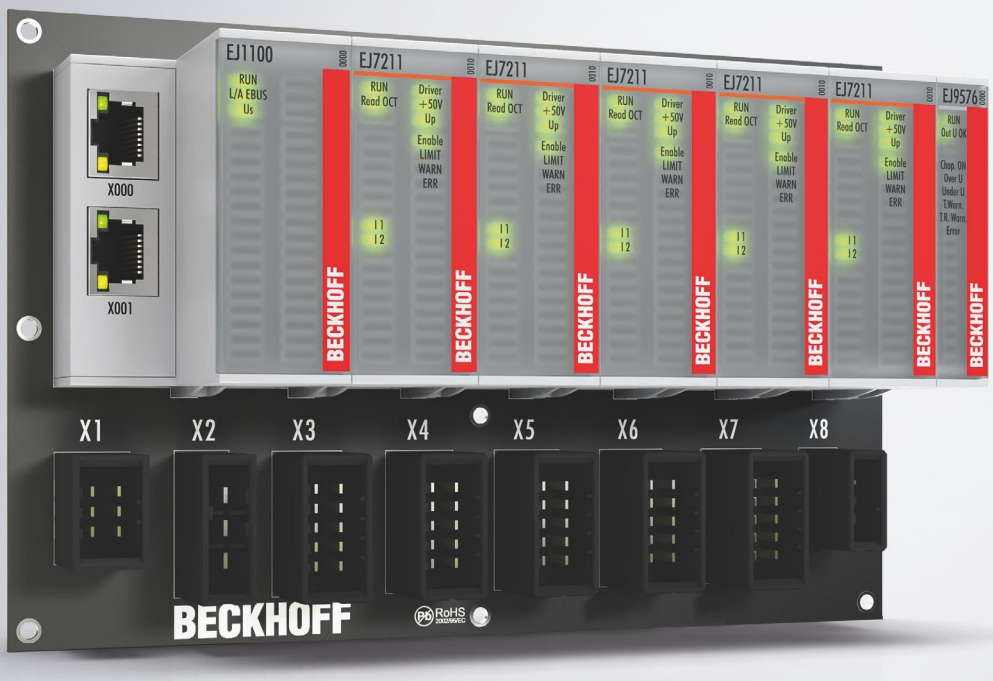
BECKHOFF New Automation Technology

Documentation | EN

EJ5021

1-channel encoder interface, SinCos, 1 Vpp



2023-02-10 | Version: 1.0

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1 Foreword

1.1 Notes on the documentation

Intended audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.
It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.
It is the duty of the technical personnel to use the documentation published at the respective time of each installation and commissioning.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

Disclaimer

The documentation has been prepared with care. The products described are, however, constantly under development.

We reserve the right to revise and change the documentation at any time and without prior announcement.

No claims for the modification of products that have already been supplied may be made on the basis of the data, diagrams and descriptions in this documentation.

Trademarks

Beckhoff®, TwinCAT®, TwinCAT/BSD®, TC/BSD®, EtherCAT®, EtherCAT G®, EtherCAT G10®, EtherCAT P®, Safety over EtherCAT®, TwinSAFE®, XFC®, XTS® and XPlanar® are registered trademarks of and licensed by Beckhoff Automation GmbH. Other designations used in this publication may be trademarks whose use by third parties for their own purposes could violate the rights of the owners.

Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

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

Copyright

1.2 Safety instructions

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Exclusion of liability

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

Description of instructions

In this documentation the following instructions are used.
These instructions must be read carefully and followed without fail!

⚠ DANGER

Serious risk of injury!

Failure to follow this safety instruction directly endangers the life and health of persons.

⚠ WARNING

Risk of injury!

Failure to follow this safety instruction endangers the life and health of persons.

⚠ CAUTION

Personal injuries!

Failure to follow this safety instruction can lead to injuries to persons.

NOTE

Damage to environment/equipment or data loss

Failure to follow this instruction can lead to environmental damage, equipment damage or data loss.

Tip or pointer

This symbol indicates information that contributes to better understanding.

1.3 Intended use

⚠ WARNING

Caution - Risk of injury!

EJ components may only be used for the purposes described below!

1.4 Signal distribution board

NOTE

Signal distribution board

Make sure that the EtherCAT plug-in modules are used only on a signal distribution board that has been developed and manufactured in accordance with the Design Guide.

1.5 Documentation issue status

Version	Comment
1.0	• First publication EJ5021

1.6 Guide through documentation

NOTE

Further components of documentation

The documentations named in the following table are further components of the complete documentation. These documentations are required for the use of EtherCAT plug-in modules.

No.	Title	Description
[1]	EtherCAT System Documentation	• System overview • EtherCAT basics • Cable redundancy • Hot Connect • Distributed Clocks • Configuration of EtherCAT-Components
[2]	Infrastructure for EtherCAT/Ethernet	• Technical recommendations and notes for design, implementation an testing
[3]	Design GuideSignal-Distribution-Board for standard EtherCAT plug-in modules	Requirements for the design of a Signal-Distribution-Board for standard EtherCAT plug-in modules • Backplane mounting guidelines • Module placement • Routing guidelines

1.7 Marking of EtherCAT plug-in modules

Designation

A Beckhoff EtherCAT device has a 14-digit **technical designation**, made up as follows (e.g. EJ1008-0000-0017)

- **Order identifier**
  - family key: EJ
  - product designation: The first digit of product designation is used for assignment to a product group (e.g. EJ2xxx = digital output module).
  - Version number: The four digit version number identifies different product variants.
- **Revision number:**
  It is incremented when changes are made to the product.

The Order identifier and the revision number are printed on the side of EtherCAT plug-in modules (s. following illustration (A and B).

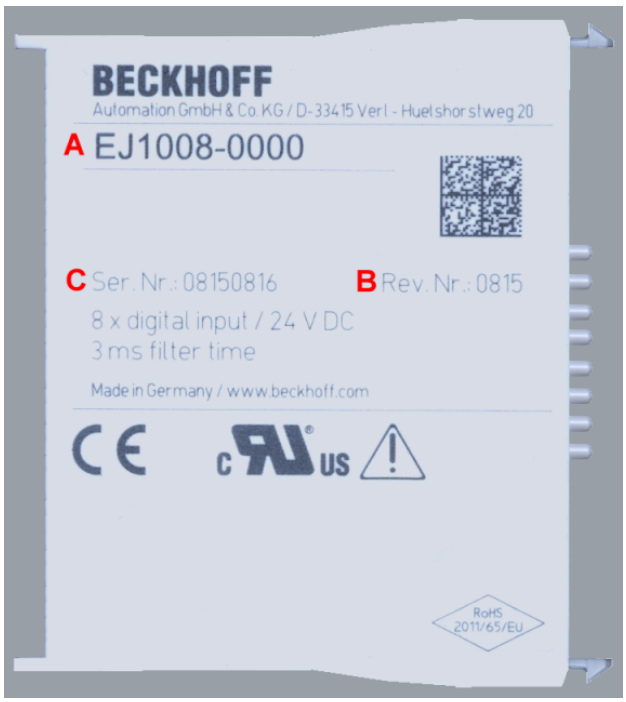


Fig. 1: Order identifier (A), Revision number (B) and serial number (C) using the example of EJ1008

Product group	Example		
	Product designation	Version	Revision
EtherCAT Coupler EJ11xx	EJ1101	-0022 (Coupler with external connectors, power supply module and optional ID switches	-0016
Digital input modules EJ1xxx	EJ1008 8-channel	-0000 (basic type)	-0017
Digital output modules EJ2xxx	EJ2521 1-channel	-0224 (2 x 24 V outputs)	-0016
Analog input modules EJ3xxx	EJ3318 8-channel thermocouple	-0000 (basic type)	-0017
Analog output modules EJ4xxx	EJ4134 4-channel	-0000 (basic type)	-0019
Special function modules EJ5xxx, EJ6xxx	EJ6224 IO-Link master	-0090 (with TwinSAFE SC)	-0016
Motion modules EJ7xxx	EJ7211 servomotor	-9414 (with ECT, STO and TwinSAFE SC)	-0029

Notes

- The elements mentioned above result in the **technical designation**. EJ1008-0000-0017 is used in the example below.
- EJ1008-0000 is the **order identifier**, in the case of “-0000” usually abbreviated to EJ1008.
- The **revision** -0017 shows the technical progress, such as the extension of features with regard to the EtherCAT communication, and is managed by Beckhoff.
  In principle, a device with a higher revision can replace a device with a lower revision, unless specified otherwise, e.g. in the documentation.
  Associated and synonymous with each revision there is usually a description (ESI, EtherCAT Slave Information) in the form of an XML file, which is available for download from the Beckhoff web site.
- The product designation, version and revision are read as decimal numbers, even if they are technically saved in hexadecimal.

Serial number

The serial number for EtherCAT plug-in modules is usually the 8-digit number printed on the side of the module (see following illustration C). The serial number indicates the configuration in delivery state and therefore refers to a whole production batch, without distinguishing the individual modules of a batch.

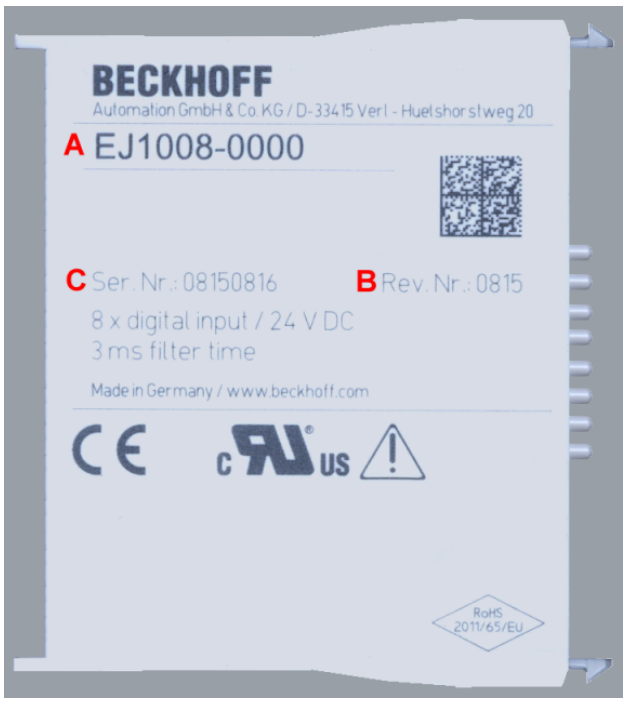


Fig. 2: Order identifier (A), revision number (B) and serial number (C) using the example of EJ1008

Serial number	Example serial number: 08 15 08 16
KK - week of production (CW, calendar week)	08 - week of production: 08
YY - year of production	15 - year of production: 2015
FF - firmware version	08 -f irmware version: 08
HH - hardware version	16 - hardware version: 16

1.7.1 Beckhoff Identification Code (BIC)

The **B**eckhoff **I**dentification **C**ode (BIC) is increasingly being applied to Beckhoff products to uniquely identify the product. The BIC is represented as a Data Matrix Code (DMC, code scheme ECC200), the content is based on the ANSI standard MH10.8.2-2016.

Fig. 3: BIC as data matrix code (DMC, code scheme ECC200)

The BIC will be introduced step by step across all product groups.

Depending on the product, it can be found in the following places:

- on the packaging unit
- directly on the product (if space suffices)
- on the packaging unit and the product

The BIC is machine-readable and contains information that can also be used by the customer for handling and product management.

Each piece of information can be uniquely identified using the so-called data identifier (ANSI MH10.8.2-2016). The data identifier is followed by a character string. Both together have a maximum length according to the table below. If the information is shorter, it shall be replaced by spaces. The data under positions 1-4 are always available.

The following information is contained:

Item no.	Type of information	Explanation	Data identifier	Number of digits incl. data identifier	Example
1	Beckhoff order number	**Beckhoff order number**	1P	8	1P072222
2	Beckhoff Traceability Number (BTN)	**Unique serial number, see note below**	S	12	SBTNk4p562d7
3	Article description	**Beckhoff article description, e.g. EL1008**	1K	32	1KEL1809
4	Quantity	**Quantity in packaging unit, e.g. 1, 10, etc.**	Q	6	Q1
5	Batch number	Optional: Year and week of production	2P	14	2P401503180016
6	ID/serial number	Optional: Present-day serial number system, e.g. with safety products	51S	12	51S678294104
7	Variant number	Optional: Product variant number on the basis of standard products	30P	32	30PF971 , 2*K183
...					

Further types of information and data identifiers are used by Beckhoff and serve internal processes.

Structure of the BIC

Example of composite information from items 1 - 4 and with the above given example value on positon 6. The data identifiers are marked in bold font for better display:

1P072222**S**BTNk4p562d7**1K**EL1809 **Q**1 **51S**678294

Accordingly as DMC:

Fig. 4: Example DMC **1P**072222**S**BTNk4p562d7**1K**EL1809 **Q**1 **51S**678294

BTN

An important component of the BIC is the Beckhoff Traceability Number (BTN, item no. 2). The BTN is a unique serial number consisting of eight characters that will replace all other serial number systems at Beckhoff in the long term (e.g. batch designations on IO components, previous serial number range for safety products, etc.). The BTN will also be introduced step by step, so it may happen that the BTN is not yet coded in the BIC.

NOTE

This information has been carefully prepared. However, the procedure described is constantly being further developed. We reserve the right to revise and change procedures and documentation at any time and without prior notice. No claims for changes can be made from the information, illustrations and descriptions in this information.

1.7.2 Electronic access to the BIC (eBIC)

Electronic BIC (eBIC)

The Beckhoff Identification Code (BIC) is applied to the outside of Beckhoff products in a visible place. If possible, it should also be electronically readable.

Decisive for the electronic readout is the interface via which the product can be electronically addressed.

K-bus devices (IP20, IP67)

Currently, no electronic storage and readout is planned for these devices.

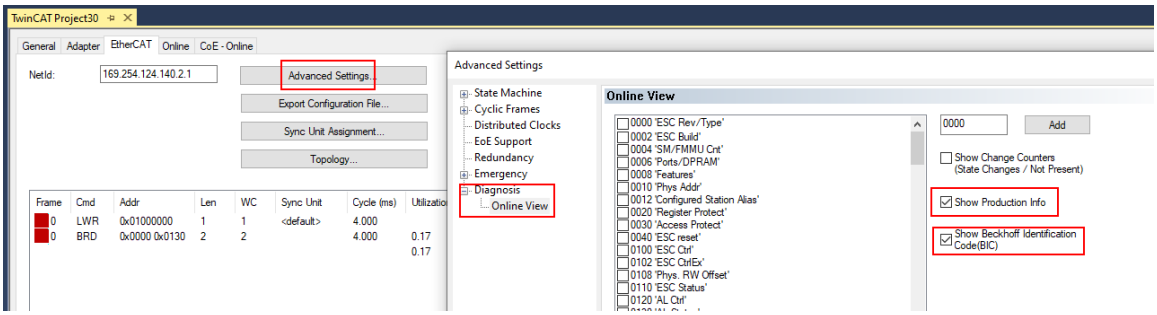
EtherCAT devices (IP20, IP67)

All Beckhoff EtherCAT devices have a so-called ESI-EEPROM, which contains the EtherCAT identity with the revision number. Stored in it is the EtherCAT slave information, also colloquially known as ESI/XML configuration file for the EtherCAT master. See the corresponding chapter in the EtherCAT system manual (Link) for the relationships.

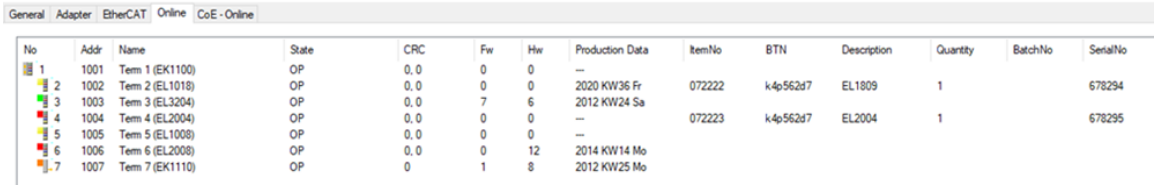
The eBIC is also stored in the ESI-EEPROM. The eBIC was introduced into the Beckhoff I/O production (terminals, box modules) from 2020; widespread implementation is expected in 2021.

The user can electronically access the eBIC (if existent) as follows:

- With all EtherCAT devices, the EtherCAT master (TwinCAT) can read the eBIC from the ESI-EEPROM
  - From TwinCAT 3.1 build 4024.11, the eBIC can be displayed in the online view.
  - To do this,
    check the checkbox "Show Beckhoff Identification Code (BIC)" under
    EtherCAT → Advanced Settings → Diagnostics:



  - The BTN and its contents are then displayed:



  - Note: as can be seen in the illustration, the production data HW version, FW version and production date, which have been programmed since 2012, can also be displayed with "Show Production Info".
  - From TwinCAT 3.1. build 4024.24 the functions *FB_EcReadBIC* and *FB_EcReadBTN* for reading into the PLC and further eBIC auxiliary functions are available in the Tc2_EtherCAT Library from v3.3.19.0.
- In the case of EtherCAT devices with CoE directory, the object 0x10E2:01 can additionally by used to display the device's own eBIC; the PLC can also simply access the information here:

- The device must be in PREOP/SAFEOP/OP for access:

Index	Name	Flags	Value
1000	Device type	RO	0x015E1389 (22942601)
1008	Device name	RO	ELM3704-0000
1009	Hardware version	RO	00
100A	Software version	RO	01
100B	Bootloader version	RO	J0.1.27.0
1011:0	Restore default parameters	RO	> 1 <
1018:0	Identity	RO	> 4 <
10E2:0	Manufacturer-specific Identification C...	RO	> 1 <
10E2:01	SubIndex 001	RO	1P158442SBTN0008jekp1KELM3704 Q1 2P482001000016
10F0:0	Backup parameter handling	RO	> 1 <
10F3:0	Diagnosis History	RO	> 21 <
10F8	Actual Time Stamp	RO	0x170bfb277e

- the object 0x10E2 will be introduced into stock products in the course of a necessary firmware revision.
- From TwinCAT 3.1. build 4024.24 the functions *FB_EcCoEReadBIC* and *FB_EcCoEReadBTN* for reading into the PLC and further eBIC auxiliary functions are available in the Tc2_EtherCAT Library from v3.3.19.0.

- Note: in the case of electronic further processing, the BTN is to be handled as a string(8); the identifier "SBTN" is not part of the BTN.
- Technical background
  The new BIC information is additionally written as a category in the ESI-EEPROM during the device production. The structure of the ESI content is largely dictated by the ETG specifications, therefore the additional vendor-specific content is stored with the help of a category according to ETG.2010. ID 03 indicates to all EtherCAT masters that they must not overwrite these data in case of an update or restore the data after an ESI update.
  The structure follows the content of the BIC, see there. This results in a memory requirement of approx. 50..200 bytes in the EEPROM.
- Special cases
  - If multiple, hierarchically arranged ESCs are installed in a device, only the top-level ESC carries the eBIC Information.
  - If multiple, non-hierarchically arranged ESCs are installed in a device, all ESCs carry the eBIC Information.
  - If the device consists of several sub-devices with their own identity, but only the top-level device is accessible via EtherCAT, the eBIC of the top-level device is located in the CoE object directory 0x10E2:01 and the eBICs of the sub-devices follow in 0x10E2:nn.

Profibus/Profinet/DeviceNet... Devices

Currently, no electronic storage and readout is planned for these devices.

1.7.3 Certificates

- The EhterCAT plug-in modules meet the requirements of the EMC and Low Voltage Directive. The CE mark is printed on the side of the modules.
- The cRUus imprint identifies devices that meet product safety requirements according to U.S. and Canadian regulations.
- The warning symbol is a request to read the corresponding documentation. The documentations for EtherCAT plug-in modules can be downloaded from the Beckhoff homepage.

Fig. 5: Marking for CE and UL using EJ1008 as an example

2 System overview

Electronically, the EJxxxx EtherCAT plug-in modules are based on the EtherCAT I/O system. The EJ system consists of the signal distribution board and EtherCAT plug-in modules. It is also possible to connect an IPC to the EJ system.
The EJ system is suitable for mass production applications, applications with small footprint and applications requiring a low total weight.
The machine complexity can be extended by means of the following:

- reserve slots,
- the use of placeholder modules,
- linking of EtherCAT Terminals and EtherCAT Boxes via an EtherCAT connection.

The following diagram illustrates an EJ system. The components shown are schematic, to illustrate the functionality.

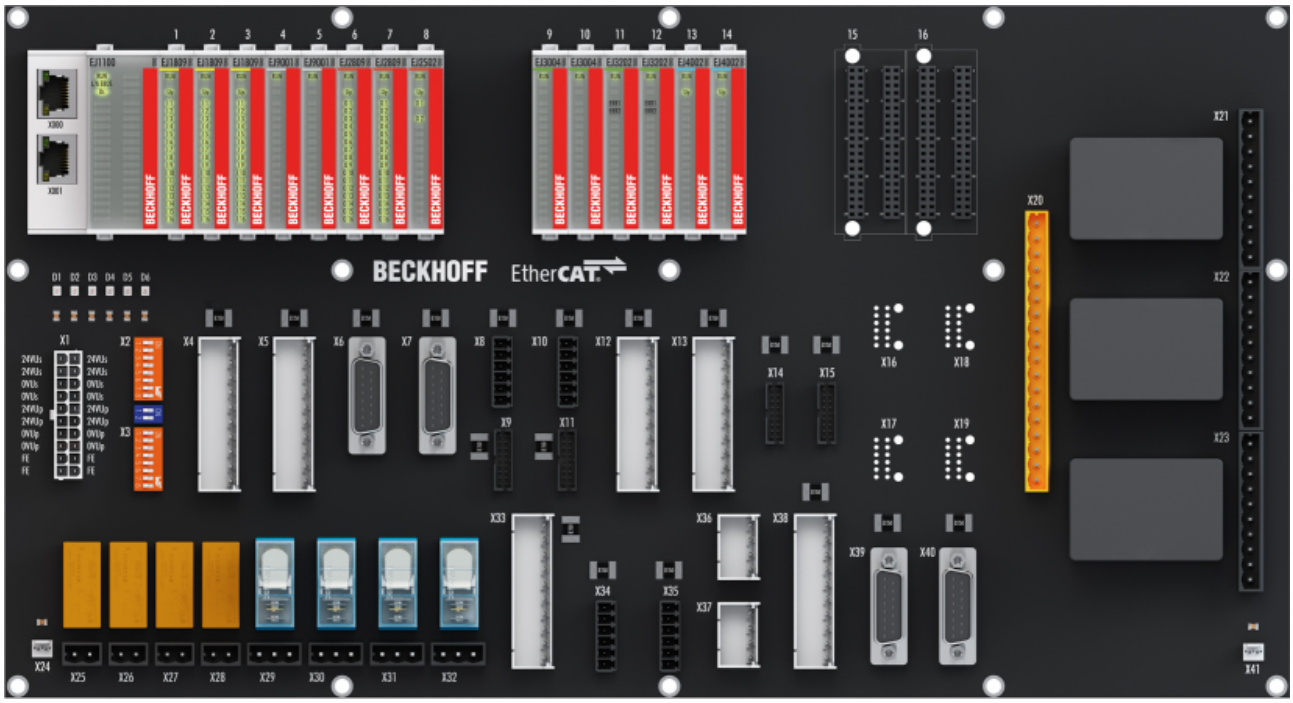


Fig. 6: EJ system sample

Signal distribution board

The signal distribution board distributes the signals and the power supply to individual application-specific plug connectors, in order to connect the controller to further machine modules. Using pre-assembled cable harnesses avoids the need for time-consuming connection of individual wires. Coded components reduce the unit costs and the risk of miswiring.
Beckhoff offers development of signal distribution boards as an engineering service. Customers have the option to develop their own signal distribution board, based on the design guide.

EtherCAT plug-in modules

Similar to the EtherCAT Terminal system, a module strand consists of a bus coupler and I/O modules. Almost all of the EtherCAT Terminals can also be manufactured in the EJ design as EtherCAT plug-in modules. The EJ modules are directly attached to the signal distribution board. The communication, signal distribution and supply take place via the contact pins at the rear of the modules and the PCB tracks of the signal distribution board. The coding pins at the rear serve as mechanical protection against incorrect connection. Color coding on the housing facilitates distinguishing of the modules.

3 EJ5021 - Product description

3.1 Introduction

Fig. 7: EJ5021

Incremental encoder interface

The EJ5021 EtherCAT plug-in module is an interface for direct connection of a measuring probe or encoder with sinusoidal, differential voltage output 1 V_{SS}. Input frequencies of max. 250 kHz can be evaluated.
The current counter value can be zeroed (reset) or stored separately via the C track of the encoder, which is also called reference mark.

The encoder is supplied with 5 V directly via the signal distribution board. The 5 V encoder operating voltage is generated from the 24 V Up.

The EJ5021 EtherCAT plug-in module has an amplitude and frequency error detection of the input signals.

The analog input signal is processed, interpolated and made available as a 32-bit counter value. The counter value consists of the number of whole periods, max. 24 bits, and the value within one sine period, with max. 13-bit resolution. Additionally the EJ5021 EtherCAT plug-in module provides an internal frequency measurement.

It supports via the high precision EtherCAT distributed clocks (DC), the synchronous reading of the encoder value together with other input data in the EtherCAT system. The use of encoder profiles allows an easy and fast linking of the process data to the Motion Control application.

3.2 Technical data

Encoder	EJ5021
Technology	Sine/cosine encoder interface for differential 1-V_{PP} signal
Number of channels	1
Encoder connection	SIN+, SIN- COS+, COS- ZERO+, ZERO- Level: nominal 1 V_{PP} (0.6 ... 1.2 V_{PP}), averaged voltage to GND: 2.5 V ***Note*** **Unipolar SinCos signals (i.e. without SIN-, COS- or ZERO-) are recognized as wire break/amplitude error.**
Position specification	32 bits (period counter + period portion, adjustable)
Period counter	19 ... 24 bits according to setting, default: 22 bits
Period resolution	8 ... 13 bits (256 ... 8192 steps per period), depending on input frequency, automatic resolution reduction depending on input frequency, default: 10 bits
Input frequency	250 kHz at 10 bits (sampling rate 70 MHz)

Function and communication	EJ5021
Min. sampling rate/cycle time	80 µs
Sampling	EtherCAT-synchronously or Distributed Clocks triggered
Distributed Clocks	Yes
Special features	• Latch, • Reset, • Change counting direction, • Amplitude and frequency error detection, • Frequency-dependent period resolution, • Period counter max. 24 bits

Supply and potentials	EJ5021
Power supply	24 V_{DC} (-15 %/+20 %)
Encoder operating voltage	5 V_{DC}, max. 0.5 A (generated from Up 24 V_{DC})
Current consumption from 24V U_P contact	50 mA typ. + load
Current consumption via E-bus	120 mA typ.
Electrical isolation	500 V (E-bus/field voltage)

Environmental conditions	EJ5021
Permissible ambient temperature range during operation	0 °C... 55 °C
Permissible ambient temperature range during storage	-25 °C... + 85 °C
Permissible relative air humidity	95 %, no condensation
Operating altitude	max. 2,000 m

General data	EJ5021
Dimensions (W x H x D)	approx. 12 mm x 66 mm x 55 mm
Weight	approx. 30 g
Mounting	on signal distribution board
Degree of pollution	2
Installation position	Standard [▶ 27]
Position of the coding pins [▶ 30]	2 and 5
Color coding	gray

Standards and approvals	EJ5021
Vibration/shock resistance	conforms to EN 60068-2-6/EN 60068-2-27 (with corresponding signal distribution board)
EMC immunity/emission	conforms to EN 61000-6-2 /EN 61000-6-4 (with corresponding signal distribution board)
Protection rating	EJ module: IP20 EJ system: dependent on the signal distribution board and housing
Approvals/markings*	CE, UKCA

*) Real applicable approvals/markings see type plate on the side (product marking).

CE approval

The CE Marking refers to the EtherCAT plug-in module mentioned above.
If the EtherCAT plug-in module is used in the production of a ready-to-use end product (PCB in conjunction with a housing), the manufacturer of the end product must check compliance of the overall system with relevant directives and CE certification.
To operate the EtherCAT plug-in modules, they must be installed in a housing.

3.3 Pinout

EJ5021				
Pin#		Signal		
1	2	U_{EBUS}	U_{EBUS}	**E-Bus contacts** The power supply U_{EBUS} is provided by the coupler and supplied from the supply voltage U_S of the EtherCAT coupler.
3	4	GND	GND	
5	6	RX0+	TX1+	
7	8	RX0-	TX1-	
9	10	GND	GND	
11	12	TX0+	RX1+	
13	14	TX0-	RX1-	
15	16	GND	GND	
17	18	SIN+	COS+	**Signals and power supply of the sensor**
19	20	SIN-	COS-	
21	22	ZERO+	5V Sensor	
23	24	ZERO-	GND Sensor	
25	26	NC	NC	
27	28	NC	NC	
29	30	NC	NC	
31	32	NC	NC	
33	34	0V Up	0V Up	**U_P-Contacts** The peripheral voltage U_P supplies the electronics on the field side.
35	36	0V Up	24V Up	
37	38	24V Up	24V Up	
39	40	SGND	SGND	

Signal	Description
U_{EBUS}	E-Bus power supply 3.3 V
GND	E-Bus GND signal. Don`t connect with 0V Up!
RXn+	Positive E-Bus receive signal
RXn-	Negative E-Bus receive signal
TXn+	Positive E-Bus transmit signal
TXn-	Negative E-Bus transmit signal
SIN+	Encoder-Input A
SIN-	Encoder-Input A
COS+	Encoder-Input B
COS-	Encoder-Input B
ZERO+	Encoder-Input C
ZERO-	Encoder-Input C
5V Sensor	5 V Encoder Supply
GND Sensor	0 V Encoder Supply
NC	Do not connect
0V Up	Field side GND signal
24V Up	Field side power supply 24 V
SGND	Shield Ground

Fig. 8: EJ5021 - Connection

The PCB footprint can be downloaded from the Beckhoff homepage

NOTE

Damage to devices possible!

- The pins named with “NC” must not be connected.
- Before installation and commissioning read the chapters Installation of EJ modules [▶ 23] and Commissioning [▶ 39]!

Differential inputs

The differential inputs SIN+/SIN-, COS+/COS- and ZERO+/ZERO- are internally provided with a 120 ohm termination resistor.

The differential signals are each expected with a 1 Vpp level with a 2.5 V averaged voltage relative to the encoder supply voltage.

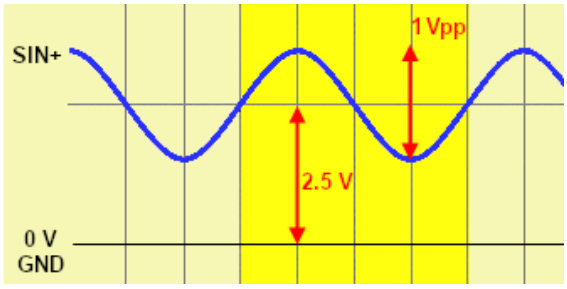


Fig. 9: typ. signal connection values

3.4 LEDs

LED No.	EJ5021
A	RUN
B	
C	Up (5V)
1	Period
2	C
3	Error
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	
16	

Fig. 10: EJ5021 - LEDs

LED	Color	Description	
RUN	green	off	State of the EtherCAT State Machine: **INIT** = initialization of the plug-in module
		flashing	State of the EtherCAT State Machine: **PREOP** = function for mailbox communication and different default settings set
		single flash	State of the EtherCAT State Machine: **SAFEOP** = verification of the Sync Manager channels and the distributed clocks. Outputs remain in safe state
		on	State of the EtherCAT State Machine: **OP** = normal operating state; mailbox and process data communication is possible
		flickering	State of the EtherCAT State Machine: **BOOTSTRAP** = function for Firmware updates of the plug-in module
Up (5V)	green	off	Supply voltage incremental encoder (5 V_{DC}) not present
		on	Supply voltage incremental encoder (5 V_{DC}) present
Period	green	Change of state of the Period LED on each period counted	
C	green	State of the encoder input C	
Error	red	Error display, equivalent to PDO error	

4 Installation of EJ modules

4.1 Power supply for the EtherCAT plug-in modules

⚠ WARNING

Power supply from SELV/PELV power supply unit!

SELV/PELV circuits (Safety Extra Low Voltage, Protective Extra Low Voltage) according to IEC 61010-2-201 must be used to supply this device.

Notes:

- SELV/PELV circuits may give rise to further requirements from standards such as IEC 60204-1 et al, for example with regard to cable spacing and insulation.
- A SELV (Safety Extra Low Voltage) supply provides safe electrical isolation and limitation of the voltage without a connection to the protective conductor,
  a PELV (Protective Extra Low Voltage) supply also requires a safe connection to the protective conductor.

The signal distribution board should have a power supply designed for the maximum possible current load of the module string. Information on the current required from the E-bus supply can be found for each module in the respective documentation in section “Technical data”, online and in the catalog. The power requirement of the module string is displayed in the TwinCAT System Manager.

E-bus power supply with EJ1100 or EJ1101-0022 and EJ940x

The EJ1100 Bus Coupler supplies the connected EJ modules with the E-bus system voltage of 3.3 V. The Coupler can accommodate a load up to 2.2 A. If a higher current is required, a combination of the coupler EJ1101-0022 and the power supply units EJ9400 (2.5 A) or EJ9404 (12 A) should be used. The EJ940x power supply units can be used as additional supply modules in the module string.

Depending on the application, the following combinations for the E-bus supply are available:

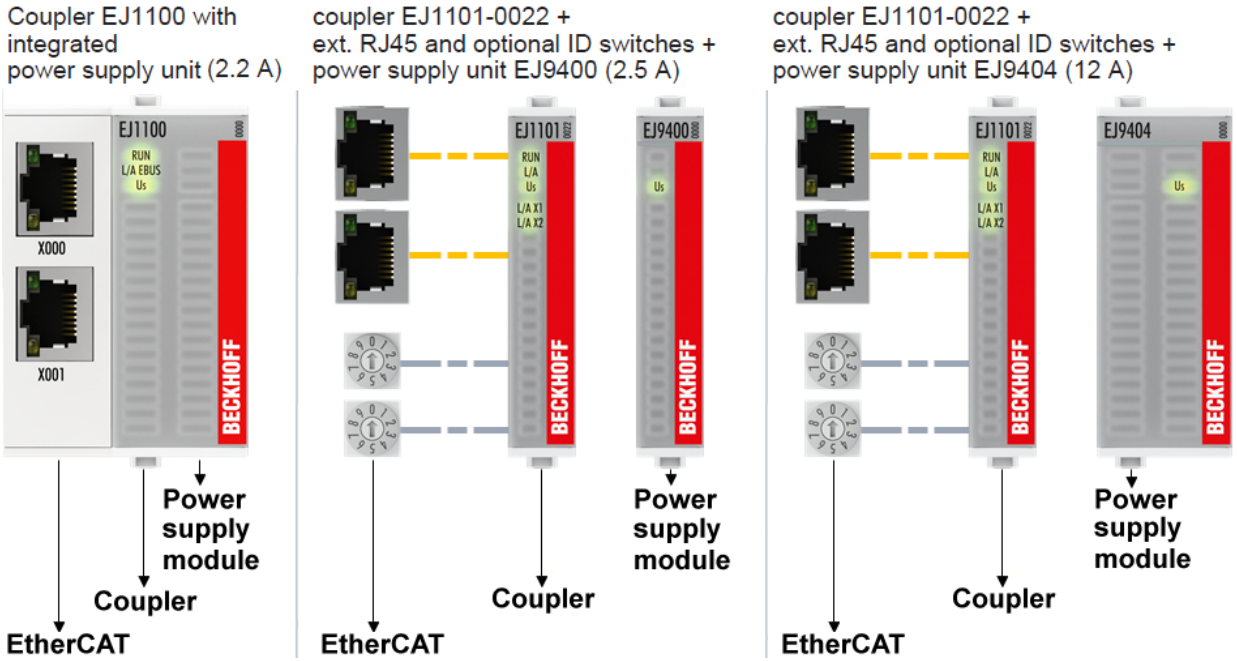


Fig. 11: E-bus power supply with EJ1100 or EJ1101-0022 + EJ940x

In the EJ1101-0022 coupler, the RJ45 connectors and optional ID switches are external and can be positioned anywhere on the signal distribution board, as required. This facilitates feeding through a housing.

The EJ940x power supply plug-in modules provide an optional reset function (see chapter Connection of the documentation for EJ9400 and EJ9404)

E-bus power supply with CXxxxx and EK1110-004x

The Embedded PC supplies the attached EtherCAT Terminals and the EtherCAT EJ coupler

- with a supply voltage Us of 24 V_{DC} (-15 %/+20%). This voltage supplies the E-bus and the bus terminal electronics.
  The CXxxxx units supply the E-bus with up to 2,000 mA E-bus current. If a higher current is required due to the attached terminals, power feed terminals or power supply plug-in modules must be used for the E-bus supply.
- with a peripheral voltage Up of 24 V_{DC} to supply the field electronics.

The EK1110-004x EtherCAT EJ couplers relay the following parameters to the signal distribution board via the rear connector:

- the E-bus signals,
- the E-bus voltage U_{EBUS} (3.3 V) and
- the peripheral voltage U_P (24 V_{DC}).

Fig. 12: PCB with Embedded PC, EK1110-0043 and EJxxxx, rear view EK1110-0043

4.2 EJxxxx - dimensions

The EJ modules are compact and lightweight thanks to their design. Their volume is approx. 50% smaller than the volume of the EL terminals. A distinction is made between four different module types, depending on the width and the height:

Module type	Dimensions (W x H x D)	Sample in figure below
Coupler	44 mm x 66 mm x 55 mm	EJ1100 (ej_44_2xrj45_coupler)
Single module	12 mm x 66 mm x 55 mm	EJ1809 (ej_12_16pin_code13)
Double module	24 mm x 66 mm x 55 mm	EJ7342 (ej_24_2x16pin_code18)
Single module (long)	12 mm x 152 mm x 55 mm	EJ1957 (ej_12_2x16pin_extended_code4747)

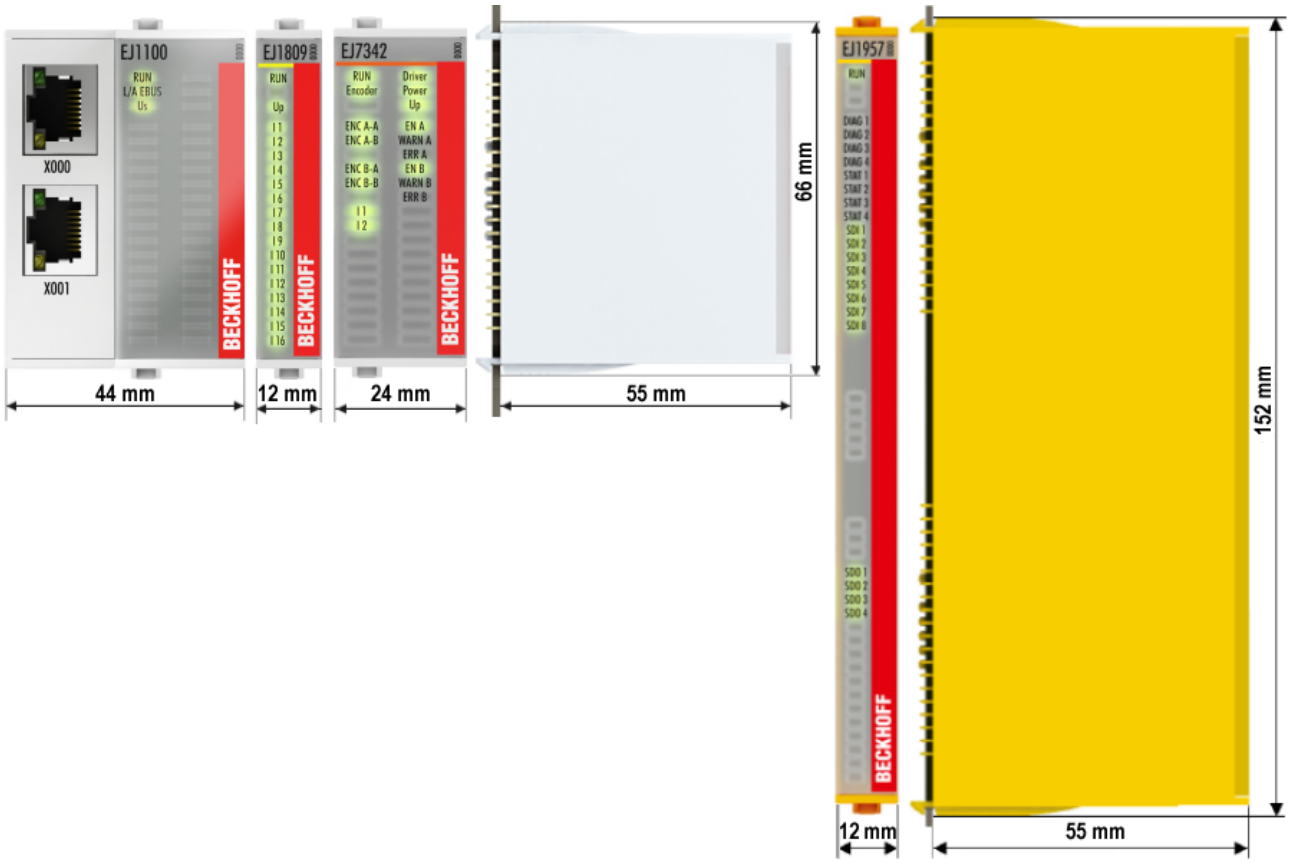


Fig. 13: EJxxxx - Dimensions

The technical drawings can be downloaded from the Beckhoff homepage. The drawings are named as described in the drawing below.

Fig. 14: Naming of the technical drawings

4.3 Installation positions and minimum distances

4.3.1 Minimum distances for ensuring installability

Note the dimensions shown in the following diagram for the design of the signal distribution board to ensure safe latching and simple assembly / disassembly of the modules.

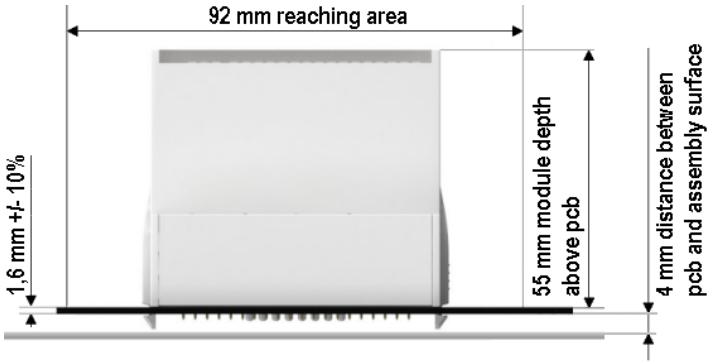


Fig. 15: Mounting distances EJ module - PCB

Observing the reaching area

A minimum reaching area of 92 mm is required for assembly / disassembly, in order to be able to reach the mounting tabs with the fingers.
Adherence to the recommended minimum distances for ventilation (see section Installation position [▶ 27]) ensures an adequate reaching area.

The signal distribution board must have a thickness of 1.6 mm and a minimum distance of 4 mm from the mounting surface, in order to ensure latching of the modules on the board.

4.3.2 Installation positions

NOTE

Constraints regarding installation position and operating temperature range

Please refer to the technical data [▶ 18] for the installed components to ascertain whether any restrictions regarding the mounting position and/or the operating temperature range have been specified. During installation of modules with increased thermal dissipation, ensure adequate distance above and below the modules to other components in order to ensure adequate ventilation of the modules during operation!

The standard installation position is recommended. If a different installation position is used, check whether additional ventilation measures are required.

Ensure that the specified conditions (see Technical data) are adhered to!

Optimum installation position (standard)

For the optimum installation position the signal distribution board is installed horizontally, and the fronts of the EJ modules face forward (see Fig. *Recommended distances for standard installation position*). The modules are ventilated from below, which enables optimum cooling of the electronics through convection. “From below” is relative to the acceleration of gravity.

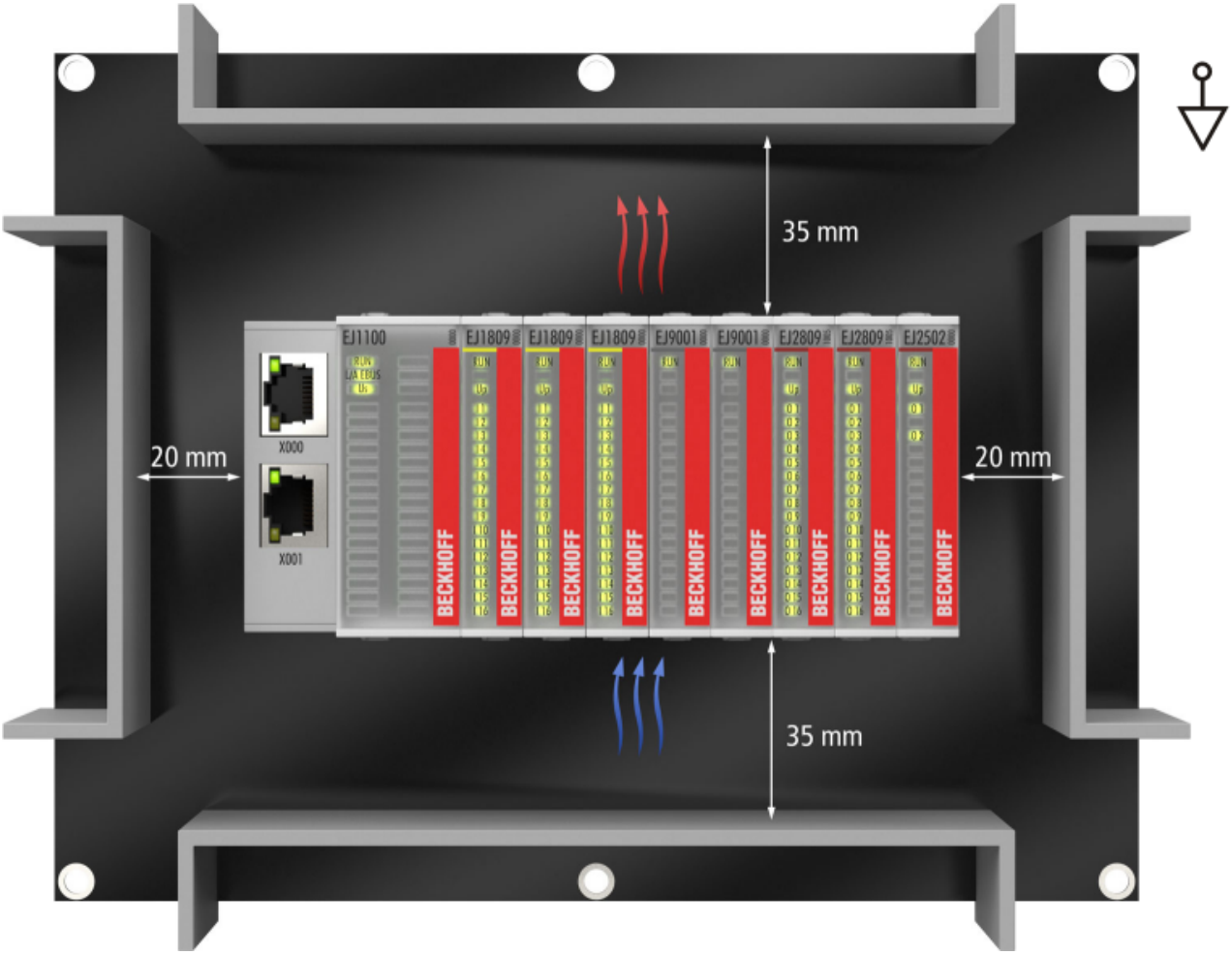


Fig. 16: Recommended distances for standard installation position

Compliance with the distances shown in Fig. *Recommended distances for standard installation position* is recommend. The recommended minimum distances should not be regarded as restricted areas for other components. The customer is responsible for verifying compliance with the environmental conditions described in the technical data. Additional cooling measures must be provided, if required.

Other installation positions

All other installation positions are characterized by a different spatial position of the signal distribution board, see Fig. *Other installation positions.*

The minimum distances to ambient specified above also apply to these installation positions.

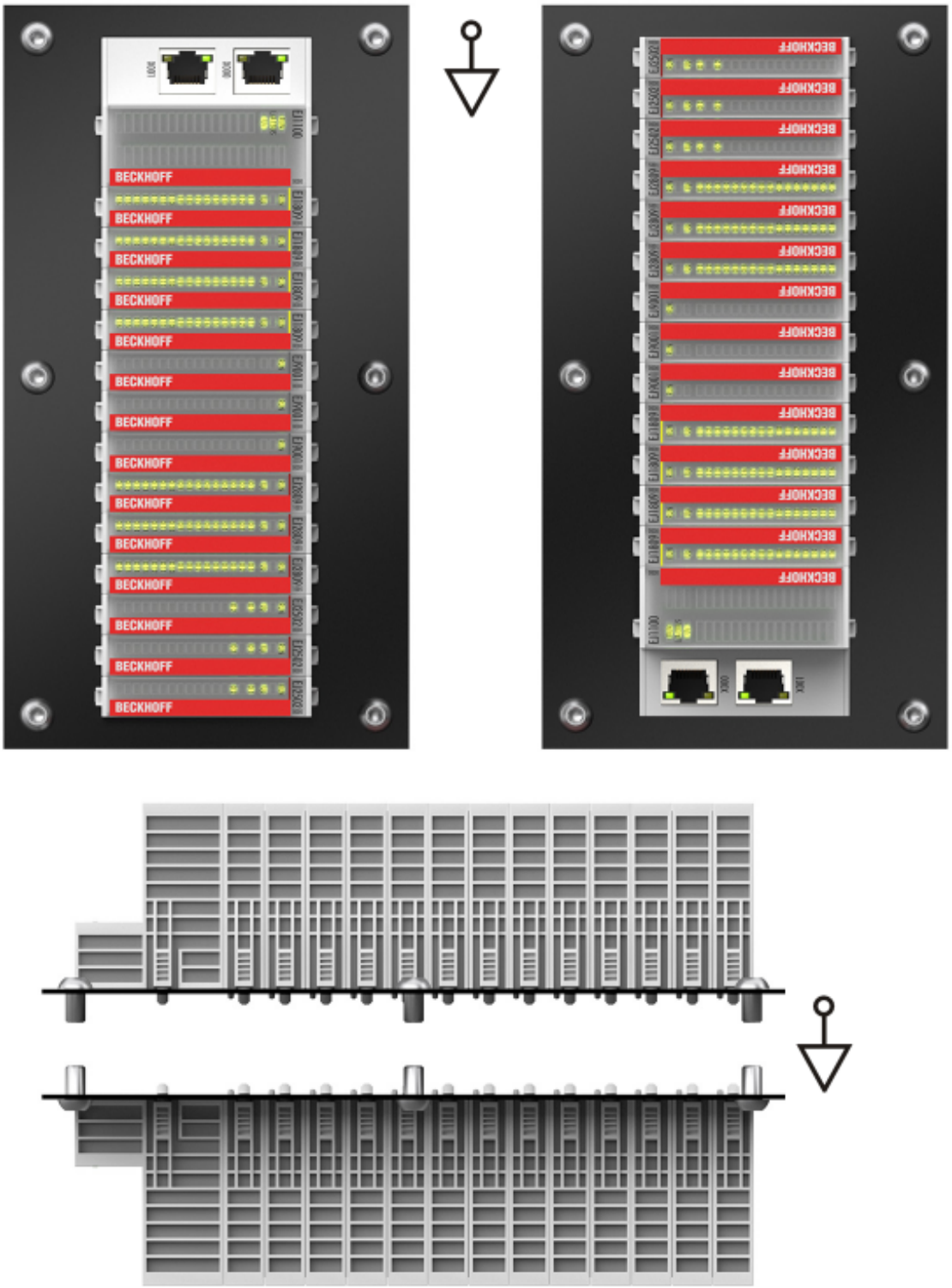


Fig. 17: Other installation positions

4.4 Codings

4.4.1 Color coding

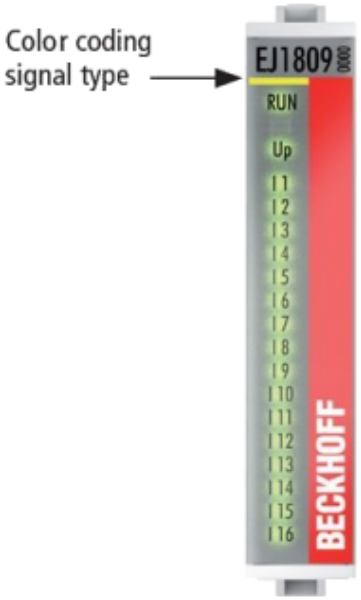


Fig. 18: EJ modules color code; sample: EJ1809

The EJ modules are color-coded for a better overview in the control cabinet (see diagram above). The color code indicates the signal type. The following table provides an overview of the signal types with corresponding color coding.

Signal type	Modules	Color
Coupler	EJ11xx	No color coding
Digital input	EJ1xxx	Yellow
Digital output	EJ2xxx	Red
Analog input	EJ3xxx	Green
Analog output	EJ4xxx	Blue
Position measurement	EJ5xxx	grey
Communication	EJ6xxx	grey
Motion	EJ7xxx	orange
System	EJ9xxx	grey

4.4.2 Mechanical position coding

The modules have two signal-specific coding pins on the underside (see Figs. B1 and B2 below). In conjunction with the coding holes in the signal distribution board (see Figs. A1 and A2 below), the coding pins provide an option for mechanical protection against incorrect connection. This significantly reduces the risk of error during installation and service.
Couplers and placeholder modules have no coding pins.

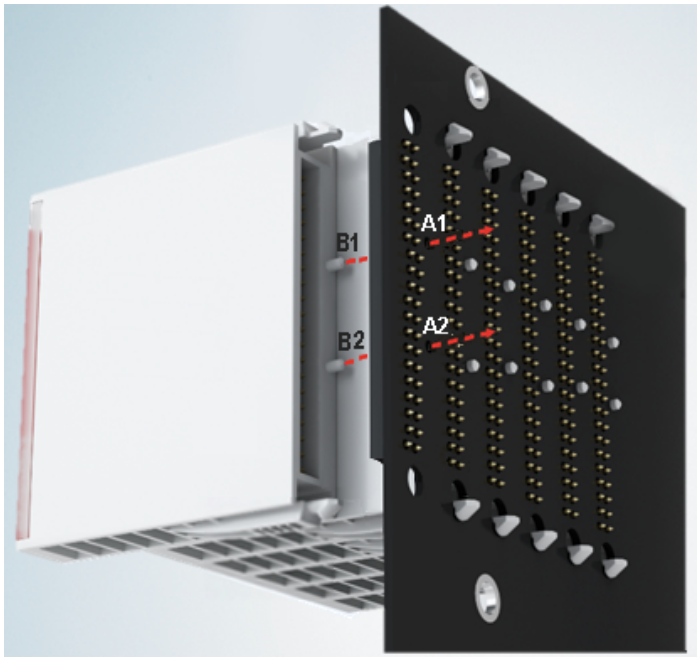


Fig. 19: Mechanical position coding with coding pins (B1 and B2) and coding holes (A1 and A2)

The following diagram shows the position of the position coding with position numbers on the left-hand side. Modules with the same signal type have the same coding. For sample, all digital input modules have the coding pins at positions one and three. There is no plug protection between modules with the same signal type. During installation the module type should therefore be verified based on the device name.

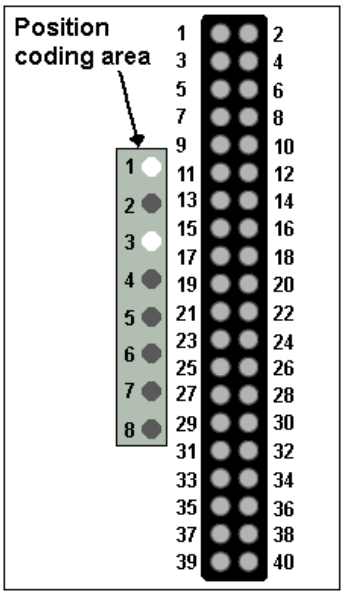


Fig. 20: Pin coding; sample: digital input modules

4.5 Installation on the signal distribution board

EJ modules are installed on the signal distribution board. The electrical connections between coupler and EJ modules are realized via the pin contacts and the signal distribution board.

The EJ components must be installed in a control cabinet or enclosure which must provide protection against fire hazards, environmental conditions and mechanical impact.

⚠ WARNING

Risk of injury through electric shock and damage to the device!

Bring the module system into a safe, de-energized state before starting installation, disassembly or wiring of the modules.

NOTE

Risk of damage to components through electrostatic discharge!

Observe the regulations for ESD protection.

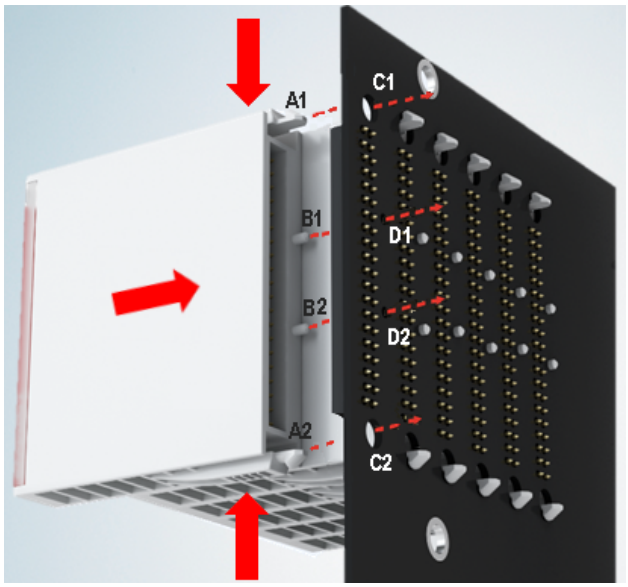


Fig. 21: Installation of EJ modules

A1 / A2	Latching lugs top / bottom	C1 / C2	Mounting holes
B1 / B2	Coding pins	D1 / D2	Coding holes

To install the modules on the signal distribution board proceed as follows:

1. Before the installation, ensure that the signal distribution board is securely connected to the mounting surface. Installation on an unsecured signal distribution board may result in damage to the board.
2. If necessary, check whether the positions of the coding pins (B) match the corresponding holes in the signal distribution board (D).
3. Compare the device name on the module with the information in the installation drawing.
4. Press the upper and the lower mounting tabs simultaneously and push the module onto the board while gently moving it up and down, until the module is latched securely.
   The required contact pressure can only be established and the maximum current carrying capacity ensured if the module is latched securely.
5. Use placeholder modules (EJ9001) to fill gaps in the module strand.

NOTE

- During installation ensure safe latching of the modules on the signal distribution board! The consequences of inadequate contact pressure include:

⇨ loss of quality of the transferred signals,

⇨ increased power dissipation of the contacts,

⇨ impairment of the service life.

4.6 Extension options

Three options are available for modifications and extensions of the EJ system.

- Replacing the placeholder modules with the function modules provided for the respective slot
- Assigning function modules specified for the respective slots for the reserve slots at the end of the module string
- Linking with EtherCAT Terminals and EtherCAT Box modules via an Ethernet/EtherCAT connection

4.6.1 Using placeholder modules for unused slots

The EJ9001 placeholder modules are used to close temporary gaps in the module strands (see Fig. A1 below). Gaps in the module strand cause interruption in EtherCAT communication and must be equipped with placeholder modules.
In contrast to the passive terminals of the EL series, the placeholder modules actively participate in the data exchange. Several placeholder modules can therefore be connected in series, without impairing the data exchange.
Unused slots at the end of the module strand can be left as reserve slots (see Fig. B1 below).

The machine complexity is extended (extended version) by allocating unused slots (see Figs. A2 below - Exchanging placeholder modules and B2 - Assigning reserve slots) according to the specifications for the signal distribution board.

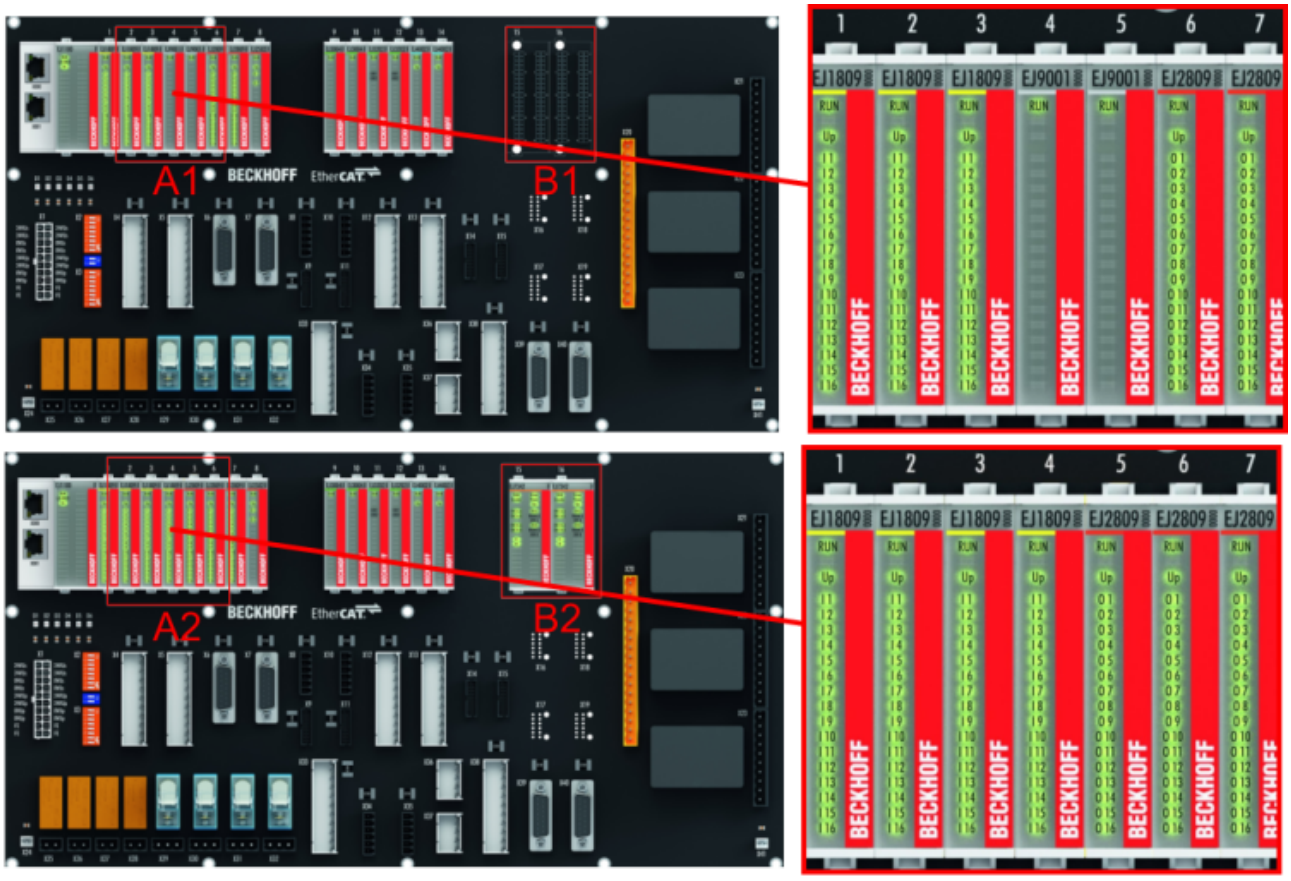


Fig. 22: Sample: Exchanging placeholder modules and assigning reserve slots

E-bus supply

Exchange the placeholder modules with other modules changes the current input from the E-Bus. Ensure that adequate power supply is provided.

4.6.2 Linking with EtherCAT Terminals and EtherCAT Box modules via an Ethernet/EtherCAT connection

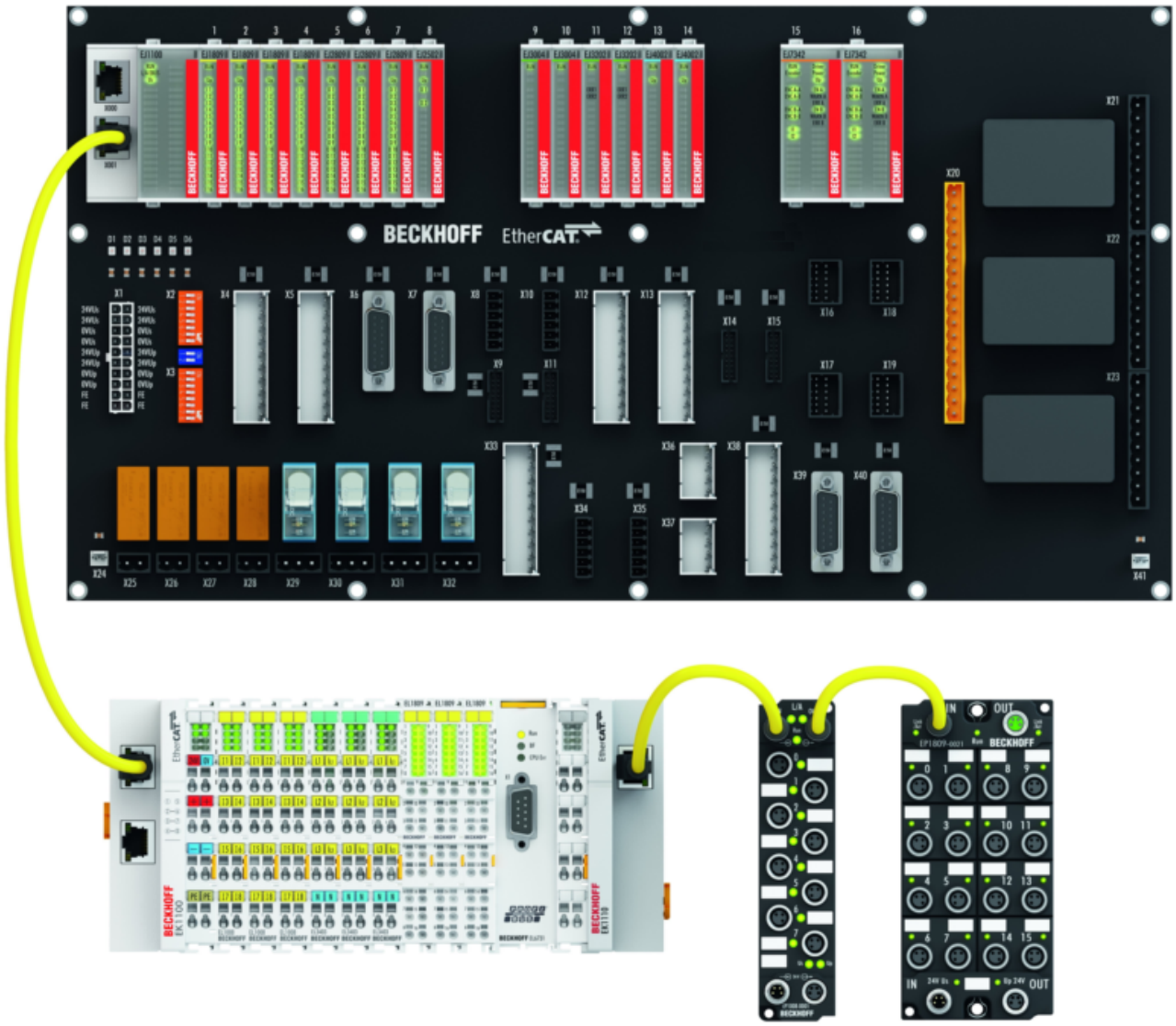


Fig. 23: Example of extension via an Ethernet/EtherCAT connection

4.7 IPC integration

Connection of CX and EL terminals via the EK1110-004x EtherCAT EJ coupler

The EK1110-0043 and EK1110-0044 EtherCAT EJ couplers connect the compact DIN-rail PCs of the CX series and attached EtherCAT Terminals (ELxxxx) with the EJ modules on the signal distribution board.

The EK1110-004x are supplied from the power supply unit of the Embedded PC.
The E-bus signals and the supply voltage of the field side U_P are routed directly to the PCB via a plug connector at the rear of the EtherCAT EJ couplers.

Due to the direct coupling of the Embedded PC and the EL terminals with the EJ modules on the PCB, no EtherCAT Extension (EK1110) or EtherCAT Coupler (EJ1100) is required.

The Embedded PC can be expanded with EtherCAT Terminals that are not yet available in the EJ system, for example.

Fig. 24: Example PCB with Embedded PC, EK1110-0043 and EJxxxx, rear view EK1110-0043

Connection of C6015 / C6017 via the EJ110x-00xx EtherCAT Coupler

Thanks to their ultra-compact design and versatile mounting options, the C6015 and C6017 IPCs are ideally suited for connection to an EJ system.

In combination with the ZS5000-0003 mounting set, it is possible to place the C6015 and C6017 IPCs compactly on the signal distribution board.
The EJ system is optimally connected to the IPC via the corresponding EtherCAT Cable (see following Fig. [A]).
The IPC can be supplied directly via the signal distribution board using the enclosed power plug (see Fig. [B] below).

NOTE

Positioning on the signal distribution board

The dimensions and distances for placement and other details can be found in the Design Guide and the documentation for the individual components.

The figure below shows the connection of a C6015 IPC to an EJ system as an example. The components shown are schematic, to illustrate the functionality.

Fig. 25: Example for the connection of a C6015 IPC to an EJ system

4.8 Disassembly of the signal distribution board

⚠ WARNING

Risk of injury through electric shock and damage to the device!

Bring the module system into a safe, de-energized state before starting installation, disassembly or wiring of the modules.

Each module is secured through latching on the distribution board, which has to be released for disassembly.

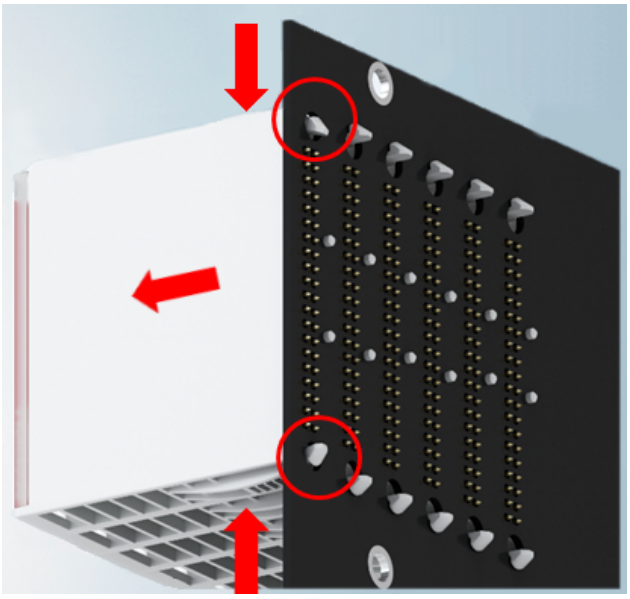


Fig. 26: Disassembly of EJ modules

To disassemble the module from the signal distribution board proceed as follows:

1. Before disassembly, ensure that the signal distribution board is securely connected to the mounting surface. Disassembly of an unsecured signal distribution board may result in damage to the board.
2. Press the upper and lower mounting tabs simultaneously and pull the module from board while gently moving it up and down.

4.9 Disposal

Products marked with a crossed-out wheeled bin shall not be discarded with the normal waste stream. The device is considered as waste electrical and electronic equipment. The national regulations for the disposal of waste electrical and electronic equipment must be observed.

5 EtherCAT basics

Please refer to the EtherCAT System Documentation for the EtherCAT fieldbus basics.

6 Commissioning

6.1 Principle of the sine/cosine measurement

A position encoder with sine/cosine interface 1 V_{pp} outputs two sine signals phase-shifted by 90° as analog voltages. Both signals are transmitted over two lines differentially as signal and counter signal, the voltage difference between the two lines giving the wanted signal in peak-to-peak volts. A level of 1 V_{pp} is usual. A full 360° cycle of the sine signal is designated as a period. Up to 10,000 periods per mechanical revolution are typical for rotary encoders.

If the rotary/linear encoder is moved, an occasionally high frequency alternating voltage is generated, which is subject to the known dynamic limits such as maximum input frequency and amplitude attenuation/level in the sequential electronics.
In extending the signal of a digital incremental encoder, which can only evaluate these full steps/cycles, the downstream circuitry can interpolate the two phase-shifted sine signals and thus determine the position n-thousand times more precisely, even within a cycle.

For the EJ5021 EtherCAT plug-in module this period resolution by interpolation is 8 ... 13 bits corresponding to 256 ... 8192-fold micro-resolution of the period.

Microincrements

For the same purpose, the EJ5021 EtherCAT plug-in module uses a time-based microincrement method to also resolve digital encoder steps into up to 256 microincrements.

In addition a Reset/C signal from the encoder can be connected in order to mark a special position, e.g. the zero position. This signal can be used for resetting or latching.

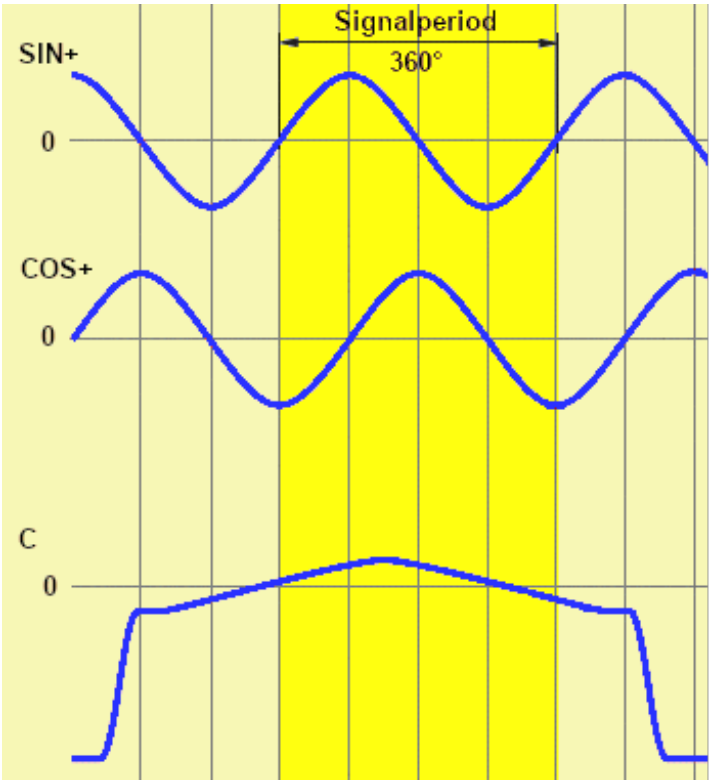


Fig. 27: Signal outputs of the position encoder

6.2 DC (Distributed Clocks)

In the "DC" tab, the trigger mode can be set via the Operation Mode selection list.

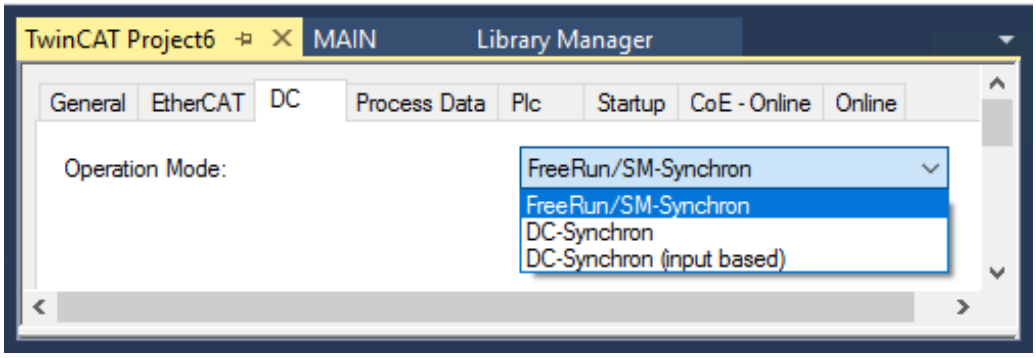


Fig. 28: "DC" tab, selection list "Operation Mode" (trigger mode)

- **FreeRun**: (frame-triggered)
  Cyclic operation is started via the SyncManagers during EtherCAT frame processing.
- **DC-Synchron**:
  Cyclic operation in the module is started by the local distributed clock at exact intervals. The start time is chosen such that it coincides with other output slaves in the EtherCAT system.
  This mode is not suitable for the EJ5021 EtherCAT plug-in module as a module of the DC group of input modules, see Note.
- **DC Synchron (input based)**:
  As DC Synchron mode, with the cyclic start time chosen such that it coincides with other input slaves in the EtherCAT system.

A detailed description of the function can be found in the chapter "Operation mode (Trigger mode) [▶ 41]"

6.2.1 Operation mode (trigger mode)

Trigger via the communication cycle, i.e. frame-triggered:

"**FreeRun/SM-synchron**"
As soon as an EtherCAT communication addresses the EJ5021 EtherCAT plug-in module, it starts a new position determination. The EtherCAT communication is usually started by the PLC/NC task.

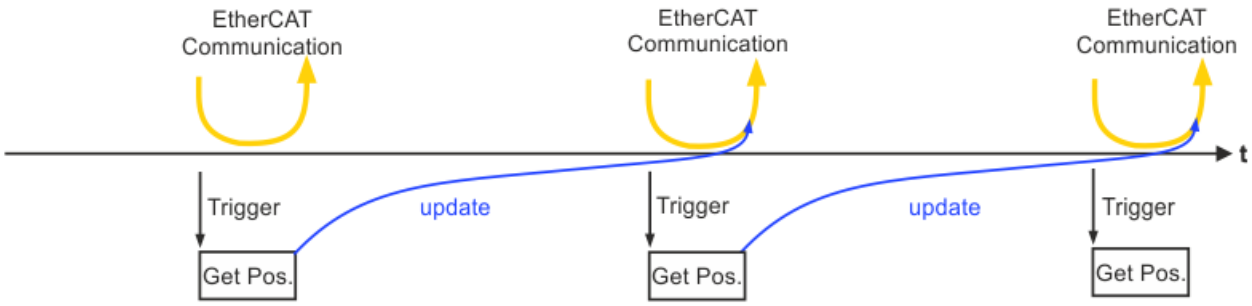


Fig. 29: Frame-triggered EtherCAT communication

Trigger via the module's own distributed clock:

1. "**DC-synchron (input based)**"
   The DC unit of the module triggers the position determination shortly before the next collecting EtherCAT telegram, so that the most up-to-date possible value is available for collection.
2. **"DC-synchron"**
   In the setting "DC-synchron" the EJ5021 module is operated in the DC group of the output modules, whereby it does not determine the position shortly before an EtherCAT communication, but shortly after the communication.
   As a result, the data are significantly older.

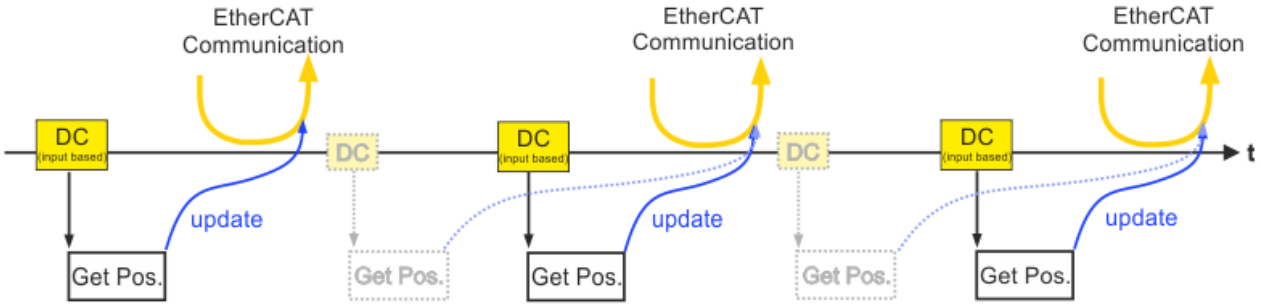


Fig. 30: DC synchron (input based) triggered EtherCAT communication

The exact DC time of the position determination is not output as process data by the EJ5021 module. It can be set via Advanced settings of the module or for all modules via Advanced settings of the EtherCAT master (see following figures). These values are calculated once during the creation/activation of the configuration and do not change any further during runtime.

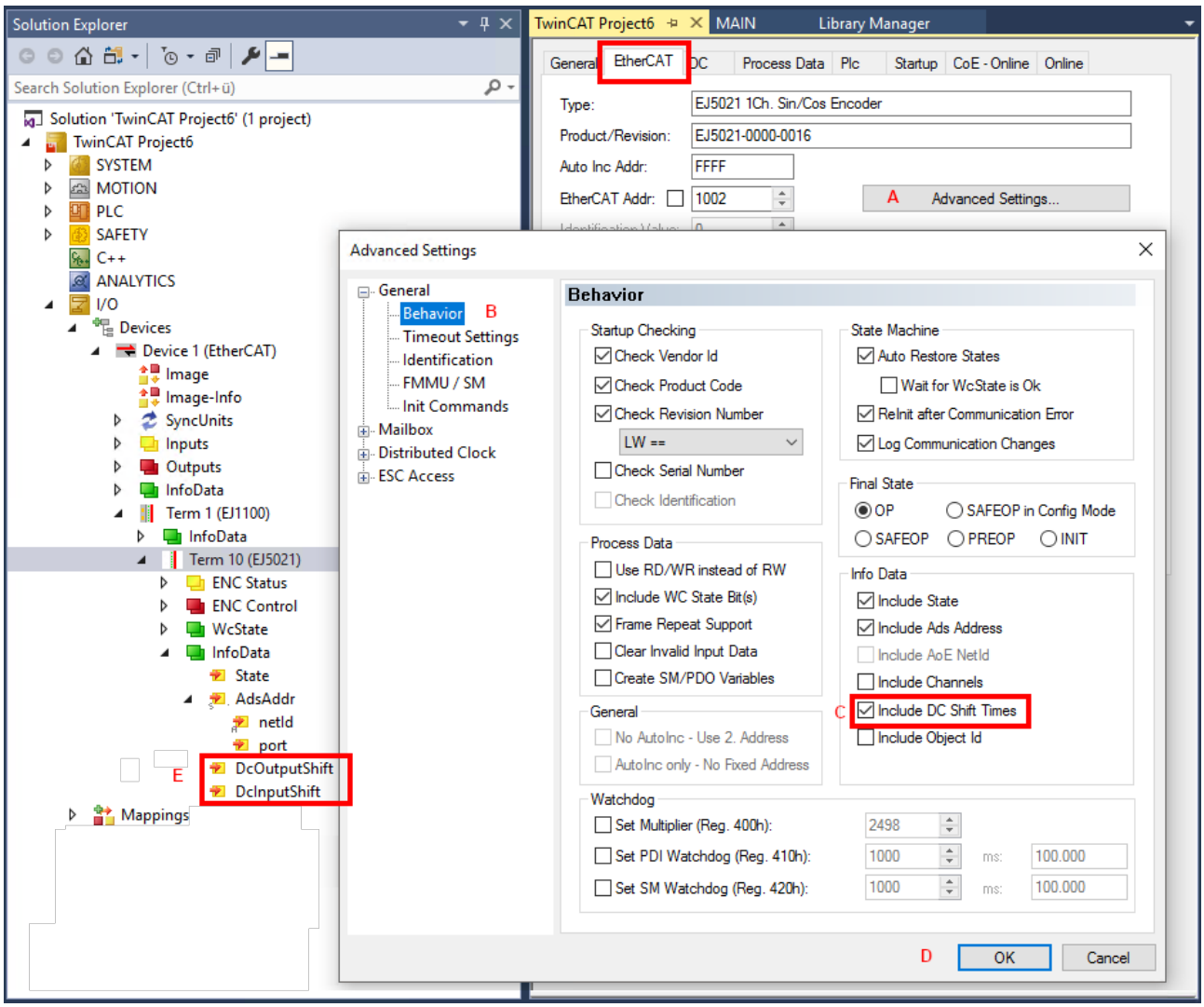


Fig. 31: Advanced settings of the EtherCAT plug-in module in TwinCAT System Manager

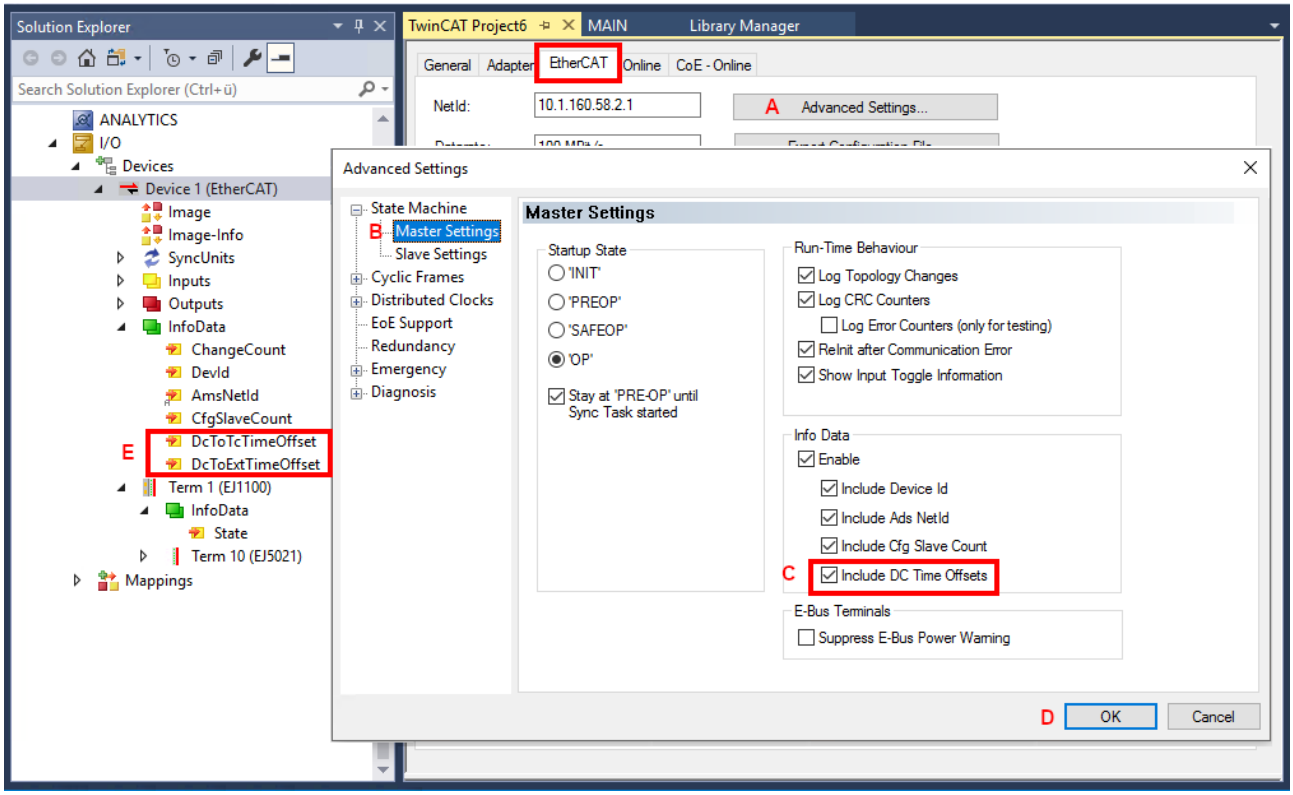


Fig. 32: Advanced settings of the EtherCAT master in the TwinCAT System Manager

The determination of the current position is subject to a constant delay of several µs. This delay is already accounted for in TwinCAT with the calculation of the InputShiftTime, so that the actual determination time and the calculated time coincide with each other.

The minimum possible sampling rate of the EtherCAT plug-in module EJ5021 is 80 µs and thus also the minimum possible EtherCAT cycle time.

6.3 Process data

Via the "Process Data" tab, the contents of the available process data objects (PDO) can be displayed in the "PDO Content" (C) field. Changes to the process data can be made via the "PDO Assignment" field.

- For the EJ5021 EtherCAT plug-in module no changes can be made via the Sync Manager SM2 "Outputs".
- Via the Sync Manager SM3 "Inputs" (A) two additional "PDO Assignments" (B) can be added for the frequency:
  - 0x1A01 "ENC Frequency (int32)"
  - 0x1A02 "ENC Frequency (uint32)"

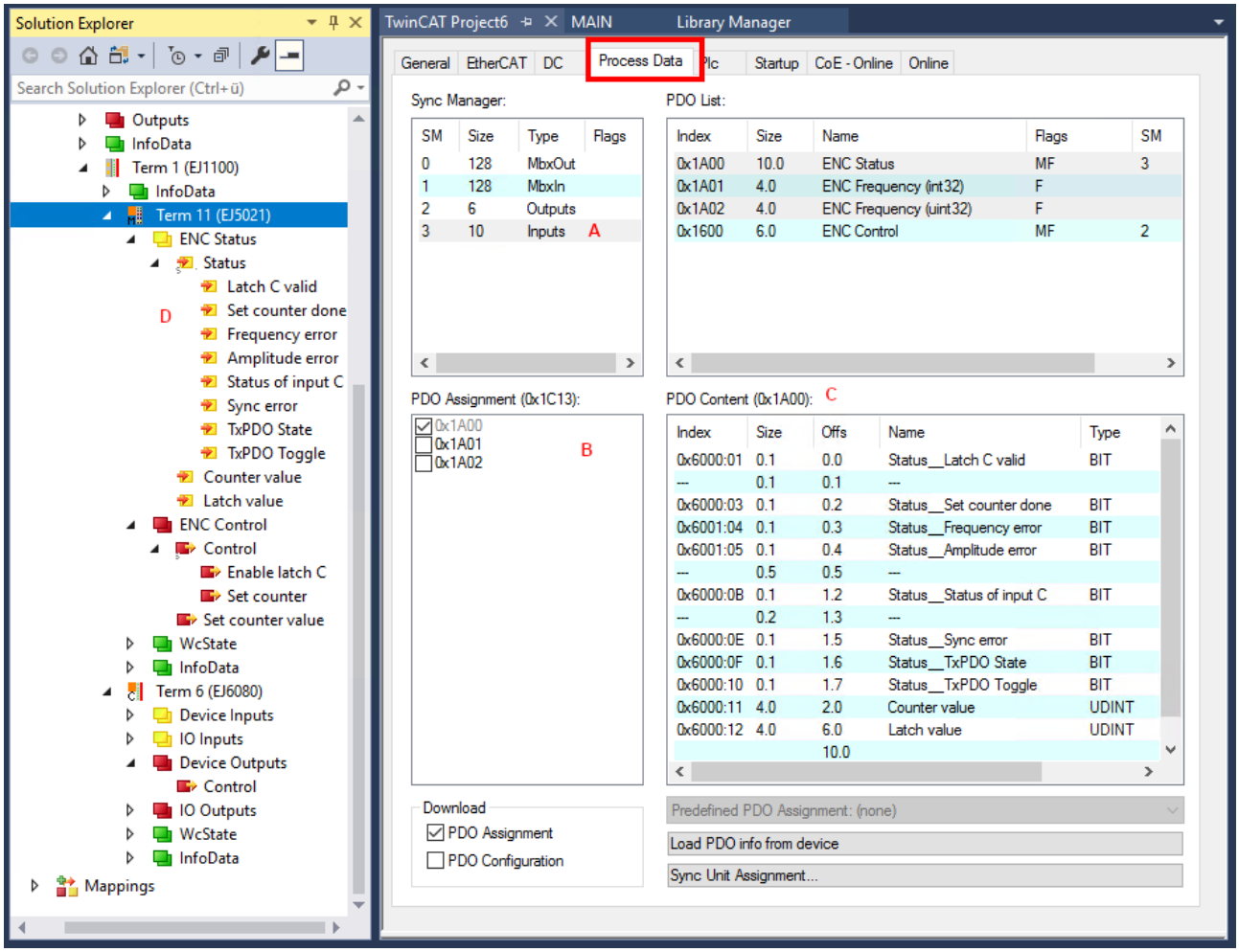


Fig. 33: EJ5021 - Process data (default)

- In order to configure the process data, select the desired Sync Manager (only SM3 can be edited here) in the upper left-hand "Sync Manager" (A) field.
- The process data assigned to this Sync Manager can then be switched on or off in the "PDO Assignment" (B) field below.
- Restarting the EtherCAT system, or reloading the configuration in Config mode (F4), causes the EtherCAT communication to restart, and the process data is transferred from the module.

All selected process data are displayed in the tree structure (D).

The process data are generated from CoE objects 0x6000 (Inputs) and 0x7000 (Outputs) and are described in chapter "Object description and parameterization [▶ 55]".

6.4 Settings via the CoE directory

NOTE

Parameterization via the CoE list (CAN over EtherCAT)

The EtherCAT device is parameterized via the CoE - Online tab (with a double click on the respective object) or via the Process Data tab (assignment of PDOs). A detailed description can be found in the EtherCAT System-Documentation in chapter "EtherCAT subscriber configuration"

Please note the general CoE notes in the EtherCAT System Documentation in chapter "CoE-interface" when using/manipulating the CoE parameters:
- Keep a startup list if components have to be replaced
- Differentiation between online/offline dictionary,
- existence of current XML description
- use "CoE reload" for resetting changes

All settings are made via the CoE directory.

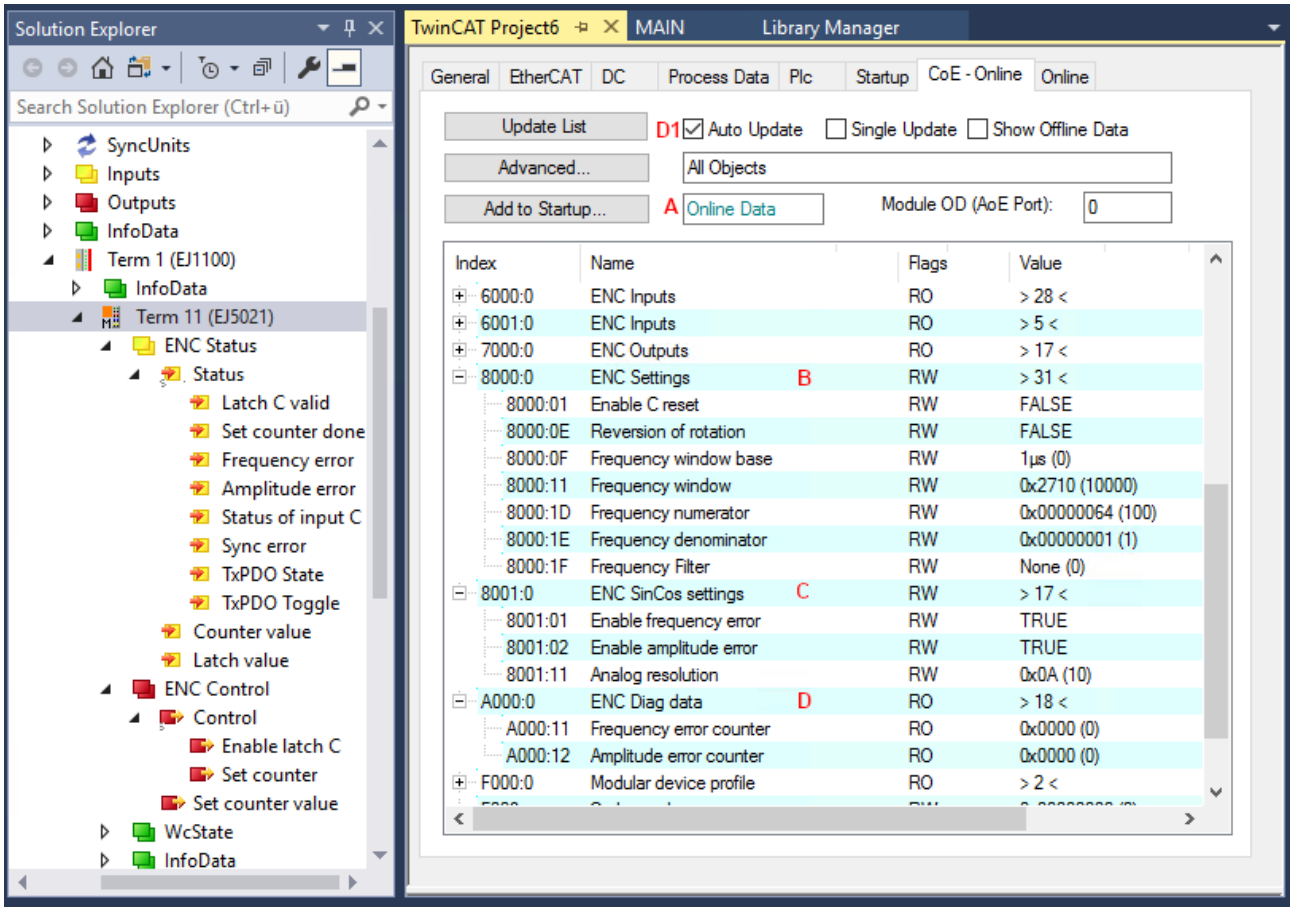


Fig. 34: CoE directory of the EJ5021 EtherCAT plug-in module

If the module is online, i.e. connected to the TwinCAT EtherCAT master and in error-free RUN state (WorkingCounter = 0), the online data are accessible (A).
The entries can be changed online in the entries Index 0x8000 [▶ 56] (B) and Index 0x8001 [▶ 56] (C).

Frequency and amplitude errors are counted and can be read at index 0xA000 [▶ 58] - the display is updated continuously in TwinCAT if (D1) has been enabled.

Latch and/or Reset can be activated on the C-signal in the CoE. It is not recommended to activate both functions at the same time.

Latch C input ("C")

Activate and store ("latch") the counter value

1. Enable the latch C input via the process data "Enable latch C" (Index 0x7000:01) = TRUE

⇨ At the first external latch pulse (positive edge at input "C") after set bit (TRUE) in index 0x7000:01 the count value is stored in "Latch value" (index 0x6000:12).
The following pulses at the other inputs have no influence on the latch value in index 0x6000:12 if the bit is set.

"Latch C valid" bit

A new counter value at the latch input can only be written once the value of the "Latch C valid" bit (index 0x6000:01) is FALSE.

Counter reset

The bit in index 0x8000:01 "Enable C reset" = TRUE must be set for the counter reset via input C.

Reversal of direction of rotation

The bit in index 0x8000:0E "Reversion of Rotation" must be set for a reversal of the direction of rotation.

TxPDO State

Index 0x6000:0F "TxPDO State", TRUE if frequency, amplitude or general error

TxPDO Toggle

Index 0x6000:10 "TxPDOToggle", toggles with each new value.

6.5 Functions

Intended use of the EJ5021 EtherCAT plug-in module

The EJ5021 EtherCAT plug-in module is designed for frequencies that remain constant or do not change abruptly.
A bouncing signal, such as can occur with a measuring probe, causes frequency jumps ("glitches"). The maximum frequencies that occur and the high rate of frequency change can be outside the working area of the module.
Since these distorted signals are no longer detected by the module, they cannot be evaluated and interpreted as a possible error.

6.5.1 Position determination

An rotary encoder usually outputs 100 ... 10,000 sine/cosine periods per revolution. The EJ5021 EtherCAT plug-in module can continuously measure, interpolate and convert these two differential analog signals into a position value consisting of:

- the number of periods --> period counter
- and the current position within the period --> period portion 0 ... 360°

According to customer's request, the maximum period proportion can be determined with a resolution of 8 ... 13 bits, equivalent to 256 ... 8192 steps per 360° sine period. This is set in the CoE, index 0x8001:11 [▶ 56] "Analog resolution". This is the theoretical maximum resolution desired by the user, which is also achieved at a standstill or during slow movement.

The actual current resolution depends, however, on the current input frequency of the sine/cosine signal.

1. As the frequency increases, the resolution automatically decreases. Starting from the least significant bit (LSB) the bits are frozen. If the maximum period resolution is set to 12 bits, 6-bit period resolution will still be achieved at the maximum input frequency of typically 80 KHz.
2. If the frequency slows down significantly, the resolution actually achieved increases again.

⇨ There is no online message about the currently applied frozen bits.

The conversion to real mechanical revolutions depends on the number of periods per revolution of the encoder employed and is calculated in the PLC or NC.

Preset period resolution [bits]	f_{max} [kHz]	Typical frequency (±15%) at which the automatic reduction of the preset period resolution begins	Min. period resolution at f_{max}
8	250	9000 Hz	
9		4500 Hz	
10 (default)		2500 Hz	
11	170	1500 Hz	
12	80	750 Hz	6 bits
13	40	650 Hz	

If f_{max} is exceeded, a frequency error is displayed (index 0x6001:04 [▶ 57] "Frequency error"), amplitude errors (level too low, input below limit) are displayed in index 0x6001:05 [▶ 57] "Amplitude error".

The position is indicated in 32 bits as a composite process data. Depending on the desired max. resolution, these 32 bits are composed, starting from the right (LSB), of:

- Analog part: 8...13 bits according to setting in index 0x8001:11 [▶ 56] "Analog resolution"
- 24...19 bits for the number of periods, extent given by the number of bits available.

Hence, a sequential 32-bit position value is available that can be linked directly to the NC, for example. The conversion factor in bits/mm must then be set in the NC, taking into account:

- the no. of sine periods per mechanical revolution, e.g. 5000
- the selected interpolation resolution,

e.g. 10 bits.

Resetting of the counter value on change of period resolution

When changing the period resolution in index 0x8001:11 [▶ 56]"Analog resolution" and "Enable C reset" (index 0x8000:01 [▶ 56]) the current counter value is reset.

Display "Period resolution 8-bit"

In the setting "Period resolution 8-bit", the display of the 32-bit process data corresponds to the EJ5101 EtherCAT plug-in module with activated microincrements.

Frequency and amplitude errors are counted and can be read at index 0xA000 [▶ 58] "ENC Diag Data".

6.5.2 Diagnostics

The "Frequency error" is output as a process data if the max. frequency limit f_{max} applicable to the respective resolution range is exceeded, see chapter Position determination. [▶ 47]
The "Amplitude error" is output as a process data if the voltage of the Sin/Cos signal is too small. This can, with suitable position, also be used for the detection of a wire break.
In CoE object 0xA000 [▶ 58] "ENC Diag Data" these errors are counted and can also be read from the PLC via SDO access.

6.5.3 Special functions: reset, latch, set position

Latch and/or Reset can be activated on the C-signal in the CoE. It is not recommended to activate both functions at the same time.

Reset

The internal counter is reset immediately to 0 when the C-signal reaches the EL5021.

Latch

When the C-signal reaches the EJ5021 EtherCAT plug-in module, a new position determination is started and the last determined position is “latched” (stored); see figure, Signal C_A.

The latch determination is handled with priority if the latch signal falls in terms of time within the range of the triggered position determination; the regular position determination is then executed immediately afterwards, see signal C_B.

This delay has no meaning in the synchronous operation mode; in DC mode sufficient time reserves are available so that *GetPos* can nevertheless be executed in time for the next EtherCAT cycle, ensuring that current data can be delivered.

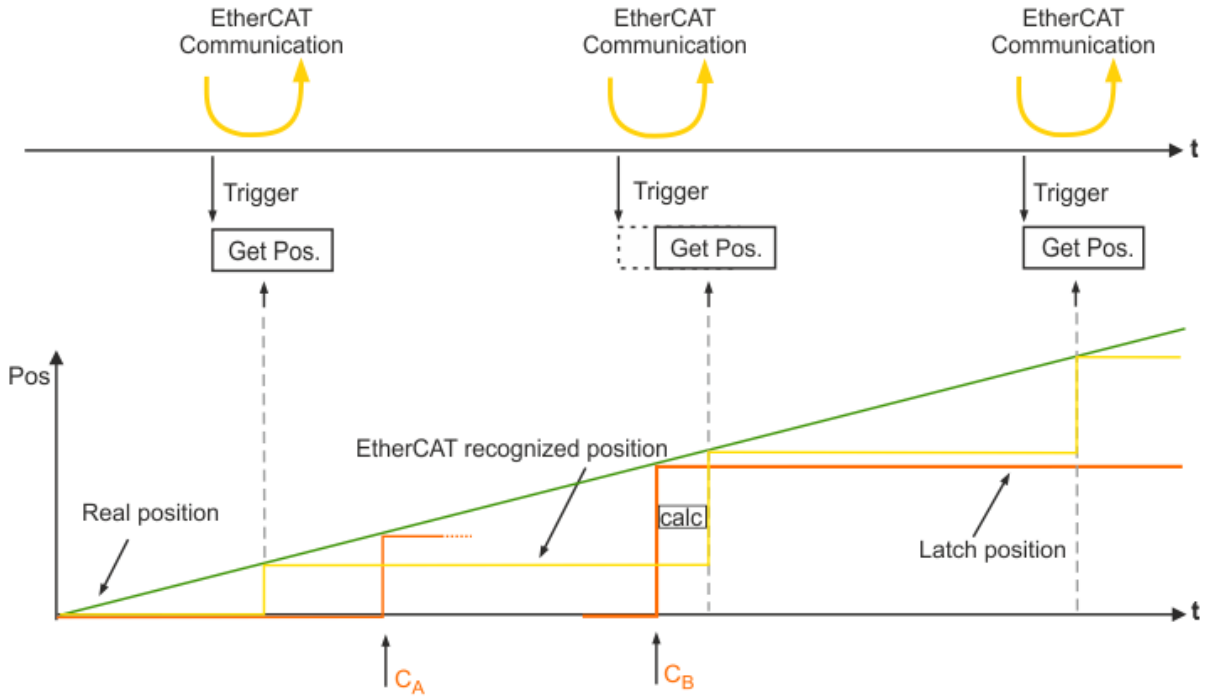


Fig. 35: Latching a position "Latch position

Set position (set counter)

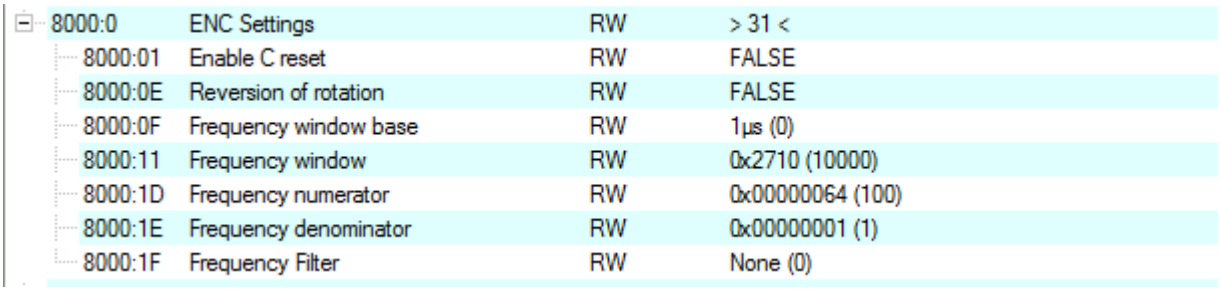
The index 0x7000:03 [▶ 57] "Set counter" is used to reset the position value (counter value) specified in 0x7000:11 [▶ 57] "Set counter value".

Set position

The use of the "Set counter" function is recommended only when the axis is at a standstill.

6.5.4 Frequency measurement/velocity measurement

The following indices are used for setting the parameters for calculating the frequency or velocity. The determined frequency or velocity is output in index 0x6000:13 "Frequency value" as 32-bit value or 0x6000:1A "Frequency value (int16)" as 16-bit value as process data.



8000:0	ENC Settings	RW	> 31 <
8000:01	Enable C reset	RW	FALSE
8000:0E	Reversion of rotation	RW	FALSE
8000:0F	Frequency window base	RW	1µs (0)
8000:11	Frequency window	RW	0x2710 (10000)
8000:1D	Frequency numerator	RW	0x00000064 (100)
8000:1E	Frequency denominator	RW	0x00000001 (1)
8000:1F	Frequency Filter	RW	None (0)

Fig. 36: CoE indices, 0x8000:0 "ENC Settings"

Index (hex)	Name	Meaning	Default
8000:0F	Frequency window base	Specifies the unit for the timeframe for the frequency measurement. Two time units (1 µs, 1 ms) are available	0x00 (1 µs)
8000:11	Frequency window	This is the time used for determining the frequency. The number of periods and the analog part (the period resolution) in the timeframe is measured and then divided by the timeframe size. Default value 10 ms [resolution: 1 µs], i.e. a new value is calculated every 10 ms. The determined frequency is output as process data • In index 0x6000:13 "Frequency value" as 32-bit value or • in index 0x6000:1A "Frequency value (int16)" as 16-bit value. The scaling of the output value is determined by Index 0x8000:1D "Frequency numerator" and Index 0x8000:1E "Frequency denominator". The frequency calculation is carried out locally without distributed clocks function.	0x2710 (10000_{dec})
8000:1D	Frequency numerator	Frequency numerator, used for scaling the frequency, cf. frequency scaling [▶ 52].	0x00000064 (100_{dec})
8000:1E	Frequency denominator	Frequency denominator value, used for scaling of frequency and velocity calculation, see Frequency scaling [▶ 52] and Example for velocity calculation [▶ 52].	0x0000001 (1_{dec})
8000:1F	Frequency Filter	IIR filter	

Frequency scaling

The frequency can be scaled via the two indices 0x8000:1D "Frequency numerator" and 0x8000:1E "Frequency denominator". The entered values yield a fraction. This number must be used as divisor to obtain the unit in hertz, for example:

0x8000:1D "Frequency numerator" = 100

0x8000:1E "Frequency denominatior" = 1

- Fraction: 100
- Output of frequency 100: 0.01 Hz

Since a position encoder with sin/cos interface is an analog output signal, in contrast to digital incremental encoders, not only the whole periods are taken into account for the frequency measurement, but also the analog part of the periods. The period determination is set in CoE, index 0x8001:11 "Analog resolution".

The "Counter Value" (0x6000:11) consists of the period counter and the period portion.

Example: Encoder output: 2048 pulses, 0x8001:11 "Analog resolution": 10 bits

- Process data "Counter Value": 32 bits, number of periods 22 bits, analog part 10 bits,
- A full mechanical revolution corresponds to 360° = 2048*1024 pulses = 2097152 increments (2048 periods)

Example for velocity calculation

The velocity calculation is based on the frequency measurement, which is determined as follows:

$f= (S_2-S_1)/t_f$	
f	frequency to be measured. Via index 0x8000:1D "Frequency numerator" the scaling of the frequency can be determined.
S_1	Counter value at position 1
S_2	Counter value at position 2
t_f	Timeframe for frequency determination, this can be set via index 0x8000:0F "Frequency window base" and index 0x8000:11 "Frequency window".

The velocity has the following relationship with the frequency:

v = f/a	
v	velocity to be calculated
f	measured frequency
a	Conversion factor [pulses/unit] for the velocity. This is entered in index 0x8000:1D "Frequency numerator" and 0x8000:1E "Frequency denominator"

The conversion factor a can be determined as follows:

Example for velocity calculation in m/s:

12 mm travel path corresponds to a full mechanical revolution and therefore a "Counter Value" of 2097152 increments (2048 periods).

- a = 2048 periods / 12 mm = 170.666667 periods/mm = 170666.667 periods/m

The output of the measured value essentially depends on the unit in which the frequency is determined and on the unit in which the conversion factor is specified.

Index (hex)	Name	Example for set value	Comment
8000:1D	Frequency numerator	100	Output of the value in 0.01 Hz
8000:1E	Frequency denominator	170666667	Conversion factor a in pulses/mm

In this case the velocity is output in index 0x6000:13 "Frequency value" as 32-bit value or 0x6000:1A "Frequency value (int16) as 16-bit value in the following unit:

$$Comparison\ of\ units: v = \frac{f}{a} = \frac{0{,}01Hz}{impulses/mm} = \frac{0{,}01 \times 1/s}{impulses \times \frac{1000}{m}} = 0{,}00001\frac{m}{s}$$

Fig. 37: Formula for velocity calculation: 0.00001 m/s

This means the value must be multiplied by 0.00001 to get the unit in m/s. To get a high resolution of the output value, the values in 0x8000:1D "Frequency numerator" and 0x8000:1E "Frequency denominator" should be specified in the same order of magnitude if possible.

Example for velocity calculation in revolutions/min:

After a full revolution the "Counter Value" is 2048 periods.

- A = 2048 periods / 1 revolution = 2048 periods / revolution

The output of the measured value essentially depends on the unit in which the frequency is determined and on the unit in which the conversion factor is specified.

Index (hex)	Name	Example for set value	Comment
8000:1D	Frequency numerator	6000	Output of the value in 0.01 rpm
8000:1E	Frequency denominator	2048	Conversion factor in periods/revolution

In this case the velocity is output in index 0x6000:13 "Frequency value" as 32-bit value or 0x6000:1A "Frequency value (int16)" as 16-bit value in the following unit:

$$Comparison\ of\ units: v = \frac{f}{a} = \frac{0{,}01Hz}{impulses/revolution} = \frac{0{,}01 \times 1/s}{impulses/revolution}$$
$$= 0{,}01\frac{revolutions}{s} = 0{,}6\ \frac{revolutions}{min}$$

Fig. 38: Formula velocity calculation: revolutions/s, revolutions/min

This means the value must be multiplied by 0.01 to get the unit in revolutions/s, or multiplication by 0.6 for revolutions/min.
To get a high resolution of the output value, the values in 0x8000:1D "Frequency numerator" and 0x8000:1E "Frequency denominator" should be specified in the same order of magnitude if possible.

6.5.5 Filter operation

Frequency Filter (index 0x8000:1F [▶ 56])

The EJ5021 EtherCAT plug-in module is equipped with a digital filter that can assume the characteristics of an *I*nfinite *I*mpulse *R*esponse filter (*IIR filter)*. The filter is disabled by default (value: "0" (None)).

IIR filter

The filter with IIR characteristics is a discrete time, linear, time invariant filter that can be set to eight levels (level 1 = weak recursive filter, up to level 8 = strong recursive filter).
The IIR can be understood as a sliding average value calculation after a low-pass filter.
Here, the IIR filters work cycle-synchronously and are thus updated depending on the cycle time.

IIR filter

Difference equation: $Y_n = X_n * a_0 + Y_{n-1} * b_1$
with $a_0 + b_1 = 1$
a_0 = (see table)
$b_1 = 1 - a_0$

Frequency Filter 0x8000:1F	Value	PDO update time	Filter property	Comment	Rise time 10-90% [samples] (typ.)
0	None	-	-	Filter disabled	-
1	IIR 1	Cycle-synchronous (up to min. 100 µs)	Low-pass filter	$a_0 = 1/2^1 = 0.5$	3
2	IIR 2			$a_0 = 1/2^2 = 0.25$	8
3	IIR 3			$a_0 = 1/2^3 = 0.125$	17
4	IIR 4			$a_0 = 1/2^4 = 0.0625$	34
5	IIR 5			$a_0 = 1/2^5 = 0.03125$	69
6	IIR 6			$a_0 = 1/2^6 = 0.015625$	140
7	IIR 7			$a_0 = 1/2^7 = 0.0078125$	280
8	IIR 8			$a_0 = 1/2^8 = 0.00390625$	562

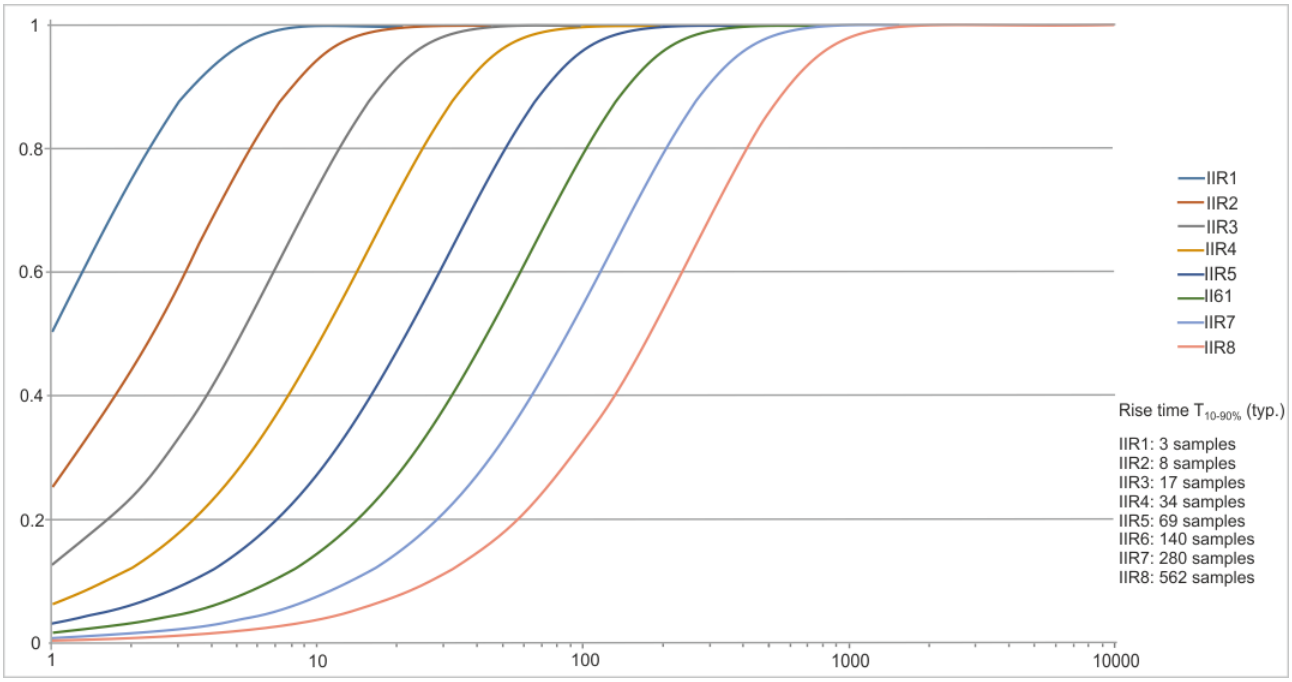


Fig. 39: Rise time $T_{10-90\%}$ (typ.)

6.6 EJ5021 - object description and parameterization

EtherCAT XML Device Description

The display matches that of the CoE objects from the EtherCAT XML Device Description. We recommend downloading the latest XML file from the download area of the Beckhoff website and installing it according to installation instructions.

NOTE

Parameterization via the CoE list (CAN over EtherCAT)

The EtherCAT device is parameterized via the CoE - Online tab (with a double click on the respective object) or via the Process Data tab (assignment of PDOs). A detailed description can be found in the EtherCAT System-Documentation in chapter "EtherCAT subscriber configuration"

Please note the general CoE notes in the EtherCAT System Documentation in chapter "CoE-interface" when using/manipulating the CoE parameters:
- Keep a startup list if components have to be replaced
- Differentiation between online/offline dictionary,
- existence of current XML description
- use "CoE reload" for resetting changes

Introduction

The CoE overview contains objects for different intended applications:

- Objects required for parameterization during commissioning:
  - Restore object [▶ 55] index 0x1011
  - Configuration data [▶ 56] index 0x80n0
- Profile-specific objects:
  - Input data [▶ 57] index 0x60n0, 0x60n1
  - Output data [▶ 57] 0x70n0, 0x70n1
  - Information and diagnostic [▶ 58] data index 0xA0n0, 0xF000, 0xF008, 0xF010
- Standard objects [▶ 58]

The following section first describes the objects required for normal operation, followed by a complete overview of missing objects.

6.6.1 Restore object

Index 1011 Restore default parameters

Index (hex)	Name	Meaning	Data type	Flags	Default
1011:0	Restore default parameters	Restore default parameters	UINT8	RO	0x01 (1_{dec})
1011:01	SubIndex 001	If this object is set to **"0x64616F6C"** in the set value dialog, all backup objects are reset to their delivery state.	UINT32	RW	0x00000000 (0_{dec})

6.6.2 Configuration data

Index 8000 ENC Settings

Index (hex)	Name	Meaning	Data type	Flags	Default
8000:0	ENC Settings	Maximum subindex	UINT8	RO	0x1F (31_{dec})
8000:01	Enable C reset	The counter is reset via the C input.	BOOLEAN	RW	0x00 (0_{dec})
8000:0E	Reversion of rotation	Activates reversion of rotation	BOOLEAN	RW	0x00 (0_{dec})
8000:0F	Frequency window base	Basic unit of the "Frequency window" (index 0x8000:11) 0: µs 1: ms	BIT1	RW	0x00 (0_{dec})
8000:11	Frequency window	This is the time over which the frequency is determined. The number of periods and the analog part (the period resolution) in the timeframe are measured and divided by the timeframe size. Default value 10 ms [resolution: 1 µs], i.e. a new value is calculated every 10 ms. The determined frequency is output in index 0x6000:13 [▶ 57] "Frequency value" as 32-bit value or in index 0x6000:1A [▶ 57] "Frequency value (int16)" as 16-bit value as process data. The scaling of the output value is determined by index: 0x8000:1D "Frequency numerator" and index 0x8000:1E "Frequency denominator".	UINT16	RW	0x2710 (10000_{dec})
8000:1D	Frequency numerator	Frequency numerator, frequency scaling	UINT32	RW	0x00000064 (100_{dec})
8000:1E	Frequency denominator	Frequency denominator, used for scaling the frequency and the velocity calculation (increments / unit).	UINT32	RW	0x00000001 (1_{dec})
8000:1F	Frequency Filter [▶ 54]	IIR filter permitted values:	UINT32	RW	0x00000000 (0_{dec})
		0: None			
		1: IIR1			
		2: IIR 2			
		3: IIR 3			
		4: IIR 4			
		5: IIR 5			
		6: IIR 6			
		7: IIR 7			
		8: IIR 8			

Index 8001 ENC SinCos settings

Index (hex)	Name	Meaning	Data type	Flags	Default
8001:0	ENC SinCos settings	Maximum subindex	UINT8	RO	0x11 (17_{dec})
8001:01	Enable frequency error	Enables the "Frequency error" counter (Index 0xA000:11 [▶ 58])	BOOLEAN	RW	0x01 (1_{dec})
8001:02	Enable amplitude error	Enables the "Amplitude error" counter (Index 0xA000:12 [▶ 58])	BOOLEAN	RW	0x01 (1_{dec})
8001:11	Analog resolution	Period resolution in bits (default: 10 bits)	UINT8	RW	0x0A (10_{dec})

6.6.3 Input data

Index 6000 ENC Inputs

Index (hex)	Name	Meaning	Data type	Flags	Default
6000:0	ENC Inputs	Maximum subindex	UINT8	RO	0x1C (28_{dec})
6000:01	Latch C valid	The counter value was latched with the "C" input. The data in index 0x6000:12 [▶ 57] "Latch value" corresponds to the latched value with the bit set. To re-enable the latch input, index 0x7000:01 [▶ 57] "Enable latch C" must first be canceled and then reset.	BOOLEAN	RO	0x00 (0_{dec})
6000:03	Set counter done	The counter was set.	BOOLEAN	RO	0x00 (0_{dec})
6000:0B	Status of input C	Status of input C	BOOLEAN	RO	0x00 (0_{dec})
6000:0E	Sync error	The Sync Error bit is only required for the DC mode. It indicates whether a synchronization error occurred in the expired cycle.	BOOLEAN	RO	0x00 (0_{dec})
6000:0F	TxPDO State	TRUE: A frequency, amplitude or general error has occurred	BOOLEAN	RO	0x00 (0_{dec})
6000:10	TxPDO Toggle	The TxPDO toggle is toggled by the slave when the data of the associated TxPDO is updated.	BOOLEAN	RO	0x00 (0_{dec})
6000:11	Counter value	Counter value	UINT32	RO	0x00000000 (0_{dec})
6000:12	Latch value	Latch value	UINT32	RO	0x00000000 (0_{dec})
6000:13	Frequency value	Frequency (32-bit value)	UINT32	RO	0x00000000 (0_{dec})
6000:1A	Frequency value (int16)	Frequency (16-bit value)	INT16	RO	0x0000 (0_{dec})
6000:1B	Frequency value (int32)	Frequency (32-bit value)	INT32	RO	0x00000000 (0_{dec})
6000:1C	Frequency value (uint16)	Frequency (16-bit value)	UINT16	RO	0x0000 (0_{dec})

Index 6001 ENC Inputs

Index (hex)	Name	Meaning	Data type	Flags	Default
6001:0	ENC Inputs	Maximum subindex	UINT8	RO	0x05 (5_{dec})
6001:04	Frequency error	TRUE: Frequency error, permissible frequency f_{max} exceeded (with preset period resolution of 10 bits, f_{max} = 250 kHz)	BOOLEAN	RO	0x00 (0_{dec})
6001:05	Amplitude error	TRUE: Amplitude error, input voltage below limit	BOOLEAN	RO	0x00 (0_{dec})

6.6.4 Output data

Index 7000 ENC Outputs

Index (hex)	Name	Meaning	Data type	Flags	Default
7000:0	ENC Outputs	Maximum subindex	UINT8	RO	0x11 (17_{dec})
7000:01	Enable latch C	Activate latching via input “C”.	BOOLEAN	RO	0x00 (0_{dec})
7000:03	Set counter	Set counter value	BOOLEAN	RO	0x00 (0_{dec})
7000:11	Set counter value	This is the counter value to be set via "Set counter" (index 0x7000:03 [▶ 57]).	UINT32	RO	0x00000000 (0_{dec})

6.6.5 Information and diagnostic data

Index F000 Modular device profile

Index (hex)	Name	Meaning	Data type	Flags	Default
F000:0	Modular device profile	General information for the modular device profile	UINT8	RO	0x02 (2_{dec})
F000:01	Module index distance	Index distance of the objects of the individual channels	UINT16	RO	0x0010 (16_{dec})
F000:02	Maximum number of modules	Number of channels	UINT16	RO	0x0001 (1_{dec})

Index F008 Code word

Index (hex)	Name	Meaning	Data type	Flags	Default
F008:0	Code word	reserved	UINT32	RW	0x00000000 (0_{dec})

Index F010 Module list

Index (hex)	Name	Meaning	Data type	Flags	Default
F010:0	Module list	Length of this object	UINT8	RW	0x01 (1_{dec})
F010:01	SubIndex 001	-	UINT32	RW	0x000001FF (511_{dec})

Index A000 ENC Diag data

Index (hex)	Name	Meaning	Data type	Flags	Default
A000:0	ENC diag data	Maximum subindex	UINT8	RO	0x12 (18_{dec})
A000:11	Frequency error counter	Number of "Frequency errors" (index 0x6001:04 [▶ 57])	UINT16	RO	0x0000 (0_{dec})
A000:12	Amplitude error counter	Number of "Amplitude errors" (index 0x6001:15 [▶ 57])	UINT16	RO	0x0000 (0_{dec})

6.6.6 Standard objects (0x1000-0x1FFF)

The standard objects have the same meaning for all EtherCAT slaves.

Index 1000 Device type

Index (hex)	Name	Meaning	Data type	Flags	Default
1000:0	Device type	Device type of the EtherCAT slave: the Lo-Word contains the used CoE profile (5001). The Hi-Word contains the module profile according to the modular device profile.	UINT32	RO	0x01FF1389 (33493897_{dec})

Index 1008 Device name

Index (hex)	Name	Meaning	Data type	Flags	Default
1008:0	Device name	Device name of the EtherCAT slave	STRING	RO	EJ5021

Index 1009 Hardware version

Index (hex)	Name	Meaning	Data type	Flags	Default
1009:0	Hardware version	Hardware version of the EtherCAT slave	STRING	RO	00

Index 100A Software version

Index (hex)	Name	Meaning	Data type	Flags	Default
100A:0	Software version	Firmware version of the EtherCAT slave	STRING	RO	01

Index 1018 Identity

Index (hex)	Name	Meaning	Data type	Flags	Default
1018:0	Identity	Information for identifying the slave	UINT8	RO	0x04 (4_{dec})
1018:01	Vendor ID	Vendor ID of the EtherCAT slave	UINT32	RO	0x00000002 (2_{dec})
1018:02	Product code	Product code of the EtherCAT slave	UINT32	RO	0x139D2852 (329066578_{dec})
1018:03	Revision	Revision number of the EtherCAT slave; the Low Word (bit 0-15) indicates the special terminal number, the High Word (bit 16-31) refers to the device description	UINT32	RO	0x00000000 (0_{dec})
1018:04	Serial number	Serial number of the EtherCAT slave; the Low Byte (bit 0-7) of the Low Word contains the year of production, the High Byte (bit 8-15) of the Low Word contains the week of production, the High Word (bit 16-31) is 0	UINT32	RO	0x00000000 (0_{dec})

Index 10F0 Backup parameter handling

Index (hex)	Name	Meaning	Data type	Flags	Default
10F0:0	Backup parameter handling	Information for standardized loading and saving of backup entries	UINT8	RO	0x01 (1_{dec})
10F0:01	Checksum	Checksum across all backup entries of the EtherCAT slave	UINT32	RO	0x00000000 (0_{dec})

Index 1600 ENC RxPDO-Map Control

Index (hex)	Name	Meaning	Data type	Flags	Default
1600:0	ENC RxPDO-Map Control	PDO Mapping RxPDO 1	UINT8	RO	0x05 (5_{dec})
1600:01	SubIndex 001	1. PDO Mapping entry (object 0x7000 (ENC Outputs), entry 0x01 (Enable latch C))	UINT32	RO	0x7000:01, 1
1600:02	SubIndex 002	2. PDO Mapping entry (1 bits align)	UINT32	RO	0x0000:00, 1
1600:03	SubIndex 003	3. PDO Mapping entry (object 0x7000 (ENC Outputs), entry 0x03 (Set counter))	UINT32	RO	0x7000:03, 1
1600:04	SubIndex 004	4. PDO Mapping entry (13 bits align)	UINT32	RO	0x0000:00, 13
1600:05	SubIndex 005	5. PDO Mapping entry (object 0x7000 (ENC Outputs), entry 0x11 (Set counter value))	UINT32	RO	0x7000:11, 32

Index 1A00 ENC TxPDO-Map Status

Index (hex)	Name	Meaning	Data type	Flags	Default
1A00:0	ENC TxPDO-Map Status	PDO Mapping TxPDO 1	UINT8	RO	0x0D (13_{dec})
1A00:01	SubIndex 001	1. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x01 (Latch C valid))	UINT32	RO	0x6000:01, 1
1A00:02	SubIndex 002	2. PDO Mapping entry (1 bits align)	UINT32	RO	0x0000:00, 1
1A00:03	SubIndex 003	3. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x03 (Set counter done))	UINT32	RO	0x6000:03, 1
1A00:04	SubIndex 004	4. PDO Mapping entry (object 0x6001 (ENC Inputs), entry 0x04 (Frequency error))	UINT32	RO	0x6001:04, 1
1A00:05	SubIndex 005	5. PDO Mapping entry (object 0x6001 (ENC Inputs), entry 0x05 (Amplitude error))	UINT32	RO	0x6001:05, 1
1A00:06	SubIndex 006	6. PDO Mapping entry (5 bits align)	UINT32	RO	0x0000:00, 5
1A00:07	SubIndex 007	7. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x0B (Status of input C))	UINT32	RO	0x6000:0B, 1
1A00:08	SubIndex 008	8. PDO Mapping entry (2 bits align)	UINT32	RO	0x0000:00, 2
1A00:09	SubIndex 009	9. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x0E (Sync error))	UINT32	RO	0x6000:0E, 1
1A00:0A	SubIndex 010	10. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x0F (TxPDO State))	UINT32	RO	0x6000:0F, 1
1A00:0B	SubIndex 011	11. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x10 (TxPDO Toggle))	UINT32	RO	0x6000:10, 1
1A00:0C	SubIndex 012	12. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x11 (Counter value))	UINT32	RO	0x6000:11, 32
1A00:0D	SubIndex 013	13. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x12 (Latch value))	UINT32	RO	0x6000:12, 32

Index 1A01 ENC TxPDO-Map Frequency (int32)

Index (hex)	Name	Meaning	Data type	Flags	Default
1A01:0	ENC TxPDO-Map Frequency (int32)	PDO Mapping TxPDO 2	UINT8	RO	0x01 (1_{dec})
1A01:01	SubIndex 001	1. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x1B (Frequency value (int32))	UINT32	RO	0x6000:1B, 32

Index 1A02 ENC TxPDO-Map Frequency (uint32)

Index (hex)	Name	Meaning	Data type	Flags	Default
1A02:0	ENC TxPDO-Map Frequency (uint32)	PDO Mapping TxPDO 3	UINT8	RO	0x01 (1_{dec})
1A02:01	SubIndex 001	1. PDO Mapping entry (object 0x6000 (ENC Inputs), entry 0x13 (Frequency value (uint32))	UINT32	RO	0x6000:13, 32

Index 1C00 Sync manager type

Index (hex)	Name	Meaning	Data type	Flags	Default
1C00:0	Sync manager type	Using the Sync Managers	UINT8	RO	0x04 (4_{dec})
1C00:01	SubIndex 001	Sync-Manager Type Channel 1: Mailbox Write	UINT8	RO	0x01 (1_{dec})
1C00:02	SubIndex 002	Sync-Manager Type Channel 2: Mailbox Read	UINT8	RO	0x02 (2_{dec})
1C00:03	SubIndex 003	Sync-Manager Type Channel 3: Process Data Write (Outputs)	UINT8	RO	0x03 (3_{dec})
1C00:04	SubIndex 004	Sync-Manager Type Channel 4: Process Data Read (Inputs)	UINT8	RO	0x04 (4_{dec})

Index 1C12 RxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C12:0	RxPDO assign	PDO Assign Outputs	UINT8	RW	0x00 (0_{dec})
1C12:01	SubIndex 001	1. allocated RxPDO (contains the index of the associated RxPDO mapping object)	UINT16	RO	0x1600 (5632_{dec})

Index 1C13 TxPDO assign

Index (hex)	Name	Meaning	Data type	Flags	Default
1C13:0	TxPDO assign	PDO Assign Inputs	UINT8	RO	0x01 (1_{dec})
1C13:01	SubIndex 001	1. allocated TxPDO (contains the index of the associated TxPDO mapping object)	UINT16	RO	0x1A00 (6656_{dec})

Index 1C32 SM output parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C32:0	SM output parameter	Synchronization parameters for the outputs	UINT8	RO	0x20 (32_{dec})
1C32:01	Sync mode	Current synchronization mode: • 0: Free Run • 1: Synchron with SM 2 Event • 2: DC-Mode - Synchron with SYNC0 Event • 3: DC-Mode - Synchron with SYNC1 Event	UINT16	RW	0x0001 (1_{dec})
1C32:02	Cycle time	Cycle time (in ns): • Free Run: cycle time of the local timer • Synchronous with SM 2 Event: cycle time of the master • DC-Mode: SYNC0/SYNC1 Cycle Time	UINT32	RW	0x000F4240 (1000000_{dec})
1C32:03	Shift time	Time between SYNC0 event and output of the outputs (in ns, DC mode only)	UINT32	RO	0x000081B0 (33200_{dec})
1C32:04	Sync modes supported	Supported synchronization modes: • Bit 0 = 1: Free Run is supported • Bit 1 = 1: Synchron with SM 2 Event is supported • Bit 2-3 = 01: DC-Mode is supported • Bit 4-5 = 10: Output Shift with SYNC1 event (only DC mode) • Bit 14 = 1: dynamic times (measurement through writing of 0x1C32:08)	UINT16	RO	0x440B (17419_{dec})
1C32:05	Minimum cycle time	Minimum cycle time (in ns)	UINT32	RO	0x0000F230 (62000_{dec})
1C32:06	Calc and copy time	Minimum time between SYNC0 and SYNC1 event (in ns, DC mode only)	UINT32	RO	0x00003C28 (15400_{dec})
1C32:07	Minimum delay time	Minimum time between SYNC1 event and output of the outputs (in ns)	UINT32	RO	0x000044C0 (17600_{dec})
1C32:08	Command	• 0: Measurement of the local cycle time is stopped • 1: Measurement of the local cycle time is started The entries 0x1C32:03, 0x1C32:05, 0x1C32:06, 0x1C32:09, 0x1C33:03, 0x1C33:06 [▶ 62], 0x1C33:09 are updated with the maximum measured values. For a subsequent measurement the measured values are reset	UINT16	RW	0x0000 (0_{dec})
1C32:09	Maximum delay time	Time between SYNC1 event and output of the outputs (in ns, DC mode only)	UINT32	RO	0x00004588 (17800_{dec})
1C32:0B	SM event missed counter	Number of missed SM events in OPERATIONAL (DC mode only)	UINT16	RO	0x0000 (0_{dec})
1C32:0C	Cycle exceeded counter	Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early)	UINT16	RO	0x0000 (0_{dec})
1C32:0D	Shift too short counter	Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only)	UINT16	RO	0x0000 (0_{dec})
1C32:14	Frame repeat time		UINT32	RW	0x00000000 (0_{dec})
1C32:20	Sync error	The synchronization was not correct in the last cycle (outputs were output too late; DC mode only)	BOOLEAN	RO	0x00 (0_{dec})

Index 1C33 SM input parameter

Index (hex)	Name	Meaning	Data type	Flags	Default
1C33:0	SM input parameter	Synchronization parameters for the inputs	UINT8	RO	0x20 (32_{dec})
1C33:01	Sync mode	Current synchronization mode: • 0: Free Run • 1: Synchron with SM 3 event (no outputs available) • 2: DC - Synchron with SYNC0 Event • 3: DC - Synchron with SYNC1 Event • 34: Synchron with SM 2 event (outputs available)	UINT16	RW	0x0022 (34_{dec})
1C33:02	Cycle time	Cycle time (in ns): • Free Run: cycle time of the local timer • Synchronous with SM 2 Event: cycle time of the master • DC-Mode: SYNC0/SYNC1 Cycle Time	UINT32	RW	0x000F4240 (1000000_{dec})
1C33:03	Shift time	Time between SYNC0 event and reading of the inputs (in ns, DC mode only)	UINT32	RO	0x00007788 (30600_{dec})
1C33:04	Sync modes supported	Supported synchronization modes: • Bit 0: Free Run is supported • Bit 1: Synchron with SM 2 Event is supported (outputs available) • Bit 1: Synchron with SM 3 Event is supported (no outputs available) • Bit 2-3 = 01: DC-Mode is supported • Bit 4-5 = 01: Input Shift through local event (outputs available) • Bit 4-5 = 10: Input Shift with SYNC1 event (no outputs available) • Bit 14 = 1: dynamic times (measurement through writing of 0x1C33:08)	UINT16	RO	0x440B (17419_{dec})
1C33:05	Minimum cycle time	Minimum cycle time (in ns)	UINT32	RO	0x0001D4C0 (120000_{dec})
1C33:06	Calc and copy time	Time between reading of the inputs and availability of the inputs for the master (in ns, only DC mode)	UINT32	RO	0x00006FB8 (28600_{dec})
1C33:07	Minimum delay time	Min. time between SYNC1 event and the reading of the inputs (in ns, DC mode only)	UINT32	RO	0x000015E0 (5600_{dec})
1C33:08	Command	With this entry the real required process data provision time can be measured. • 0: Measurement of the local cycle time is stopped • 1: Measurement of the local cycle time is started The entries 0x1C33:03, 0x1C33:06, 0x1C33:09 are updated with the maximum measured values. For a subsequent measurement the measured values are reset	UINT16	RW	0x0000 (0_{dec})
1C33:09	Maximum Delay time	Time between SYNC1 event and reading of the inputs (in ns, only DC mode)	UINT32	RO	0x000016A8 (5800_{dec})
1C33:0B	SM event missed counter	Number of missed SM events in OPERATIONAL (DC mode only)	UINT16	RO	0x0000 (0_{dec})
1C33:0C	Cycle exceeded counter	Number of occasions the cycle time was exceeded in OPERATIONAL (cycle was not completed in time or the next cycle began too early)	UINT16	RO	0x0000 (0_{dec})
1C33:0D	Shift too short counter	Number of occasions that the interval between SYNC0 and SYNC1 event was too short (DC mode only)	UINT16	RO	0x0000 (0_{dec})
1C33:20	Sync error	The synchronization was not correct in the last cycle (outputs were output too late; DC mode only)	BOOLEAN	RO	0x00 (0_{dec})

Index F082 MDP Profile Compatibility

Index (hex)	Name	Meaning	Data type	Flags	Default
F082:0	MDP profile compatibility	Maximum subindex	UINT8	RO	0x01 (1_{dec})
F082:01	Compatible input cycle counter	reserved	BOOLEAN	RW	0x00 (0_{dec})

7 Appendix

7.1 Support and Service

Beckhoff and their partners around the world offer comprehensive support and service, making available fast and competent assistance with all questions related to Beckhoff products and system solutions.

Beckhoff's branch offices and representatives

Please contact your Beckhoff branch office or representative for local support and service on Beckhoff products!

The addresses of Beckhoff's branch offices and representatives round the world can be found on her internet pages: www.beckhoff.com

You will also find further documentation for Beckhoff components there.

Beckhoff Support

Support offers you comprehensive technical assistance, helping you not only with the application of individual Beckhoff products, but also with other, wide-ranging services:

- support
- design, programming and commissioning of complex automation systems
- and extensive training program for Beckhoff system components

Hotline:	+49 5246 963 157
e-mail:	support@beckhoff.com

Beckhoff Service

The Beckhoff Service Center supports you in all matters of after-sales service:

- on-site service
- repair service
- spare parts service
- hotline service

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