

# Absolute Encoder CD\_-75 EtherCAT/FSoE

 Explosion-proof enclosure

A\*\*75\*

Protection Enclosure

CDV115



DIN EN 61508:  
DIN EN ISO 13849:

SIL CL3  
PL e

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

**User Manual  
Interface**

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### Revision index

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| Safety values for double magnetic scanning system edited   | 08/15/16 | 01    |
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# 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<br>C      | Explosion-proof enclosure (ATEX); <br>Absolute encoder, programmable |
| * 2      | D           | Redundant dual scanning   |
| * 3      | V<br>H      | Solid shaft<br>Hollow shaft   |
| * 4      | 75<br>115   | Outer diameter Ø 75 mm<br>Outer diameter Ø 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](http://www.tr-electronic.de/f/TR-ECE-BA-GB-0107)
- optional: -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):<br>Safety over EtherCAT protocol specification  |
| 3.  | EN 50325:4        | Industrial Communication Systems, based on<br>ISO 11898 (CAN) for Controller Device Interfaces.<br>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<br>- Fieldbus for use in industrial control systems<br>- Protocols and services, type 12 = EtherCAT  |
| 7.  | IEC 61784-2       | Digital data communications for measurement and control<br>- Additional profiles for ISO/IEC 8802-3 based<br>communication networks in real-time applications, 12 = EtherCAT   |
| 8.  | IEC 61784-3       | Industrial communication networks<br>- Profiles - Part 3: Functional safety fieldbuses- General rules and<br>profile definitions   |
| 9.  | IEC 61784-5 - 12  | Industrial communication networks - Profiles<br>- Part 5-12: Installation of fieldbuses - Installation profiles for CPF 12   |
| 10. | IEC 61918         | Industrial communication networks<br>- Installation of communication networks in industrial premises   |
| 11. | ISO/IEC 8802-3    | Carrier Sense Multiple Access with Collision Detection<br>(CSMA/CD)<br>Access Method and Physical Layer Specifications   |
| 12. | ISO 15745-4 AMD 2 | Industrial automation systems and integration<br>- Open systems application integration framework<br>- Part 4: Reference description for Ethernet-based control systems;<br>Amendment 2:<br>Profiles for Modbus TCP, EtherCAT and ETHERNET Powerlink |
| 13. | IEEE 1588-2002    | IEEE Standard for a Precision Clock Synchronization<br>Protocol for Networked Measurement and Control Systems  |

### 1.3 Abbreviations and terms used

|                          |  |
|--------------------------|--|
| 0x                       | Hexadecimal representation   |
| A**75*                   | Explosion-proof enclosure Ø 75 mm with integrated measuring system, all variants   |
| CAN                      | Controller Area Network. Data Layer Protocol for serial communication, described in ISO 11898.   |
| CAT                      | Category:<br>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 <sub>avg</sub>        | <b>D</b> iagnostic <b>C</b> overage<br>Average diagnostic coverage   |
| EU                       | <b>E</b> uropean <b>U</b> nion   |
| EMC                      | <b>E</b> lectro <b>M</b> agnetic <b>C</b> ompatibility   |
| ESM                      | <b>E</b> therCAT <b>S</b> tate <b>M</b> achine   |
| ETG                      | " <b>E</b> therCAT <b>T</b> echnology <b>G</b> roup" user association  |
| FSoE                     | Safety over EtherCAT   |
| IEC                      | International Electrotechnical Commission  |
| IP                       | <b>I</b> nternet <b>P</b> rotocol  |
| ISO                      | <b>I</b> nternational <b>S</b> tandard <b>O</b> rganisation  |
| MTTF <sub>d</sub>        | <b>M</b> ean <b>T</b> ime <b>T</b> o <b>F</b> ailure (dangerous)<br>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                      | <b>P</b> rotocol <b>D</b> ata <b>U</b> nit. Contains protocol information such as source and destination address, checksum and service parameter information   |
| PFD <sub>av</sub>        | <b>A</b> verage <b>P</b> robability of <b>F</b> ailure on <b>D</b> emand<br>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. |

## General information

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Continued

|                          |   |
|--------------------------|---|
| PFH                      | Probability of Failure per Hour<br>Operating mode with high requirement rate or continuous demand.<br>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                      | <b>Safety Integrity Level</b> : 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                      | <b>Shielded Twisted Pair</b>  |
| Repeat test (proof test) | Repetitive test to detect hidden dangerous failures in a safety-related system.   |
| XML                      | <b>Extensible Markup Language</b> , 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



means that death or serious injury will occur if the required precautions are not met.



means that death or serious injury can occur if the required precautions are not met.



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 = <code>FailSafeData</code> -> STOP |
| FSOE watchdog time: Monitoring of the measuring system - response time. For checking e.g. cable breakage, power failure etc.<br>The permissible max. value for the FSoE-Watchdog is 65530 ms. | STOP  |

## 3 Technical data

### 3.1 Safety

|  |   |
|--|---|
| <b>Startup time</b> .....                            | Time between POWER-UP and safe position output                          |
| Overall system.....                                  | around 7s, Beckhoff CX9020 (500µs) with EL6900                          |
| <b>PFH, operating mode</b> .....                     | $3.25 \cdot 10^{-10}$ 1/h   |
| Double magnetic scanning system ..                   | $8,35 \cdot 10^{-10}$ 1/h   |
| <b>PFD<sub>av</sub> (T<sub>1</sub> = 20 a)</b> ..... | $2.81 \cdot 10^{-5}$  |
| Double magnetic scanning system ..                   | $7,28 \cdot 10^{-5}$  |
| <b>MTTF<sub>d</sub></b> .....                        | 197 a, HIGH   |
| Double magnetic scanning system ..                   | 202 a, HIGH   |
| <b>* DC<sub>avg</sub></b> .....                      | 98 %, HIGH  |
| Double magnetic scanning system ..                   | 98 %, HIGH  |
| <b>Internal process safety time</b> .....            | Time between occurrence of a safety-relevant error and alarm indication |
| Overall system.....                                  | ≤ 7,5 ms  |
| <b>Process safety angle</b> .....                    | 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                        |
| <b>T<sub>1</sub>, repeat test (proof test)</b> ..... | 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

|   |   |
|---|---|
| <b>Supply voltage</b> .....                 | 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  |
| <b>Power consumption without load</b> ..... | ≤ 165 mA at 24 V DC   |
| Optional HTL level, 13...27 VDC ..          | Increased power consumption, see page 26  |

### 3.2.2 Device-specific

|   |   |
|---|---|
| <b>Complete solution</b> .....                  | ≤ 268 435 456 Steps   |
| <b>Number of steps / revolution</b> .....       | ≤ 8192  |
| <b>Number of revolutions</b> .....              | ≤ 32768   |
| <b>Functional accuracy</b> .....                | 8192 steps, single-turn   |
| Double magnetic scanning system....             | 256 steps, single-turn  |
| <b>Accuracy, usable from a safety viewpoint</b> |   |
| Optical/magnetic scanning system .              | 256 steps, single-turn  |
| Double magnetic scanning system...              | 128 steps, single-turn  |
| <b>Safety principle</b> .....                   | 2 redundant scanning units with internal triangulation                                      |
| <b>EtherCAT Interface</b> .....                 | 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   |
| <b>Incremental interface</b>                    | Cable specification, see page 22  |
| Availability .....                              | only for optical/magnetic scanning system   |
| Pulses / revolution .....                       | 1024, 2048, 3072, 4096, 5120 or<br>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   |
| <b>SIN/COS interface, alternative</b>           | 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 V <sub>ss</sub> ± 0.2 V / 100 Ω, differential   |
| Short-circuit proof .....                       | yes   |
| <b>Cycle time</b>                               |   |
| NOT safety-oriented.....                        | 0.5 ms  |
| Safety-oriented .....                           | 5 ms  |
| <b>Preset write cycles</b> .....                | ≥ 32 000 000  |

\* parameterizable via EtherCAT

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

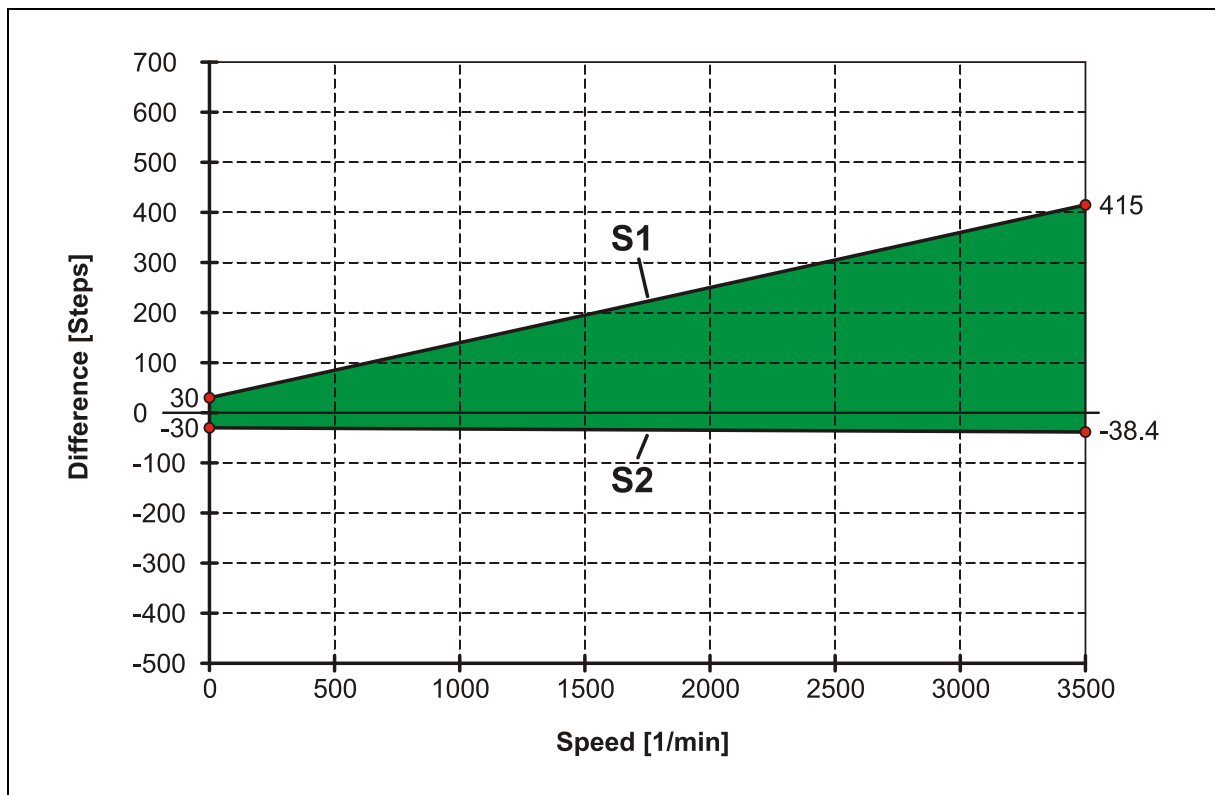


Figure 1: Dynamic view of step deviation, counting direction increasing (looking at the flange connection)

#### Function of straight line S1:

$$S1 = 30 \text{ steps} + (0.11 \text{ steps per rev.} \cdot \text{act. speed [1/min]})$$

#### Function of straight line S2:

$$S2 = -30 \text{ steps} + (-0.0024 \text{ steps per rev.} \cdot \text{act. speed [1/min]})$$

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

#### Example: Maximum possible step deviation at 3500 1/min

$$S1 = 30 \text{ steps} + (0.11 \text{ steps per rev.} \cdot 3500 \text{ 1/min}) = 415 \text{ steps}$$

$$S2 = -30 \text{ steps} + (-0.0024 \text{ steps per rev.} \cdot 3500 \text{ 1/min}) = -38.4 \text{ steps}$$

$$\text{Maximum possible step deviation} = 415 \text{ steps} - (-38.4 \text{ steps}) = \underline{\underline{453.4 \text{ steps}}}$$

# 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

---

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

**⚠ WARNING**

**NOTICE**

- 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.
- 

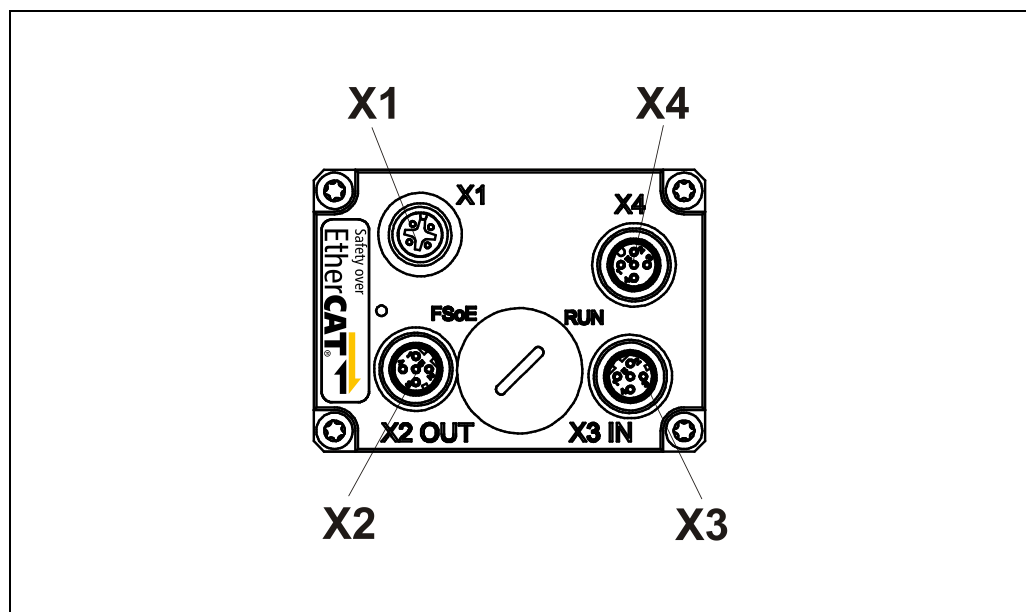


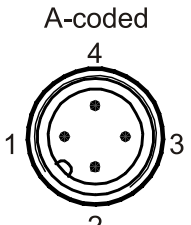
Figure 2: Connector assignment

### 4.3.1 Supply voltage

#### **NOTICE**

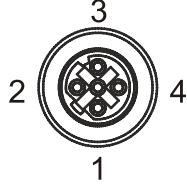
***Danger of unnoticed damage to the internal electronics, due to unacceptable overvoltages!***

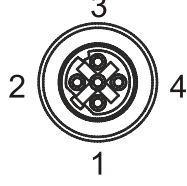
- If an overvoltage of >36 V DC is inadvertently applied, the measuring system must be checked in the factory. The measuring system is permanently switched off for safety reasons, if the overvoltage is applied for more than 200 ms.
  - The measuring system must be shut down immediately
  - When sending 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<br> |
| 2  | N.C.                     | -              |   |
| 3  | 0 V                      | GND            |   |
| 4  | N.C.                     | -              |   |

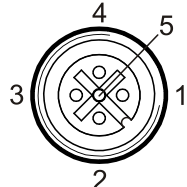
Cable specification: min. 0.34 mm<sup>2</sup> (recommendation 0.5 mm<sup>2</sup>) and shielded.  
Generally the cable cross-section must be matched to the cable length.

## 4.3.2 EtherCAT

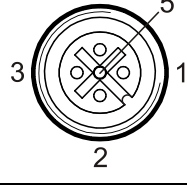
| X2 | Signal                    | Description | Socket, M12x1, 4 pole  |
|----|---------------------------|-------------|--|
| 1  | TxD+, transmission data + | PORT-OUT    | D-coded<br> |
| 2  | RxD+, received data +     |             |  |
| 3  | TxD-, transmission data - |             |  |
| 4  | RxD-,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

| X3 | Signal                    | Description | Socket, M12x1, 4 pole  |
|----|---------------------------|-------------|--|
| 1  | TxD+, transmission data + | PORT-IN     | D-coded<br> |
| 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 <sup>1)</sup> | Channel B + | 5 V differential / 13...27 V DC | A-coded<br> |
| 2 <sup>1)</sup> | Channel B - |                                 |  |
| 3 <sup>1)</sup> | Channel A + | 5 V differential / 13...27 V DC |  |
| 4 <sup>1)</sup> | Channel A - |                                 |  |
| 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<br> |
| 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<sup>2</sup> and shielded.  
 However, to ensure signal quality and to minimize possible environmental influences, the use of a twisted-pair cable is also recommended.

<sup>1)</sup> 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**

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

### **NOTICE**

- 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.

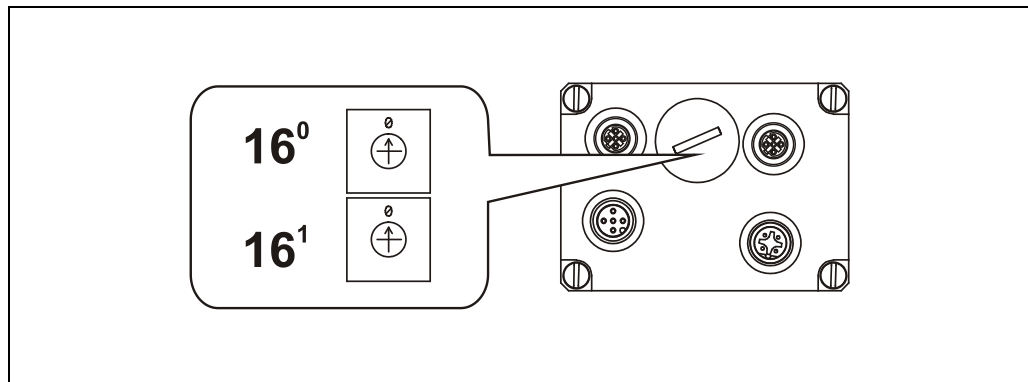


Figure 3: FSoE address, switch assignment

### 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

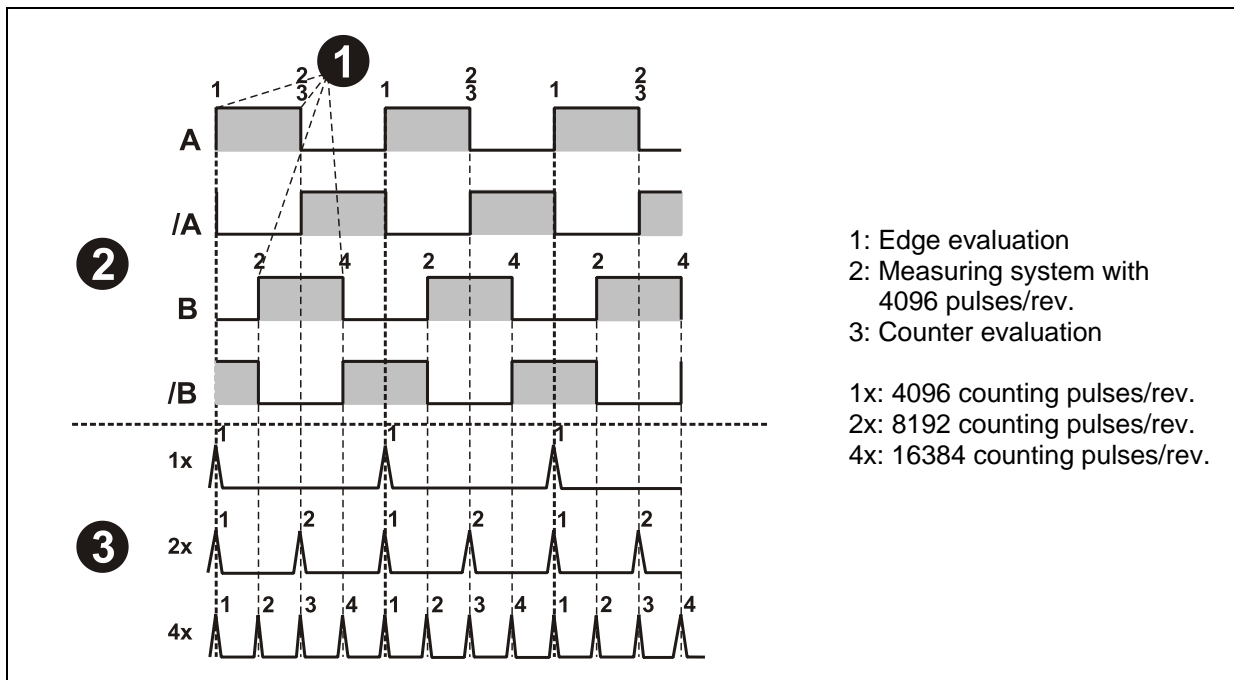


Figure 4: Counter evaluation, incremental interface

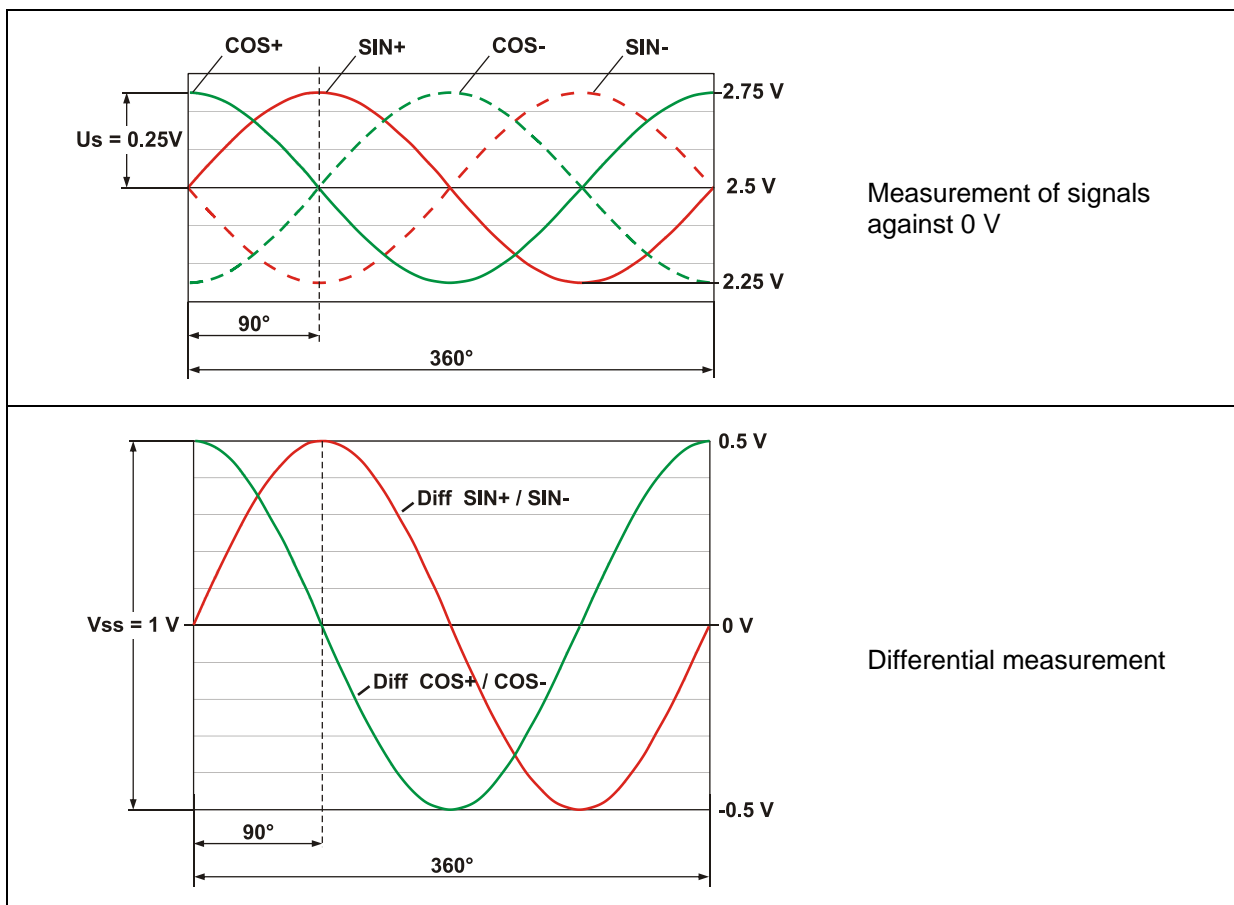


Figure 5: Level definition, SIN/COS interface

### 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

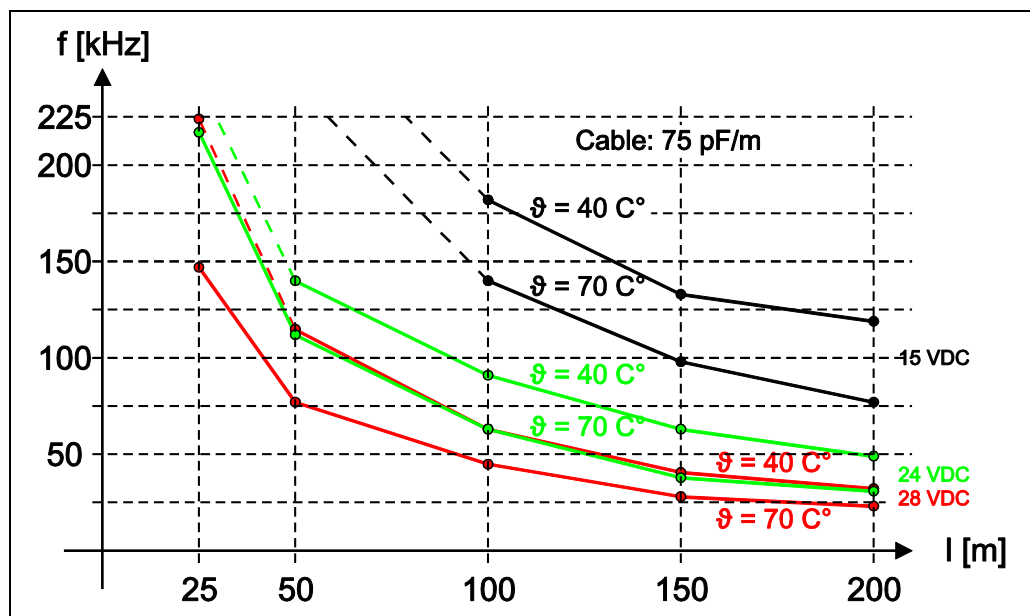


Figure 6: Cable lengths / limit frequencies

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](mailto:info@ethercat.org)  
Internet: [www.ethercat.org](http://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](http://www.tr-electronic.de/f/TR-ECE-ID-MUL-0051)

## 5.3 Bus status display

### ⚠ WARNING

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

### NOTICE

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

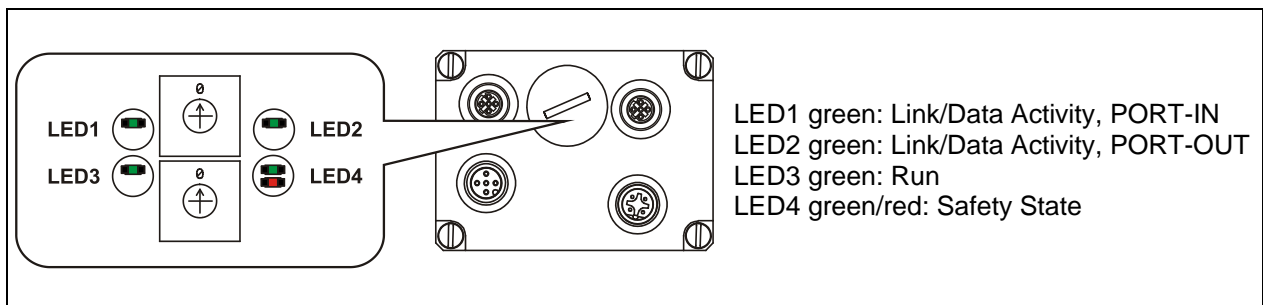


Figure 7: Bus status display

### 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:<br>ON = 50 ms, OFF = 50 ms.      |
| Blinking     | Same ON and OFF times with a frequency of around 2.5 Hz:<br>ON = 200 ms, OFF = 200 ms.   |
| Single flash | Single short flash, ON around 200 ms,<br>followed by a long OFF time, around 1000 ms     |
| Double flash | Double short flash, ON/OFF around 200 ms,<br>followed by a long OFF time, around 1000 ms |
| Triple flash | Triple short flash, ON/OFF around 200 ms,<br>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 <i>INIT</i> state             |
| Blinking     | Device is in <i>PRE-OPERATIONAL</i> state  |
| Single flash | Device is in <i>SAFE-OPERATIONAL</i> state |
| ON           | Device is in <i>OPERATIONAL</i> 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](http://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

- **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<sup>4</sup>!**

#### NOTICE

- The output actual values are only valid if SafeState bit 2<sup>4</sup> = 1.

Unsigned16

| Byte | X+0                             | X+1                              |
|------|---------------------------------|----------------------------------|
| Bit  | 7 – 0                           | 15 – 8                           |
| Data | 2 <sup>7</sup> – 2 <sup>0</sup> | 2 <sup>15</sup> – 2 <sup>8</sup> |

| Bit                               | Description  |
|-----------------------------------|--|
| 2 <sup>0</sup>                    | Velocity Error<br>Bit = 1, if the speed value is outside the range of –32768...+32767.   |
| 2 <sup>1</sup>                    | Error Ack Request<br>Bit = 1, if the measuring system is in safe state and is waiting for an error acknowledgement.  |
| 2 <sup>2</sup>                    | Preset OK<br>Bit = 1, if a preset request was successfully executed.   |
| 2 <sup>3</sup>                    | Preset Error<br>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 <sup>4</sup>                    | SafeState<br>Bit = 0,<br><ul style="list-style-type: none"> <li>- in the initialization phase, or if the initialization could not be successfully completed</li> <li>- if a preset request is initiated via the control bit Preset_Preparation</li> <li>- if an exception error is present during the preset execution</li> <li>- if the measuring system is in safe state</li> </ul> Bit = 1,<br><ul style="list-style-type: none"> <li>- if the initialization was successfully completed</li> <li>- if a preset request was successfully completed and the preset control bits Preset_Request and Preset_Preparation have been reset</li> </ul> |
| 2 <sup>5</sup>                    | Preset Active<br>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 <sup>6</sup> ...2 <sup>15</sup> | 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  $-32768 \dots +32767$ , 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:

|   |
|---|
| $\text{Position in steps} = (\text{steps per revolution} * \text{number of revolutions}) + \text{Single-Turn position}$ |
|---|

Steps per revolution: 8192  $\hat{=}$  13 bit

Number of revolutions: 0...32767  $\hat{=}$  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 <sup>0</sup>                    | <code>Preset_Preparation</code><br>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 [ <code>Preset_Request</code> ]. A precise sequence must be observed in order to execute the function, see chapter "Preset Adjustment Function" on page 50.                                       |
| 2 <sup>1</sup>                    | <code>Preset_Request</code><br>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 <code>SafePresetMulti/SafePresetSingle</code> registers. A precise sequence must be observed in order to execute the function, see chapter "Preset Adjustment Function" on page 50. |
| 2 <sup>2</sup> ...2 <sup>5</sup>  | reserved   |
| 2 <sup>6</sup>                    | <code>Error Acknowledge (error acknowledgement by user)</code><br>Occurs on <code>Error Ack Request</code> from measuring system, see chapter "SafeStatus", Bit 2 <sup>1</sup> on page 31.   |
| 2 <sup>7</sup> ...2 <sup>15</sup> | 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:

$$\text{Number of revolutions} = \text{desired preset value} / \text{steps per revolution}$$

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

$$\text{Single-Turn-Position} = \text{desired preset value} - (\text{steps per revolution} * \text{no. of revolutions})$$

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<br>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  $-32768 \dots +32767$ , 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:

|   |
|---|
| $\text{Position in steps} = (\text{steps per revolution} * \text{number of revolutions}) + \text{Single-Turn position}$ |
|---|

Steps per revolution: 8192  $\hat{=}$  13 bit

Number of revolutions: 0...32767  $\hat{=}$  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      | 1 <sup>st</sup> Receive PDO Mapping  |
| 1A00      | 1 <sup>st</sup> Transmit PDO Mapping |
| 1A01      | 2 <sup>nd</sup> 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  |
|--------------------|---|
| <b>Description</b> | Status  |
| <b>Data type</b>   | UNSIGNED8   |
| <b>Access</b>      | ro  |
| <b>PDO mapping</b> | no  |
| <b>Value</b>       | Bit 1 = 0: Device in operation<br>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         |
|--------------------|----------------|
| <b>Description</b> | Cycle Time Bus |
| <b>Data type</b>   | UNSIGNED32     |
| <b>Access</b>      | ro             |
| <b>PDO mapping</b> | no             |
| <b>Unit</b>        | µs             |

## 7.2.4 Object 3002h: Cycle Time Encoder

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

| Index              | 0x3002             |
|--------------------|--------------------|
| <b>Description</b> | Cycle Time Encoder |
| <b>Data type</b>   | UNSIGNED32         |
| <b>Access</b>      | ro                 |
| <b>PDO mapping</b> | no                 |
| <b>Unit</b>        | 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 | 2       | 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**

- **Danger of death, serious physical injury and/or damage to property due to malfunction, caused by incorrect parameterization!**

**NOTICE**

- 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<br>1: increasing [default] |
| Safe integration time       | UNSIGNED16 | Default = 2<br>Range: 1-10               |
| Window increments           | UNSIGNED16 | Default = 1000<br>Range: 50-4000         |
| Preset standstill tolerance | UNSIGNED16 | Default = 1<br>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 = 2 \* 50 ms = 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:  
 $\geq 3$  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 =  $20 * 5 \text{ ms} = 100 \text{ ms}$ .

---

## 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 the FSoE 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

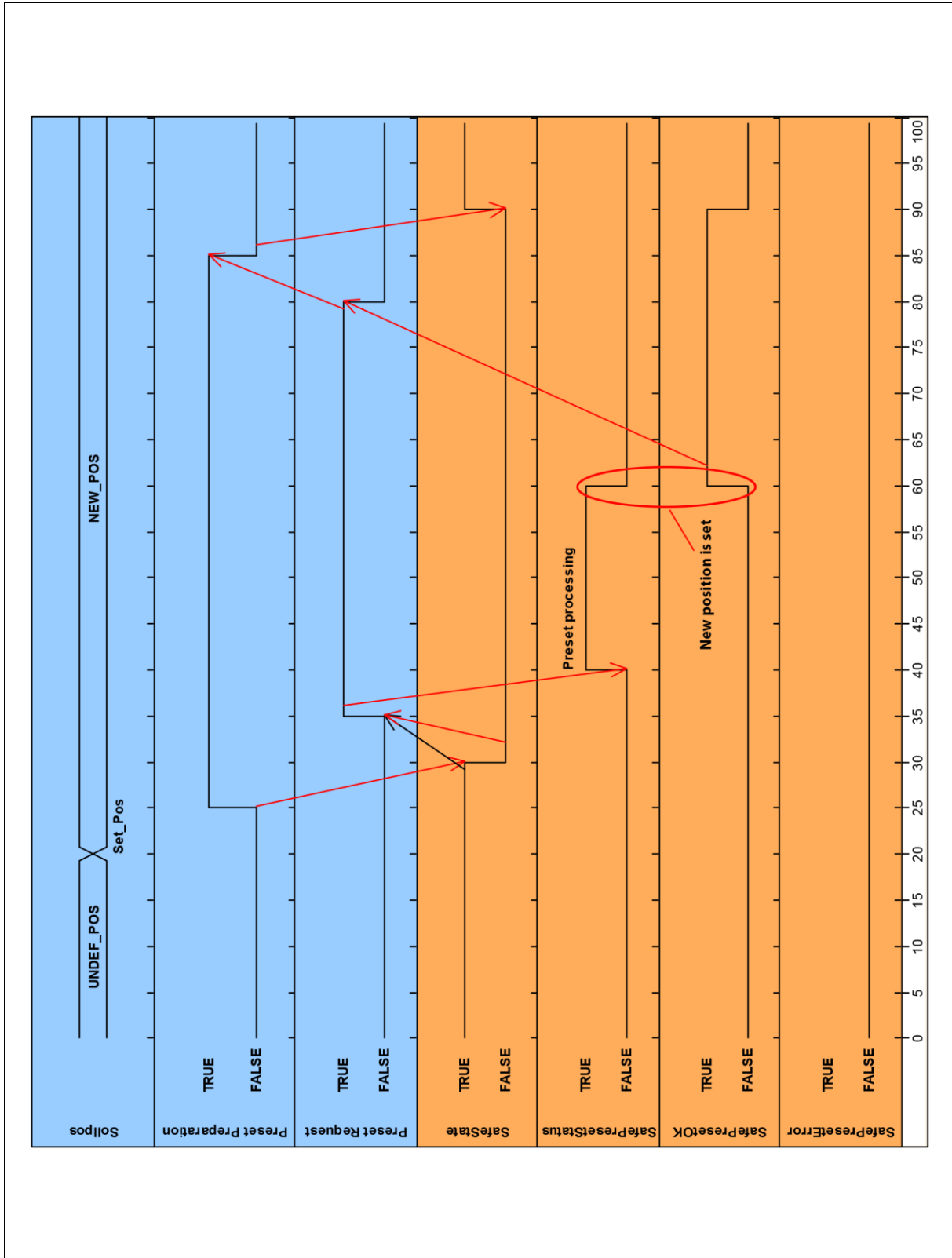


Figure 8: Preset timing diagram

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

| red LED                       | Cause   | Solution  |
|-------------------------------|---|---|
| Single flash<br>(green = OFF) | Measuring system waiting for an error acknowledgement.<br><code>SafeStatus</code> bits:<br>- <code>Error Ack Request</code> = 1<br>- <code>SafeState</code> = 0 | Reset the error via Bit 2 <sup>6</sup> <code>Error Acknowledge SafeControl</code> in the control word, see page 33.   |
| ON<br>(green = OFF)           | <b>A safety-relevant error was detected, the measuring system was put into fail-safe status and is outputting its passivated data:</b>                          | <b>To be able to restart the measuring system after a safety relevant error, the error must generally be eliminated first of all. The <code>SafeState</code> bit can then change back to 1 through</b><br><br>1. <b>error acknowledgement by means of <code>Error Acknowledge</code>, if <code>Error Ack Request</code> = 1</b><br>(red LED flashes after error elimination)<br>2. <b>supply voltage OFF/ON</b><br>(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 <code>Window increments</code> parameter was exceeded   | - Check that the set value for the <code>Window increments</code> 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.<br>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

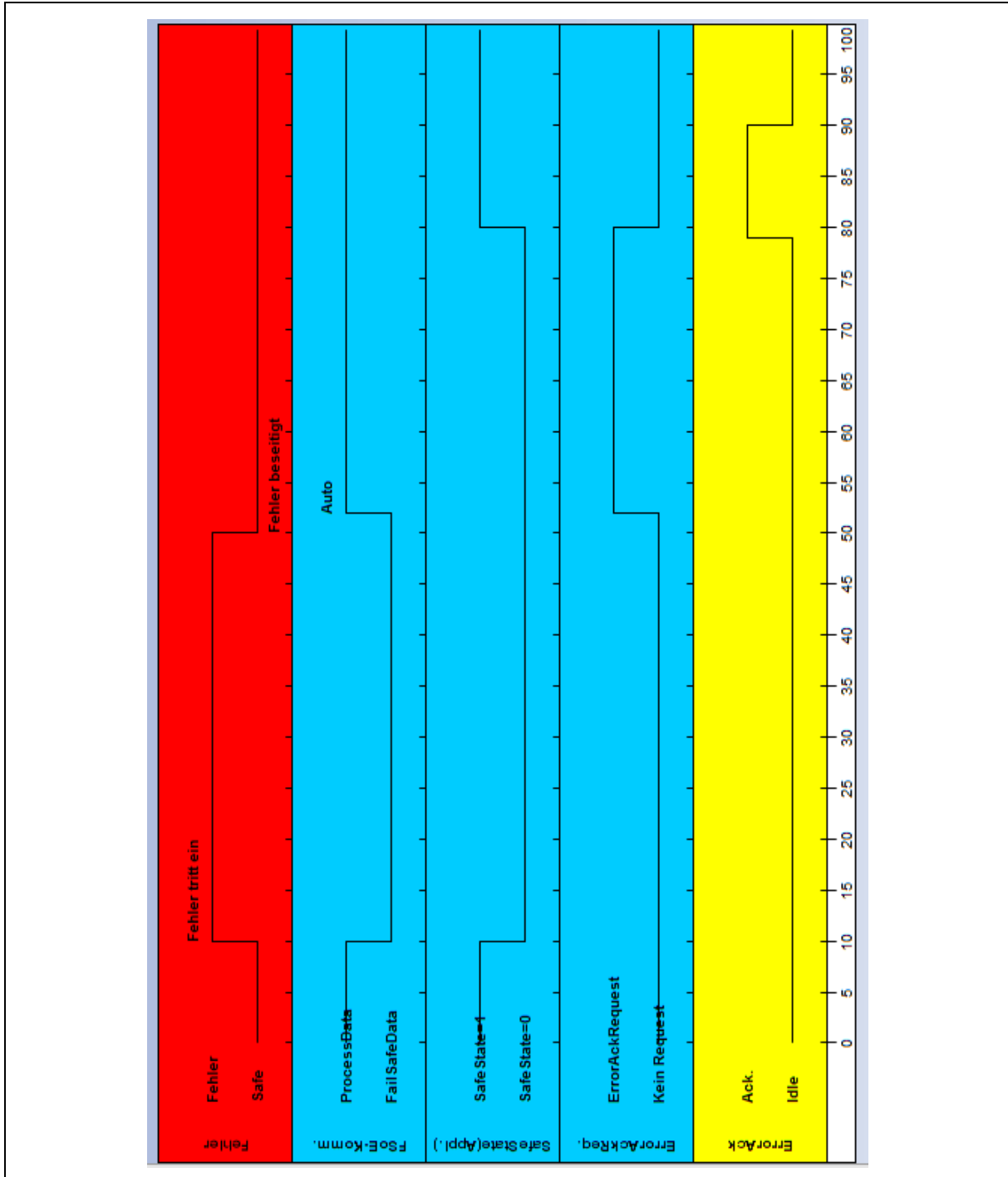


Figure 9: Error acknowledgement flow diagram

### 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   | <input type="checkbox"/> |
| Check that the measuring system can be used for the present automation task on the basis of the specified safety requirements | <ul style="list-style-type: none"> <li>• Safety functions of the fail-safe processing unit</li> <li>• Compliance with all technical data</li> </ul>  | <ul style="list-style-type: none"> <li>• Chapter Safety functions of the fail-safe processing unit, page 14</li> <li>• Chapter Technical data, page 15</li> </ul> | <input type="checkbox"/> |
| Voltage supply requirement  | <ul style="list-style-type: none"> <li>• The power supply used must meet the requirements of SELV/PELV (IEC 60364-4-41:2005)</li> </ul>  | <ul style="list-style-type: none"> <li>• Chapter Supply voltage, page 21</li> </ul>   | <input type="checkbox"/> |
| Correct<br>- electrical installation (shielding)<br>- network installation  | <ul style="list-style-type: none"> <li>• Observance of basic rules for installation</li> <li>• Observance of wiring standards and directives specified by EtherCATthe User Organization</li> </ul>   | <ul style="list-style-type: none"> <li>• Chapter Installation / Preparation for Commissioning, from page 18</li> <li>• Chapter Commissioning, page 27</li> </ul>  | <input type="checkbox"/> |
| System test after commissioning and parameterization  | <ul style="list-style-type: none"> <li>• During commissioning and after each parameter change all affected safety functions must be checked</li> </ul>   | <ul style="list-style-type: none"> <li>• Chapter Parameterization from page 47</li> </ul>   | <input type="checkbox"/> |
| Preset Adjustment Function  | <ul style="list-style-type: none"> <li>• The preset adjustment function may only be executed when the affected axis is stationary</li> <li>• It must be ensured that the Preset adjustment function cannot be inadvertently triggered</li> <li>• After execution of the preset adjustment function the new position must be checked before restarting</li> </ul> | <ul style="list-style-type: none"> <li>• Chapter Preset Adjustment Function, Page 50</li> </ul>   | <input type="checkbox"/> |
| Device replacement  | <ul style="list-style-type: none"> <li>• It must be ensured that the new device corresponds to the replaced device</li> <li>• All affected safety functions must be checked</li> </ul>   | <ul style="list-style-type: none"> <li>• Safety Manual (Checklist, Part 1 of 2)</li> <li>• Chapter Parameterization, from page 47</li> </ul>                      | <input type="checkbox"/> |

---

## 13 Appendix

### 13.1 TÜV certificate

Download

- [www.tr-electronic.de/f/TR-ECE-TI-DGB-0297](http://www.tr-electronic.de/f/TR-ECE-TI-DGB-0297)

### 13.2 EtherCAT certificate

Download

- [www.tr-electronic.de/f/TR-ECE-TI-GB-0289](http://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](http://www.tr-electronic.de/f/TR-ECE-TI-GB-0288)

### 13.4 EU Declaration of Conformity

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- [www.tr-electronic.de/f/TR-ECE-KE-DGB-0337](http://www.tr-electronic.de/f/TR-ECE-KE-DGB-0337)

### 13.5 Drawings

See back section of document

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- [www.tr-electronic.de/f/04-CDV75M-M0021](http://www.tr-electronic.de/f/04-CDV75M-M0021)
- [www.tr-electronic.de/f/04-CDH75M-M0016](http://www.tr-electronic.de/f/04-CDH75M-M0016)