guided referencing of the CiA 402 and CiA 402 HiRes Motion applications (with transfer of reference position, referencing method and an NC axis)	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_Action	Execute actions on the drive controller	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_Power_Action	Execute actions on the drive controller after enabling the drive controller (with transfer of an NC axis)	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_Phase_Test	Execute phase test action on the drive controller (with transfer of an NC axis)	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_PRM_LoadMatrix	Read out the load matrix from the drive controller (R118) and write it to an array (with transfer of an NC axis)	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_PRM_LoadMatrix_AMS	Read out the load matrix from the drive controller (R118) and write it to an array	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_PRM_LoadMatrix_File	Read out the load matrix from the drive controller (R118) and save it as a file in a directory (with transfer of an NC axis)	V 3.1.4024.40 and later	V 3.1.2.0 and later
STOBER_PRM_LoadMatrix_File_AMS	Read out the load matrix from the drive controller (R118) and save it as a file in a directory	V 3.1.4024.40 and later	V 3.1.2.3 and later
STOBER_SDO_Info	Determine whether the SDO Info service is active in the drive controller	V 3.1.4024.40 and later	V 3.1.2.0 and later

Tab. 12: Function blocks for TwinCAT 3

Detailed information on the function blocks for TwinCAT 3 can be found in the corresponding manual (see Detailed information [▶ 105]).

10 Appendix

10.1 Supported communication objects

The following chapters provide an overview of the supported communication objects of the standardized ETG (EtherCAT Technology Group) profile as well as their mapping to the corresponding parameters of STOBER.

Information about the supported communication objects of the CiA 402 profile as well as about the standard mapping of the CiA 402 application and EtherCAT can be found in the corresponding application manual.

10.1.1 ETG.1000.6 EtherCAT specification: 1000 hex – 1FFF hex

The following table includes the supported communication objects for the standardized profile ETG.1000.6 EtherCAT specification – CANopen over EtherCAT (CoE) Communication Area as well as how the objects are mapped to the corresponding parameters of STOBER.

Index	Subindex	TxPDO	RxPDO	Name	Comment
1000 hex	0 hex	—	—	Device type	Constant value 20192 hex Bit 0 – 15: Device profile number, 192 hex = 402 Bit 16 – 23: Type, 2 hex = Servo drive Bit 24 – 31: Reserved
1001 hex	0 hex	—	—	Error register	
1008 hex	0 hex	—	—	Manufacturer device name	E50
1009 hex	0 hex	—	—	Manufacturer hardware version	E52[1]
100A hex	0 hex	—	—	Manufacturer software version	E52[3]
1018 hex				Identity object	Record with 4 elements
1018 hex	0 hex	—	—	Highest subindex supported	Constant value of 4 hex
1018 hex	1 hex	—	—	Vendor ID	manufacturer ID: B9 hex
1018 hex	2 hex	—	—	Product code	Nominal power in unit 0.1 kW
1018 hex	3 hex	—	—	Revision number	Software build number
1018 hex	4 hex	—	—	Serial number	E52[2]
1600 hex				1st RxPDO mapping parameter	Array with 24 elements
1600 hex	0 hex	—	✓	Number of mapped application objects in RxPDO	Constant value of 18 hex
1600 hex	1 hex – 18 hex	—	✓	Application objects	A225[0] – A225[23]
1601 hex				2nd RxPDO mapping parameter	Array with 24 elements
1601 hex	0 hex	—	✓	Number of mapped application objects in RxPDO	Constant value of 18 hex
1601 hex	1 hex – 18 hex	—	✓	Application objects	A226[0] – A226[23]
1602 hex				3rd RxPDO mapping parameter	Array with 24 elements

Index	Subindex	TxPDO	RxPDO	Name	Comment
1602 hex	0 hex	—	✓	Number of mapped application objects in RxPDO	Constant value of 18 hex
1602 hex	1 hex – 18 hex	—	✓	Application objects	A227[0] – A227[23]
1603 hex				4th RxPDO mapping parameter	Array with 24 elements
1603 hex	0 hex	—	—	Number of mapped application objects in RxPDO	Constant value of 18 hex
1603 hex	1 hex – 18 hex	—	—	Application objects	A228[0] – A228[23]
1A00 hex				1st TxPDO mapping parameter	Array with 24 elements
1A00 hex	0 hex	—	✓	Number of mapped application objects in TxPDO	Constant value of 18 hex
1A00 hex	1 hex – 18 hex	—	✓	Application objects	A233[0] - A233[23]
1A01 hex				2nd TxPDO mapping parameter	Array with 24 elements
1A01 hex	0 hex	—	✓	Number of mapped application objects in TxPDO	Constant value of 18 hex
1A01 hex	1 hex – 18 hex	—	✓	Application objects	A234[0] - A234[23]
1A02 hex				3rd TxPDO mapping parameter	Array with 24 elements
1A02 hex	0 hex	—	✓	Number of mapped application objects in TxPDO	Constant value of 18 hex
1A02 hex	1 hex – 18 hex	—	✓	Application objects	A235[0] - A235[23]
1A03 hex				4th TxPDO mapping parameter	Array with 24 elements
1A03 hex	0 hex	—	—	Number of mapped application objects in TxPDO	Constant value of 18 hex
1A03 hex	1 hex – 18 hex	—	—	Application objects	A236[0] - A236[23]
1C00 hex				Sync manager communication type	Record with 4 elements
1C00 hex	0 hex	—	—	Highest subindex supported	Constant value of 4 hex
1C00 hex	1 hex	—	—	Communication type sync manager 0	
1C00 hex	2 hex	—	—	Communication type sync manager 1	
1C00 hex	3 hex	—	—	Communication type sync manager 2	
1C00 hex	4 hex	—	—	Communication type sync manager 3	
1C12 hex				Sync manager 2	Record with 4 elements
1C12 hex	0 hex	—	✓	Highest subindex supported	Constant value of 4 hex
1C12 hex	1 hex	—	✓	PDO receive assign 1st PDO	A252[0]
1C12 hex	2 hex	—	✓	PDO receive assign 2nd PDO	A252[1]
1C12 hex	3 hex	—	✓	PDO receive assign 3rd PDO	A252[2]
1C12 hex	4 hex	—	✓	PDO receive assign 4th PDO	A252[3]
1C13 hex				Sync manager 3	Record with 4 elements

Index	Subindex	TxPDO	RxPDO	Name	Comment
1C13 hex	0 hex	—	✓	Highest subindex supported	Constant value of 4 hex
1C13 hex	1 hex	—	✓	PDO transmit assign 1st PDO	A253[0]
1C13 hex	2 hex	—	✓	PDO transmit assign 2nd PDO	A253[1]
1C13 hex	3 hex	—	✓	PDO transmit assign 3rd PDO	A253[2]
1C13 hex	4 hex	—	✓	PDO transmit assign 4th PDO	A253[3]
1C32 hex				Output SyncManager parameter	Record with 10 elements
1C32 hex	0 hex	—	—	Highest subindex supported	Constant value of 20 hex
1C32 hex	1 hex	—	—	Synchronization type	A264[0]
1C32 hex	2 hex	—	—	Cycle time	A264[1]
1C32 hex	3 hex	—	—	Shift time	A264[2]
1C32 hex	4 hex	—	—	Synchronization types supported	A264[3]
1C32 hex	5 hex	—	—	Minimum Cycle Time	A264[4]
1C32 hex	6 hex	—	—	Calc and Copy Time	A264[5]
1C32 hex	9 hex	—	—	Delay Time	A264[6]
1C32 hex	B hex	—	—	SM-Event missed Counter	A264[7]
1C32 hex	C hex	—	—	Cycle Time too small Counter	A264[8]
1C32 hex	20 hex	—	—	Sync Error	A264[9]
1C33 hex				Input SyncManager parameter	Record with 10 elements
1C33 hex	0 hex	—	—	Highest subindex supported	Constant value of 20 hex
1C33 hex	1 hex	—	—	Synchronization type	A265[0]
1C33 hex	2 hex	—	—	Cycle time	A265[1]
1C33 hex	3 hex	—	—	Shift time	A265[2]
1C33 hex	4 hex	—	—	Synchronization types supported	A265[3]
1C33 hex	5 hex	—	—	Minimum Cycle Time	A265[4]
1C33 hex	6 hex	—	—	Calc and Copy Time	A265[5]
1C33 hex	9 hex	—	—	Delay Time	A265[6]
1C33 hex	B hex	—	—	SM-Event missed Counter	A265[7]
1C33 hex	C hex	—	—	Cycle Time too small Counter	A265[8]
1C33 hex	20 hex	—	—	Sync Error	A265[9]

Tab. 13: CiA 301 communication objects: 1000 hex – 1FFFF hex

10.1.2 ETG.1020 EtherCAT protocol enhancements

The following table contains the supported communication objects of the ETG.1020 EtherCAT Protocol Enhancements profile and their mapping to the corresponding parameters of STOBER. The listed extensions are part of the EtherCAT specification and may become part of the ETG.1000 series in the future.

Index	Subindex	TxPDO	RxPDO	Name	Comment
10F3 hex				Diagnosis History Object	
10F3 hex	1 hex	—	—	Maximum messages	
10F3 hex	2 hex	—	—	Newest Message	
10F3 hex	3 hex	—	—	Newest Acknowledged Message	
10F3 hex	4 hex	✓	—	New Messages Available	A250
10F3 hex	5 hex	—	—	Flags	
10F3 hex	6 hex	—	—	Diagnosis message	

Tab. 14: CiA 301 communication object: 10F3 hex

10.1.3 ETG.5000.1 Modular Device Profile: F000 hex – FFFF hex

The following table includes the supported communication objects of the standardized profile ETG.5000.1 Modular Device Profile.

Index	Subindex	TxPDO	RxPDO	Name	Comment
F050 hex				Detected module ident list	Array with 1 element
F050 hex	0 hex	—	—	Highest subindex supported	Constant value of 1 hex
F050 hex	1 hex	—	—	Module ident	

Tab. 15: ETG.5000.1 communication objects: F000 hex – FFFF hex

10.1.4 Manufacturer-specific parameters: 2000 hex – 53FF hex

Information

Index and **Subindex** must be specified in the format required by the controller.

Information

The calculation described below is only valid for converting the manufacturer-specific parameters.

The index is calculated from the group and line of the parameter according to the following formula:
Index = 8192 + (number of the group × 512) + number of the line

The subindex for simple parameters is always 0.

For array or record parameters, the subindex for EtherCAT Rx corresponds to the element number of the parameter.

The subindex for EtherCAT Rx SDO Info corresponds to the element number of the parameter + 1 for array or record parameters.

	Simple parameters	Array or record parameter
Index	8192 + (number of the group × 512) + number of the line	
Subindex for EtherCAT Rx	0	Element number
Subindex for EtherCAT Rx SDO Info	0	Element number + 1

Tab. 16: Index and subindex for manufacturer-specific parameters

Calculation example

Calculation for parameter E200[0]:

Number of the group = 4

Number of the line = 200

Index = 8192 + (4 × 512) + 200 = 10440 = 28C8 hex

Subindex for EtherCAT Rx = 0 = 0 hex

Subindex for EtherCAT Rx SDO Info = 1 = 1 hex

Communication objects

The following table includes the supported communication objects and how they are mapped to the corresponding parameters of STOBER.

Index	Group	Number	Parameters
2000 hex – 21FF hex	A: Drive controller	0	A00 – A511
2200 hex – 23FF hex	B: Motor	1	B00 – B511
2400 hex – 25FF hex	C: Machine	2	C00 – C511
2600 hex – 27FF hex	D: Set value	3	D00 – D511
2800 hex – 29FF hex	E: Show	4	E00 – E511
2A00 hex – 2BFF hex	F: Terminals	5	F00 – F511
2C00 hex – 2DFF hex	G: Technology	6	G00 – G511
2E00 hex – 2FFF hex	H: Encoders	7	H00 – H511
3000 hex – 31FF hex	I: Motion	8	I00 – I511
3200 hex – 33FF hex	J: Motion blocks	9	J00 – J511
3400 hex – 35FF hex	K: Control panel	10	K00 – K511
3600 hex – 37FF hex	M: Profile	12	M00 – M511
3E00 hex – 3FFF hex	P: Customer-specific parameters	15	P00 – P511
4000 hex – 41FF hex	Q: Customer-specific parameters, instance-dependent	16	Q00 – Q511
4200 hex – 43FF hex	R: Production data	17	R00 – R511
4400 hex – 45FF hex	S: Safety	18	S00 – S511
4600 hex – 47FF hex	T: Scope	19	T00 – T511
4800 hex – 49FF hex	U: Protection functions	20	U00 – U511
5200 hex – 53FF hex	Z: Fault counter	25	Z00 – Z511

Tab. 17: Manufacturer-specific communication objects: 2000 hex – 53FF hex

10.2 SDO transmission: Error codes

If the drive controller cannot process an SDO frame, it sends an SDO Abort Domain Transfer and outputs one of the following errors – along with the error class, error code and additional information – over the Abort SDO Transfer Protocol in case of an error.

Error class	Error code	Additional code	Meaning
5 hex	3 hex	0 hex	Toggle bit not changed
5 hex	4 hex	0 hex	SDO protocol timeout expired
5 hex	4 hex	1 hex	SDO command specifier invalid or unknown
5 hex	4 hex	5 hex	Memory not sufficient
6 hex	1 hex	0 hex	Access to object is not supported
6 hex	1 hex	1 hex	Read attempt on a write-only parameter
6 hex	1 hex	2 hex	Write attempt on a read-only parameter
6 hex	2 hex	0 hex	Object not present in the object directory
6 hex	4 hex	41 hex	Object cannot be mapped to PDO
6 hex	4 hex	42 hex	Number and/or length of the object to be transmitted exceeds PDO length
6 hex	4 hex	43 hex	General parameter incompatibility
6 hex	4 hex	47 hex	General internal device incompatibility
6 hex	6 hex	0 hex	Access terminated due to hardware error
6 hex	7 hex	10 hex	Incorrect data type or parameter length
6 hex	7 hex	12 hex	Incorrect data type or parameter length too long
6 hex	7 hex	13 hex	Incorrect data type or parameter length too short
6 hex	9 hex	11 hex	Subindex not available
6 hex	9 hex	30 hex	Invalid parameter value (write process)
6 hex	9 hex	31 hex	Parameter value too large
6 hex	9 hex	32 hex	Parameter value too small
6 hex	9 hex	36 hex	Maximum value is less than minimum value
8 hex	0 hex	0 hex	General SDO error
8 hex	0 hex	20 hex	Access not possible
8 hex	0 hex	21 hex	Access not possible due to local controller
8 hex	0 hex	22 hex	Access not possible in current device state
8 hex	0 hex	23 hex	Dynamic generation of the object directory failed or no object directory available

Tab. 18: SDO: Error codes

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10.3 EMCY message: Incorrect state transition error codes

Error code	Meaning
A000 hex	Incorrect transition from pre-operational to safe-operational state
A001 hex	Incorrect transition from safe-operational to pre-operational state

Tab. 19: EMCY: Transition error codes

Error register specifies the state of the EtherCAT state machine at the time the EMCY is sent.

Error register	State
1 hex	Initializing
2 hex	Pre-operational
3 hex	Safe-operational
4 hex	Operational

Tab. 20: EMCY: Error codes for transitions, error register (state of the EtherCAT state machine)

Diag code provides information about the cause of the error.

Diag code	Error cause	
0 hex	SyncManager at address that is not permitted	SyncManager 0 (write mailbox data from frame in mailbox)
1 hex	SyncManager at address that is not permitted	
2 hex	PDO length not correct	
3 hex	SyncManager parameterized incorrectly	
4 hex	SyncManager at address that is not permitted	SyncManager 1 (write mailbox data from mailbox to frame)
5 hex	SyncManager at address that is not permitted	
6 hex	PDO length not correct	
7 hex	SyncManager parameterized incorrectly	
8 hex	SyncManager at address that is not permitted	SyncManager 2 (write process data from frame in process data memory)
9 hex	SyncManager at address that is not permitted	
A hex	PDO length not correct	
B hex	SyncManager parameterized incorrectly	
C hex	SyncManager at address that is not permitted	SyncManager 3 (write process data to frame from process data memory)
D hex	SyncManager at address that is not permitted	
E hex	PDO length not correct	
F hex	SyncManager parameterized incorrectly	

Tab. 21: EMCY: Error codes for transitions, Diag code (cause of error)

10.4 EMCY message: Device fault error codes

Error code	Error register	Event (E82)
0 hex: No error	0 hex: No error	30: Inactive
2110 hex: Short-circuit earth	2 hex: Current	31: Short/ground
2230 hex: Intern short-circuit earth	2 hex: Current	32: Short/ground internal
2310 hex: Continous overcurrent	2 hex: Current	33: Overcurrent
3110 hex: Mains overvoltage	4 hex: Voltage	36: High voltage
3120 hex: Mains undervoltage	4 hex: Voltage	46: Low voltage
3130 hex: Phase failure	1 hex: Generic error	83: Failure of one/ all phases (mains)
3180 hex: Mains failure	1 hex: Generic error	84: Drop in network voltage when power section active
4210 hex: Temperature	8 hex: Temperature	38: Temperature drive controller sensor
4280 hex: Temperature device I^2t	8 hex: Temperature	39: Overtemperature drive controller i2t or 59: Overtemperature drive controller i2t
4310 hex: Temperature drive	8 hex: Temperature	41: Temp.MotorTMP
4380 hex: Temperature drive I^2t	8 hex: Temperature	45: Overtemp.motor i2t
5200 hex: Device hardware	1 hex: Generic error	34: Hardware fault or 55: Option module
5440 hex: Contacts	1 hex: Generic error	43: AI1 wire break
6010 hex: Internal software	1 hex: Generic error	35: Watchdog, 57: Runtime requirement or 71: Firmware
6320 hex: Loss of parameters	1 hex: Generic error	40: Invalid data or 70: Parameter consistency
6330 hex: Unknown Lean motor type	1 hex: Generic error	86: Unknown LeanMotor
7110 hex: Brake chopper	1 hex: Generic error	48: Brake release monitoring, 49: Brake, 72: Brake test timeout or 73: Axis 2 brake test timeout
	8 hex: Temperature	42: TempBrakeRes
7120 hex: Motor	1 hex: Generic error	69: Motor connection or 81: Motor allocation
7303 hex: Resolver 1 fault	1 hex: Generic error	37: Motor encoder
7304 hex: Resolver 2 fault	1 hex: Generic error	76: Position encoder, 77: Master encoder or 79: Motor/position encoder plausibility
7500 hex: Communication	10 hex: Communication	52: Communication
7580 hex: Communication control panel	1 hex: Generic error	88: Control panel
8311 hex: Excess torque	1 hex: Generic error	47: Torque/force-max. limit
8400 hex: Velocity speed control	1 hex: Generic error	56: Overspeed
8500 hex: Position control	1 hex: Generic error	53: Limit switch
8510 hex: Excessive reference position jump	1 hex: Generic error	85: Excessive jump in reference value
8600 hex: Positioning controller	1 hex: Generic error	51: Virtual master software limit switch

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Error code	Error register	Event (E82)
8611 hex: Following error	1 hex: Generic error	54: Following error
8612 hex: Reference limit	1 hex: Generic error	78: Position limit cyclic
FF00 – FF07 hex: Manufacturer specific error	1 hex: Generic error	60: Application event 0 – 67: Application event 7
FF09 hex: Manufacturer specific error	1 hex: Generic error	44: External fault 1
FF0A hex: Manufacturer specific error	1 hex: Generic error	68: External fault 2

Tab. 22: EMCY: Device fault error codes

10.5 EMCY message: EoE-error error codes

Error code	Error register	Meaning
0 hex: No error	0 hex: No error	No error occurred
FFF0 hex: Manufacturer specific error	23 hex: EoE address occupied	IP address cannot be opened (IP address does not match the subnet mask, IP address already assigned, etc.)

Tab. 23: EMCY: Device fault error codes

10.6 Simple Network Time Protocol (SNTP)

An SNTP client is implemented in the drive controller in accordance with RFC4330. This client sets the internal clock of the drive controller to the current time, which it obtains from an external time server. The internal clock runs with an (inaccurate) controllable internal clock in the drive controller. As a result, the time is queried from the server in intervals. It is compared with the internal time and the clock for the internal clock is readjusted accordingly. You define the settings in parameter A199.

Two NTP servers can be defined as time sources, both of which are used as possible time servers. In the case of data traffic via the service interface, the computer through which the drive controller is connected via DriveControlSuite automatically counts as one of the possible time servers. The time servers must be accessible either via EoE, service interface X9 or terminals X200 and X201. Make sure that the time server is accessible from the drive controller. It may be necessary to set the gateway parameter A175 accordingly.

The time is always requested from the same NTP server and then cyclically repeated by the server to track the synchronicity control loop. If the current server fails, the next one in the list is used. A server that was once active is discarded only in case of connection failure to this server or server unavailability.

After the drive controller is switched on, it takes a random time of 1 to 5 minutes (in accordance with RFC4330) until the SNTP client sends its first request to one of the time servers.

The cyclic repetition of a request occurs approximately every 5 to 6 hours.

10.6.1 Setting up time service on the computer

On a Windows PC with DriveControlSuite, you can use the registry editor to set up the time service. You must stop the time server in advance and restart it after changing the registry. Proceed as follows:

1. Open the command prompt, e.g. as follows:
    1.1. Use the [Windows]+[r] key combination to open the Run dialog box.
    1.2. Enter the command `cmd` and confirm with OK.
    ⇨ The command prompt opens.
2. Stop the time server by using the command `net stop w32time`.
3. Open the registry editor, e.g. as follows:
    3.1. Use the [Windows]+[r] key combination to open the Run dialog box.
    3.2. Enter the command `regedit` and confirm with OK.
    ⇨ The registry editor opens.
4. Select HKEY_LOCAL_MACHINE > SYSTEM > CurrentControlSet > Services > W32Time > TimeProvider > NtpServer.
5. Set Enable to the value `1` and confirm with OK.
6. Close the registry editor.
7. Open the command prompt again.
8. Start the time server in the command prompt by using the command `net start w32time`.

⇨ The time service is set up on the PC.

Automation using a command script

If you want to change the registry on the PC via a command script, create a *.reg file by creating an empty text file and renaming the file extension. Then open the file and enter the following content:

```
[HKEY_LOCAL_MACHINE\SYSTEM\CurrentControlSet\Services\W32Time\TimeProviders\NtpServ
er] "Enabled"=dword:00000001
```

Run the file in the command line of the command prompt.

More commands

If you want to query the status on the current PC, use the following command in the command prompt:

```
w32tm /query /status
```

To query the IP address by PC name, use the following command at the command prompt:

```
nslookup <name>
```

Example:

```
nslookup ptbtime1.ptb.de
Name: ptbtime1.ptb.de
Addresses: 2001:638:610:be01::108 192.53.103.108
```

The IP address is: 192.53.103.108.

10.7 Detailed information

The documentation listed below provides you with further relevant information on the 6th STOBER drive controller generation. The current status of the documentation can be found in our download center at: http://www.stoeber.de/en/downloads/.
Enter the ID of the documentation in the search field.

Title	Documentation	Contents	ID
SB6 drive controller	Manual	System design, technical data, project configuration, storage, installation, connection, commissioning, operation, service, diagnostics	443340
CiA 402 application – SB6	Manual	Project configuration, configuration, parameterization, function test, detailed information	443510
Drive Based application (DB) – SB6	Manual	Project configuration, configuration, parameterization, function test, detailed information	443498
Drive Based Synchronous application (DBS) – SB6	Manual	Project configuration, configuration, parameterization, function test, detailed information	443501
Drive Based Center Winder application (DBCW) – SB6	Manual	Project configuration, configuration, parameterization, function test, detailed information	443504
SY6 safety technology – STO and SS1 via FSoE	Manual	Technical data, installation, commissioning, diagnostics, detailed information	442744
TwinCAT 3 – Function blocks for 6th generation drive controllers	Manual	Installation, description, diagnostics, example code	443371

Additional information and sources that form the basis of this documentation or are referenced by the documentation:

Beckhoff Automation GmbH & Co. KG (publisher): *EtherCAT System Documentation*. Version 5.1. Verl, 2016.

A free basic version of the TwinCAT 3 automation software is available at https://www.beckhoff.com/en-us/products/automation/twincat/te1xxx-twincat-3-engineering/te1000.html.

EtherCAT Technology Group (ETG), 2015. *ETG.1300: EtherCAT Indicator and Labeling*. ETG.1300 S (R) V1.1.0. Specification. 2015-07-03.

10.8 Abbreviations

Abbreviation	Meaning
AT	Acknowledge Telegram
CiA	CAN in Automation
CNC	Computerized Numerical Control
CoE	CANopen over EtherCAT
EMCY	Emergency
EMC	Electromagnetic Compatibility
EoE	Ethernet over EtherCAT
ESC	EtherCAT SubDevice Controller
ESI	EtherCAT SubDevice Information (device description of an EtherCAT SubDevice)
ESM	EtherCAT State Machine
ETG	EtherCAT Technology Group
EtherCAT	Ethernet for Control Automation Technology
FTP	File Transfer Protocol
HTTP	Hypertext Transfer Protocol
I/O	Input/Output
IP	Internet Protocol
LSB	Least Significant Bit
LSW	Least Significant Word
MDevice	MainDevice
MDT	MainDevice Data Telegram
MSB	Most Significant Bit
MSW	Most Significant Word
NC	Numerical Control
NTP	Network Time Protocol
PDO	Process Data Objects
RFC	Request For Comments
RxPDO	Receive PDO (receive process data)
S/FTP	Screened/Foiled Twisted Pair
SDO	Service Data Objects
SF/FTP	Screened Foiled/Foiled Twisted Pair
SF/UTP	Screened Foiled/Unshielded Twisted Pair
SNTP	Simple Network Time Protocol
PLC	Programmable Logic Controller
SubDevice	SubordinateDevice
SYNC	Synchronization
TCP	Transmission Control Protocol
TwinCat	The Windows Control and Automation Technology (automation software from Beckhoff Automation GmbH)
TxPDO	Transmit PDO (transmit process data)
UDP	User Data Protocol

11 Contact

11.1 Consultation, service and address

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Glossary

Broadcast domain

Logical grouping of network devices within a local network that reaches all nodes via broadcast.

CiA 402

Application of the commissioning software, which includes both the controller-based and drive-based operating modes (csp, csv, cst, ip, pp, vl, pv, pt).

CiA 402 HiRes Motion

Application of of the commissioning software, which includes both the controller-based and drive-based operating modes (csp, csv, cst, ip, pp, vl, pv, pt). The interface for the controller is tailored to the HiRes CODESYS device driver, meaning that set and actual values are represented and transmitted in units that can be defined by the user.

CoE

EtherCAT protocol that provides CANopen-compliant communication mechanisms, enabling the use of the entire CANopen profile family over EtherCAT.

DC-Sync

Also: Synchronization using distributed clocks. Method for EtherCAT network synchronization. Each EtherCAT SubDevice with distributed clocks functionality has a local clock. Normally, the time from the first DC-Sync-capable EtherCAT SubDevice downstream of the MainDevice in the network serves as the reference time: Both the MainDevice and the SubDevices synchronize with this reference clock when prompted by the MainDevice. The event belonging to a synchronization is labeled as a Sync 0 signal and is generated cyclically by the SyncManager of each SubDevice.

EMCY

Communication objects in a CANopen or EtherCAT network that, in the event of incorrect state transitions or device-internal errors, transmit the associated error codes and causes.

EoE

Acyclical EtherCAT protocol that enables any data traffic between EoE-capable nodes of an EtherCAT network. The Ethernet frames are tunneled through the EtherCAT protocol; the EtherCAT real-time properties remain unimpaired. The EtherCAT MainDevice is used as a gateway to the Ethernet network.

ESI file

Device description file for EtherCAT SubDevices. In accordance with ETG.2000: XML file that contains all relevant data for an EtherCAT node in the EtherCAT system, such as the identity of the manufacturer, the product code, the version or the production number. The EtherCAT MainDevice requires this file to configure the EtherCAT system.

EtherCAT MainDevice

Device that is responsible for network management and organizes the access of nodes to the shared medium. It is the only node that actively sends frames.

EtherCAT SubDevice

Network node that processes and forwards frames. The last node sends the frame back to the device responsible for network management.

EtherCAT SubDevice Controller (ESC)

A component integrated in an EtherCAT SubDevice as ASIC or based on FPGA which receives the respective receive data addressed to the respective SubDevice as the EtherCat frame passes by and transmits it as its own transmit data on the fly.

IPv4 limited broadcast

Type of broadcast in a network with IPv4 (Internet Protocol version 4). The IP address 255.255.255.255 is entered as the destination. The content of the broadcast is not forwarded by a router, which limits it to the local network.

Jitter

Generally refers to slight fluctuations in the clock when transmitting digital signals or a slight accuracy fluctuation in the transmission clock. In network technology, it is also variance in the runtime of data packets.

Network Time Protocol (NTP)

Standard for synchronizing clocks in computer systems via packet-based communication networks. The protocol uses the connectionless transport protocol UDP or the connection-based TCP. It is specifically designed to provide reliable timing over networks with variable packet runtime.

Process Data Objects (PDO)

Communication objects in a CANopen or EtherCAT network that transmit data such as set and actual values, control commands or status information based on events or objectives, in cycles or in real time on request. PDOs are generally exchanged over the process data channel with high priority. Depending on the view of the respective node, a distinction is made between receive PDOs (RxPDO) and transmit PDOs (TxPDO).

RFC

Proposed and published Internet standards, reviewed by the Internet Engineering Task Force (IETF), as consensus-building body that facilitates discussion, and eventually a new standard is established.

SDO

Communication objects in a CANopen or EtherCAT network that grant access to the object directory and enable device configuration. SDOs are transmitted over the mailbox channel acyclically during ongoing cyclical CANopen or EtherCAT operation.

SDO Info

Service that enables the EtherCAT controller to read out objects from the drive controller. During the read-out, all relevant object properties, such as data type, write and read access rights as well as mapping capabilities, are transmitted to the controller.

Simple Network Time Protocol (SNTP)

Simplified version of the Network Time Protocol (NTP). The structure of the protocol is identical to that of NTP. SNTP clients can thus also obtain the time from NTP servers. The main difference lies in the algorithms used for time synchronization. While NTP usually uses multiple time servers for time synchronization, SNTP uses only one time server.

SM-Sync

Also: Synchronization using SyncManager event. Method for EtherCAT network synchronization where the EtherCAT SubDevices synchronize with an event from incoming data.

Startup list

Predefined list of CiA objects that is processed every time EtherCAT is started. The values it contains are sent to the corresponding EtherCAT SubDevice with the defined state change.

Synchronization

Time synchronization of EtherCAT network nodes that allows the EtherCAT MainDevice and SubDevices to work synchronously with each other in the same cycle. EtherCAT provides two different methods for precisely synchronizing the MainDevice and SubDevices: a SyncManager event (SM-Sync) and distributed clocks (DC-Sync). The FreeRun state exists if the MainDevice and SubDevices are not synchronized.

Template

In the context of the DriveControlSuite commissioning software, a template for graphical programming. This template can be selected in the configuration dialog for device control, communication (fieldbus) or application in a certain version.

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