Original Operating Instructions

Safety over EtherCAT®

Absolute Encoder CD_-75 EtherCAT/FSoE

Explosion-proof enclosure

_A**75*

Protection Enclosure

_CDV115

CDH 75 M

CDV 75 M

DIN EN 61508: **SIL CL3**
DIN EN ISO 13849: **PL e**

_Safety information
_Device-specific characteristics
_Installation/Commissioning
_Parameterization
_Error causes and solutions

User Manual Interface

TR - ECE - BA - GB - 0118 - 07 07/09/2020

TR-Electronic GmbH
D-78647 Trossingen
Eglishalde 6
Tel.: (0049) 07425/228-0
Fax: (0049) 07425/228-33
Email: info@tr-electronic.de
www.tr-electronic.de

Copyright protection

Subject to modifications

The right to make any changes in the interest of technical progress is reserved.

Document information

Release date / Rev. date:	07/09/2020
Document rev. no.:	TR - ECE - BA - GB - 0118 - 07
File name:	TR-ECE-BA-GB-0118-07.docx
Author:	MÜJ

Font styles

Italic or **bold** font styles are used for the title of a document or are used for highlighting.

`Courier` font displays text, which is visible on the screen and software menu selections.

" <   > " indicates keys on your computer keyboard (such as <RETURN>).

Brand names

EtherCAT® and Safety over EtherCAT® are registered trademarks and patented technologies, licensed by Beckhoff Automation GmbH, Germany.

All other specified products, names and logos serve exclusively for information purposes and may be trademarks of their respective owners, without any special marking to indicate this.

Contents

Revision index

Modification	Date	Index
First release	08/12/16	00
Safety values for double magnetic scanning system edited	08/15/16	01
“auto-crossover-function” added	02/28/17	02
1024 ppr to factor 5 for incremental interface	10/11/17	03
CDV115 protection enclosure added	12/04/17	04
FSoE-Watchdog: permissible max. value = 65530 ms	12/19/17	05
Safety-related applicable accuracy edited	12/13/18	06
Correction of the rotary switches: 16^0, 16^1	07/09/20	07

1 General information

This interface-specific user manual contains the following topics:

- Safety information
- Device-specific characteristics
- Installation/Commissioning
- Parameterization
- Error causes and solutions

As the documentation is arranged in a modular structure, this User Manual is supplementary to other documentation, such as product data sheets, dimensional drawings, brochures and safety manual etc.

The User Manual may be included in the customer's specific delivery package or it may be requested separately.

1.1 Applicability

This User Manual applies exclusively for measuring system series in accordance with the following type code with ***EtherCAT*** interface und ***FSoE*** protocol:

* 1	* 2	* 3	* 4	* 5	-	* 6	* 6	* 6	* 6	* 6

Position	Designation	Description
* 1	A C	Explosion-proof enclosure (ATEX); Ex Absolute encoder, programmable
* 2	D	Redundant dual scanning
* 3	V H	Solid shaft Hollow shaft
* 4	75 115	Outer diameter ∅ 75 mm Outer diameter ∅ 115 mm
* 5	M	Multi-turn
* 6	-	Consecutive number

* = placeholder

The products are labeled with affixed nameplates and are components of a system.

The following documentation therefore also applies:

- operator's operating instructions specific to the system
- this User Manual
- and the safety manual which is enclosed with the delivery www.tr-electronic.de/f/TR-ECE-BA-GB-0107
- optional: Ex-user manual

1.2 References

1.	ETG.1000.1 - 6	EtherCAT Technology Group (ETG): EtherCAT specification
2.	ETG.5100, V1.2.0	EtherCAT Technology Group (ETG): Safety over EtherCAT protocol specification
3.	EN 50325:4	Industrial Communication Systems, based on ISO 11898 (CAN) for Controller Device Interfaces. Part 4: CANopen
4.	CiA DS-301	CANopen communication profile based on CAL
5.	CiA DS-406	CANopen profile for encoders
6.	IEC 61158-1 - 6	Digital data communications for measurement and control - Fieldbus for use in industrial control systems - Protocols and services, type 12 = EtherCAT
7.	IEC 61784-2	Digital data communications for measurement and control - Additional profiles for ISO/IEC 8802-3 based communication networks in real-time applications, 12 = EtherCAT
8.	IEC 61784-3	Industrial communication networks - Profiles - Part 3: Functional safety fieldbuses- General rules and profile definitions
9.	IEC 61784-5 - 12	Industrial communication networks - Profiles - Part 5-12: Installation of fieldbuses - Installation profiles for CPF 12
10.	IEC 61918	Industrial communication networks - Installation of communication networks in industrial premises
11.	ISO/IEC 8802-3	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
12.	ISO 15745-4 AMD 2	Industrial automation systems and integration - Open systems application integration framework - Part 4: Reference description for Ethernet-based control systems; Amendment 2: Profiles for Modbus TCP, EtherCAT and ETHERNET Powerlink
13.	IEEE 1588-2002	IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems

1.3 Abbreviations and terms used

0x	Hexadecimal representation
A**75*	Explosion-proof enclosure ∅ 75 mm with integrated measuring system, all variants
CAN	Controller Area Network. Data Layer Protocol for serial communication, described in ISO 11898.
CAT	Category: Classification of cables which are also used for Ethernet.
CDV115	Series 75 measuring system installed in a 115 "Heavy Duty" protection enclosure
CD_	Absolute encoder with redundant dual scanning, all designs
CiA	CAN in Automation. Internationale Anwender- und Herstellervereinigung e.V.: non-profit organization for the Controller Area Network (CAN).
CoE	CANopen over EtherCAT
DC_{avg}	***D***iagnostic ***C***overage Average diagnostic coverage
EU	***E***uropean ***U***nion
EMC	***E***lectro ***M***agnetic ***C***ompatibility
ESM	***E***therCAT ***S***tate ***M***achine
ETG	"***E***therCAT ***T***echnology ***G***roup" user association
FSoE	Safety over EtherCAT
IEC	International Electrotechnical Commission
IP	***I***nternet ***P***rotocol
ISO	***I***nternational ***S***tandard ***O***rganisation
$MTTF_d$	***M***ean ***T***ime ***T***o ***F***ailure (dangerous) Mean time until dangerous failure
NMT	Network Management. One of the service elements in the application layer in the CAN reference model. Executes initialization, configuration and troubleshooting in bus traffic.
PDO	Process Data Object. Object for data exchange between several devices.
PDU	***P***rotocol ***D***ata ***U***nit. Contains protocol information such as source and destination address, checksum and service parameter information
PFD_{av}	***Av***erage ***P***robability of ***F***ailure on ***D***emand Average probability of failure of a safety function with low demand
Safe data (FailSafeData)	In the case of a safety-oriented periphery with outputs, the safety-oriented system transmits substitute values (e.g. 0) to the fail-safe outputs in the case of error instead of the output values provided in the process image by the safety program.

Continued

PFH	Probability of Failure per Hour Operating mode with high requirement rate or continuous demand. Probability of dangerous failure per hour.
SDO	Service Data Object. Point to point communication with access to the object data list of a device.
SIL	***S***afety ***I***ntegrity ***L***evel: Four discrete levels (SIL1 to SIL4). The higher the SIL of a safety-related system, the lower the probability that the system cannot execute the required safety functions.
STP	***S***hielded ***T***wisted ***P***air
Repeat test (proof test)	Repetitive test to detect hidden dangerous failures in a safety-related system.
XML	E**x**tensible **M**arkup **L**anguage, description file for commissioning the measuring system.

1.4 Main features

- EtherCAT - Interface with FSoE protocol, for transfer of a safe position and speed
- Quick process data channel over EtherCAT, not safety-oriented
- Only for variant 1:
  Additional incremental or SIN/COS interface, not safety-oriented
- Two-channel scanning system, for generation of reliable measured data through internal channel comparison
  - Variant 1:
    Channel 1, master system:
    optical single-turn scanning via code disk with transmitted light and magnetic multi-turn scanning

    Channel 2, inspection system:
    magnetic single and multi-turn scanning
  - Variant 2:
    Channel 1, master system:
    magnetic single and multi-turn scanning

    Channel 2, inspection system:
    magnetic single and multi-turn scanning
- A common drive shaft

The data of the master system are unevaluated in the non-safety-oriented process data channel in the standard EtherCAT-frame, but are made available with a short cycle time.

The inspection system serves for the internal safety check. The "safe data" obtained through two-channel data comparison are embedded in the process data of the cyclical communication as a safety container and also made available over EtherCAT. Initiated via an FSoE master frame, the measuring system responds with an FSoE slave frame and transmits the safe input data to the FSoE master.

The incremental interface available in variant 1, or the optionally available SIN/COS interface, is derived from the master system and is not evaluated from a safety viewpoint.

1.5 Principle of the safety function

System safety results when:

- Each of the two scanning channels is largely fail-safe thanks to individual diagnostic measures
- The measuring system internally compares the positions detected by both channels in two channels, also determines the speed in two channels and transfers the safe data in the FSoE frame via EtherCAT to the FSoE master
- In the event of a failed channel comparison or other errors detected through internal diagnostic mechanisms, the measuring system switches the Safety channel into error state
- The measuring system initialization and execution of the preset adjustment function are appropriately verified
- The control additionally checks whether the obtained position data lie in the position window expected by the control. Unexpected position data are e.g. position jumps, tracking error deviations and incorrect direction of travel
- When errors are detected the control introduces appropriate safety measures defined by the system manufacturer
- The system manufacturer ensures, through correct mounting of the measuring system, that the measuring system is always driven by the axis to be measured and is not overloaded
- The system manufacturer performs a verified test during commissioning and in the event of any parameter modification

2 Safety information

2.1 Definition of symbols and notes

⚠ DANGER	means that death or serious injury will occur if the required precautions are not met.
⚠ WARNING	means that death or serious injury can occur if the required precautions are not met.
⚠ CAUTION	means that minor injuries can occur if the required precautions are not met.
NOTICE	means that damage to property can occur if the required precautions are not met.
	indicates important information or features and application tips for the product used.

2.2 Organizational measures

- This User Manual must always be kept ready-to-hand at the place of use of the measuring system.
- Prior to commencing work, the personnel working on the measuring system must have read and understood
  - the Safety Manual, particularly the chapter ***"Basic safety instructions"***
  - and this User Manual, particularly the chapter ***"Safety information"***

This particularly applies for personnel who are only deployed occasionally, e.g. in the parameterization of the measurement system.

2.3 Safety functions of the fail-safe processing unit

The measuring system does not make any decisions about valid states of motion of the system in which it is used. The system must check the consistency between the position information of the measuring system and the expected movement of the system.
The **FSoE master**, to which the measuring system is connected, must perform the following safety checks.

To enable the correct measures to be taken in the case of error, the following applies:

If no safe position can be output due to an error detected by the measuring system, the safety channel is set to `FailSafeData` state and automatically put into fail-safe state, safety status LED = red. In this state so-called "safe data" are output via the safety channel. Also see the chapter "Output of safe data (substitute values)" on page 49.

Fail-safe state from the viewpoint of the measuring system:

- Safety state: FailSafeData
- Safety frame: Data are set to 0

Upon receipt of safe data the FSoE master must put the system into a safe state. You can only leave this error state by eliminating and then acknowledging the error, see chapter Error acknowledgement flow diagram on page 54.

The process data channel addressable via EtherCAT Standard is not necessarily affected by this. If the internal diagnosis in the master channel does not detect an error, the process data are still output.

2.3.1 Mandatory safety checks / measures

Measures for commissioning, changes	Error reaction
Application-dependent parameterization of safety parameters, see chapter "Safety-oriented parameters" on page 47.	–
In the event of parameter changes, check that the measure is executed as desired.	STOP

Check by FSoE master	Error reaction
Cyclical consistency check of the current safety-oriented data in the TR-PROFIsafe module in relation to the previous data.	STOP
Consistency check between safety position information of the measuring system and the movement of the system.	STOP
Monitoring of cyclical safety data.	PDU command = FailSafeData-> STOP
FSoE watchdog time: Monitoring of the measuring system - response time. For checking e.g. cable breakage, power failure etc. The permissible max. value for the FSoE-Watchdog is 65530 ms.	STOP

3 Technical data

3.1 Safety

Startup time .... Time between POWER-UP and safe position output
Overall system .... around 7s, Beckhoff CX9020 (500µs) with EL6900

PFH, operating mode .... $3.25*10^{-10}$ 1/h
Double magnetic scanning system .. $8,35*10^{-10}$ 1/h

PFD_{av} (T_1 = 20 a) .... $2.81*10^{-5}$
Double magnetic scanning system .. $7,28*10^{-5}$

$MTTF_d$ .... 197 a, HIGH
Double magnetic scanning system .. 202 a, HIGH

*** DC_{avg}** .... 98 %, HIGH
Double magnetic scanning system .. 98 %, HIGH

Internal process safety time .... Time between occurrence of a safety-relevant error and alarm indication
Overall system .... ≤ 7,5 ms

Process safety angle .... Angle between error occurrence and alarm indication
Through channel-internal self-diagnosis .... ± 100 °, in relation to the measuring system shaft, at 6000 rpm
Through channel comparison .... parameterizable with parameter `Window increments`

T_1, repeat test (proof test) .... 20 years

* The assessment occurred in accordance with Note 2 on Table 6 of EN ISO 13849-1

3.2 Electrical characteristics

3.2.1 General

Supply voltage .... 13…27 V DC according to IEC 60364-4-41, SELV/PELV
Feed .... single feed input, but electrically separated internally by means of two power supplies
Reverse polarity protection .... yes
Short-circuit protection .... yes, by internal 2 A safety fuse
Overvoltage protection .... yes, up to ≤ 36 V DC

Power consumption without load .... ≤ 165 mA at 24 V DC
Optional HTL level, 13…27 VDC .. Increased power consumption, see page 26

3.2.2 Device-specific

Complete solution	≤ 268 435 456 Steps
Number of steps / revolution	≤ 8192
Number of revolutions	≤ 32768
Functional accuracy	8192 steps, single-turn
Double magnetic scanning system	256 steps, single-turn
Accuracy, usable from a safety viewpoint	
Optical/magnetic scanning system	256 steps, single-turn
Double magnetic scanning system	128 steps, single-turn
Safety principle	2 redundant scanning units with internal triangulation
EtherCAT Interface	according to IEC 61158-1 – 6 and IEC 61784-2
Safety over EtherCAT, FSoE	IEC 61784-3
Additional functions	Preset
* Parameter	
- Safe integration time	50 ms…500 ms
- Unsafe integration time	5 ms…500 ms
- Size of monitoring window	50…4000 increments
- Preset standstill tolerance	1…5 increments/Safe integration time
- Counting direction	Forward motion, return motion
Physical Layer	EtherCAT 100Base-TX, Fast Ethernet, ISO/IEC 8802-3
Communication profile	CiA DS-301
Output code	Binary
Device profile	based on CiA DS-406
Bus cycle time	≥ 500 µs
Transmission rate	100 MBit/s
Transmission	CAT-5 cable shielded (STP), ISO/IEC 11801
* TR-specific functions	Speed output in increments/integration time
Incremental interface	Cable specification, see page 22
Availability	only for optical/magnetic scanning system
Pulses / revolution	1024, 2048, 3072, 4096, 5120 or 4096, 8192, 12288, 16384, 20480, via factory programming
A, /A, B, /B, TTL	EIA standard RS422 (2-wire)
A, /A, B, /B, HTL	optional 13…27 V DC, see page 26
Output frequency, TTL	≤ 500 KHz
Output frequency, HTL	see page 26
SIN/COS interface, alternative	Cable specification, see page 22
Availability	only for optical/magnetic scanning system
Number of periods	4096 / revolution; optional: 1024 / revolution
SIN+, SIN–, COS+, COS–	1 Vss ± 0.2 V / 100 Ω, differential
Short-circuit proof	yes
Cycle time	
NOT safety-oriented	0.5 ms
Safety-oriented	5 ms
Preset write cycles	≥ 32 000 000

* parameterizable via EtherCAT

3.3 Max. possible step deviation (master system / inspection system)

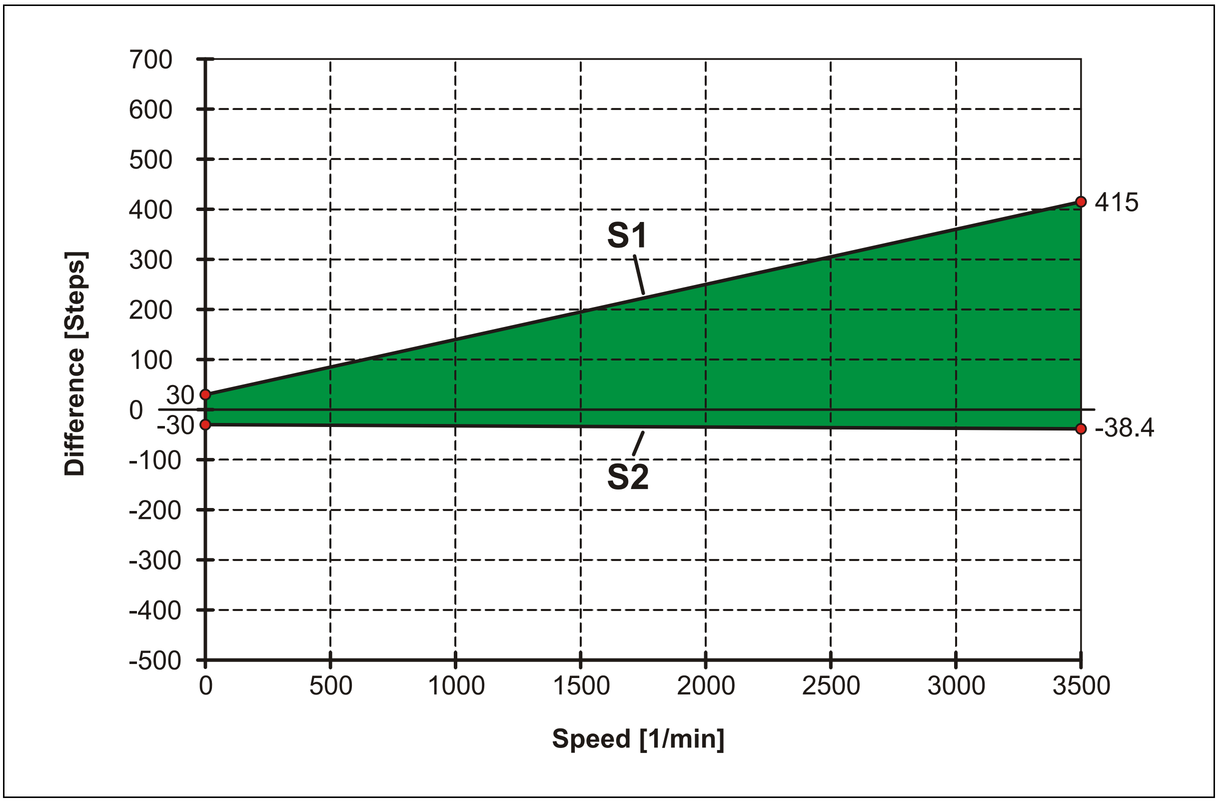


Figure 1: Dynamic view of step deviation, counting direction increasing (looking at the flange connection)

Function of straight line S1:

S1 = 30 steps + (0.11 steps per rev. * act. speed [1/min])

Function of straight line S2:

S2 = -30 steps + (-0.0024 steps per rev.* act. speed [1/min])

The maximum possible step deviation results from the difference between S1 and S2

Example: Maximum possible step deviation at 3500 1/min

S1 = 30 steps + (0.11 steps per rev. * 3500 1/min) = 415 steps
S2 = -30 steps + (-0.0024 steps per rev. * 3500 1/min) = -38.4 steps

Maximum possible step deviation = 415 steps – (-38.4 steps) = **453.4 steps**

4 Installation / Preparation for Commissioning

4.1 Basic rules

⚠ WARNING ***Deactivation of the safety function through conducted interference sources!***

- All EtherCAT FSoE devices used on the bus must have an EtherCAT- and an FSoE-certificate.
- All safety-oriented devices must also have a certificate from a "Notified Body" (e.g. TÜV, BIA, HSE, INRS, UL, etc.).
- The 24V power supplies used must fulfil the requirements according to IEC 60364-4-41 SELV/PELV.
- The shielding effect of cables must also be guaranteed after installation (bending radii/tensile strength!) and after connector changes. In cases of doubt, use more flexible cables with a higher current carrying capacity.
- For connecting the measuring system only use M12 connectors, which guarantee good contact between the cable shield and connector housing. The cable shield must be connected to the connector housing over a large area.
- Compensating currents due to potential differences across the shield to the measuring system must be avoided.
- A shielded and stranded data cable must be used to ensure high electromagnetic interference stability of the system. The shielding should be connected with low resistance to protective ground using large shield clips **at both ends**. The shielding should be grounded **in the switch cabinet only** if the machine ground is heavily contaminated with interference towards the switch cabinet ground.
- Equipotential bonding measures must be provided for the complete processing chain of the system.
- Power and signal cables must be laid separately. During installation the national safety and installation directives for data and energy cables must be observed.
- Observe the manufacturer's instructions for the installation of converters and for shielding power cables between frequency converter and motor.
- Ensure adequate dimensioning of the energy supply.

Upon completion of installation, a visual inspection with report should be carried out. Wherever possible, the quality of the network should be verified using a suitable bus analysis tool.

To ensure safe and fault-free operation,

- *ISO/IEC 11801, EN 50173 (European standard)*
- *ISO/IEC 8802-3*
- *IEC 60204-1*
- *IEC 61784-5*
- *IEC 61918*
- *and the standards and directives referenced therein must be observed!*

In particular the EMC directive in its valid version must be observed!

4.2 EtherCAT Transmission technology, cable specification

The safety-oriented FSoE communication is embedded in the standard protocol of EtherCAT and transmitted over the same network.

EtherCAT supports linear, tree or star structures. The bus or linear structure used in the field buses is thus also available for Ethernet. This is particularly practical for system wiring, as a combination of line and stubs is possible.

For transmission according to the 100Base-TX Fast Ethernet standard, patch cables in category STP CAT5 must be used (2 x 2 shielded twisted pair copper wire cables). The cables are designed for bit rates of up to 100 MBit/s. Because the measuring system supports the “auto-crossover-function”, it can be used crossover cables as well as uncrossed cables. The transmission speed is automatically detected by the measuring system and does not have to be set by means of a switch.

EtherCAT addressing by switch is also not necessary; this is done automatically using the addressing options of the EtherCAT master.

The cable length between two nodes may be max. 100 m; a total of 65535 nodes are possible in the EtherCAT network.

4.3 Connection

⚠ WARNING

NOTICE

Destruction, damage and malfunction of the measuring system due to penetration of moisture!

- During storage and operation of the measuring system unused connection plugs must either be provided with a mating plug or a protective cap. The appropriate IP protection class must be selected to meet the relevant requirements.
- Closing elements with O-ring:
  When re-closing, check that the O-ring is present and correctly positioned.
- For appropriate protective caps, see the "Accessories" chapter in the Safety manual.

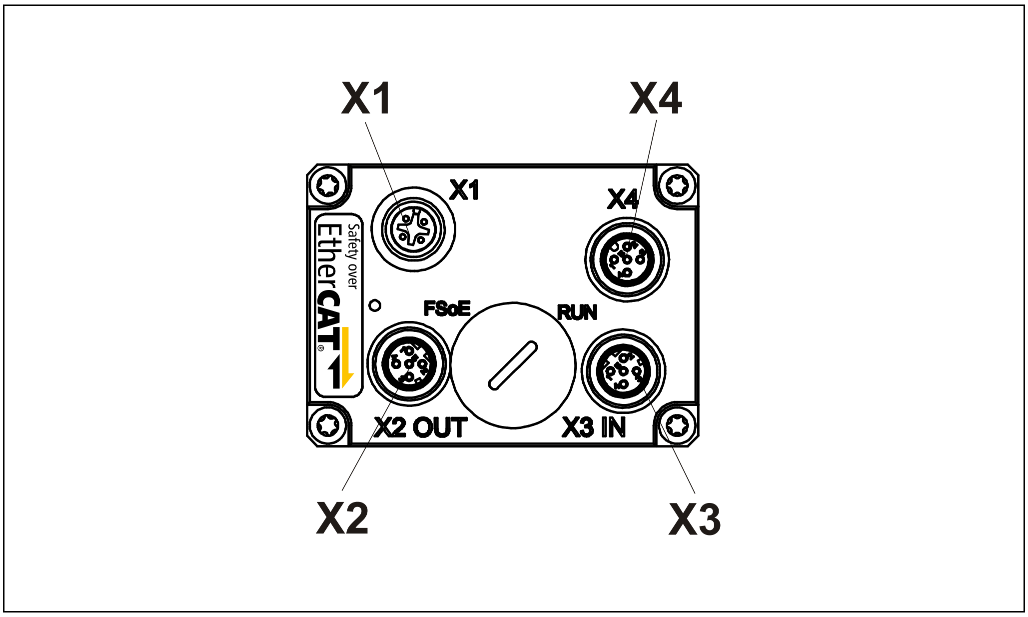


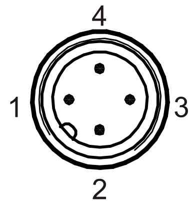
Figure 2: Connector assignment

4.3.1 Supply voltage

NOTICE

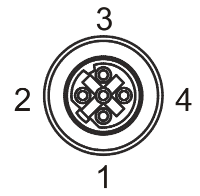
Danger of unnoticed damage to the internal electronics, due to unacceptable overvoltages!

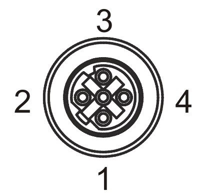
- If an overvoltage of >36 V DC is inadvertently applied, the measuring system must be checked in the factory. The measuring system is permanently switched off for safety reasons, if the overvoltage is applied for more than 200 ms.
  - ➢ The measuring system must be shut down immediately
  - ➢ When sending the measuring system to the factory, the reasons and circumstances relating to the overvoltage must be specified
  - ➢ The power supply used must meet the requirements of SELV/PELV (IEC 60364-4-41:2005)

X1	Signal	Description	Pin, M12x1, 4 pole
1	+ 24 V DC (13…27 V DC)	Supply voltage	A-coded 
2	N.C.	-	
3	0 V	GND	
4	N.C.	-	

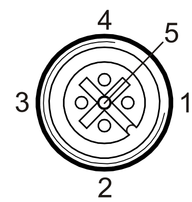
Cable specification: min. 0.34 mm² (recommendation 0.5 mm²) and shielded.
Generally the cable cross-section must be matched to the cable length.

4.3.2 EtherCAT

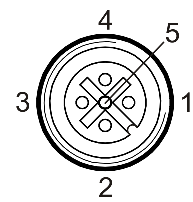
X2	Signal	Description	Socket, M12x1, 4 pole
1	TxD+, transmission data +	PORT-OUT	D-coded 
2	RxD+, received data +		
3	TxD+, transmission data –		
4	RxD–, received data –		

X3	Signal	Description	Socket, M12x1, 4 pole
1	TxD+, transmission data +	PORT-IN	D-coded 
2	RxD+, received data +		
3	TxD+, transmission data –		
4	RxD–, received data –		

4.3.3 Incremental interface / SIN/COS interface

X4	Signal	Level, see type plate	Socket, M12x1, 5 pole
[1] 1	Channel B +	5 V differential / 13…27 V DC	A-coded 
[1] 2	Channel B –	5 V differential / 13…27 V DC	
[1] 3	Channel A +	5 V differential / 13…27 V DC	
[1] 4	Channel A –	5 V differential / 13…27 V DC	
5	0 V, GND	Data reference potential	

Alternatively with SIN/COS signals

X4´	Signal	Description	Socket, M12x1, 5 pole
1	SIN +	1 Vss, differential	A-coded 
2	SIN –	1 Vss, differential	
3	COS +	1 Vss, differential	
4	COS –	1 Vss, differential	
5	0 V, GND	Data reference potential	

Cable specification: min. 0.25 mm^2 and shielded.
However, to ensure signal quality and to minimize possible environmental influences, the use of a twisted-pair cable is also recommended.

[1] TTL/HTL level variant: see type plate

4.4 Setting the FSoE address

Each FSoE slave device is addressed via a system-wide unique 16-bit safety address. However, the measuring system only supports a settable address range of eight bits: 1 to 255.
The set safety address can be read out via the object 0xF980.

WARNING

NOTICE

Destruction, damage and malfunction of the measuring system due to penetration of foreign bodies and moisture!

- Make sure that the closing screw is securely closed again after accessing the address switches to make settings.

The safety address is set via two HEX rotary switches, which are only read at the moment of switch-on. Subsequent settings during operation are therefore not recognized.

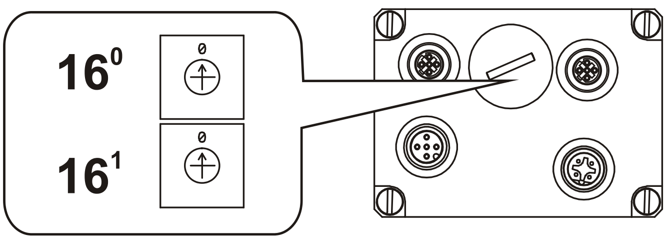


Figure 3: FSoE address, switch assignment

4.5 Incremental interface / SIN/COS interface

In addition to the EtherCAT – interface, for output of the absolute position the measuring system in the standard version also has an incremental interface.

Alternatively, however, this can also be designed as a SIN/COS interface.

⚠ WARNING

This additional interface is not evaluated in relation to safety and must not be used for safety-related purposes!

- ➢ The measuring system checks the outputs of this interface for the feed-in of external voltages. In the event of voltages > 5.7 V, the measuring system is switched into `FailSafeData` state for safety reasons.
- ➢ The interface is generally used as position feedback for motor control applications.

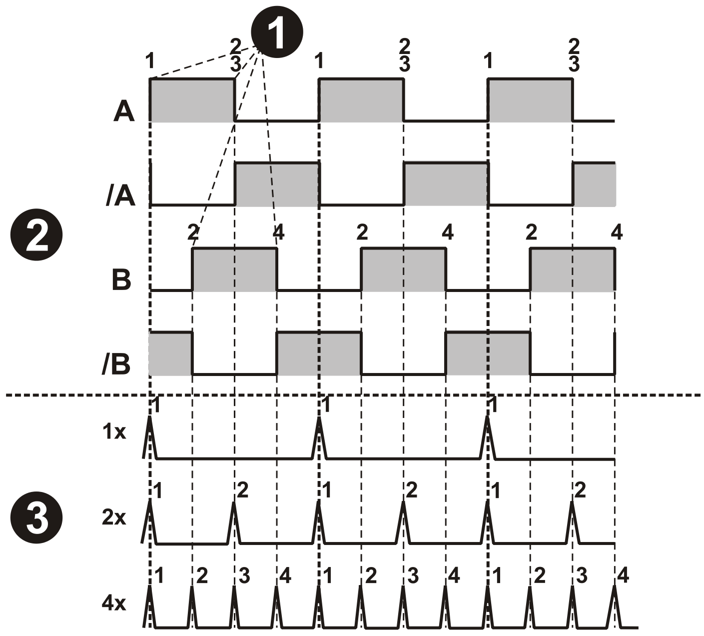
NOTICE

Danger of damage to subsequent electronics due to overvoltages caused by a missing ground reference point!

- If the ground reference point is completely missing, e.g. 0 V of the power supply not connected, voltages equal to the supply voltage can occur at the outputs of this interface.
  - ➢ It must be ensured that a ground reference point is present at any time,
  - ➢ or the system operator must provide appropriate protective mechanisms for the subsequent electronics.

The signal characteristics of the two possible interfaces are shown below.

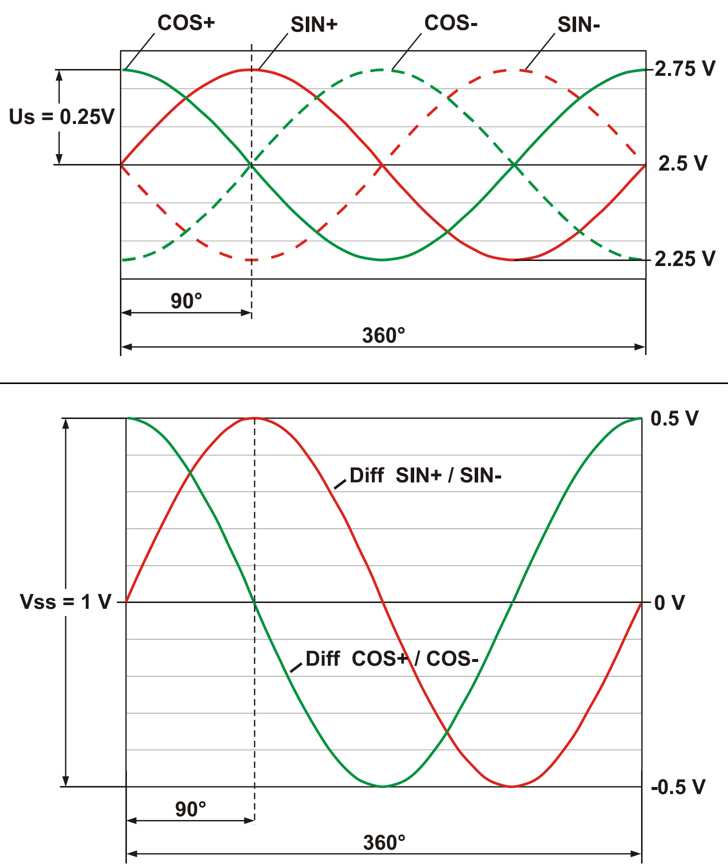
4.5.1 Signal characteristics



1: Edge evaluation
2: Measuring system with
4096 pulses/rev.
3: Counter evaluation

1x: 4096 counting pulses/rev.
2x: 8192 counting pulses/rev.
4x: 16384 counting pulses/rev.

Figure 4: Counter evaluation, incremental interface



Measurement of signals against 0 V

Differential measurement

Figure 5: Level definition, SIN/COS interface

4.5.2 Optional HTL level, 13…27 VDC

The incremental interface is optionally also available with HTL levels. For technical reasons the user must observe the following boundary conditions with this: Ambient temperature, cable length, cable capacity, supply voltage and output frequency.
The maximum output frequencies achievable via the incremental interface depend on the cable capacity, supply voltage and ambient temperature. Use of this interface is therefore only advisable if the interface characteristics meet the technical requirements.

From the viewpoint of the measuring system the transmission cable represents a capacitive load, which must be reloaded with each pulse. The necessary load quantity varies drastically, depending on the cable capacity. This reloading of the cable capacities is responsible for the high power loss and heat which occurs in the measuring system.

With a cable length (75 pF/m) of 100 m, half the limit frequency associated with the rated voltage of 24 VDC, the power consumption of the measuring system is twice as high, for example.

Due to the resulting heat, the measuring system may now only be operated at around 80 % of the specified working temperature.

The following graph shows the different dependencies in relation to three different supply voltages.

Fixed variables are

- Capacity of the cable: 75 pF/m
- Ambient temperature: 40 °C and 70 °C

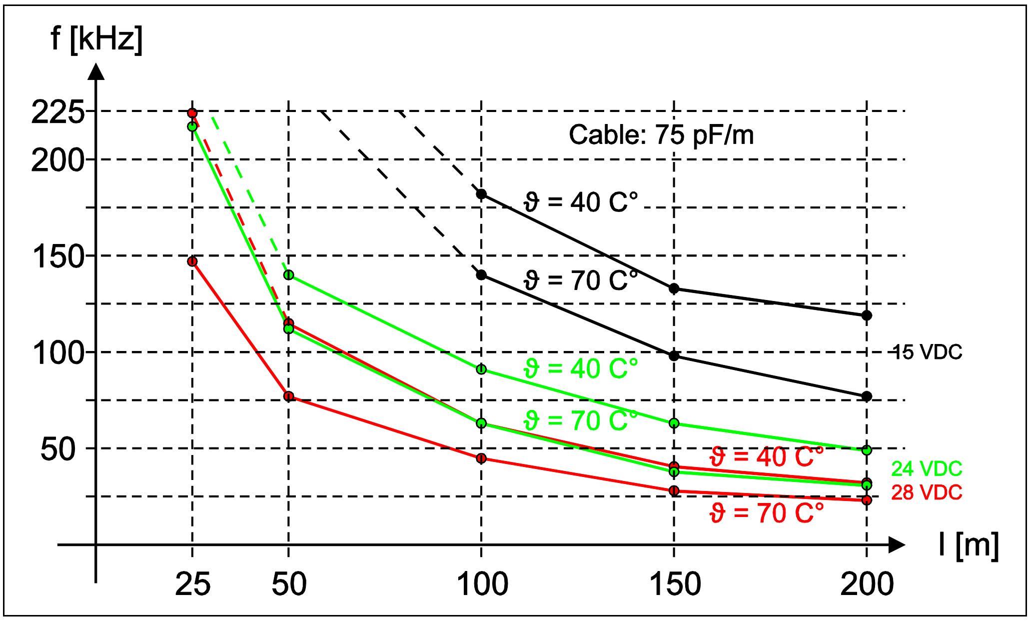


Figure 6: Cable lengths / limit frequencies

Other cable parameters, frequencies and ambient temperatures, as well as bearing heat and temperature loading via the shaft and flange, can give a much worse result in practice.

Faultless operation of the incremental interface must therefore be checked with the application-dependent parameters before the device is operated in the productive mode.

5 Commissioning

5.1 EtherCAT / FSoE

The EtherCAT functional principle of and the entire communication handling are described in the ETG specifications *ETG.1000.1* to *ETG.1000.6 EtherCAT Specification – Part 1* to *Part 6.*
The *Safety over EtherCAT (FSoE)* safety protocol is described in the ETG-specification *ETG.5100 Protocol Specification.*

This and further information on EtherCAT or FSoE is available on request from the ***EtherCAT Technology Group*** (ETG) at the following address:

ETG Headquarter
Ostendstraße 196
90482 Nuremberg
Germany

Phone:	+ 49 (0) 9 11 / 5 40 5620
Fax:	+ 49 (0) 9 11 / 5 40 5629
Email:	info@ethercat.org
Internet:	www.ethercat.org

5.2 Device description file (XML)

The XML file is a component of the measuring system.

Download

- www.tr-electronic.de/f/TR-ECE-ID-MUL-0051

5.3 Bus status display

⚠ WARNING

NOTICE

Destruction, damage and malfunction of the measuring system due to penetration of foreign bodies and moisture!

- ➢ Securely seal the access to the LEDs again with the closing screw after completing the settings.

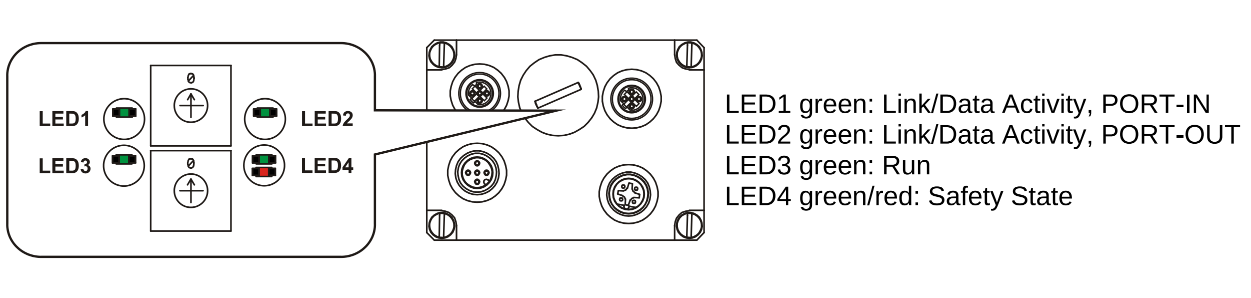


Figure 7: Bus status display

5.3.1 Display states and flashing frequency

LED	Description
ON	Continuously ON
OFF	Continuously OFF
Flickering	Same ON and OFF times with a frequency of around 10 Hz: ON = 50 ms, OFF = 50 ms.
Blinking	Same ON and OFF times with a frequency of around 2.5 Hz: ON = 200 ms, OFF = 200 ms.
Single flash	Single short flash, ON around 200 ms, followed by a long OFF time, around 1000 ms
Double flash	Double short flash, ON/OFF around 200 ms, followed by a long OFF time, around 1000 ms
Triple flash	Triple short flash, ON/OFF around 200 ms, followed by a long OFF time, around 1000 ms

5.3.2 Link / Data Activity LEDs

LED 1/2	Description
OFF	No Ethernet connection
ON	Ethernet connection established
Flickering	Data transmission TxD/RxD

For appropriate measures in case of error, see chapter "Troubleshooting and Diagnosis Options", page 52.

5.3.3 EtherCAT Run LED

LED 3	EtherCAT state machine
OFF	Device is in `INIT` state
Blinking	Device is in `PRE-OPERATIONAL` state
Single flash	Device is in `SAFE-OPERATIONAL` state
ON	Device is in `OPERATIONAL` state

For appropriate measures in case of error, see chapter "Troubleshooting and Diagnosis Options", page 52.

5.3.4 Safety State LED

LED 4, green	State
OFF	Initialization, device off
Single flash	INIT state, booting
Double flash	Data state – output of safe data
ON	Data state – output of process data

LED 4, red	State
Single flash; green = OFF	Error acknowledgement required by the user
ON; green = OFF	System or safety error

For appropriate measures in case of error, see chapter "Troubleshooting and Diagnosis Options", page 52.

5.4 Commissioning via TwinCAT System Manager

Download

- Technical information: www.tr-electronic.de/f/TR-ECE-TI-DGB-0280

6 Structure of Process Data

6.1 Safety-oriented process data

Structure of input data

Byte	Bit	Input data	
X+0	2^0-2^7	SafeStatus	UNSIGNED16
X+1	2^8-2^{15}		
X+2	2^0-2^7	SafeVelocity	INTEGER16
X+3	2^8-2^{15}		
X+4	2^0-2^7	Actual value, SafeMultiturn, 15 bit	UNSIGNED16
X+5	2^8-2^{15}		
X+6	2^0-2^7	Actual value, SafeSingleturn, 13 bit	UNSIGNED16
X+7	2^8-2^{15}		
X+8	2^0-2^7	Actual value scaled, SafeScaled	UNSIGNED32
X+9	2^8-2^{15}		
X+10	2^{16}-2^{23}		
X+11	2^{24}-2^{31}		

Structure of output data

Byte	Bit	Output data	
X+0	2^0-2^7	SafeControl	UNSIGNED16
X+1	2^8-2^{15}		
X+2	2^0-2^7	SafePresetSingle	UNSIGNED16
X+3	2^8-2^{15}		
X+4	2^0-2^7	SafePresetMulti	UNSIGNED16
X+5	2^8-2^{15}		
X+6	2^0-2^7	SafeOutRes	UNSIGNED16
X+7	2^8-2^{15}		

6.1.1 Input data

6.1.1.1 SafeStatus

⚠ WARNING

NOTICE

- **Danger of death, serious physical injuries and/or damage to property due to uncontrolled start-up of the drive system, in the event of NON-evaluation of `SafeState` bit 2^4!**
  - ➢ The output actual values are only valid if `SafeState` bit 2^4 = 1.

Unsigned16

Byte	**X+0**	**X+1**
Bit	7 – 0	15 – 8
Data	$2^7 – 2^0$	$2^{15} – 2^8$

Bit	**Description**
2^0	`Velocity Error` Bit = 1, if the speed value is outside the range of –32768…+32767.
2^1	`Error Ack Request` Bit = 1, if the measuring system is in safe state and is waiting for an error acknowledgement.
2^2	`Preset OK` Bit = 1, if a preset request was successfully executed.
2^3	`Preset Error` Bit = 1, if a preset request could not be executed due to excessive speed. The current speed must be in the range of the speed set under `Preset Standstill Tolerance`. The bit can be reset again via the preset control bits `Preset_Request` and `Preset_Preparation`, also see page 50.
2^4	`SafeState` Bit = 0, - in the initialization phase, or if the initialization could not be successfully completed - if a preset request is initiated via the control bit `Preset`_Preparation - if an exception error is present during the preset execution - if the measuring system is in safe state Bit = 1, - if the initialization was successfully completed - if a preset request was successfully completed and the preset control bits `Preset_Request` and `Preset_Preparation` have been reset
2^5	`Preset Active` Bit = 1, if the preset execution is triggered via the control bit `Preset_Request`. When the preset has been executed the bit is automatically reset, also see page 50.
$2^6…2^{15}$	reserved

6.1.1.2 SafeVelocity

INTEGER16

Byte	X+2	X+3
Bit	7 – 0	15 – 8
Data	$2^7 - 2^0$	$2^{15} - 2^8$

The speed is output as a two's complement value with preceding sign.

Setting of direction of rotation = forward

- Looking at the flange connection, turn the shaft clockwise:
  --> positive speed output

Setting of direction of rotation = backward

- Looking at the flange connection, turn the shaft clockwise:
  --> negative speed output

If the measured speed exceeds the display range of –32768…+32767, this results in an overflow, which is indicated in the status register via Bit 2^0. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in the Status bits register is also deleted.
The speed is specified in `Increments` per `Safe Integration time`.

6.1.1.3 SafeMultiturn / SafeSingleturn

SafeMultiturn, UNSIGNED16

Byte	X+4	X+5
Bit	7 – 0	15 – 8
Data	$2^7 - 2^0$	$2^{15} - 2^8$

SafeSingleturn, UNSIGNED16

Byte	X+6	X+7
Bit	7 – 0	15 – 8
Data	$2^7 - 2^0$	$2^{15} - 2^8$

The number of revolutions is recorded in the `SafeMultiturn` register and the current single-turn position is recorded in steps in the `SafeSingleturn` register. Together with the resolution of the measuring system, max. number of steps per revolution according to the type plate, the actual position can then be calculated, which corresponds to the `SafeScaled` position:

Position in steps = (steps per revolution * number of revolutions) + Single-Turn position

Steps per revolution:	8192	≙ 13 bit
Number of revolutions:	0…32767	≙ 15 bit

The output position does not have a preceding sign.

6.1.1.4 SafeScaled

Actual value scaled, UNSIGNED32

Byte	X+8	X+9	X+10	X+11
Bit	7 – 0	15 – 8	23 – 16	31 – 24
Data	$2^7 - 2^0$	$2^{15} - 2^8$	$2^{23} - 2^{16}$	$2^{31} - 2^{24}$

The current scaled actual position is output via the `SafeScaled` register.

The output position does not have a preceding sign.

6.1.2 Output data

6.1.2.1 SafeControl

UNSIGNED16

Byte	X+0	X+1
Bit	7 – 0	15 – 8
Data	$2^7 - 2^0$	$2^{15} - 2^8$

Bit	Description
2^0	`Preset_Preparation` The bit serves to prepare the preset adjustment function. Only if this bit is set the actual preset can be executed via the control bit [`Preset_Request`]. A precise sequence must be observed in order to execute the function, see chapter "Preset Adjustment Function" on page 50.
2^1	`Preset_Request` The bit serves to control the preset adjustment function. When this function is executed, the measuring system is set to the position value stored in the `SafePresetMulti`/`SafePresetSingle` registers. A precise sequence must be observed in order to execute the function, see chapter "Preset Adjustment Function" on page 50.
$2^2 \ldots 2^5$	reserved
2^6	`Error Acknowledge` (error acknowledgement by user) Occurs on `Error Ack Request` from measuring system, see chapter "SafeStatus", Bit 2^1 on page 31.
$2^7 \ldots 2^{15}$	reserved

6.1.2.2 SafePresetSingle / SafePresetMulti

SafePresetSingle, UNSIGNED16

Byte	**X+2**	**X+3**
Bit	7 – 0	15 – 8
Data	$2^7 – 2^0$	$2^{15} – 2^8$

SafePresetMulti, UNSIGNED16

Byte	**X+4**	**X+5**
Bit	7 – 0	15 – 8
Data	$2^7 – 2^0$	$2^{15} – 2^8$

The desired preset value must be in the range of 0 to 268 435 455 (28 bit). Together with the measuring system resolution, max. number of steps per revolution according to type plate (8192), the corresponding values for `SafePresetSingle/SafePresetMulti` can then be calculated:

Number of revolutions = desired preset value / steps per revolution

The integer part from this division gives the number of revolutions and must be entered in the `SafePresetMulti` register.

Single-Turn-Position = desired preset value – (steps per revolution* no. of revolutions)

The result of this calculation is entered in the `SafePresetSingle` register.

The preset value is set as new position when the preset adjustment function is executed, see chapter "Preset Adjustment Function" on page 50.

6.2 NON-safety-oriented process data

The NON-safety-oriented process data can be faded in or out in the input process data via the FSoE master.

Structure of input data

Byte	Bit	Input data	
X+0	2^0-2^7	Status bits	UNSIGNED8
X+1	2^0-2^7	Velocity	INTEGER16
X+2	2^8-2^{15}		
X+3	2^0-2^7	Multiturn (actual value, 15 bit)	UNSIGNED16
X+4	2^8-2^{15}		
X+5	2^0-2^7	Singleturn (actual value, 13 bit)	UNSIGNED16
X+6	2^8-2^{15}		
X+7	2^0-2^7	Scaled (actual value scaled, 28 bit)	UNSIGNED32
X+8	2^8-2^{15}		
X+9	2^{16}-2^{23}		
X+10	2^{24}-2^{31}		

6.2.1 Input data

6.2.1.1 Status bits

UNSIGNED8

Byte	X+0
Bit	7 – 0
Data	2^7 – 2^0

Bit	Description
2^0	Overflow Bit = 1, if the speed value is outside the range of –32768…+32767.
2^1…2^7	reserved

6.2.1.2 Velocity

Speed, INTEGER16

Byte	X+1	X+2
Bit	7 – 0	15 – 8
Data	$2^7 – 2^0$	$2^{15} – 2^8$

The speed is output as a two's complement value with preceding sign.

Setting of direction of rotation = forward

– Looking at the flange connection, turn the shaft clockwise:
--> positive speed output

Setting of direction of rotation = backward

– Looking at the flange connection, turn the shaft clockwise:
--> negative speed output

If the measured speed exceeds the display range of –32768…+32767, this results in an overflow, which is reported via the status bit 2^0. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in the Status bits register is also deleted.
The speed is specified in `Increments` per `Unsafe Integration time`.

6.2.1.3 Multiturn / Singleturn

Multiturn, UNSIGNED16

Byte	X+3	X+4
Bit	7 – 0	15 – 8
Data	$2^7 – 2^0$	$2^{15} – 2^8$

Singleturn, UNSIGNED16

Byte	X+5	X+6
Bit	7 – 0	15 – 8
Data	$2^7 – 2^0$	$2^{15} – 2^8$

The number of revolutions is recorded in the `Multiturn` register and the current single-turn position is recorded in steps in the `Singleturn` register. Together with the measuring system resolution, max. number of steps per revolution according to type plate, the actual position can then be calculated:

Position in steps = (steps per revolution * number of revolutions) + Single-Turn position

Steps per revolution:	8192	≙ 13 bit
Number of revolutions:	0…32767	≙ 15 bit

The output position does not have a preceding sign.

6.2.1.4 Scaled

Actual value scaled, UNSIGNED32

Byte	X+7	X+8	X+9	X+10
Bit	7 – 0	15 – 8	23 – 16	31 – 24
Data	$2^7 - 2^0$	$2^{15} - 2^8$	$2^{23} - 2^{16}$	$2^{31} - 2^{24}$

The current scaled actual position is output via the `Scaled` register.

The output position does not have a preceding sign.

7 EtherCAT Object Directory

Both NON-safety-oriented and the safety-oriented data packed in safety frames are transferred via the objects in the EtherCAT directory. However, the use of safety-oriented data in the NON-safety-oriented control is not safe for the purposes of a safety standard.
The overall management occurs via the NON-safety-oriented control section.

7.1 CoE communication-specific objects (CiA DS-301)

References, ETG specifications:
- *ETG.1000.6 Application Layer Protocol Specification*
- *ETG.1020 Protocol Enhancements*

Supported communication-specific objects:

Index (h)	Name
1000	Device Type
1008	Manufacturer Device Name
1009	Manufacturer Hardware Version
100A	Manufacturer Software Version
1018	Identity Object
10E0	Device Identification Reload Object
1600	1st Receive PDO Mapping
1A00	1st Transmit PDO Mapping
1A01	2nd Transmit PDO Mapping
1C00	Sync Manager Communication Type
1C12	Sync Manager 2 PDO Assignment
1C13	Sync Manager 3 PDO Assignment
1C32	Sync Manager 2 Synchronization
1C33	Sync Manager 3 Synchronization

7.2 Manufacturer-specific objects

Index (h)	Object	Name	Data length	Attr.	Page
2000	RECORD	Parameter grey	Unsigned16	rw	40
2200	RECORD	TRDiagV2	Octet String	ro	55
3000	VAR	Status	Unsigned8	ro	40
3001	VAR	Cycle Time Bus	Unsigned32	ro	40
3002	VAR	Cycle Time Encoder	Unsigned32	ro	40
3010	VAR	Status bits	Unsigned8	ro	41
3011	VAR	Velocity	Integer16	ro	41
3012	VAR	Multiturn	Unsigned16	ro	41
3013	VAR	Singleturn	Unsigned16	ro	42
3014	VAR	Scaled	Unsigned32	ro	42

Table 1: Manufacturer profile range

7.2.1 Object 2000h: Parameter grey

The object contains the NON-safety-oriented settable parameter for the `Unsafe Integration Time`, for functional description see chapter "Unsafe Integration Time" on page 48.

Index	Subindex	Comment	Type	Attr.
2000h	0	No. of entries = 1	UNSIGNED8	ro
	1	Integration time grey	UNSIGNED16	rw

7.2.2 Object 3000h: Status

The initialization state is output via the object.

Index	0x3000
Description	Status
Data type	UNSIGNED8
Access	ro
PDO mapping	no
Value	Bit 1 = 0: Device in operation Bit 1 = 1: Device in initialization state for calculation of the bus cycle --> no valid output data

7.2.3 Object 3001h: Cycle Time Bus

The current EtherCAT bus cycle time is output via the object.

Index	0x3001
Description	Cycle Time Bus
Data type	UNSIGNED32
Access	ro
PDO mapping	no
Unit	µs

7.2.4 Object 3002h: Cycle Time Encoder

The current internal measuring system cycle time is output via the object.

Index	0x3002
Description	Cycle Time Encoder
Data type	UNSIGNED32
Access	ro
PDO mapping	no
Unit	µs

7.2.5 Object 3010h: Status bits

The object contains the status bit for the speed overrun and is part of the NON-safety-oriented process data, see from page 35.

Index	**0x3010**
Description	Status bits
Data type	UNSIGNED8
Access	ro
PDO mapping	yes
Lower limit	0 = no overflow
Upper limit	1 = overflow

7.2.6 Object 3011h: Velocity

The current speed is output via the object and is part of the NON-safety-oriented process data, see from page 35.

Index	**0x3011**
Description	Velocity
Data type	INTEGER16
Access	ro
PDO mapping	yes
Lower limit	–32768
Upper limit	+32767
Unit	Increments / Unsafe integration time

7.2.7 Object 3012h: Multiturn

The current number of revolutions is output via the object and is part of the NON-safety-oriented process data, see from page 35.

Index	**0x3012**
Description	Multiturn
Data type	UNSIGNED16
Access	ro
PDO mapping	yes
Lower limit	0
Upper limit	32767
Unit	Revolutions

7.2.8 Object 3013h: Singleturn

The current single-turn position is output in steps via the object and is part of the NON-safety-oriented process data, see from page 35.

Index	**0x3013**
Description	Singleturn
Data type	UNSIGNED16
Access	ro
PDO mapping	yes
Lower limit	0
Upper limit	8192
Unit	Steps

7.2.9 Object 3014h: Scaled

The current scaled actual position is output via the object and is part of the NON-safety-oriented process data, see from page 35.

Index	**0x3013**
Description	Scaled
Data type	UNSIGNED32
Access	ro
PDO mapping	yes
Lower limit	0
Upper limit	268 435 456
Unit	Steps

7.3 Profile-specific objects

Index (h)	Object	Name	Attr.	Page
6000	RECORD	FSoE Slave Frame Elements	ro	44
6001	RECORD	FSoE Slave Frame Data	ro	44
7000	RECORD	FSoE Master Frame Elements	ro	45
7001	RECORD	FSoE Master Frame Data	ro	45
8000	RECORD	FSoE parameter settings	rw	45
F980	RECORD	Safe Address	ro	46

Table 2: Device profile range

7.3.1 Object 6000h: FSoE Slave Frame Elements

The object is required to describe the complete FSoE Slave Frame in the TxPDO Mapping Object 0x1A00, together with "Object 6001h: FSoE Slave Frame Data".

Index	Subindex	Comment	Type	Attr.
6000h	0	No. of entries = 8	UNSIGNED8	ro
	1	FSoE Slave Command	UNSIGNED8	ro
	2	FSoE Slave CRC_0	UNSIGNED16	ro
	3	FSoE Slave Connection ID	UNSIGNED16	ro
	4	FSoE Slave CRC_1	UNSIGNED16	ro
	5	FSoE Slave CRC_2	UNSIGNED16	ro
	6	FSoE Slave CRC_3	UNSIGNED16	ro
	7	FSoE Slave CRC_4	UNSIGNED16	ro
	8	FSoE Slave CRC_5	UNSIGNED16	ro

7.3.2 Object 6001h: FSoE Slave Frame Data

The object contains the cyclical safety-oriented useful input data, structure see from page 30.

Index	Subindex	Comment	Type	Attr.
6001h	0	No. of entries = 10	UNSIGNED8	ro
	1	Velocity Error	BOOL	ro
	2	Error Ack Request	BOOL	ro
	3	Preset OK	BOOL	ro
	4	Preset Error	BOOL	ro
	5	SafeState	BOOL	ro
	6	Preset Active	BOOL	ro
	7	SafeVelocity	INTEGER16	ro
	8	SafeMultiturn	UNSIGNED16	ro
	9	SafeSingleturn	UNSIGNED16	ro
	10	SafeScaled	UNSIGNED32	ro

7.3.3 Object 7000h: FSoE Master Frame Elements

The object is required to describe the complete FSoE Master Frame in the RxPDO Mapping Object 0x1600, together with "Object 7001h: FSoE Master Frame Data".

Index	Subindex	Comment	Type	Attr.
7000h	0	No. of entries = 6	UNSIGNED8	ro
	1	FSoE Master Command	UNSIGNED8	ro
	2	FSoE Master CRC_0	UNSIGNED16	ro
	3	FSoE Master Connection ID	UNSIGNED16	ro
	4	FSoE Master CRC_1	UNSIGNED16	ro
	5	FSoE Master CRC_2	UNSIGNED16	ro
	6	FSoE Master CRC_3	UNSIGNED16	ro

7.3.4 Object 7001h: FSoE Master Frame Data

The object contains the cyclical safety-oriented useful output data, structure see from page 30.

Index	Subindex	Comment	Type	Attr.
7001h	0	No. of entries = 6	UNSIGNED8	ro
	1	Preset_Preparation	BOOL	ro
	2	Preset_Request	BOOL	ro
	3	Error Acknowledge	BOOL	ro
	4	SafePresetSingle	UNSIGNED16	ro
	5	SafePresetMulti	UNSIGNED16	ro
	6	SafeOutRes	UNSIGNED16	ro

7.3.5 Object 8000h: FSoE parameter settings

The object contains the safety-oriented parameters, for functional description see from page 47.

Index	Subindex	Comment	Default	Type	Attr.
8000h	0	No. of entries	4	UNSIGNED8	ro
	1	Direction of rotation	1	BOOL	rw
	2	Window increments	1000	UNSIGNED16	rw
	3	Safe integration time	10	UNSIGNED16	rw
	4	Preset tolerance	1	UNSIGNED16	rw

7.3.6 Object F980h: Safe Address

In Subindex 1 the object contains the safety address set via the HEX rotary switches, see chapter "Setting the FSoE address" on page 23. The serial no. of the measuring system is noted under Subindex two.

Index	Subindex	Comment	Default	Type	Attr.
F980h	0	No. of entries	2	UNSIGNED8	ro
	1	FSoE Address	18	UNSIGNED16	ro
	2	Serial Number	TR-specific (TRIC)	UNSIGNED32	ro

8 Parameterization

Input masks are normally made available by the controls, where the user can enter the parameter data or select it from lists. The structure of the input masks is stored in the device master file.

DANGER

NOTICE

- **Danger of death, serious physical injury and/or damage to property due to malfunction, caused by incorrect parameterization!**
  - ➢ The system manufacturer must ensure correct functioning by carrying out a protected test run during commissioning and after each parameter change.

8.1 Safety-oriented parameters

With the safety-oriented parameters application dependent device characteristics are defined and provided via the FSoE-master.

Parameter	Type	Description
Direction of rotation	BOOL	0: decreasing 1: increasing [default]
Safe integration time	UNSIGNED16	Default = 10 Range: 1-10
Window increments	UNSIGNED16	Default = 1000 Range: 50-4000
Preset standstill tolerance	UNSIGNED16	Default = 1 Range: 1-5

8.1.1 Direction of rotation

This parameter defines the current counting direction of the position value looking at the flange connection, turning the shaft clockwise.

1 = Increasing counting direction
0 = Decreasing counting direction

Default value = increasing

8.1.2 Safe integration time

This parameter serves for calculating the safe speed, which is output via the process data of the safety channel. High integration times enable high-resolution measurements at low speeds. Low integration times show speed changes more quickly and are suitable for high speeds and high dynamics. The time basis is preset to 50 ms. 50…500 ms can thus be set using the value range of 1…10.

Default value = 100 ms.

8.1.3 Window increments

This parameter defines the maximum permissible position deviation in increments of the master / slave scanning systems integrated into the measuring system. The permissible tolerance window is basically dependent on the maximum speed occurring in the system and must first be determined by the system operator. Higher speeds require a larger tolerance window. The value range extends from 50…4000 increments.

Default value = 1000 increments.

The larger the window increments the greater the angle, until an error is detected.

8.1.4 Preset standstill tolerance

This parameter defines the maximum permissible speed in `Increments` per `Safe Integration Time` for execution of the preset function, see page 50. The permissible speed is dependent on the bus behavior and the system speed, and must be determined by the system operator first. The value range extends from 1 increment per `Safe Integration Time` to 5 increments per `Safe Integration Time`. This means that the measuring system shaft must be practically at a standstill for the preset function to be executed.
Setting recommendation for measuring systems with double-magnetic scanning:
≥ 3 increments per default value of `Safe Integration Time`.

Standard value = 1 increment per standard value `Safe Integration Time`.

8.2 NON-safety-oriented parameter

8.2.1 Unsafe Integration Time

This parameter serves for calculating the unsafe speed, which is output via the process data of the NON-safety-oriented data channel. High integration times enable high-resolution measurements at low speeds. Low integration times show speed changes more quickly and are suitable for high speeds and high dynamics. The time basis is preset to 5 ms. 5…500 ms can thus be set using the value range of 1…100.

Default value = 100 ms.

9 Output of safe data (substitute values)

The safety function requires, that in the case of an error in the safety-oriented safety channel, instead of the cyclically output values the **safe data (0)** are used in the following cases (FailSafeData).

- On start-up of the safety-oriented system
- In the case of errors in the safety-oriented communication between FSoE master and measuring system via the FSoE protocol
- If the value set for the `Window increments` under the safety-oriented parameters is exceeded and/or the internally calculated safety telegram is defective
- if the permissible ambient temperature range specified under the corresponding article number is not reached or is exceeded
- If the measuring system is supplied with >36 V DC for longer than 200 ms
- Technical hardware faults in the measuring system
- Double magnetic scanning system: if the electrically permissible speed defined in the safety manual has been exceeded.
  As error-free operation is guaranteed up to this limit value, the actual output of safe data only occurs considerably above the specified limit value.

The process data channel addressable via EtherCAT Standard is not necessarily affected by this. If the internal diagnosis in the master channel does not detect an error, the process data are still output. However, these data are not safe for the purposes of a safety standard.

If the internal diagnosis in the master channel detects an error, **safe data (1)** are also used for the NON-safety-oriented channel.

10 Preset Adjustment Function

WARNING

NOTICE

- **Danger of death, serious physical injury and/or damage to property due to uncontrolled start-up of the drive system during execution of the preset adjustment function!**
  - ➢ Only execute the preset function with the drive system stationary, see chapter "Preset standstill tolerance" on page 48
  - ➢ The relevant drive systems must be locked to prevent automatic start-up
  - ➢ It is advisable to protect the preset triggering via the FSoE master using additional protective measures, e.g. key-operated switch, password etc.
  - ➢ The process specified below must be observed; in particular, the status bits must be evaluated by the FSoE master, in order to check successful or incorrect execution
  - ➢ The new position must be checked after execution of the preset function

The preset adjustment function is used to set the currently output position value to any position value within the measuring range. The displayed position can thus be set to a machine reference position purely electronically.

10.1 Procedure using FSoE master

- ➢ Prerequisite: The measuring system is in cyclical data exchange.
- ➢ Write the desired preset value to the `SafePresetMulti` and `SafePresetSingle` registers, in the output data of theFSoE master.
- ➢ Set `Preset_Preparation` and Preset_Request control bits to 0.
- ➢ Set `Preset_Preparation` control bit to 1. As a result the `SafeState` status bit is set to 0, and the FSoE master must then switch the system to a safe state. The output position value is no longer safe!
- ➢ With a rising edge of the `Preset_Request` control bit, the preset value is accepted. Receipt of the preset value is acknowledged by setting (=1) the `Preset Active` status bit. When the preset has been executed, the `Preset Active` status bit is reset to 0.
- ➢ After receipt of the preset value, the measuring system checks that all prerequisites for execution of the preset adjustment function are fulfilled. If so, the preset value is written as the new position value. In case of error, the execution is rejected and an error message is output by setting the `Preset Error` status bit.
- ➢ After successful execution of the preset adjustment function, the measuring system sets the `Preset OK` status bit to 1 and thus indicates to the FSoE master that the preset execution is complete.
- ➢ Reset the `Preset_Request` control bit to 0.
- ➢ Reset the `Preset_Preparation` control bit to 0. As a result the `SafeState` status bit is reset to 1.
- ➢ Finally, the FSoE master must check that the new position corresponds to the new set position.

10.2 Timing diagram

Blue area:	Output signals FSoE master -> measuring system
Orange area:	Input signals measuring system -> FSoE master

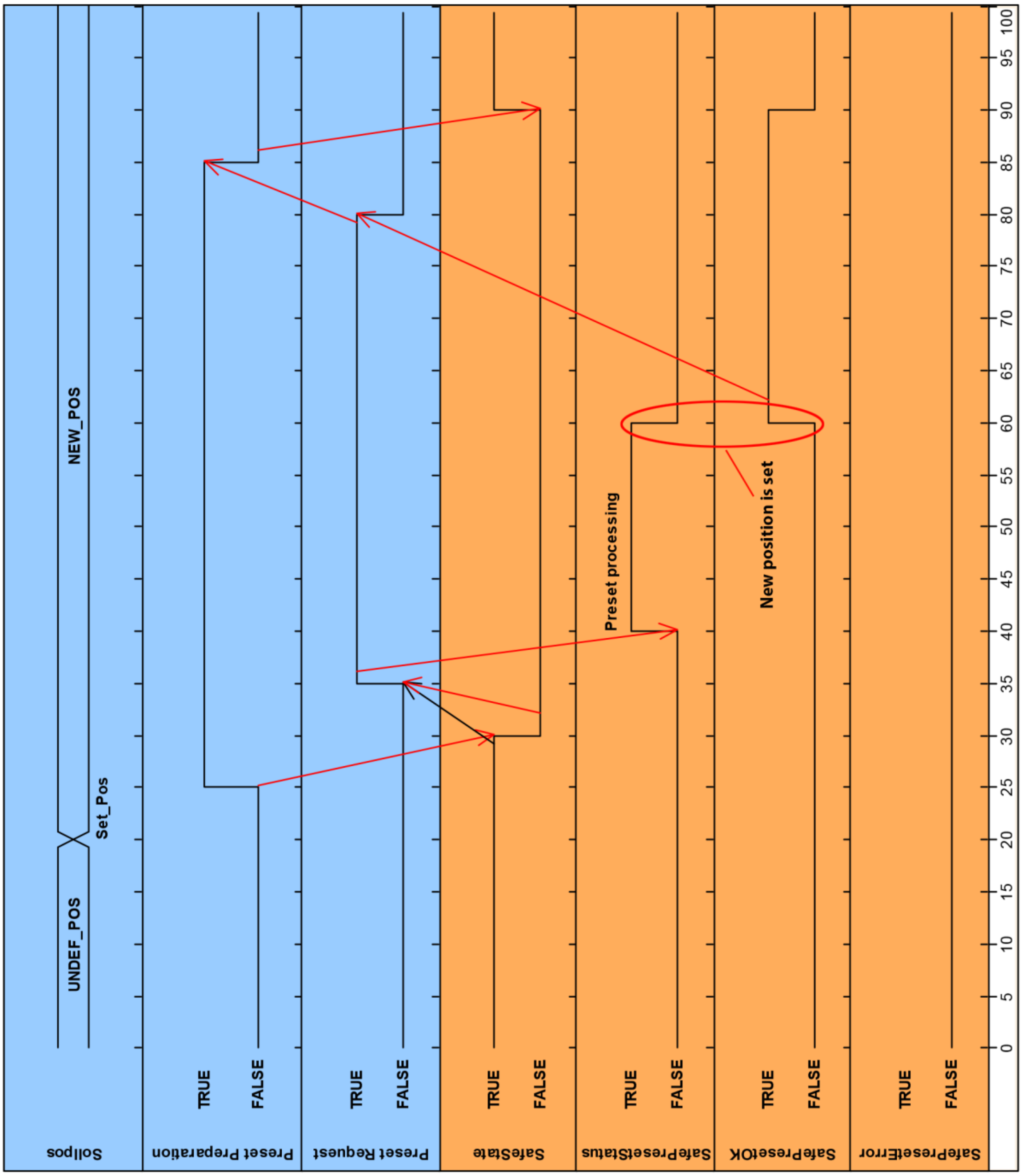


Figure 8: Preset timing diagram

11 Troubleshooting and Diagnosis Options

11.1 Optical displays

For assignment and position of the status LEDs see chapter "Bus status display" on page 28.

11.1.1 Link / Data Activity LEDs

green LED	Cause	Solution
OFF	Voltage supply absent or too low	- Check power supply, wiring - Is the voltage supply in the permissible range?
	No Ethernet connection	Check cable
	Hardware error, measuring system defective	Replace measuring system
ON	Measuring system ready for operation, Ethernet connection established	-

11.1.2 EtherCAT RUN LED

green LED	Cause	Solution
ON -> Double flash	Measuring system has been switched from OPERATIONAL state to SAFE-OPERATIONAL state due to the following causes: - No connection to EtherCAT master - EtherCAT watchdog exceeded	- Check complete wiring between measuring system and EtherCAT master - Check watchdog times, the permissible max. value is 65530 ms

11.1.3 Safety State LED

green LED	Cause	Solution
OFF	Measuring system is in initialization or switched off	-
	Voltage supply absent or too low	- Check power supply, wiring - Is the voltage supply in the permissible range?
	Hardware error, measuring system defective	Replace measuring system
Single flash (continuous)	Measuring system remains in the initialization phase due to the following causes: - No connection to FSoE master - EtherCAT master is not in "RUN-Modus" - Wrong FSoE address - Incorrect or non-adjusted FSoE parameters	- Check complete wiring between measuring system and FSoE master - Check EtherCAT master configuration - Check that the EtherCAT master is in RUN mode - Check FSoE address, this must be unique system-wide - Check FSoE parameters, see from page 47
Double flash (continuous)	Measuring system remains in output of safe data due to the following causes: - FSoE communication was interrupted and restored again. - FSoE Time Out	- Check that the set timeout times are suitable for the automation task - Check whether the connection between FSoE master and measuring system is faulty - Check whether the FSoE master requires an error acknowledgement
ON	OPERATIONAL	Normal operating state, `SafeState` bit = 1

red LED	Cause	Solution
Single flash (green = OFF)	Measuring system waiting for an error acknowledgement. `SafeStatus` bits: - `Error Ack Request` = 1 - `SafeState` = 0	Reset the error via Bit 2^6 `Error Acknowledge SafeControl` in the control word, see page 33.
ON (green = OFF)	**A safety-relevant error was detected, the measuring system was put into fail-safe status and is outputting its passivated data:**	**To be able to restart the measuring system after a safety relevant error, the error must generally be eliminated first of all. The** `SafeState` **bit can then change back to 1 through** **1. error acknowledgement by means of** `Error Acknowledge`**, if** `Error Ack Request` **= 1** (red LED flashes after error elimination) **2. supply voltage OFF/ON** (red LED constantly lit after error elimination)
	– Error in the safety-oriented communication	– Try to localize the error with the aid of diagnostic mechanisms (control-dependent)
	– The set value for the `Window increments` parameter was exceeded	– Check that the set value for the `Window increments` parameter is suitable for the automation task, see chapter Window increments" on page 48
	– The permissible ambient temperature range specified under the corresponding article number is not reached or is exceeded	– Suitable measures must be taken to ensure that the permissible ambient temperature range can be observed at all times
	– The measuring system was supplied with >36 VDC for longer than 200 ms	– The measuring system must be shut down immediately and checked in the factory. When sending the measuring system to the factory, the reasons and circumstances relating to the overvoltage must be specified
	– Double magnetic scanning system: The electrically permissible speed defined in the Safety Manual was exceeded	– Bring speed into the permissible range. Acknowledge error via Supply voltage OFF/ON

11.2 Error acknowledgement flow diagram

When the measuring system detects a safety-relevant error, it automatically switches from process data output to the FailSafeData state. If the error is eliminated and the error type permits restarting, the measuring system automatically switches back to process data output. However, the SafeState bit remains at "0" and with the bit Error Ack Request = 1 the measuring system indicates any required error acknowledgement via the Error Acknowledge bit. Once the error has been acknowledged, the SafeState bit is reset to "1", and the process data can be used again.

Areas: red = error occurrence / blue = measuring system / yellow = FSoE application on FSoE master

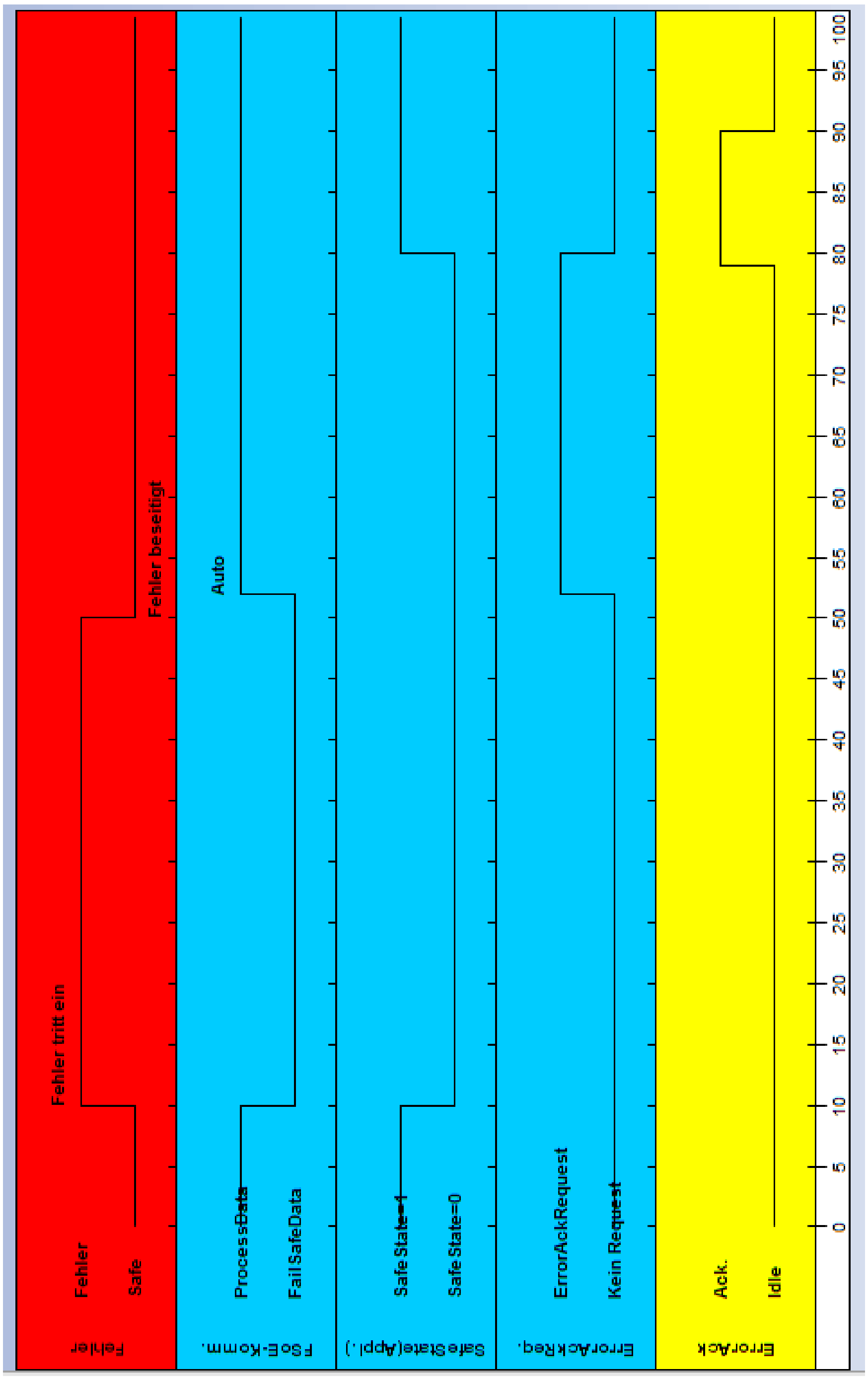


Figure 9: Error acknowledgement flow diagram

11.3 Manufacturer-specific diagnosis EtherCAT (object)

The measuring system supports the following manufacturer-specific diagnosis object:

Index	Subindex	Comment	Type	Attr.
2200h	0	No. of entries	UNSIGNED8	ro
	1	Manufacturer-specific diagnosis	OCTET STRING	ro
	2	Manufacturer-specific diagnosis	OCTET STRING	ro
	3	Manufacturer-specific diagnosis	OCTET STRING	ro
	…	…	…	…
	38	Manufacturer-specific diagnosis	OCTET STRING	ro

OCTET STRINGs are simple UNSIGNED8 arrays with a length of 32 bytes.

The error must be eliminated as described in chapter "Optical displays". If the error cannot be eliminated, the diagnostic codes can be sent to TR-Electronic for evaluation, stating the article number.

12 Checklist, Part 2 of 2

We recommend that you print out and work through the Checklist for commissioning, when replacing the measuring system and when changing the parameterization of a previously accepted system and store it as part of the overall system documentation.

Documentation basis	Date	Edited	Checked

Sub-item	To note	Can be found under	yes
Present user manual has been read and understood	–	Document no.: TR-ECE-BA-GB-0118	☐
Check that the measuring system can be used for the present automation task on the basis of the specified safety requirements	• Safety functions of the fail-safe processing unit • Compliance with all technical data	• Chapter Safety functions of the fail-safe processing unit, page 14 • Chapter Technical data, page 15	☐
Voltage supply requirement	• The power supply used must meet the requirements of SELV/PELV (IEC 60364-4-41:2005)	• Chapter Supply voltage, page 21	☐
Correct - electrical installation (shielding) - network installation	• Observance of basic rules for installation • Observance of wiring standards and directives specified by EtherCATthe User Organization	• Chapter Installation / Preparation for Commissioning, from page 18 • Chapter Commissioning, page 27	☐
System test after commissioning and parameterization	• During commissioning and after each parameter change all affected safety functions must be checked	• Chapter Parameterization from page 47	☐
Preset Adjustment Function	• The preset adjustment function may only be executed when the affected axis is stationary • It must be ensured that the Preset adjustment function cannot be inadvertently triggered • After execution of the preset adjustment function the new position must be checked before restarting	• Chapter Preset Adjustment Function, Page 50	☐
Device replacement	• It must be ensured that the new device corresponds to the replaced device • All affected safety functions must be checked	• Safety Manual (Checklist, Part 1 of 2) • Chapter Parameterization, from page 47	☐

13 Appendix

13.1 TÜV certificate

Download

- www.tr-electronic.de/f/TR-ECE-TI-DGB-0297

13.2 EtherCAT certicate

Download

- www.tr-electronic.de/f/TR-ECE-TI-GB-0289

13.3 Safety over EtherCAT certificate

Download

- www.tr-electronic.de/f/TR-ECE-TI-GB-0288

13.4 EU Declaration of Conformity

Download

- www.tr-electronic.de/f/TR-ECE-KE-DGB-0337

13.5 Drawings

See back section of document

Download

- www.tr-electronic.de/f/04-CDV75M-M0021
- www.tr-electronic.de/f/04-CDH75M-M0016