Operating Guide

iC7-Hybrid EtherCAT®

EtherCAT OS7EC

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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

Beckhoff is a registered trademark of and licensed by Beckhoff Automation GmbH, Germany.

CANopen® is a registered community trademark of CAN in Automation e.V.

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
AQ549035231056, version 0101	First release.

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 4.1 EtherCAT Subdevice Information File.
CANopen over EtherCAT (CoE)	• Complete access • Diagnosis history
Ethernet over EtherCAT (EoE)	• Device MAC address used. • Virtual MAC address is not assigned.
Modular Device Profile for application profiles	• iC Generic Profile • iC Hybrid Profile • iC Speed Profile • CiA 402 Velocity Profile
Addressing method	• Explicit device identification • Station alias (second slave address)

2.2 Communication Profiles and Objects

2.2.1 Overview

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***.

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

Profile	Grid Converter	Grid Converter with Grid Codes	DC/DC Converter	Generator
iC Generic Profile	–	–	–	X
iC Hybrid Profile	X	X	X	–
iC Speed Profile	–	–	–	X
CiA 402 profile	–	–	–	X

2.2.2 iC Generic

2.2.2.1 Overview

The iC Generic profile is used for motor control operation with the iC7 Series Generator application software.

2.2.2.2 Control Word

Table 6: iC Generic Profile Control Word Bits

Bit	Name	Description
0	Ramp Stop	0: The ramp stop request is inactive. The drive can be started. 1: The drive is ready to operate.
1	Coast Stop	0: A running drive coasts to a stop (modulation stops). 1: The coast request is inactive. The drive can be started.
2	Quick Stop	0: The drive stops with the Quick Stop function. 1: The Quick Stop request is inactive. The drive can be started.
3	Start	0: The drive stops operating with the method determined by the parameter ***Missing Start Response*** (4717). 1: The drive starts to operate on the rising edge of this signal.
4	–	Reserved
5	–	Reserved
6	–	Reserved
7	Event Reset	0: Event Reset Inactive. 1: Event Reset Active. A rising edge of this signal resets events (warnings, faults, and so on), which do not have active triggering conditions. After a fault the drive goes to a Switching On Inhibited state, which must be acknowledged with bit 0.
8	Reference Reverse	0: The speed reference remains normal. 1: The speed reference is reversed. The reference can also be reversed with a negative setpoint. Double negatives result in a forward reference.
9	–	Reserved
10	Data Valid	0: Ignores the current process data. Uses the previously processed data when the Data Valid bit was previously true. 1: Reads the current process data. For most of the control word commands to be acknowledged by the drive, fieldbus must be the commanding control place. See options in parameter group ***Control Places*** in parameter group ***2 Parameters***.
11	Watchdog	0: Watchdog low. 1: Watchdog high. Continuous toggling 0–1 can be used as a sign of life between the drive and the fieldbus master. The value of this bit is also passed through the fieldbus status word as is.

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

Bit	Name	Description
12	Fieldbus Digital Input 1	0: Fieldbus Digital Input 1 inactive. 1: Fieldbus Digital Input 1 active. Select the value ***CTW B12*** for any input parameter to use this signal for the activation of a selected function.
13	Fieldbus Digital Input 2	0: Fieldbus Digital Input 2 inactive. 1: Fieldbus Digital Input 2 active. Select the value ***CTW B13*** for any input parameter to use this signal for the activation of a selected function.
14	Fieldbus Digital Input 3	0: Fieldbus Digital Input 3 inactive. 1: Fieldbus Digital Input 3 active. Select the value ***CTW B14*** for any input parameter to use this signal for the activation of a selected function.
15	Fieldbus Digital Input 4	0: Fieldbus Digital Input 4 inactive. 1: Fieldbus Digital Input 4 active. Select the value ***CTW B15*** for any input parameter to use this signal for the activation of a selected function

2.2.2.3 Status Word

Table 7: iC Generic Profile Status Word Bits

Bit	Name	Description
0	Ready To Switch On	0: The drive is not ready to receive a start command because of at least 1 of the following conditions is true: Fault Active, Ramp Stop Active, Coast Stop Active, or Quick Stop Active. 1: The drive is ready to accept a start command.
1	Power Unit Ready	0: The drive cannot be set running because the ready conditions of the power unit are not met. Check parameter ***Motor Control Start Ready Status Word*** (6207) for any conditions that are not met. 1: All power unit ready conditions are met.
2	Drive Running	0: The drive is not running. 1: The drive is running.
3	Fault Active	0: No active drive faults. 1: One or more drive faults are active. Switching on is inhibited.
4	–	Reserved
5	Quick Stop Active	0: The quick stop command is inactive. A new start command is required. 1: The quick stop command is active. This command can also be given from another control source than fieldbus.
6	–	Reserved
7	Warning Active	0: All drive warnings are inactive. 1: One or more drive warnings are active.
8	–	Reserved
9	Fieldbus Control Active	0: Fieldbus is not the active control place. 1: Fieldbus is the active control place.

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

Bit	Name	Description
10	–	Reserved
11	Run Enabled	0: The digital input signal ***Run Enable Input*** (103) is inactive, and modulation is disabled. 1: The digital input signal ***Run Enable Input*** (103) is active, and modulation is enabled.
12	–	Reserved
13	–	Reserved
14	–	Reserved
15	Watchdog Feedback	0: The watchdog signal that the drive has received is low. 1: The watchdog signal that the drive has received is high.

2.2.3 iC Hybrid

2.2.3.1 Overview

The iC Hybrid profile is used in the iC7 series with Grid Converter, Grid Converter with Grid Codes and DC/DC Converter applications, and with the Generator application in grid control mode.

2.2.3.2 Control Word

Table 8: Control Word Bits in iC Hybrid Profile

Bit	Name	Description
0	Switch On Enabled	0: Pre-charging(1), closing the main circuit breaker(1), and running are prevented or interrupted. If the main circuit breaker is closed, it opens(1). 1: Pre-charging(1), closing the main circuit breaker(1), and running are not prevented or interrupted.
1	MCB Close Enabled	0: Closing the main circuit breaker is prevented(1) or the main circuit breaker is opened(1), and running is prevented or interrupted. 1: Closing the main circuit breaker is not prevented(1).
2	Quick Stop	0: Activate Quick Stop. 1: Do not activate Quick Stop.
3	Start	0: Stop the unit if it is running, or stop the startup sequence if it is not completed. 1: Initiate the startup sequence (DC-link pre-charging(2), closing the main circuit breaker(2), and start running), or keep the unit running.
4	Pre-charge	0: Stop the DC-link pre-charging, if ongoing. 1: Start or continue the DC-link pre-charging.
5	–	Reserved
6	–	Reserved
7	Event Reset	0: No action. 1: Reset active warnings/faults.
8	–	Reserved
9	–	Reserved

Table 8: Control Word Bits in iC Hybrid Profile - (continued)

Bit	Name	Description
10	Data Valid	0: Ignore the current incoming process data values, instead use the last processed value when the Data Valid bit was true. 1: Use the current incoming process data values. For most of the control word commands to be acknowledged by the drive or power converter, the active control place must be set to fieldbus control in parameter group ***Control Places*** in parameter group ***2 Parameters***.
11	Watchdog	Incoming watchdog bit. With continuous toggling between 0 and 1, this bit can be used as a sign-of-life between the drive or power converter and fieldbus controller. The value of this bit is passed through the fieldbus status word as is.
12	Fieldbus Digital Input 1	0: Fieldbus Digital Input 1 inactive. 1: Fieldbus Digital Input 1 active. Select the value ***CTW B12*** for any input parameter to use this signal to activate a function.
13	Fieldbus Digital Input 2	0: Fieldbus Digital Input 2 inactive. 1: Fieldbus Digital Input 2 active. Select the value ***CTW B13*** for any input parameter to use this signal to activate a function.
14	Fieldbus Digital Input 3	0: Fieldbus Digital Input 3 inactive. 1: Fieldbus Digital Input 3 active. Select the value ***CTW B14*** for any input parameter to use this signal to activate a function.
15	Fieldbus Digital Input 4	0: Fieldbus Digital Input 4 inactive. 1: Fieldbus Digital Input 4 active. Select the value ***CTW B15*** for any input parameter to use this signal to activate a function.

1) If controlled by the grid converter unit.

2) If applicable.

2.2.3.3 Status Word

Table 9: Status Word Bits in iC Hybrid Profile

Bit	Name	Description
0	Ready to Switch On	0: Not ready to switch on. 1: Ready to switch on.
1	Ready to Run	0: The converter is not ready to start modulation. Check ***Grid Control Ready Status*** (5096) or ***DC/DC Control Ready Status*** (6520), and ***Application Ready Status Word*** (6525). 1: The converter is ready to start modulating.
2	Running	0: The converter is not modulating. 1: The converter is modulating.
3	Fault	0: No faults are active. 1: One or more faults are active.
4	–	Reserved

Table 9: Status Word Bits in iC Hybrid Profile - (continued)

Bit	Name	Description
5	Quick Stop	0: Quick stop active. 1: Quick stop not active.
6	–	Reserved
7	Warning	0: No warnings active. 1: One or more warnings are active.
8	–	Reserved
9	Control by PLC	0: The active control place is not fieldbus. 1: The active control place is fieldbus.
10	–	Reserved
11	Run Enabled	0: Run enable from the dedicated input signal is missing. 1: Run enable from the dedicated input signal is present.
12	–	Reserved
13	–	Reserved
14	–	Reserved
15	Watchdog Feedback	0: The watchdog signal is low. 1: The watchdog signal is high.

2.2.4 iC Speed

2.2.4.1 Overview

The iC Speed profile is used with iC7 series Generator application software. The iC Speed profile differs from the PROFIdrive 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.

2.2.4.2 Control Word

Table 10: iC Speed Profile Control Word Bits

Bit number	Name	Description
0	Speed Preset Reference Selector 1	Use these bits to select between speed presets: 00: Preset reference 1 01: Preset reference 2 10: Preset reference 3 11: Preset reference 4
1	Speed Preset Reference selector 1	Use these bits to select between speed presets: 00: Preset reference 1 01: Preset reference 2 10: Preset reference 3 11: Preset reference 4
2	–	Reserved

Table 10: iC Speed Profile Control Word Bits - (continued)

Bit number	Name	Description
3	Coast Stop	0: The drive coasts to a stop. 1: The coast request is inactive. The drive can be started.
4	Quick Stop	0: The drive stops with the quick stop function. 1: The quick stop request is inactive. The drive can be started.
5	Freeze Speed Reference	0: The speed reference (input of the ramp generator) is frozen to its latest value. 1: The speed reference can be changed freely.
6	Start	0: The drive stops operating with the method determined by parameter ***Missing Start Response*** (4717). 1: The drive starts to operate on the rising edge of this signal.
7	Event Reset	0: Event reset inactive. 1: Event reset active. The rising edge of this signal resets events (warnings, faults, and so on), which do not have active triggering conditions.
8	–	Reserved
9	Speed Ramp	0: Ramp 1 is active. Configure ramp in parameter group ***2.4.1.2 Ramp 1***. 1: Ramp 2 is active. Configure ramp in parameter group ***2.4.1.3 Ramp 2***.
10	Data Valid	0: Ignores the current process data. Uses the previously processed data when the Data Valid bit was previously true. 1: Reads the current process data (controlled by PLC). For most of the control word commands to be acknowledged by the drive, fieldbus must be the commanding control place. See options in parameter group ***Control Places*** in parameter group ***2 Parameters***.
11	–	Reserved.
12	Fieldbus Digital Input 1	0: Fieldbus Digital Input 1 inactive. 1: Fieldbus Digital Input 1 active. Select the value ***CTW B12*** for any input parameter to use this signal for the activation of a selected function.
13	Fieldbus Digital Input 2	0: Fieldbus Digital Input 2 inactive. 1: Fieldbus Digital Input 2 active. Select the value ***CTW B13*** for any input parameter to use this signal for the activation of a selected function.
14	Fieldbus Digital Input 3	0: Fieldbus Digital Input 3 inactive. 1: Fieldbus Digital Input 3 active. Select the value ***CTW B14*** for any input parameter to use this signal for the activation of a selected function.
15	Fieldbus Digital Input 4	0: Fieldbus Digital Input 4 inactive. 1: Fieldbus Digital Input 4 active. Select the value ***CTW B15*** for any input parameter to use this signal for the activation of a selected function.

2.2.4.3 Status Word

Table 11: 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	Drive Ready	0: The drive is not ready for operation. 1: The drive is ready for operation.
2	Coast	0: There is an active coast stop command and the drive is in a coast stop state. 1: There are no active coast signals. The drive can be started.
3	Fault	0: There are no active faults. 1: There is at least 1 active fault. The drive cannot be started before the fault condition is cleared and the fault is reset.
4	–	Reserved
5	–	Reserved
6	–	Reserved
7	Warning	0: There are no active warnings. 1: There is at least 1 active warning. The cause of the warning should be investigated and mitigated.
8	Speed Reference	0: Speed not at reference. The motor speed differs from the given speed reference, for example, due to ramping. 1: Speed at reference. The motor speed matches the given speed reference.
9	Fieldbus Control	0: Fieldbus control inactive. None of the basic command functions of the drive are affected by fieldbus commands. 1: Fieldbus control active. Fieldbus is the active control place, or configured as part of the advanced control place.
10	Limiter	0: Limiter inactive. All limiters (regulators) are inactive. 1: Limiter active. One or more limiters (regulator) are actively limiting the drive current, torque, and so on. See parameter ***Motor Regulator Status Word*** (1715) for further details.
11	Operation	0: The drive is not modulating (operating). 1: The drive is modulating (operating).
12	–	Reserved
13	–	Reserved
14	–	Reserved
15	–	Reserved

2.2.5 CiA 402 – Velocity Mode

2.2.5.1 Overview

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

2.2.5.2 Control Word

Table 12: 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.

2.2.5.3 Status Word

Table 13: 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 13: 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.

2.2.5.4 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 2.2.5.2 Control Word and 2.2.5.3 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 14: 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 15: 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 15: 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.	–

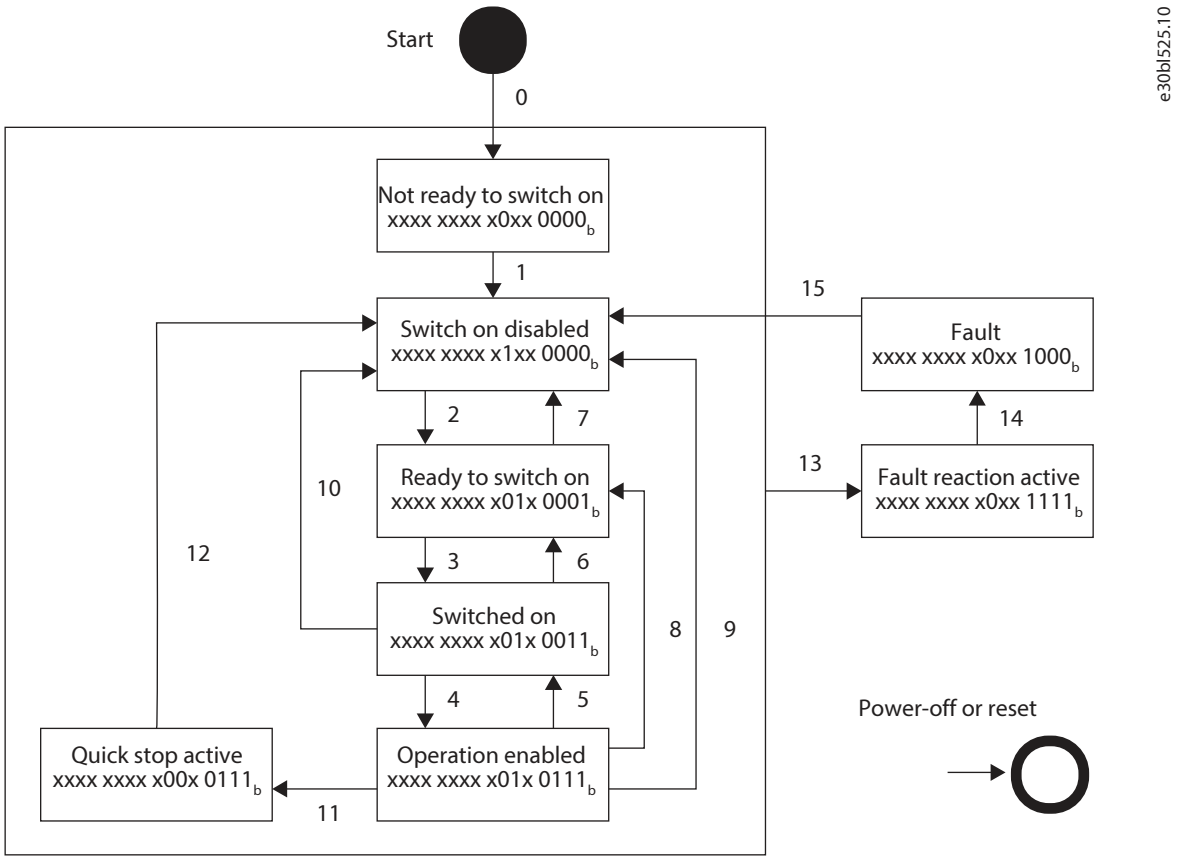


Figure 1: CiA 402 General State Diagram

2.2.5.5 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).

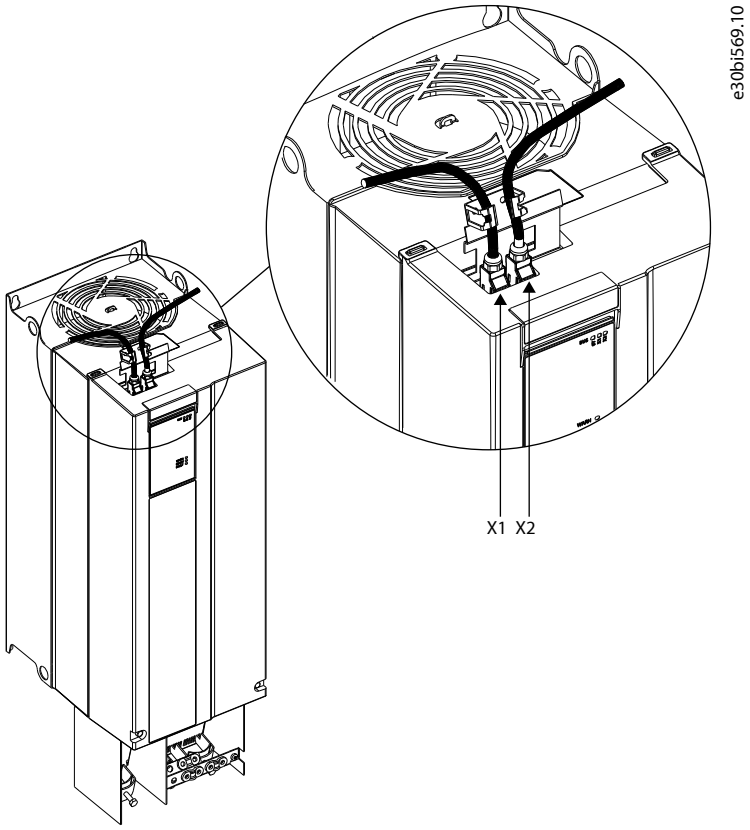


Figure 2: Location of the Communication Interface, X1/X2 in FA02-FA12 Frames (with the Optional EMC Plate)

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).

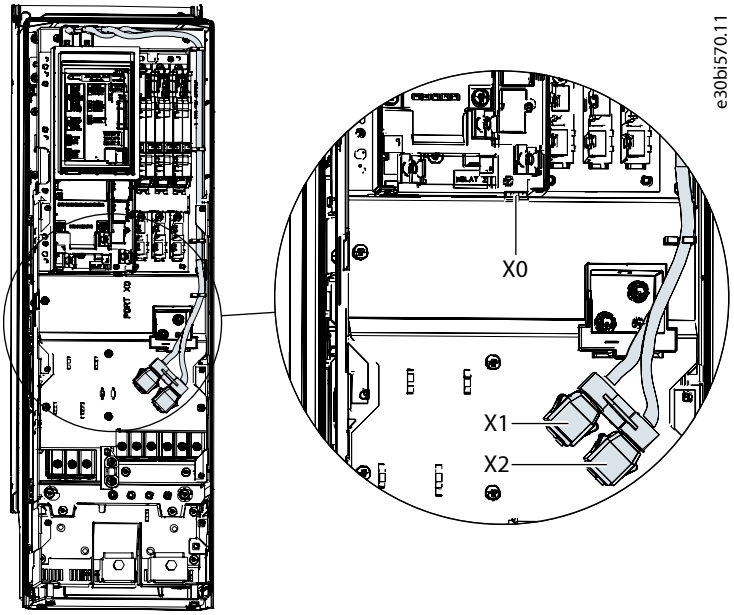


Figure 3: Communication Port X0, X1, and X2 Locations in FK06–FK08 Frames

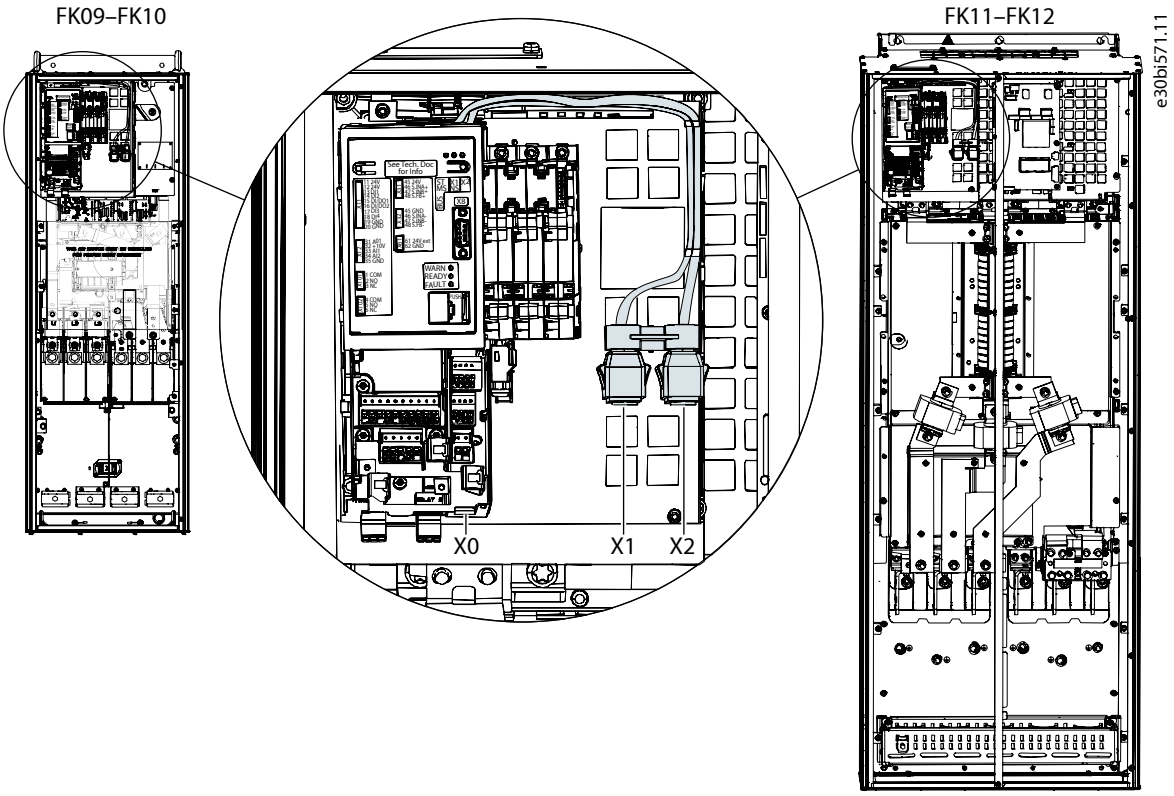


Figure 4: Communication Port X0, X1, and X2 Locations in FB09–FB12/FK09–FK12 Frames

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.

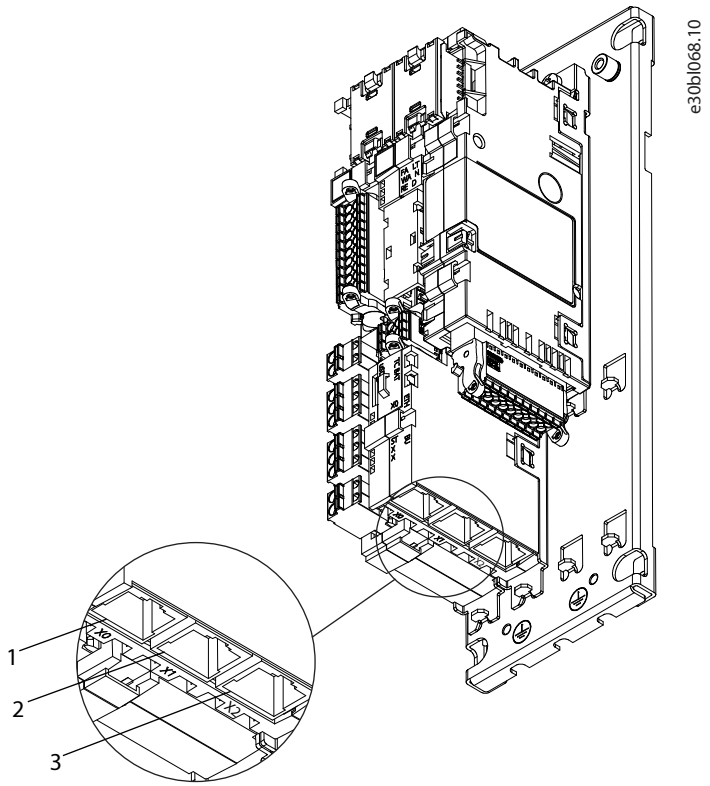


Figure 5: Communication Port X0, X1, and X2 Locations in the Modular Control Unit

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°.

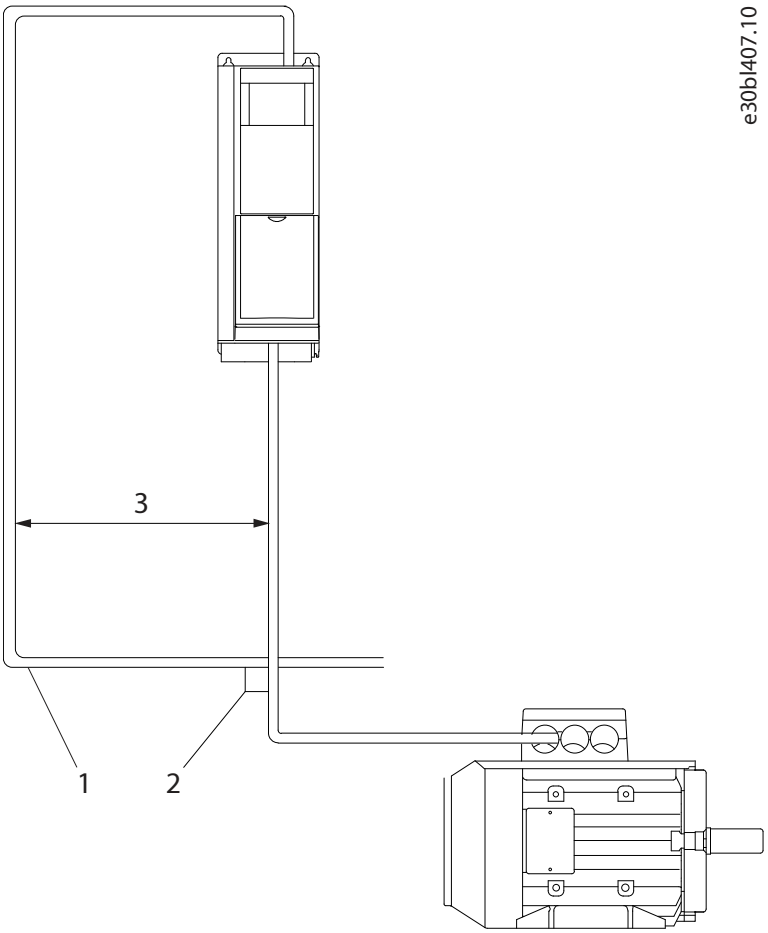


Figure 7: Cable Routing

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 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.

4.2 Reference and Main Actual Handling

The fieldbus speed reference scaling depends on the fieldbus profile, selected with parameter ***Fieldbus Profile*** (1301). For the profiles iC Generic, iC Speed and PROFIdrive Standard Telegram 1, the drive uses signal ***FB PCD Main Reference Value*** (1339) as the speed reference input, and a bidirectional linear scaling is applied.

Use parameter ***Fieldbus Speed Signal Max*** (6312) to define the maximum value of the incoming fieldbus signal and then set the corresponding speed value with parameter ***Fieldbus Speed Scale Max*** (6310). Likewise, set the minimum incoming value with parameter ***Fieldbus Speed Signal Min*** (6313) and the corresponding speed value with parameter ***Fieldbus Speed Scale Min*** (6311).

If CiA-402 Velocity Mode is selected as the fieldbus profile, signal ***FB PCD Speed Reference*** (1345) is used as the speed reference input, and it is limited with ***Fieldbus Speed Scale Max*** (6310) and ***Fieldbus Speed Scale Min*** (6311).

For details on the parameters, refer to iC7 Series Generator Application Guide (danfoss.com).

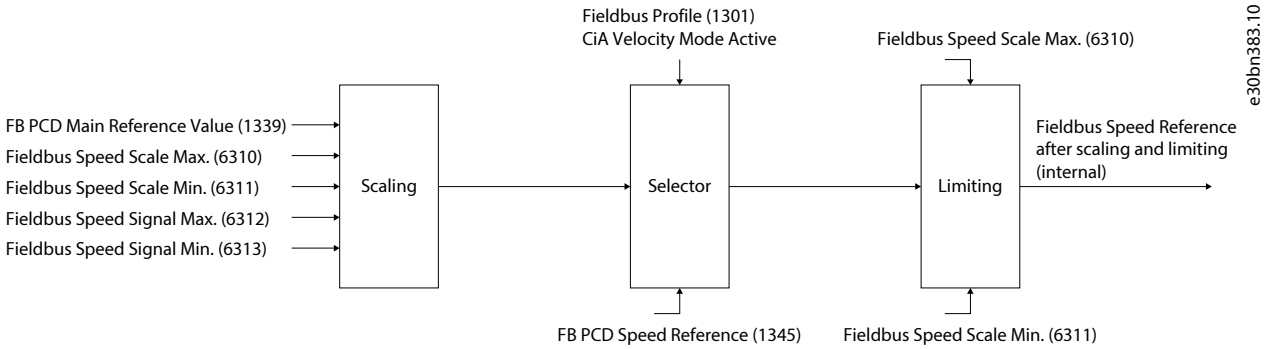


Figure 8: Fieldbus Speed Reference Scaling in the Generator Application

> IMPORTANT: The fieldbus signal scaling also applies to the interpretation of the fieldbus main actual value ***FB PCD Main Actual Value*** (1308). Whenever the parameter ***Fieldbus Profile*** (1301) is set to ***iC Speed*** or ***PROFIdrive® Standard Telegram 1***, the scaling is automatically set for the input values +32767/-32768 to correspond to speed values of +199.99%/-200.00% of motor nominal speed. For ***iC Generic***, the scaling is set to +10000/-10000 and +199.99%/-200.00%. Scaling is also set when the iC Generic, iC Speed, or PROFIdrive® Standard Telegram 1 profile is in use and ***Motor Nominal Frequency*** (403) is changed.

4.3 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.

4.4 Configuring Fieldbus Protection Settings for the DC/DC Converter Application

When using the iC7 series DC/DC Converter application, the fieldbus profile is selected automatically.

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

Table 16: Fieldbus Protection Setting Parameters for DC/DC Converter

Parameter	Parameter number	Value	Description
Fieldbus Fault Response	1304	• No response • Info • Warning • Fault (default) See Table 17 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 See Table 17 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	Select the response when a process data timeout occurs.
Process Data Timeout Delay	1340	50.0–3.4 x 10^{38} s (Default value: 1000.0 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.
Fieldbus Watchdog Response	5244	• No response • Info • Warning (default) • Fault	Select the drive 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 the startup delay time for activating the fieldbus watchdog event. The counter starts when the converter wakes up.

Table 17: Event Descriptions

Value	Description
No response	The event is ignored.
Info	The event is logged in the event log.

Table 17: Event Descriptions - (continued)

Value	Description
Warning	The drive or power converter issues a warning.
Fault	The drive or power converter issues a fault and modulation is stopped.

4.5 Configuring Fieldbus Protection Settings for the Grid Converter and Grid Converter with Grid Codes Applications

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

Table 18: Fieldbus Protection Setting Parameters for Grid Converter and Grid Converter with Grid Codes

Parameter	Parameter number	Value	Description
Fieldbus Fault Response	1304	• No response • Info • Warning • Warning, Current Lim. Ramp – Persistent • Fault (default) • Fault, Open MCB 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	1305	• No response (default) • Info • Warning • Warning, Current Lim. Ramp – Persistent • Fault • Fault, Open MCB See Table 19 for descriptions of the events.	Select the response if there is no fieldbus connection.
Process Data Timeout Response	1306	• No response • Info (default) • Warning • Warning, Current Lim. Ramp – Persistent • Fault • Fault, Open MCB See Table 19 for descriptions of the events.	Select the response to a process data timeout.
Process Data Timeout Delay	1340	50.0–3.4 x 10^{38} s (Default value: 1000.0 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 Grid Converter and Grid Converter with Grid Codes - (continued)

Parameter	Parameter number	Value	Description
Fieldbus Watchdog Response	5244	• No response • Info • Warning (default) • Warning, Current Lim. Ramp – Persistent • Fault • Fault, Open MCB	Select the drive 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 the startup delay time for activating the fieldbus watchdog event. The counter starts when the converter wakes up.

Table 19: Event Descriptions

Value	Description
No response	The event is ignored.
Info	The event is logged in the event log.
Warning	The drive or power converter issues a warning.
Warning, Current Lim. Ramp – Persistent	The drive or power converter issues a warning, and the positive/negative active current limits are ramped to preset values. The current limit overrides stay active until the warning is acknowledged by a reset.
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.

4.6 Configuring Fieldbus Protection Settings for the Generator Application

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

Table 20: Fieldbus Protection Setting Parameters for Generator

Parameter	Parameter number	Value	Description
Fieldbus Fault Response	1303	• No response • Info (default) • Warning • Warning, ramp to coast • Fault, coast See Table 21 for descriptions of the events.	Select the behavior when a fieldbus fault, for example, loss of I/O connection occurs.
Process Data Timeout Response	5291	• No response (default) • Info • Warning • Fault, ramp to coast • Fault, coast See Table 21 for descriptions of the events.	Select the response to a process data timeout.
Process Data Timeout Delay	1340	50.0–3.4 x 10^{38} s (Default value: 1000.0 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.
Fieldbus Watchdog Response	5244	• No response (default) • Info • Warning • Fault, ramp to coast • Fault, coast See Table 21 for descriptions of the events.	Select the drive response for the fieldbus watchdog event.
Fieldbus Watchdog Delay	5245	0.0–3000.0 (Default value: 5.0 s)	Set a delay for activating the fieldbus watchdog event.
Fieldbus Watchdog Start Delay	5246	0.0–3000.0 (Default value: 30.0 s)	Set a startup delay time for activating the fieldbus watchdog event. Counter begins when drive wakes up.
FB Monitoring Control Place Dependency	1338	• Disabled • Enabled (default)	Set the control place dependency for fieldbus monitoring functions (Fieldbus Fault, Process Data Timeout, and Fieldbus Watchdog). When enabled the monitoring functions are active only in the fieldbus control place. When disabled the functions are active regardless of control place.

Table 21: Event Descriptions

Value	Description
No response	The event is ignored.
Info	The event is logged in the event log.

Table 21: Event Descriptions - (continued)

Value	Description
Warning	The drive or power converter issues a warning.
Fault, ramp to coast	The drive or power converter issues a fault, and ramps the motor speed to 0 before stopping modulation.
Fault, coast	The drive or power converter issues a fault and modulation is stopped.

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.

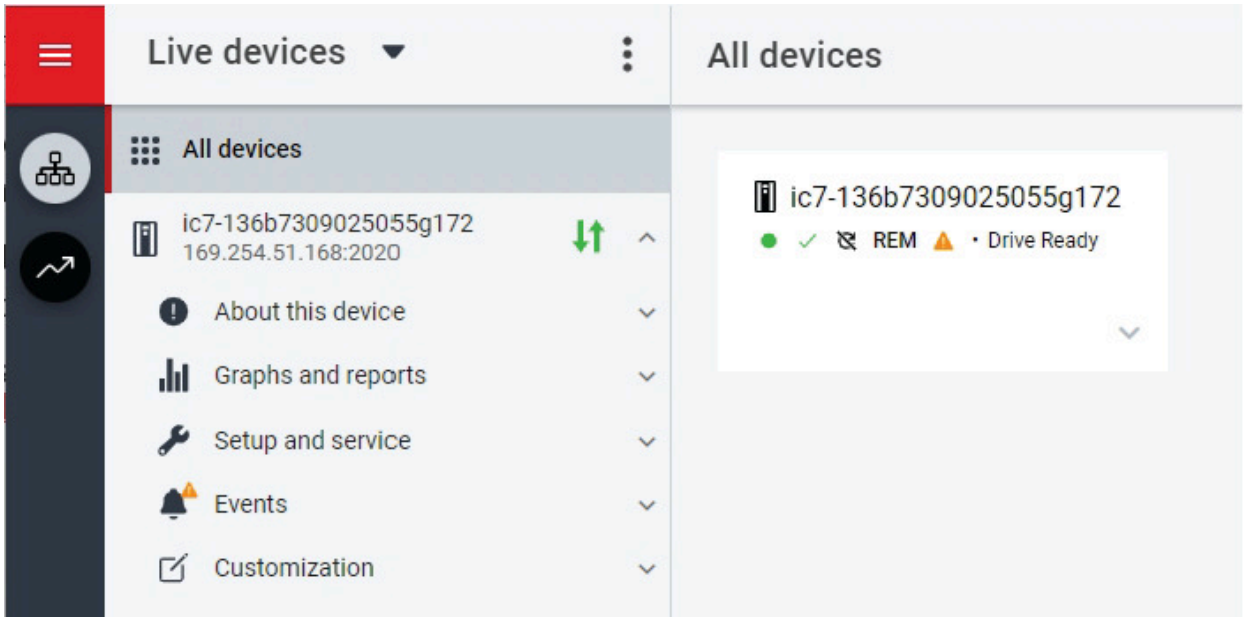


Figure 9: Connecting to a Drive with MyDrive® Insight

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

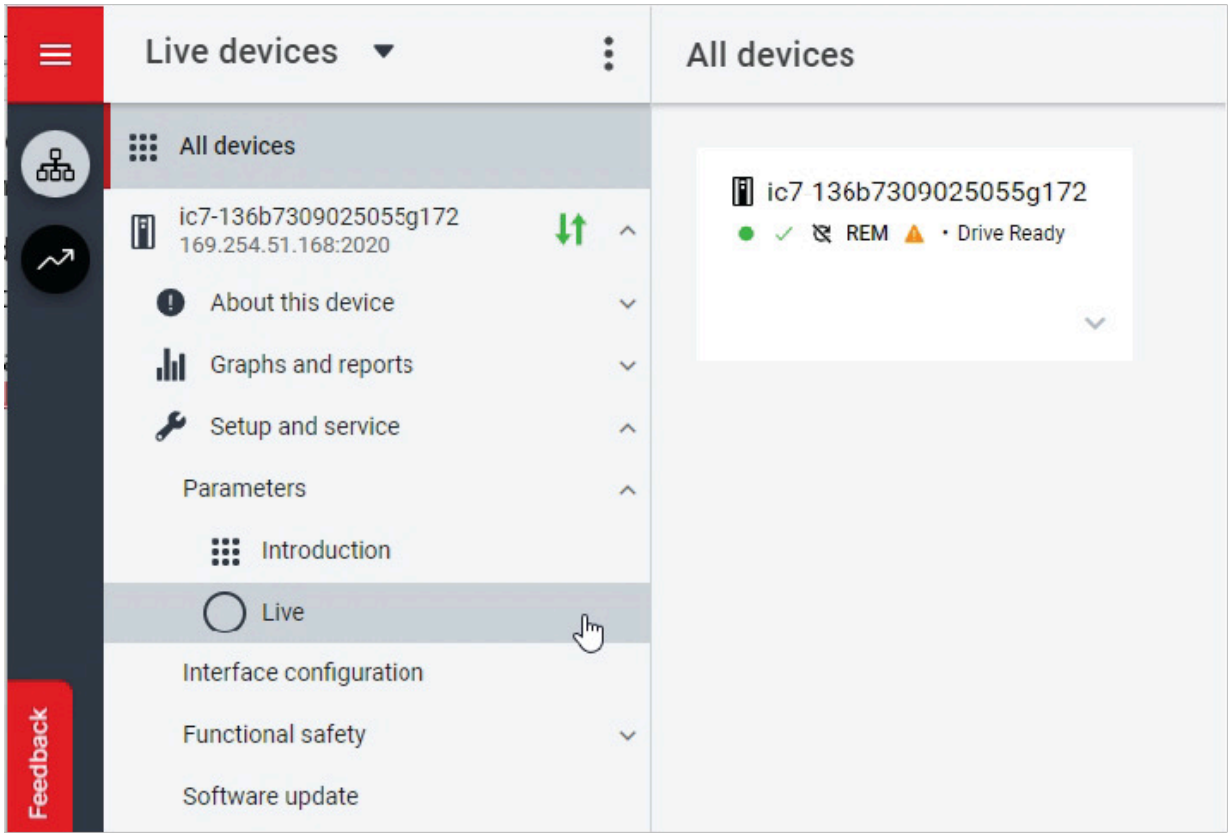
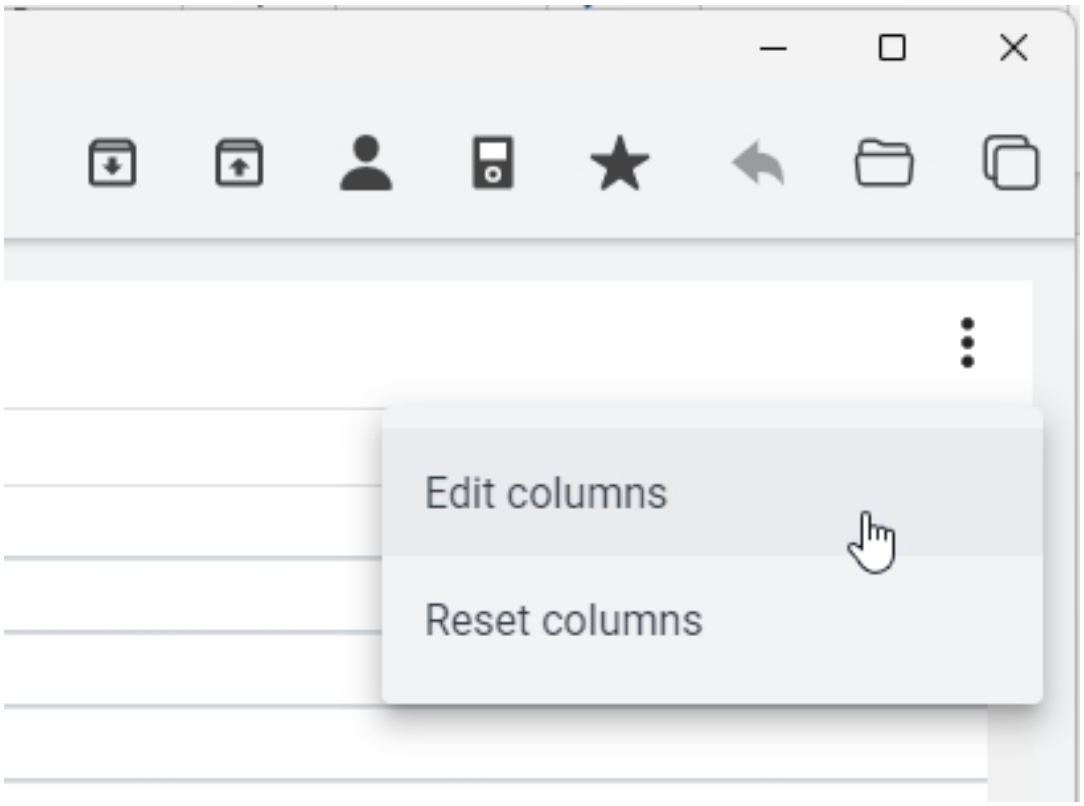


Figure 10: Live Parameters in MyDrive® Insight

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

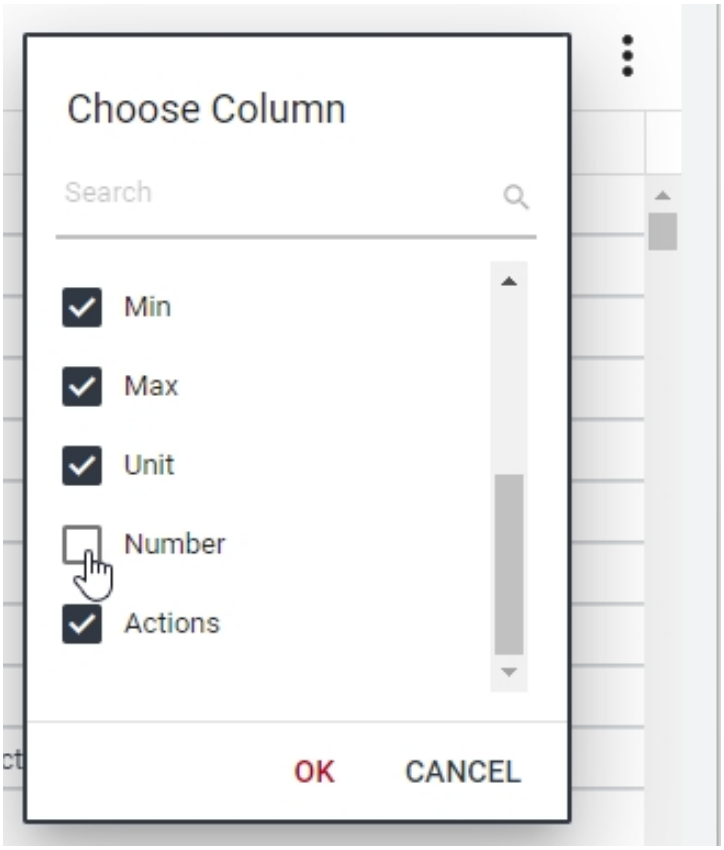
6. In the upper right corner, select the 3 dots and *Edit columns*.



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.

MAX	UNIT	NUMBER
590.0	Hz	9041
1000.0	V	9040
1000.0	V	9048
1000.0	V	9049
1000.0	V	9050
100.0	%	9047
100.0	%	9046
8.31	kW	9064
5		2942
2		2943

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.

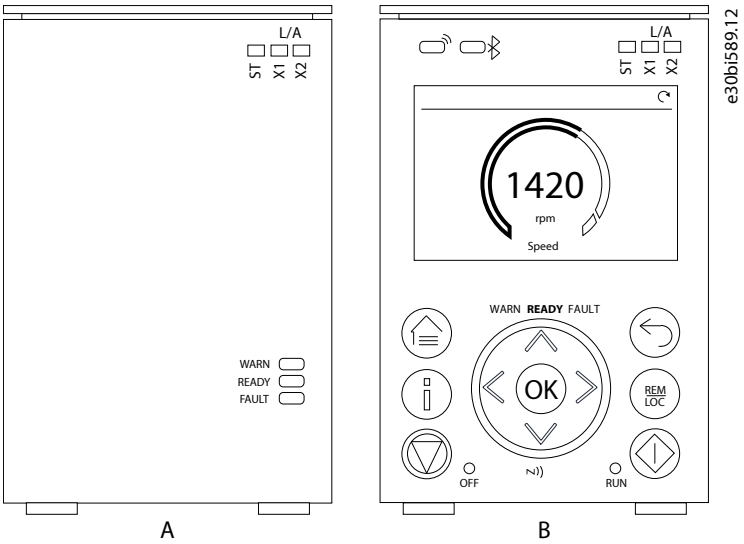


Figure 15: Fieldbus Indicator LEDs on Control Panel

A	Blind Panel	B	Control Panel 2.8

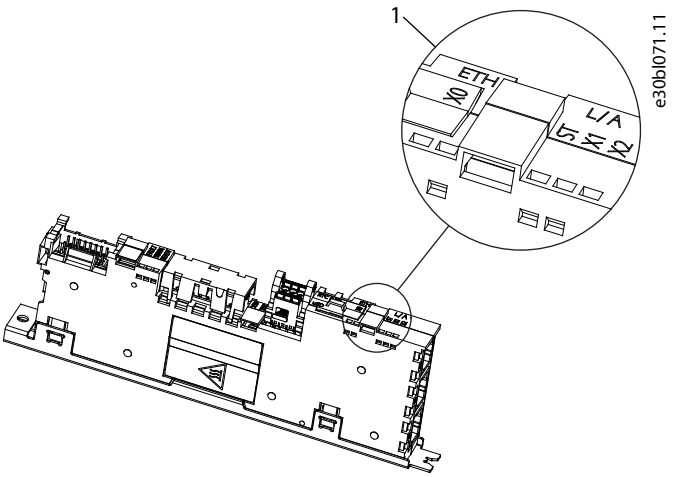


Figure 16: Fieldbus Indicator LEDs on Modular Control Board

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 22: 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 timeout	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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1 7 2 Z 2 2 2 4 A