Operating Guide

iC7-Automation EtherCAT®

EtherCAT OS7EC

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Contents

1 Introduction and Safety

1.1 Purpose of the Operating Guide

This operating guide provides information about configuring the system, controlling the drive or power converter, accessing parameters, programming, troubleshooting, and some typical application examples.

The operating guide is intended for use by qualified personnel, who are familiar with the iC7 drives and power converters, EtherCAT technology, and the PC or PLC that is used as a master in the system.

Read the instructions before configuring EtherCAT, and follow the procedures in this guide.

1.2 Additional Resources

Additional resources are available to help understand the features, and safely install and operate the iC7 series products:

- Safety guides, which provide important safety information related to installing iC7 series drives and power converters.
- Installation guides, which cover the mechanical and electrical installation of drives, power converters, or functional extension options.
- Design guides, which provide technical information to understand the capabilities of the iC7 series drives or power converters for integration into motor control and monitoring systems.
- Operating guides, which include instructions for control options, and other components for the drive.
- Application guides, which provide instructions on setting up the drive or power converter for a specific end use. Application guides for application software packages also provide an overview of the parameters and value ranges for operating the drives or power converters, configuration examples with recommended parameter settings, and troubleshooting steps.
- *Facts Worth Knowing about AC Drives*, available for download on www.danfoss.com.
- Other supplemental publications, drawings, and guides are available at www.danfoss.com.

Latest versions of Danfoss product guides are available for download at https://www.danfoss.com/en/service-and-support/documentation/.

1.3 Safety Symbols

The following symbols are used in Danfoss documentation and products.

⚠ DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE

Indicates information considered important, but not hazard-related (for example, messages relating to property damage).

	ISO warning symbol for general warnings
	ISO warning symbol for hot surfaces and burn hazard
	ISO warning symbol for high voltage and electric shock
	Symbol for indicating the required discharge time of the capacitors in the product.
	ISO action symbol for referring to the instructions

1.4 Qualified Personnel

Correct and reliable transport, storage, installation, operation, and maintenance are required for the trouble-free and safe operation of the product. Only qualified personnel are allowed to install and operate this equipment.

Qualified personnel are defined as trained staff, who are authorized to install, commission, and maintain equipment, systems, and circuits in accordance with pertinent laws and regulations. Also, the qualified personnel must be familiar with the instructions and safety measures described in this guide.

1.5 Safety Precautions

⚠ DANGER

HIGH VOLTAGE

Drives and power converters contain high voltage when connected to AC mains input, DC supply, or load sharing. Failure to perform installation, startup, and maintenance by qualified personnel can result in death or serious injury.

- Only qualified personnel are allowed to perform installation, startup, and maintenance.

⚠ WARNING

UNINTENDED START

When the drive or power converter is connected to the AC mains or connected on the DC terminals, the motor may start at any time, causing risk of death, serious injury, and equipment or property damage.

- Stop the drive or power converter before configuring parameters.
- Make sure that the drive or power converter cannot be started by an external switch, a fieldbus command, an input reference signal from the control panel, or after a cleared fault condition.
- Disconnect the drive or power converter from the mains whenever safety considerations make it necessary to avoid an unintended motor start.
- Check that the drive or power converter and any driven equipment are in operational readiness.

⚠ WARNING

DISCHARGE TIME

The drive or power converter contains DC-link capacitors, which can remain charged even when the drive or power converter is not powered. High voltage can be present even when the warning indicator lights are off. Failure to wait the specified time after power has been removed before performing service or repair work can result in death or serious injury.

- Stop the motor.
- Disconnect all power sources, including permanent magnet type motors.
- Wait for capacitors to discharge fully. The discharge time is specified on the drive or power converter product label.
- Measure the voltage level to verify full discharge.

⚠ WARNING

LEAKAGE CURRENT HAZARD

Leakage currents exceed 3.5 mA. Failure to ground the drive or power converter properly can result in death or serious injury.

- Ensure that the minimum size of the ground conductor complies with the local safety regulations for high touch current equipment.

⚠ WARNING

EQUIPMENT HAZARD

Contact with rotating shafts and electrical equipment can result in death or serious injury.

- Ensure that only trained and qualified personnel perform installation, start-up, and maintenance.
- Ensure that electrical work conforms to national and local electrical regulations.
- Follow the procedures in this guide.

⚠ CAUTION

INTERNAL FAILURE HAZARD

An internal failure in the drive or power converter can result in serious injury when the drive or power converter is not properly closed.

- Ensure that all safety covers are in place and securely fastened before applying power.

1.6 Abbreviations

Table 1: Abbreviations

Abbreviation	Definition
CE	European test and certification mark.
CiA	CAN in Automation
CiA 402	Device profile for drives and motion control.
CP	Control panel
CTW	Control word
DHCP	Dynamic host configuration protocol

Table 1: Abbreviations - (continued)

Abbreviation	Definition
EMC	Electromagnetic compatibility
ESC	EtherCAT® Slave Controller
ESI	EtherCAT® slave information
ESM	EtherCAT® State Machine
ETG	EtherCAT® technology group
EtherCAT	Ethernet for Control Automation Technology
Firmware	Software in the unit. Firmware runs on the control board.
I/O	Input/Output
IP	Internet protocol
IPC	Industrial Personal Computer
LED	Light-emitting diode
LSB	Least significant bit
MAV	Main Actual Value
MRV	Main Reference Value
MSB	Most significant bit
PDO	Process Data Object (cyclic data access)
PELV	Protected extra low voltage. Low Voltage Directive regarding voltage levels and distances between lines.
PLC	Programmable logic controller. A programmable logic controller is a digital computer used for automation of electromechanical processes, such as control of machinery on factor assembly lines.
REF	Reference
RFG	Ramp frequency generator
RJ45	Registered Jack 45. A variant of the 8P8C (Modular connector 8 Position 8 Contact) connector.
RPDO	Receive PDO
SDO	Service Data Object (acyclic data access)
STW	Status word
TPDO	Transmit PDO
vl	Velocity mode according to CiA 402

1.7 Trademarks

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CiA is a registered trademark of CAN in Automation e.V.

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

1.8 Version History

This guide is regularly reviewed and updated. All suggestions for improvement are welcome.

The original language of this guide is English.

Table 2: Version History

Version	Remarks
AQ481922104455, version 0201	Updated to include the Active Front End application.
AQ481922104455, version 0101	First release. The information in this version applies to iC7-Automation frequency converters (1.3–1260 A).

2 Product Overview

2.1 EtherCAT Features and Technical Data

Fieldbus options for iC7 are integrated in the control board. Fieldbuses are enabled on communication interfaces X1 and X2 only. Modbus TCP is offered as standard, and other protocols such as EtherCAT can be selected in the configurator when ordering a drive, or alternatively, they can be activated later by a proof-of-purchase token.

Table 3: EtherCAT Model Codes

Model code	Description
+BAEC	EtherCAT OS7EC

EtherCAT is an open high-performance Ethernet-based fieldbus system.

Table 4: EtherCAT Features

Feature	Technical Data
Cyclic response	• 1 ms or higher update cycle • 1 RPDO and 1 TPDO assignment object, not configurable • 1 RPDO and 1 TPDO mapping object, freely configurable
System integration	Supported ESI file versions: • ESI version: current version For more information on the ESI files, see 4.5 EtherCAT Subdevice Information File.
CANopen over EtherCAT (CoE)	• Complete access • Diagnosis history
Modular Device Profile for application profiles	• iC Speed Profile • iC Motion Profile • CiA 402 Velocity Profile
Addressing method	• Explicit device identification • Station alias (second slave address)

2.2 Communication Profiles and Objects

The iC7 series complies with EtherCAT and CiA DS402 profile standards, mandatory CiA and EtherCAT objects, Diagnostics and a range of vendor-specific profiles and objects for product-specific applications. Communication profiles are selected in parameter ***Fieldbus Profile*** (1301).

Table 5: Communication Profiles and Supported Applications for iC7-Automation

Profile	Application software		
	Industry	Motion	Active Front End
CiA 402	X	X	–
iC Speed	X	X	–
iC Motion	–	X	–
iC Active Front End	–	–	X

2.3 iC Speed Profile

2.3.1 Overview

The iC Speed profile is used with the iC7 series. The iC Speed profile differs from the CiA 402 profile because it does not have a State Machine. It is only controlled by the actual state 1/0 of the control bits, not the sequence in which they are manipulated.

2.3.2 Control Word

Table 6: iC Speed Profile Control Word Bits

Bit number	Name	Description
0+1	Preset reference selector	00: Preset reference 1 01: Preset reference 2 10: Preset reference 3 11: Preset reference 4
2	Reserved	Reserved for future use. Any control words sent to the device should keep this bit at 0 to ensure compatibility with future extensions of the control word.
3	No coast/Coast	0: Causes the drive to immediately coast the motor. 1: No function.
4	No quick stop/Quick stop	0: Quick stops the drive and ramps down the motor speed to stop as defined with the quick stop ramp parameter. 1: No function.
5	No hold/Hold output frequency	0: Hold the present output frequency (in Hz). 1: No function.
6	Start/No start	0: Stops the drive and ramps down the motor speed as defined with the ramp-down parameter. 1: If the other starting conditions are fulfilled, this selection allows the drive to start the motor.
7	Reset	0: No function. 0 ⇒ 1: Reset faults.[1]
8	Jog/No jog	0: No function. 1: Sets the output frequency to the jog speed defined with the jog speed parameter.
9	Ramp select	0: Ramp 1 is active. 1: Ramp 2 is active.
10	Data valid	0: Ignore the current process data. This is linked to the submodule where the CTW is present. If signals are to be covered, the CTW/STW profile (for example, the iC Speed profile) must be part of the signals list. 1: Use process data (controlled by PLC). Use the previously processed data when the data valid bit was true (no control by PLC).
11	Reserved	Reserved for future use.

Table 6: iC Speed Profile Control Word Bits - (continued)

Bit number	Name	Description
12	User-defined	These bits are reserved for application-specific advanced control. Select the value ***CTW bit x***for any input parameter to use this signal for the activation of a selected function. For more information, refer to the *Parameter Descriptions* chapter in the application guide.
13	User-defined	
14	User-defined	
15	User-defined	

1) Edge-triggered from 0 to 1 to reset the fault.

2.3.3 Status Word

Table 7: iC Speed Profile Status Word Bits

Bit number	Name	Description
0	Control ready	0 = The device controls are not ready and do not react to process data. 1 = The device controls are ready and react to process data.
1	Frequency converter ready	0 = The frequency converter is not ready for operation. This status does not involve faults and warnings as they are indicated in their respective bits elsewhere. 1 = The frequency converter is ready for operation.
2	Coast	0 = The frequency converter has an active coast signal and has released the motor. 1 = There are no active coast signals, and the motor can start when a start signal is given.
3	Fault	0 = There are no faults. 1 = A fault has occurred, and an acknowledge signal is required to re-establish operation.
4	Reserved	Reserved.
5	Reserved	Reserved.
6	Reserved	Reserved.
7	Warning	0 = There are no warnings. 1 = A warning is active.
8	Speed=reference	0 = The motor runs, but the current speed is different from the current speed reference, for example, while the speed ramps up or down during start or stop. 1 = The current motor speed matches the current speed reference within a given tolerance. The tolerance is product-specific.
9	Bus control/Local operation	0 = The device does not react on commands from the fieldbus, for 1 of the following reasons: • CTW bit 10 = 0. • HMI is in local mode. • MyDrive® Insight has taken control. • Control places do not include fieldbus. 1 = The device is controlled and reacting to I/O and process data.

Table 7: iC Speed Profile Status Word Bits - (continued)

Bit number	Name	Description
10	Frequency limit	0 = The output frequency has exceeded the defined motor limits. 1 = The output frequency is within the defined motor limits. The speed limits are set with the parameters in parameter group ***5.8.3 Speed Limits and Monitors***.
11	Operation	0 = There are no active start requests, and the process does not run. The motor is coasted and is not started. 1 = The process is running, and the motor can be running or start at any time.
12	Reserved	Reserved.
13	Reserved	Reserved.
14	User-defined	These bits are reserved for application-specific advanced control. For more information, refer to the *Parameter Descriptions* chapter in the application guide.
15	User-defined	

2.4 iC Motion Profile

2.4.1 Overview

The iC Motion profile is used with the motion features of iC7-Automation and consists of:

- Motion-specific control word, speed reference, and position reference for controlling the drive.
- Motion-specific status word, actual speed, and actual position as status.

Table 8: Telegram Layout

	Word 1	Word 2	Word 3 and 4
Input to drive	Control word	Speed reference	Position reference
Output from drive	Status word	Actual speed	Actual position

Fieldbus reference is the default selection as the source for speed and position reference in the ***5.5 Control Places*** parameters but the references can be ignored if the ***Control Places*** settings are modified.

2.4.2 iC Motion Profile Control and Status Words

The iC Motion profile control and status words are based on the iC speed profile, with the addition of the most used signals for positioning and synchronizing. The Motion-specific signals require the selection of the appropriate operating mode, see parameter ***5.4.2.16 Operation Mode***.

Table 9: Control Word

Bit	Name	Description
0	Preset position reference Bit 0	000 = Preset Position Ref. 1 001 = Preset Position Ref. 2 010 = Preset Position Ref. 3 011 = Preset Position Ref. 4 100 = Preset Position Ref. 5 101 = Preset Position Ref. 6 110 = Preset Position Ref. 7 111 = Preset Position Ref. 8
1	Preset position reference Bit 1	
2	Preset position reference Bit 2	
3	No Coast	0: Causes the drive to immediately coast the motor. 1: No function.
4	Start Synchronizing	0 = Ramp down to standstill. 1 = Follower locked to synchronizing master.
5	Enable Reference	0 = No Function. 1 = New position reference enabled.
6	Start	0 = Stop the frequency converter and ramp down the motor speed as defined with the ramp down parameter. 1 = If the other starting conditions are fulfilled, this selection allows the frequency converter to start the motor.
7	Reset	0: No function. 0 ⇒ 1: Acknowledge faults.[1]
8	Enable Superimposed	0 = No function. 1 = Execute superimposed movement.
9	Relative Positioning	0 = Absolute positioning. 1 = Relative positioning.
10	Data Valid	0 = Ignore the current process data. This is linked to the submodule where the CTW is present. If signals are to be covered, the CTW/STW profile (the iC Speed Profile for example) must be part of the signals list. 1 = Use process data (control by PLC). Use the previously processed data when the data valid bit was true (no control by PLC).
11	Enable Home	0 = Abort homing function. 1 = Execute homing function.
12	User-defined	These bits are reserved for application-specific advanced control. For more information, refer to the *Parameter Descriptions* chapter in the application guide.
13	User-defined	
14	User-defined	
15	User-defined	

1) Acknowledge is edge-triggered, when the logic is changed from 0 to 1. Faults can only be acknowledged is the triggering condition has been removed and any required acknowledgment has been done.

The basic commands such as ***Start*** and ***Coast*** are configured via ***5.5 Control Places***. By default, the commands are mapped to the corresponding control word bits, but that can change if the ***Control Places*** settings are modified. The Motion-specific commands are not available for configuration in ***Control Places***, but the logic when mapping these signals to digital inputs is "OR".

Table 10: Status Word

Bit	Name	Description
0	Control Ready	0 = The device controls are not ready and do not react to process data. 1 = The device controls are ready and react to process data.
1	Drive Ready	0 = The device is not ready for operation. This status does not involve faults and warnings as they are indicated in their respective bits elsewhere. 1 = The device is ready for operation.
2	No coast (Enabled)	0 = The frequency converter has an active coast signal and has released the motor. 1 = There are no active coast signals, and the motor can start when a start signal is given.
3	Fault	0 = There are no faults. 1 = A fault has occurred, and an acknowledge signal is required to re-establish operation.
4	Home Done	0 = Homing is not completed. 1 = Homing is completed.
5	In Sync	0 = Follower is not in sync with master. 1 = Follower is in sync with master within the tolerance specified by parameter ***5.15.2.2 Synchronization Window***.
6	Reserved	Reserved.
7	Warning	0 = There are no warnings. 1 = A warning is active.
8	Position error within tolerance	0 = Position error is greater than the tolerance specified by parameter ***5.13.5.1 Position Error Window***. 1 = Position error is within the tolerance specified by parameter ***5.13.5.1 Position Error Window***.
9	Bus control	0 = The device does not react on commands from the fieldbus, for 1 of the following reasons: • CTW bit 10 = 0. • HMI is in local mode. • MyDrive® Insight has taken control. • Control places do not include fieldbus. 1 = The device is controlled and reacting to I/O and process data.
10	Frequency limit OK	0 = The output frequency has exceeded the defined motor limits. 1 = The output frequency is within the defined motor limits. The speed limits are set with the parameters: • ***5.8.3.1 Positive Speed Limit*** • ***5.8.3.2 Negative Speed Limit*** • ***5.8.3.3 Minimum Speed Limit***
11	In operation	0 = There are no active start requests, and the process does not run. The motor is coasted and is not started. 1 = The process is running, and the motor can be running or start at any time.

Table 10: Status Word - (continued)

Bit	Name	Description
12	Target position reached	0 = Target position is not reached. 1 = Target position is reached within the window defined by parameter ***5.14.2.18 On-target Window*** around the position reference.
13	Superimposed target reached	0 = Superimposed movement is not completed. 1 = Superimposed movement is completed.
14	User-defined	These bits are reserved for application-specific advanced control. For more information, refer to the *Parameter Descriptions* chapter in the application guide.
15	User-defined	

2.4.3 Speed Reference and Actual Speed

The speed values are represented by the N2 format, a 16-bit normalized value defined in the PROFIdrive profile. They are represented in percent of nominal motor speed.

PROFIdrive profile definition of N2

N2 is a linear normalized value. 0% corresponds to 0 (0x0), 100% corresponds to 2^{14} (0x4000).

Table 11: Range of N2 values

Coding	Data type	Range of values	Resolution	Length
113	N2	$-200\% \le I \le (200-2^{-14})\%$	$2^{-14} = 0.006\ 1\%$	2 Octet

Coding:

- Representation in twos complement, the most significant bit (MSB) is the bit after the sign bit (SN) of the 1st octet.
- SN = 0: positive numbers including 0.
- SN = 1: negative numbers.

2.4.4 Position Reference and Actual Position

Position values are expressed in 32-bit signed position units. The units are scaled by parameters ***5.13.4.4 Position Unit Numerator*** and ***5.13.4.5 Position Unit Denominator***.

2.5 iC Active Front End Profile

2.5.1 Overview

The iC Active Front End profile is used in the iC7 series with the Active Front End application.

2.5.2 Control Word

Table 12: iC Active Front End Profile Control Word Bits

Bit number	Name	Description
0	Switch On Enabled	0: DC-link pre-charging, MCB closure, and running are prevented/interrupted. MCB is opened if closed. 1: DC-link pre-charging, MCB closure, and running are not prevented/interrupted. MCB is not opened if closed.
1	MCB Close Enabled	0: If pre-charging is completed, the MCB is not allowed to close. Running is also prevented or interrupted. MCB is opened if closed. 1: If pre-charging is completed, the MCB is allowed to close.
2	Quick Stop Inverse	0: Initiate quick stop. 1: Do not initiate quick stop.
3	Start	0: Stop the unit if it is running, or stop the pre-charging sequence if it is not completed. 1: Start running if already precharged. Otherwise initiate pre-charging and then start running. Use the parameter ***Fieldbus Start Mode*** (5114) to configure whether a new start command is required after the unit has been stopped, or whether the unit starts running immediately after all stopping conditions (quick stop, faults, and so on) are cleared.
4	Pre-charge	0: Stop the DC-link pre-charging, if ongoing. 1: Start/continue the DC-link pre-charging. Only used when the DC-link pre-charging is not controlled externally.
5	–	Reserved
6	–	Reserved
7	Fault Reset	0: Do not reset faults. 1: Reset active faults. A rising edge (a transition from false to true) on this bit issues a fault reset request.
8	–	Reserved
9	–	Reserved
10	Data Valid	0: Ignore the current incoming process data values, instead use the last processed value when ***Data Valid*** bit was true.1: Use the current incoming process data values.
11	Watchdog	Incoming fieldbus watchdog bit. used for monitoring the fieldbus connection.
12	User-defined	These bits are reserved for application-specific advanced control. Select the value ***CTW bit x*** for any input parameter to use this signal for the activation of a selected function. For more information, refer to the *Parameter Descriptions* chapter in the application guide.
13	User-defined	
14	User-defined	
15	User-defined	

2.5.3 Status Word

Table 13: iC Active Front End Profile Status Word Bits

Bit number	Name	Description
0	Ready to Switch On	0: The unit is not ready to run. 1: The unit is ready to run. This bit indicates that the unit is ready to start the startup sequence, that is, pre-charging and/or MCB closure, if controlled by the application. There are no active faults and the Switch on Enabled bit is active.
1	Converter Ready	0: The unit is not ready to run. 1: The unit is ready to run. When this bit is true, it indicates that the unit can be successfully started with the Start bit (bit 3) of the control word.
2	Running	0: The unit is not running (modulating). 1: The unit is running (modulating).
3	Fault	0: No faults active. 1: One or more faults active.
4	--	Reserved
5	Quick Stop Inverse	0: Quick stop is active. 1: Quick stop not active.
6	--	Reserved
7	Warning	0: No active warnings. 1: One or more warnings are active.
8	--	Reserved
9	Control by PLC	0: Fieldbus is not the active control place. 1: Fieldbus is the active control place.
10	--	Reserved
11	Run Enabled	0: Run enable from a dedicated input signal is missing. 1: Run enable from a dedicated input signal is present. This bit indicates the state of parameter ***Run Enable Input*** (103)
12	--	Reserved
13	--	Reserved
14	--	Reserved
15	Watchdog	Outgoing fieldbus watchdog bit, mirroring control word bit Watchdog (bit 11).

2.6 CiA 402 Profile

2.6.1 Overview

Velocity mode is implemented according to the CiA 402 profile as defined in the CiA 402 standard and state machine diagram.

2.6.2 Control Word

Table 14: Control Word Bits in CiA 402 – Velocity Mode

Bit number	Name	Description
0	Switch On-Off	1 = On. 0 = Off.
1	Voltage Enable-Disable (coast)	1= No coast stop. 0 = Coast stop.
2	Quick stop	1= No quick stop. 0 = Quick stop.
3	Operation Enable-Disable	1 = Enable operation. 0 = Disable operation.
4	Ramp generator Enable-Disable	1 = Enable ramp generator (RFG). 0 = Reset ramp generator.
5	Ramp generator Lock-Unlock (freeze)	1 = Unfreeze ramp generator. 0= Freeze ramp generator. Freezes the present output frequency (in Hz).
6	Reference ramp Enable-Disable (setpoint)	1 = Enable setpoint. 0 = Disable setpoint.
7	Fault acknowledge (reset)	0 ⇒ 1 = Acknowledge faults. Acknowledging is edge triggered, when changing from logic 0 to logic 1. 0 = No function.
8	Halt (stop)	1 = Motor ramp stop. 0 = No function.
9	Reserved	Operation mode specific.
10	Manufacturer-specific (reserved)	Reserved for future use.
11	Manufacturer-specific (reserved)	Reserved for future use.
12	Manufacturer-specific (reserved)	Reserved for future use.
13	Manufacturer-specific (reserved)	Reserved for future use.
14	Manufacturer-specific (reserved)	Reserved for future use.
15	Manufacturer-specific (reserved)	Reserved for future use.

2.6.3 Status Word

Table 15: Status Word Bits in CiA 402 – Velocity Mode

Bit number	Name	Description
0	Ready to switch on	0= Not ready to switch on. 1= Ready to switch on.
1	Switched on (operational)	0 = Not ready to operate. 1 = Ready to operate.
2	Operation enabled	0 = Operation disabled. 1= Operation enabled.

Table 15: Status Word Bits in CiA 402 – Velocity Mode - (continued)

Bit number	Name	Description
3	Fault	0 = No fault. 1= Fault present.
4	Voltage Enabled-Disabled (coast)	0 = Coast stop activated. 1= Coast stop not activated.
5	Quick stop	0 = Quick stop activated. 1= Quick stop not activated.
6	Switching on Enabled-Disabled	0 = Switching on Disabled. 1 = Switching on Enabled.
7	Warning	0 = There are no warnings. 1= A warning has occurred.
8	Manufacturer-specific (reserved)	Reserved for future use.
9	Control Remote(bus)-Local	0 = The device does not react on commands from fieldbus, because of one of the following reasons: • HMI is in local mode. • MyDrive® Insight has taken control. • Control places do not include fieldbus. 1 = The device is controlled and reacting to I/O and process data.
10	Target reached (speed=reference)	0 = The motor runs, but the current speed is different from the current speed reference, for example while the speed ramps up or down during start or stop. 1= The current motor speed matches the current speed reference within a given tolerance. The tolerance is product-specific.
11	Speed limit	0 = The output frequency is within the defined motor limits. 1 = The output frequency has exceeded the defined motor limits. The speed limits are set with the parameters: • ***5.8.3.1 Positive Speed Limit*** • ***5.8.3.2 Negative Speed Limit*** • ***5.8.3.3 Minimum Speed Limit***
12	Reserved	Operation-mode specific.
13	Reserved	Operation-mode specific.
14	Manufacturer-specific (reserved)	Reserved for future use.
15	Manufacturer-specific (reserved)	Reserved for future use.

2.6.4 CiA 402 State Machine

In the CiA 402 control profile, the control bits perform different functions:

- Transition 0–3 and 6-7 perform the basic startup and power-down functions.
- Transition 4–5 and 11-12 perform application-oriented control.
- Transition 13–15 perform fault and fault acknowledge functions.

The general state diagram is defined in the CiA 402 standard.

Data objects CiA 402 control word and CiA 402 status word can be used to control the CiA 402 state machine of the drive and to read the state of the CiA 402 state machine of the drive. See descriptions in 2.6.2 Control Word and 2.6.3 Status Word. The possible CiA 402 state machine states and transitions are shown in Figure 1. The state of the CiA 402 state machine of the drive can be changed by writing the corresponding bits 0–3 and 7 to the CiA 402 Control Word data object. The needed bit values for each command are shown in Figure 1.

Table 16: CiA 402 Control Word Commands

Command	Control word bits					Transitions
	Bit 7	Bit 3	Bit 2	Bit 1	Bit 0	
Shutdown	0	X	1	1	0	2.6.8
Switch on	0	0	1	1	1	3
Switch on + enable operation	0	1	1	1	1	3 + 4(1)
Disable voltage	0	X	X	0	X	7, 9, 10, 12
Quick stop	0	X	0	1	X	7, 10, 11
Disable operation	0	0	1	1	1	5
Enable operation	0	1	1	1	1	4, 16
Fault reset		X	X	X	X	15

1) Automatic transition to Enable operation state after executing SWITCHED ON state functionality.

If CiA 402 mode is enabled, the state machine will always follow the state of the drive. However, the state machine is controllable via CiA 402 Control Word only if parameter ***5.5.1.1 Active Control Place*** is set to ***Advanced Control*** or ***Fieldbus Control***. The table below explains the actions taken in different state transitions and which event triggers which state transition. If the used drive/application does not support different stop bits in Fixed Control Word, the stop method will always be according to set stop function.

Table 17: State Transition Events and Actions

Transition	Event(s)	Action(s)	Drive state
0	Automatic transition after power-on or reset	Self-initialization is performed	–
1	Automatic transition after drive status is **ready**.	None	Start Interlock
2, 6	Shutdown command	None	Drive Off
3	Shutdown command	None	Drive Ready
4	Enable operation command	Drive function is enabled	Running Disabled Reference 0.0 rpm
5	Disable operation command	Drive function ramp stop	Stopping
7	Disable voltage or quick stop command	None	Quick Stop/Drive Off
8	Shutdown command	Ramp stop	Stopping
9, 12	Disable voltage command	Coast stop	Start Interlock
10	Disable voltage command	None	Start Interlock
11	Quick stop command	Quick stop	Quick Stop
13	Fault signal	Go to fault state	Fault! Start Blocked

Table 17: State Transition Events and Actions - (continued)

Transition	Event(s)	Action(s)	Drive state
14	Automatic transition	None	–
15	Fault reset command	Reset fault currently active. The fault trigger must be solved before the fault can be reset.	–

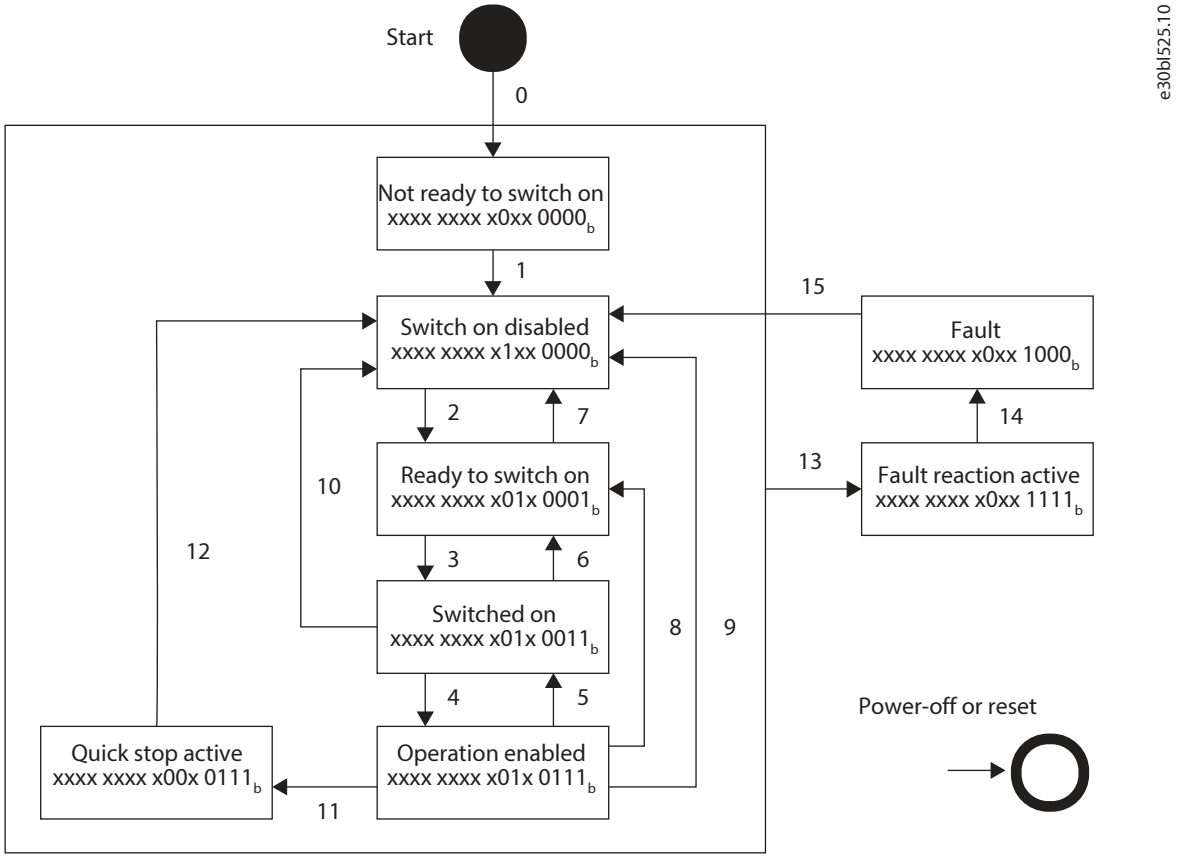


Figure 1: CiA 402 General State Diagram

2.6.5 Configuring Quick Start

Prerequisites:

The drive is connected to mains, is powered on, and reports *Start Interlock*.

1. Type in motor nameplate data and perform AMA.

   Wait for AMA to be completed.

2. Write 0x0006 in the CTW.

   The drive reports *Motor Off*.

3. Write 0x0007 in the CTW.

   The drive reports *Drive Ready*.

4. Write 0x000F in the CTW.

The drive reports *Running Disabled Reference 0.0 rpm*.

5. Write 0x007F in the CTW.

The drive reports *Running at Standstill*.

The reference can now be changed and the motor follows the requested reference.

3 Fieldbus Cable Connections

3.1 Prerequisites for Installation

Communication interfaces are integrated in the control board in iC7 drives and power converters.

The position of the connections differs based on the control board concept and frame, for example. For more information on the location of the connections, cabling, and shielding, refer to the product-specific design guide.

3.2 Communication Interface X1/X2 in Frequency Converters

3.2.1 Communication Interface X1/X2 in Frames FA02–FA12

The communication interface is on the top of the frequency converter as shown in Figure 2. Industrial-grade RJ45 connectors are recommended for optimal connection. A combined shield/fixing plate, the Fieldbus EMC plate, is available as an accessory to strengthen the mechanical fixation of the cables. For information on ordering the EMC plate, refer to the product-specific design guide.

> **IMPORTANT:** Ethernet port X1 in the frequency converter corresponds to EtherCAT Port 0 (IN), and Ethernet port X2 in the frequency converter corresponds to EtherCAT Port 1 (OUT).

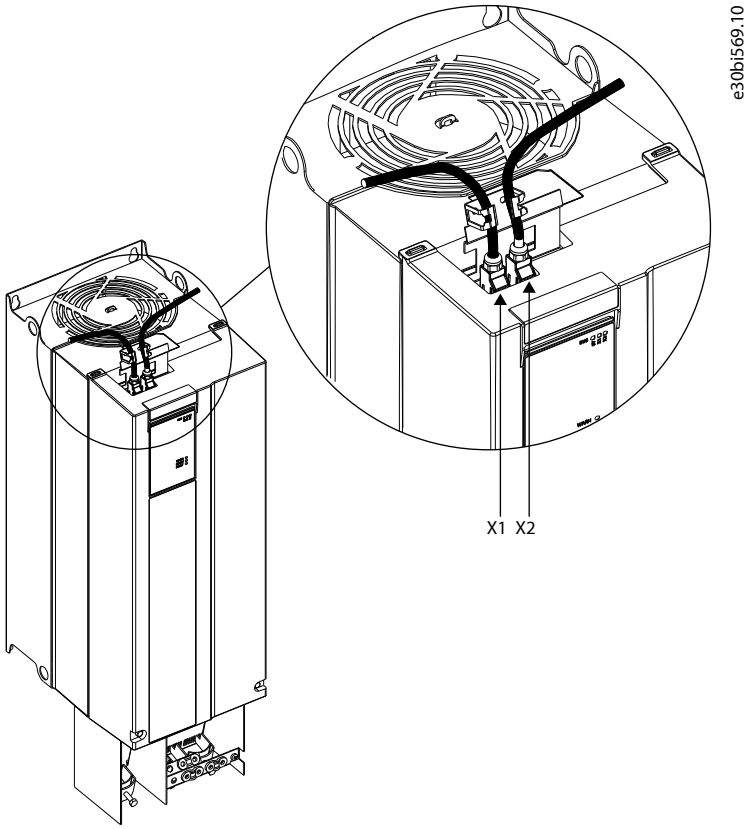


Figure 2: Location of the Communication Interface, X1/X2 in FA02-FA12 Frames (with the Optional EMC Plate)

3.2.2 Communication Interface X1/X2 in Frames FB09–FB12/FK06–FK12

The communication interface ports are located inside the frequency converter. The position of the ports and the recommended wiring path are shown in Figure 3 and Figure 4.

IMPORTANT: Ethernet port X1 in the frequency converter corresponds to EtherCAT Port 0 (IN), and Ethernet port X2 in the frequency converter corresponds to EtherCAT Port 1 (OUT).

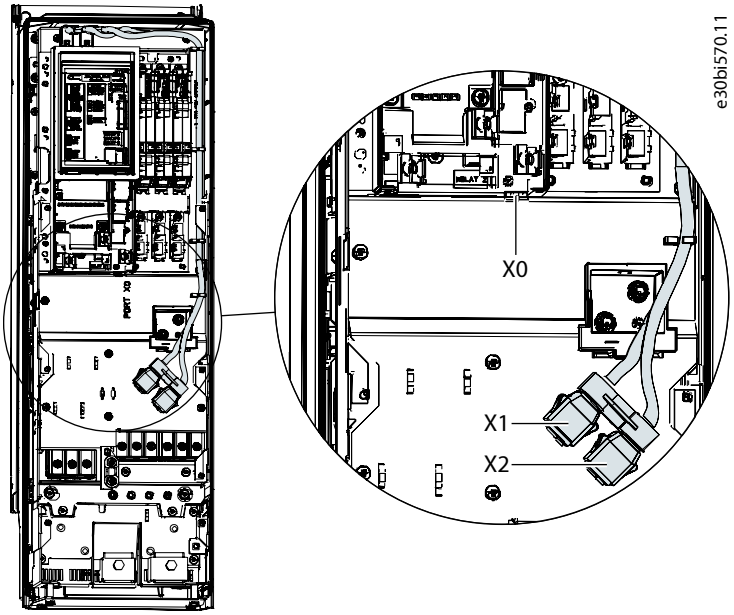


Figure 3: Communication Port X0, X1, and X2 Locations in FK06–FK08 Frames

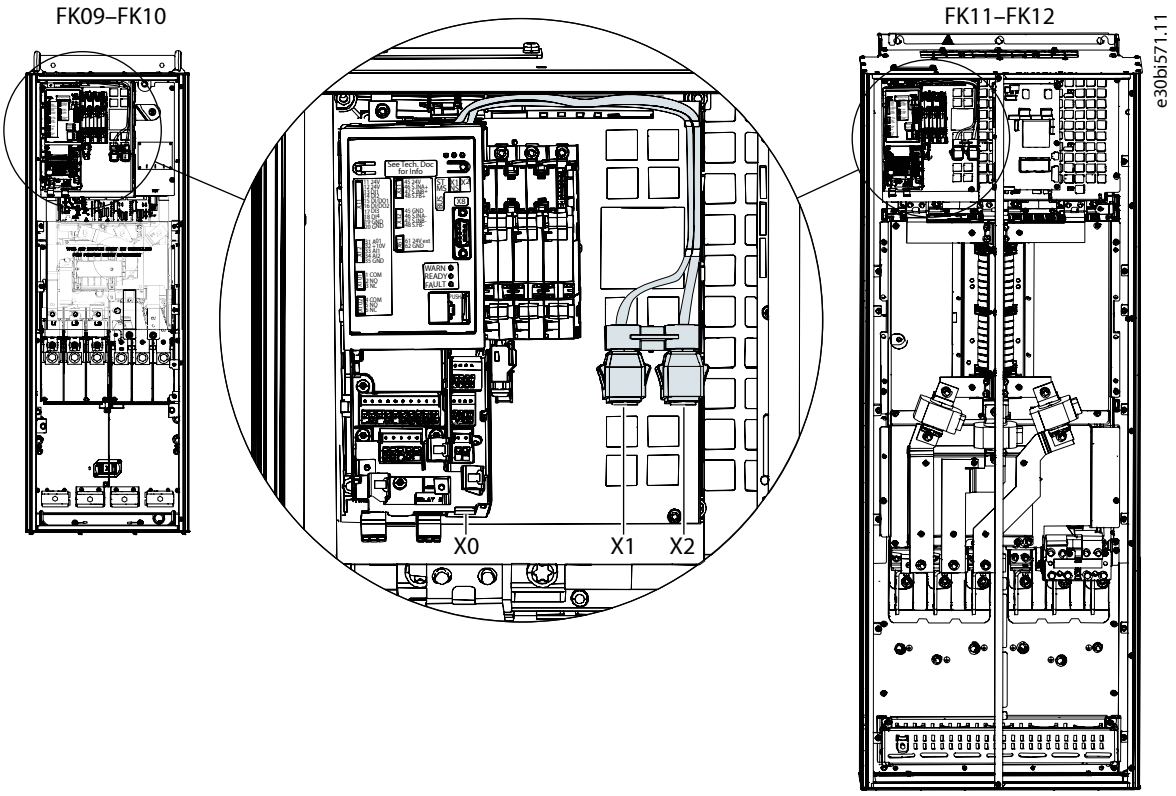


Figure 4: Communication Port X0, X1, and X2 Locations in FB09–FB12/FK09–FK12 Frames

3.3 Installation in System Modules

3.3.1 Communication Interface X1/X2 in System Modules

For systems that use system modules, the communication interface ports are located at the bottom facing side of the modular control unit as shown in Figure 5.

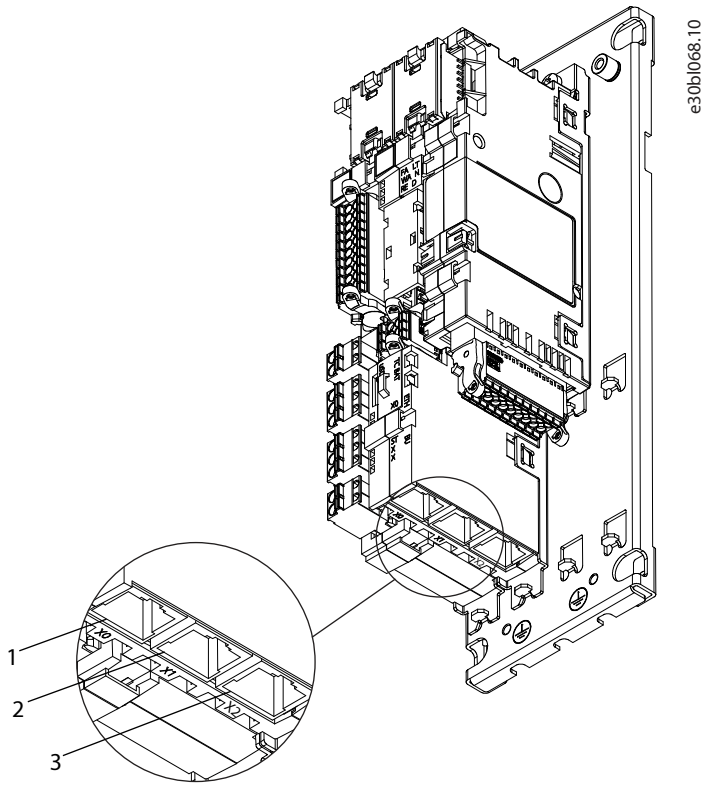


Figure 5: Communication Port X0, X1, and X2 Locations in the Modular Control Unit

1	Ethernet port (X0)	2	Ethernet port (X1)
3	Ethernet port (X2)		

3.4 EtherCAT Port Assignment

The EtherCAT port assignment for the iC7 products is shown in Figure 6.

Figure 6: EtherCAT Port Assignment

3.5 EMC-compliant Installation

3.5.1 Overview

To obtain an EMC-compliant installation, follow the instructions provided in the product-specific design guide and the installation guide included in the shipment.

3.5.2 Grounding

- Ensure that all stations connected to the fieldbus network are connected to the same ground potential. When distances between the stations in a fieldbus network are long, connect the individual station to the same ground potential. Install equalizing cables between the system components.
- Establish a grounding connection with low HF impedance, for example, by mounting the unit on a conductive backplate.
- Keep the ground wire connections as short as possible.

3.5.3 Cable Routing

For more information on cabling, refer to the product-specific design guide and installation guide included in the shipment.

NOTICE

EMC INTERFERENCE

Failure to isolate fieldbus communication, motor, and brake resistor cables can result in unintended behavior or reduced performance.

- Use shielded cables for motor and control wiring, and separate cables for fieldbus communication, motor wiring, and brake resistor.
- A minimum of 200 mm (7.9 in) clearance between power, motor, and control cables is required. For power sizes above 315 kW (450 hp), increase the minimum distance to 500 mm (20 in).

NOTICE

CABLE ROUTING

- When the fieldbus cable intersects with a motor cable or a brake resistor cable, ensure that the cables intersect at an angle of 90°.

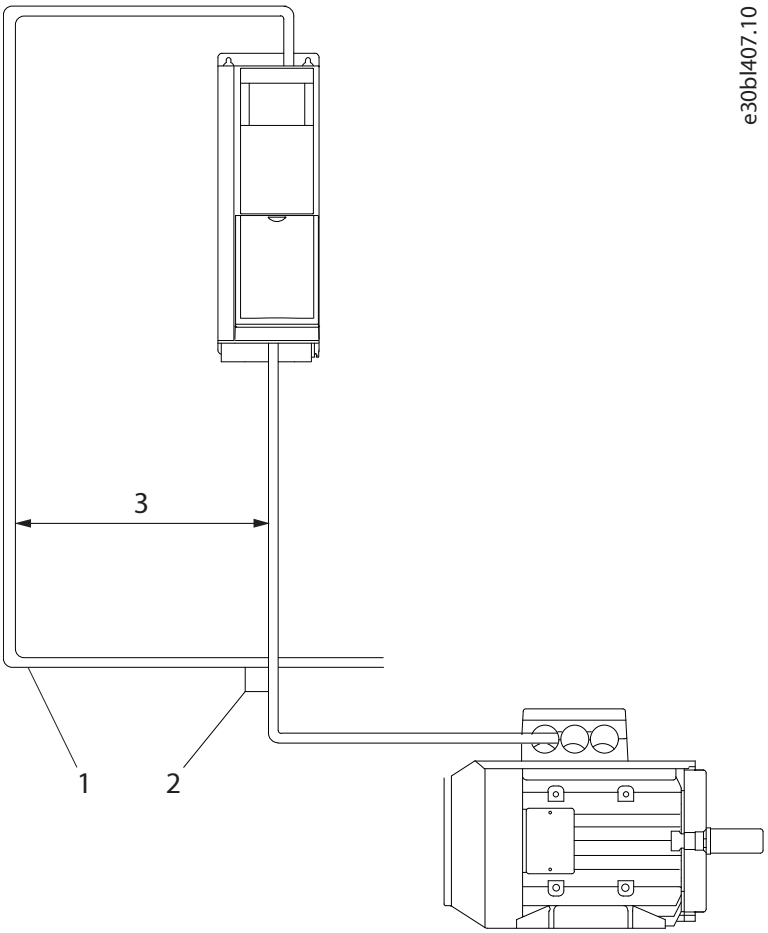


Figure 7: Cable Routing

1	Fieldbus cable	2	90° intersection
3	≥200 mm (7.9 in) (≥ 500 mm (20 in) for power sizes >315 kW (450 hp))		

4 Configuration

4.1 Selecting the Fieldbus Profile

For more information about the available profiles for the application in use, see Communication Profiles and Objects.

1. Navigate to ***Parameters*** > ***Control Places*** > ***Fieldbus Control*** > ***Fieldbus Profile***.
2. Select the fieldbus profile.

The selection affects the interpretation of the control word and status word. Selecting a profile may also automatically set specific values for certain parameters or affect control schemes. For details, refer to the application guide.

4.2 Configuring Fieldbus Protection Settings for the Industry Application

1. Navigate to ***Connectivity*** > ***Protocols*** > ***General Settings***.
2. Configure fieldbus protection settings.

Table 18: Fieldbus Protection Setting Parameters for the Industry Application

Parameter	Parameter number	Value	Description
Fieldbus Fault Response	1303	• Info (default) • Warning • Fault, ramp to coast • Fault See Table 19 for descriptions of the events.	Select the behavior when a fieldbus fault, for example loss of I/O connection occurs.
No Fieldbus Connection Response	1327	• Info (default) • Warning • Fault, ramp to coast • Fault See Table 19 for descriptions of the events.	Select the response in case there is no fieldbus connection.
Process Data Timeout Time	1340	0.05–18000 s (Default value: 1.00 s)	Set the timeout time. If process data is not received within the time set, a process data timeout is triggered.

Table 18: Fieldbus Protection Setting Parameters for the Industry Application - (continued)

Parameter	Parameter number	Value	Description
Process Data Timeout Response	1341	• Info (default) • Warning • Warning - Change Control Place • Warning - Change Control Place - Persistent • Fault, Ramp to Coast • Fault, coast See Table 19 for descriptions of the events.	Select the response to a process data timeout.
Process Data Timeout Control Place	112	• Local control • Fieldbus control • I/O control • Advanced control	Select the alternative control place to be used in case of fieldbus timeout. This is only valid if there is a timeout warning or info.

Table 19: Event Descriptions for the Industry Application

Value	Description
Info	The event is logged in the event log.
Warning	The drive issues a warning. The motor can still be controlled, but with limited performance.
Warning - Change Control Place	The drive issues a warning, and the control place changes to the selected alternative while the timeout warning is active. The control place changes back to the original one when the fieldbus process data returns.
Warning - Change Control Place - Persistent	The drive issues a warning, and the control place changes to the selected alternative while the timeout warning is active. The control place requires a reset command to change back to the original one after the fieldbus process data returns.
Fault, ramp to coast	The drive issues a fault, ramps down, and coasts. Motor control is no longer possible.
Fault	The drive issues a fault and coasts the motor. Motor control is no longer possible.

4.3 Configuring Fieldbus Protection Settings for the Motion Application

1. Navigate to ***Connectivity*** > ***Protocols*** > ***General Settings***.
2. Configure fieldbus protection settings.

Table 20: Fieldbus Protection Setting Parameters for the Motion Application

Parameter	Parameter number	Value	Description
Fieldbus Fault Response	1303	• Info (default) • Warning • Fault, ramp to coast • Fault See Table 19 for descriptions of the events.	Select the behavior when a fieldbus fault, for example loss of I/O connection occurs.
No Fieldbus Connection Response	1327	• Info (default) • Warning • Fault, ramp to coast • Fault See Table 19 for descriptions of the events.	Select the response in case there is no fieldbus connection.
Process Data Timeout Time	1340	0.05–18000 s (Default value: 1.00 s)	Set the timeout time. If process data is not received within the time set, a process data timeout is triggered.
Process Data Timeout Response	1341	• Info (default) • Warning • Warning - Change Control Place • Warning - Change Control Place - Persistent • Fault, Ramp to Coast • Fault, coast See Table 19 for descriptions of the events.	Select the response to a process data timeout.
Process Data Timeout Control Place	112	• Local control • Fieldbus control • I/O control • Advanced control	Select the alternative control place to be used in case of fieldbus timeout. This is only valid if there is a timeout warning or info.

Table 21: Event Descriptions for the Motion Application

Value	Description
Info	The event is logged in the event log.
Warning	The drive issues a warning. The motor can still be controlled, but with limited performance.
Warning - Change Control Place	The drive issues a warning, and the control place changes to the selected alternative while the timeout warning is active. The control place changes back to the original one when the fieldbus process data returns.
Warning - Change Control Place - Persistent	The drive issues a warning, and the control place changes to the selected alternative while the timeout warning is active. The control place requires a reset command to change back to the original one after the fieldbus process data returns.

Table 21: Event Descriptions for the Motion Application - (continued)

Value	Description
Fault, ramp to coast	The drive issues a fault, ramps down, and coasts. Motor control is no longer possible.
Fault	The drive issues a fault and coasts the motor. Motor control is no longer possible.

4.4 Configuring Fieldbus Protection Settings for the Active Front End Application

When using the iC7 series Active Front End application, the fieldbus profile is selected automatically.

1. Navigate to parameter group ***Parameters*** > ***Protections and Responses*** > ***Fieldbus Protections***.
2. Configure fieldbus protection settings.

Table 22: Fieldbus Protection Setting Parameters for the Active Front End Application

Parameter	Parameter number	Value	Description
Fieldbus Fault Response	1304	• No response • Info • Warning • Fault (default) • Fault, open MCB See Table 23 for descriptions of the events.	Select the behavior when a fieldbus fault, for example, loss of I/O connection occurs.
No Fieldbus Connection Response	1305	• No response (default) • Info • Warning • Fault • Fault, open MCB See Table 23 for descriptions of the events.	Select the response if there is no fieldbus connection.
Process Data Timeout Response	1306	• No response • Info (default) • Warning • Fault • Fault, open MCB See Table 23 for descriptions of the events.	Select the response to a process data timeout.
Process Data Timeout Delay	1340	0.05–18000 s (Default value: 1.00 s)	Set a delay for the triggering of the Process Data Timeout event. If process data has not been updated within this delay time the event is triggered.

Table 22: Fieldbus Protection Setting Parameters for the Active Front End Application - (continued)

Parameter	Parameter number	Value	Description
Fieldbus Watchdog Response	5244	• No response • Info • Warning (default) • Fault • Fault, open MCB See Table 23 for descriptions of the events.	Select the converter response for the fieldbus watchdog event.
Fieldbus Watchdog Delay	5245	0.0–3000.0 s (Default value: 5.00 s)	Set a delay for activating the fieldbus watchdog event.
Fieldbus Watchdog Start Delay	5246	0.0–3000.0 s (Default value: 30.00 s)	Set a startup delay time for activating the fieldbus watchdog event. The counter starts when the converter wakes up.

Table 23: Event Descriptions

Value	Description
No response	–
Info	The event is logged in the event log.
Warning	The drive or power converter issues a warning.
Fault	The drive or power converter issues a fault and stops modulation.
Fault, open MCB	The drive or power converter issues a fault, stops modulation, and opens the main circuit breaker.

4.5 EtherCAT Subdevice Information File

To configure a EtherCAT master, the configuration tool needs an EtherCAT Subdevice Information (ESI) file for each type of device in the network. The ESI file is an XML file containing the necessary device description information for a given device.

Download the ESI files for the iC7 series from https://www.danfoss.com/en/service-and-support/downloads/dds/fieldbus-configuration-files/. Check that the ESI file version is compatible with the firmware and application version used in the product.

4.6 Reference Handling

4.6.1 Industry and Motion Applications

The speed reference is scaled as a normalized relative value in percent (N2). The value is transmitted in hexadecimal:

- 0% = 0 hex
- 100% = 4000 hex
- -100% = C000 hex

Table 24: Reference Handling Parameters

Parameter	Parameter number	Unit	Range
Nominal Speed	402	[RPM]	0–100000
Positive Speed Limit	1729	[RPM]	0–35400
Negative Speed Limit	1728	[RPM]	-35400–0

For some applications, reversing is not wanted.

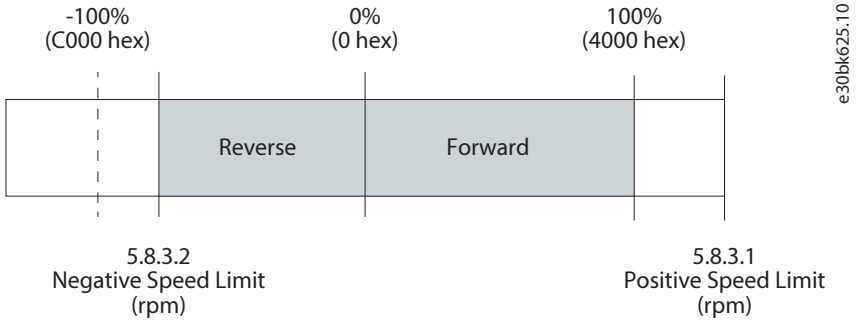


Figure 8: Example of Fieldbus Speed Reference in iC7-Automation

4.6.2 Active Front End Application

For the Active Front End application, the Main Reference [REF] and Main Actual Value [MAV] are tied to the DC-link voltage of the converter. Both of these signals are interfaced as 32-bit floating-point values. They are expressed in % of the ***Grid Nominal Voltage*** parameter (parameter number ***6537***).

5 Parameter Access

5.1 Overview

iC7 series supports access to parameters via SDO. The data mechanism transmits requests and replies acyclically. The requests and replies are transmitted by the Acyclic Data Exchange mechanism.

For detailed instructions on how to access parameters via service data objects, refer to the documentation provided by the EtherCAT master controller manufacturer.

Parameters are accessible from the object dictionary 0x2000+parameter number.

5.2 Accessing Parameters

Prerequisites:
MyDrive® Insight must be installed to access the parameters related to EtherCAT.

This example illustrates how the corresponding parameter number is allocated to each index number.

1. Connect the Ethernet cable from the PC to the Ethernet port X0 on the drive. To locate port X0, see Fieldbus Cable Connections.
2. Add a link local IP address (169.254.x.x) to the network interface used on the PC connected to the drive.
3. Open MyDrive® Insight on the PC.
4. In MyDrive® Insight, click the discovered drive to which a connection should be established.

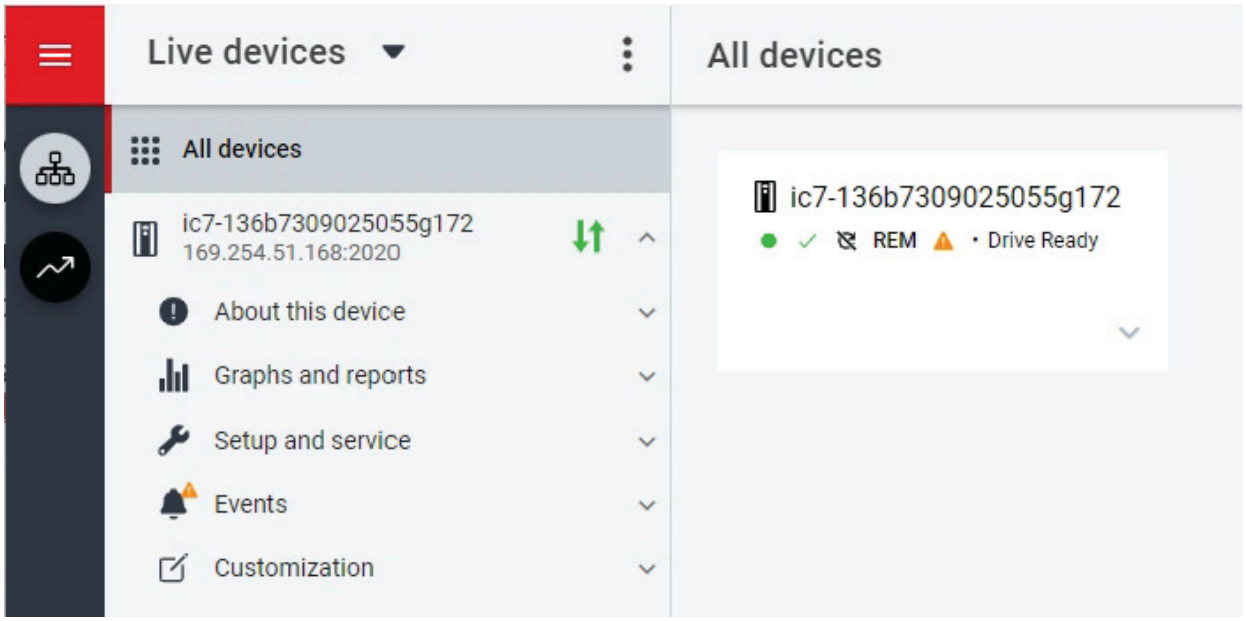


Figure 9: Connecting to a Drive with MyDrive® Insight

5. Select *Setup and service* > *Parameters* > *Live*.

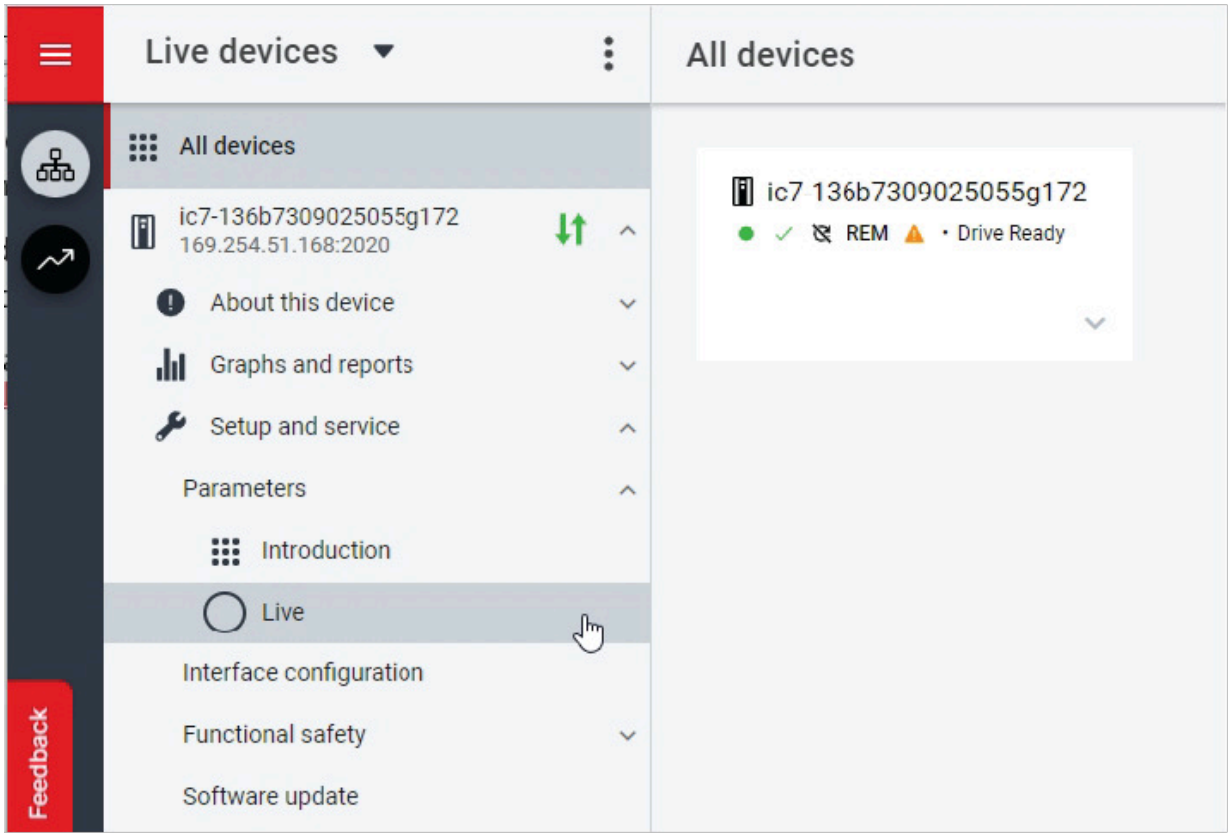
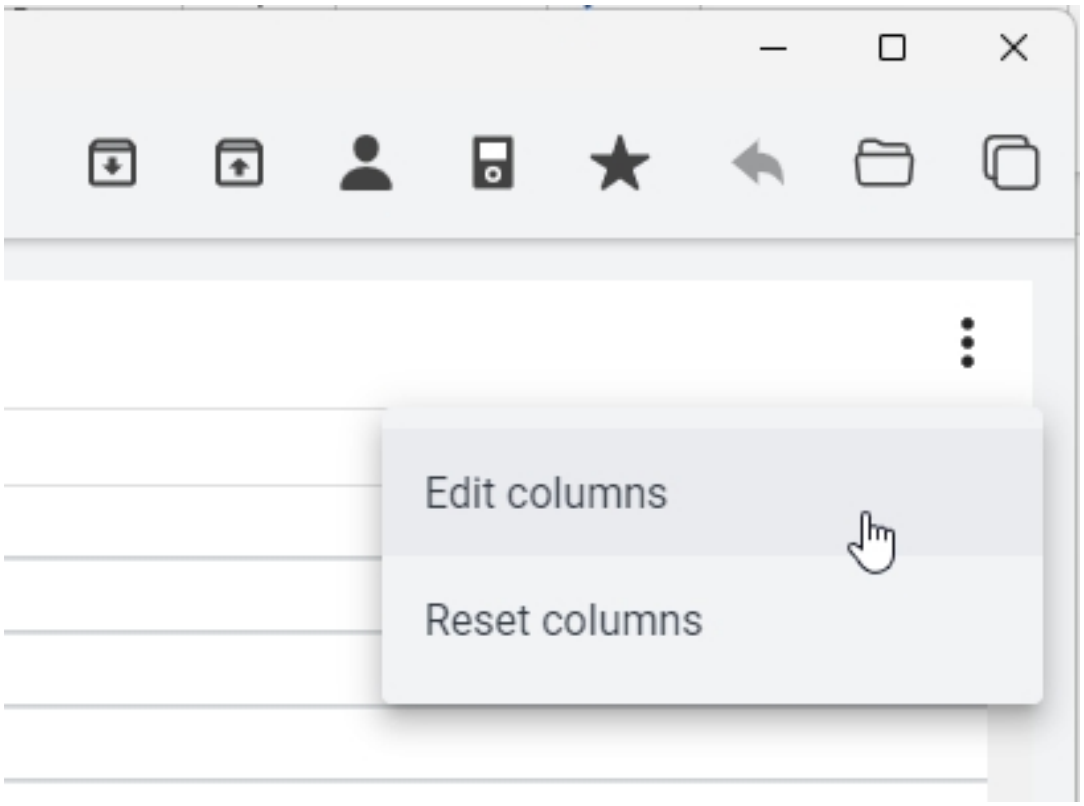


Figure 10: Live Parameters in MyDrive® Insight

A list of all available parameters in the drive is generated.

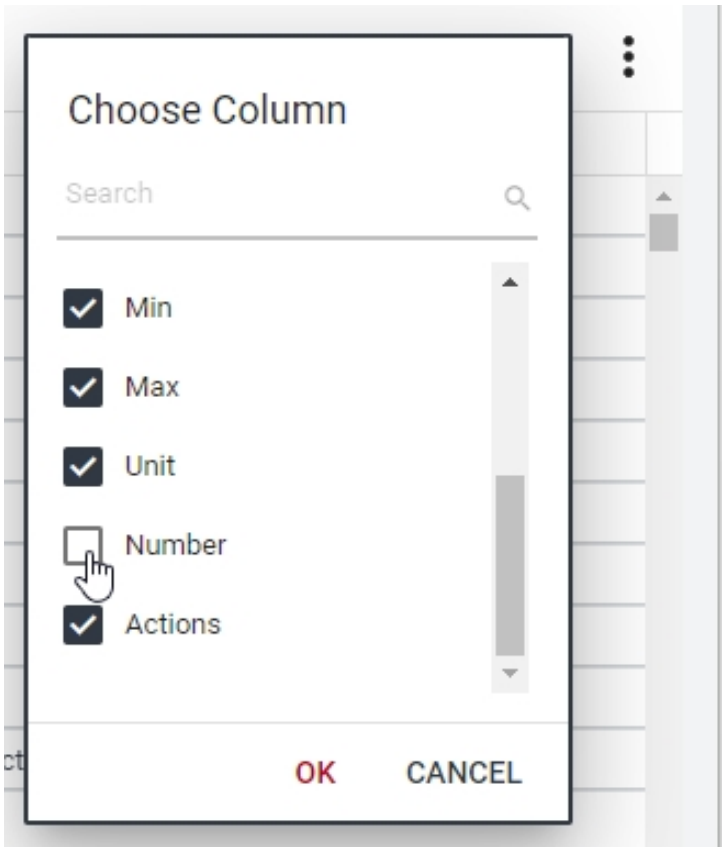
6. In the upper right corner, select the 3 dots and *Edit columns*.



e30bl654.10

Figure 11: Editing Columns in MyDrive® Insight

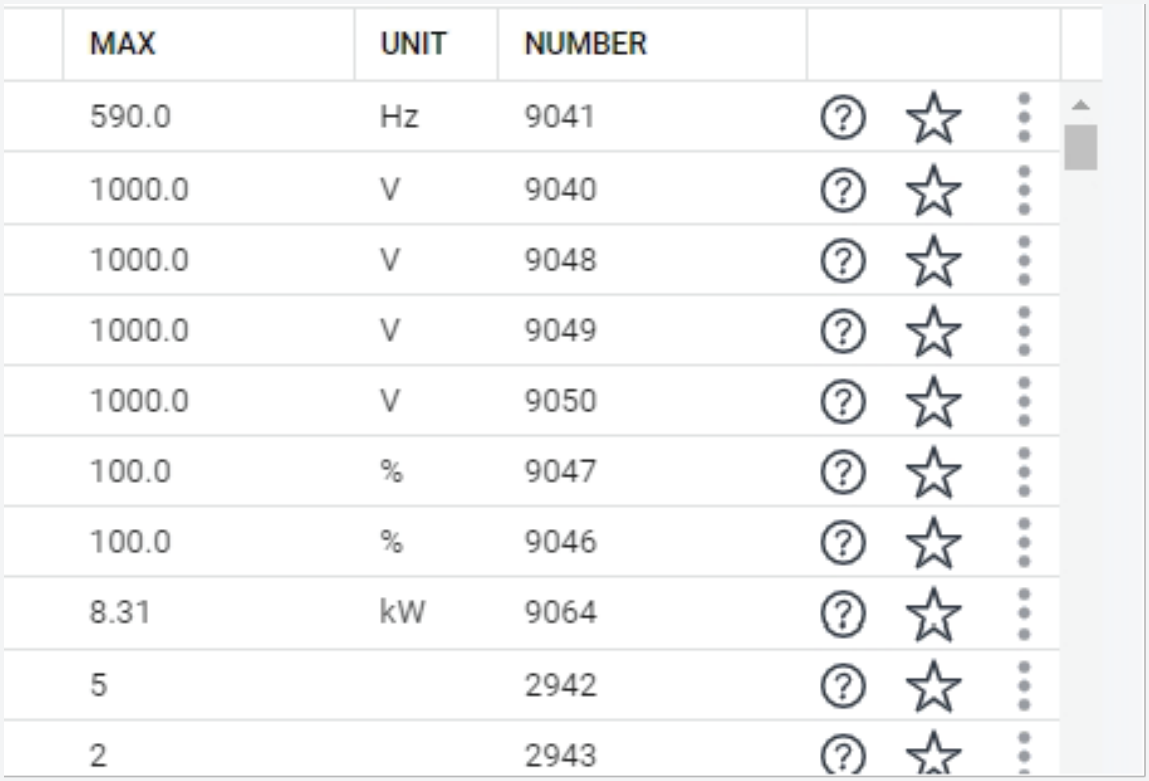
7. In the *Choose Column* dialog, select *Number*, and click *OK*.



e30bl655.10

Figure 12: Adding Columns in MyDrive® Insight

The *NUMBER* column is added to the parameter overview.



e30bl656.10

Figure 13: Parameter Overview

The parameter overview includes the *NUMBER* column with the parameter numbers that are used to address parameters from EtherCAT.

For example, index ***1.1.3 L1-L2 Line Voltage (RMS)*** has the corresponding parameter number ***9048***. To address this parameter, it must be converted to a hexadecimal number first. The decimal number 9048 corresponds to 0x2358 hexadecimal number. To address this number from EtherCAT, the value 0x2000 must be added. This means that the parameter addressing value for parameter ***9048*** from EtherCAT is 0x2000 + 0x2358 = 0x4358h.

INDEX	NAME	VALUE	DEFAULT	MIN	MAX	UNIT	NUMBER
1.1.1	Grid Frequency	0.0		-590.0	590.0	Hz	9041
1.1.2	Line-To-Line Voltage (RMS)	410.0		0.0	1000.0	V	9040
1.1.3	L1-L2 Line Voltage (RMS)	410.0		0.0	1000.0	V	9048
1.1.4	L2-L3 Line Voltage (RMS)	410.0		0.0	1000.0	V	9049
1.1.5	L3-L1 Line Voltage (RMS)	410.0		0.0	1000.0	V	9050
1.1.6	Grid Voltage Imbalance	0.0		0.0	100.0	%	9047
1.1.7	Total Harmonic Distortion (THDv)	0.0		0.0	100.0	%	9046

e30bl657.10

Figure 14: Example of Parameters

6 Troubleshooting

6.1 Fieldbus Indicator LEDs

The fieldbus indicator LEDs are in the top right corner of the control panel and the bottom part of the front-facing side of the modular control unit.

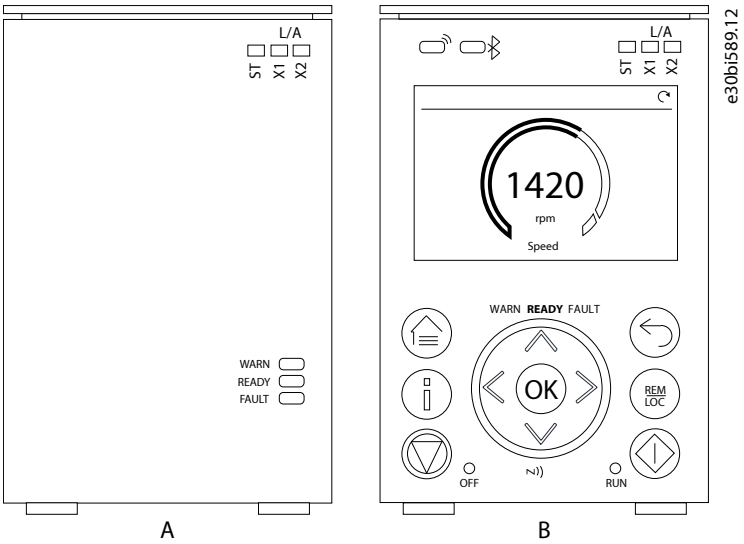


Figure 15: Fieldbus Indicator LEDs on Control Panel

A	Blind Panel	B	Control Panel 2.8

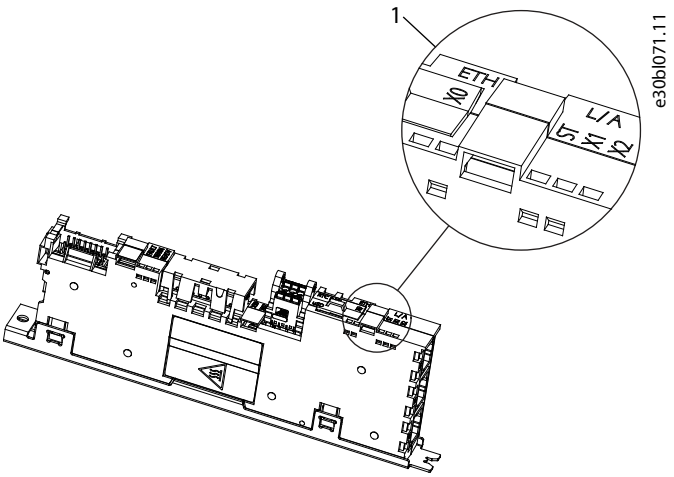


Figure 16: Fieldbus Indicator LEDs on Modular Control Board

1	Fieldbus indicator LEDs (ST, X1, and X2)

- The LED labeled ST shows the module status.
- The LED labeled X1 shows the network status on Ethernet port X1.
- The LED labeled X2 shows the network status on Ethernet port X2.

Table 25: Fieldbus Indicator LED Functions

LED label	Color	Status	LED pattern	Description
ST	Green	Initialization	Off	The device is in state INIT
		Pre-operational	Blinking	The device is in state PRE-OPERATIONAL
		Safe-operational	Single flash	The device is in state SAFE-OPERATIONAL
		Operational	On	The device is in OPERATIONAL
	Red/Green	Application watchdog time-out	Red double flash in between green	Process data watchdog timeout/EtherCAT watchdog timeout
		Local error	Red single flash in between green	EtherCAT state has been changed autonomously
		Invalid configuration	Blinking red/green with 50% duty cycle.	General configuration error
X0	Green	X0 link activity	Off	No link
			On	Link OK, no data
			Blinking	Link OK, data communication
	Orange	X0 link speed	Off	No link or 10 Mbps link
			On	100 Mbps link
X1	Green	-	-	Link/activity status of the IN port (X1)
		Link, but no activity	On	Ethernet link established
		Link and activity	Flickering	Ethernet link established and active
		-	Off	No Ethernet link
X2	Green	-	-	Link/activity status of the OUT port (X2)
		Link, but no activity	On	Ethernet link established
		Link and activity	Flickering	Ethernet link established and active
		-	Off	No Ethernet link

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