Translation of the original manual

ETHERNET POWERLINK certified product

open SAFETY certified product

Absolute Encoder CD_-75 POWERLINK/openSAFETY

Explosion Protection Enclosure

_A**75*

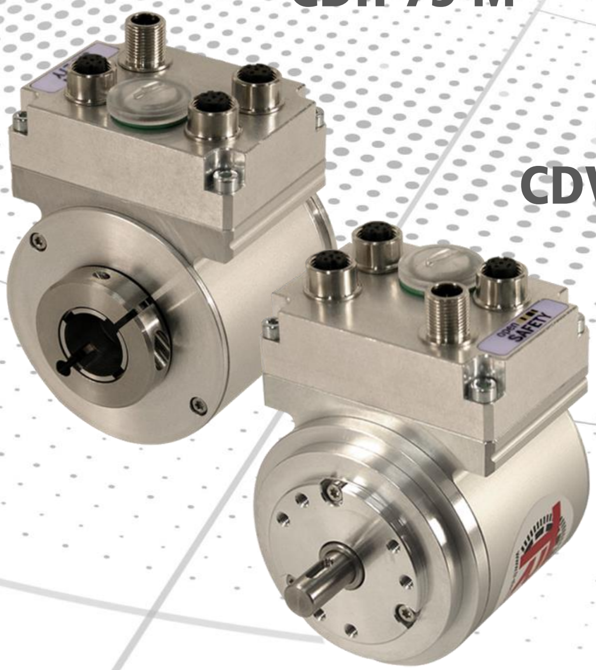
_A**88*

Protection Enclosure

_CDV115

CDH 75 M

CDV 75 M



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_Safety instructions
_Device-specific specifications
_Installation/commissioning
_Parameterization
_Error causes and remedies

User Manual Interface

TR-ECE-BA-GB-0110 v10 12/08/2020

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

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First edition	02/13/15	00
Documents in the appendix replaced by links	12/09/15	01
Scanning system, double magnetic: additional information in relation to the electrically permissible speed	03/08/16	02
TÜV certificate TR-ECE-TI-DGB-0266 is replaced by common certificate TR-ECE-TI-DGB-0297 Declaration of conformity TR-ECE-KE-DGB-0329 is replaced by common declaration of conformity TR-ECE-KE-DGB-0337	07/18/16	03
"auto-crossover-function" added	02/28/17	04
1024 ppr to factor 5 for incremental interface	10/11/17	05
CDV115 protection enclosure added	12/04/17	06
Safety-related applicable accuracy edited	12/13/18	07
Revised: 24V power supply (single fault condition)	06/05/19	08
Automation Studio V4.5 and openSAFETY version V1.5: - 0x0000025C_TR-Electronic_CD_75_-EPL.xdd - 0x0000025C_TR-Electronic_CD_75_-EPL.xosdd - 0x0000025C_TR-Electronic_AD_88_-EPL.xdd - 0x0000025C_TR-Electronic_AD_88_-EPL.xosdd	06/14/19	09
Correction of the byte order for the process data (Little Endian)	12/08/20	10

1 General

The present interface-specific User Manual addresses the following topics:

- Safety instructions
- Device-specific specifications
- Installation/commissioning
- Parameterization
- Error causes and remedies

Since it has a modular structure, this User Manual is supplementary to other documentations, such as product data sheets, dimensional drawings, brochures, the Safety Manual, etc.

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

1.1 Scope

This User Manual is only applicable to measuring system model ranges having the following type designation codes and featuring the ***POWERLINK*** interface and ***openSAFETY*** protocol:

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

Position	Designation	Description
* 1	A C	Explosion protection enclosure (ATEX); Absolute encoder, programmable
* 2	D	Redundant dual scanning system
* 3	V H S W	Solid shaft Hollow shaft Blind-hole shaft Rope length transmitter (wire)
* 4	75 88 115	External diameter ∅ 75 mm External diameter ∅ 88 mm External diameter ∅ 115 mm
* 5	M	Multi-turn
* 6	-	Consecutive number

* = Wild card

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

This means that, all in all, the following documentations are applicable:

- The responsible organization's system-specific operating instructions
- This User Manual
- The Safety Manual that is included in the delivery
  www.tr-electronic.de/f/TR-ECE-BA-GB-0107
- Optional: User Manual

1.2 References

1.	EPSG DS-301	Ethernet POWERLINK Communication Profile
2.	EPSG WDP-304	openSAFETY Profile Specification
3.	CiA DS-406	CANopen profile for encoders
4.	IEC 61158-300	Digital data communications for measurement and control - Fieldbus for use in industrial control systems - Part 300: Data Link Layer service definition
5.	IEC 61158-400	Digital data communications for measurement and control - Fieldbus for use in industrial control systems - Part 400: Data Link Layer protocol specification
6.	IEC 61158-500	Digital data communications for measurement and control - Fieldbus for use in industrial control systems - Part 500: Application Layer service definition
7.	IEC 61158-600	Digital data communications for measurement and control - Fieldbus for use in industrial control systems - Part 600: Application Layer protocol specification
8.	IEC 61784-2	Digital data communications for measurement and control - Additional profiles for ISO/IEC 8802-3 based communication networks in real-time applications
9.	ISO/IEC 8802-3	Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
10.	IAONA Guide	Industrial Ethernet - Planning and Installation Guide
11.	ISO/IEC 11801, EN 50173	Information technology - Generic cabling for customer premises

1.3 Abbreviations and terms used

0x	Hexadecimal representation
A**75*	Explosion protection enclosure with ∅ 75 mm and built-in measuring system, all variants
A**88*	Explosion protection enclosure with ∅ 88 mm and built-in measuring system, all variants
Automation Studio	Programming tool by B&R
CAT	Category: Cable classification also used for Ethernet
CDV115	Series 75 measuring system installed in a 115 "Heavy Duty" protection enclosure
CD_	Absolute encoder with redundant dual scanning system, all designs
CiA	CAN in Automation. international users' and manufacturers' organization: non-profit organization for CAN (Controller Area Network)
CN	***C***ontrolled ***N***ode: node in the EPL network without ability to control the "slot communication network management" (slave)
CRC	***C***yclic ***R***edundancy ***C***heck
DC_{avg}	***D***iagnostic ***C***overage Average diagnostic coverage
EU	***E***uropean ***U***nion
EMC	***E***lectro***M***agnetic ***C***ompatibility
EPL	***E***thernet ***P***ower***L***ink
EPSG	***E***THERNET ***P***owerlink ***S***tandardization ***G***roup
Forced values	If the peripheral devices are safety instrumented and feature outputs, the safety instrumented system does not transmit the output values which the safety program provides in the process image to the fail-safe outputs in the event of an error but sends substitute values (e.g., 0) instead.
Hub	A hub interconnects various network segments, e.g., in an Ethernet network.
IAONA	***I***ndustrial ***A***utomation ***O***pen ***N***etworking ***A***lliance
IEC	International Electrotechnical Commission
IP	***I***nternet ***P***rotocol
ISO	***I***nternational ***O***rganization for ***S***tandardization
MAC	***M***edia ***A***ccess Control, ***E***thernet ID
MNnmt	***M***anaging ***N***ode: node in the EPL network with the ability to control the "slot communication network management" (master)

Continued

$MTTF_d$	***M**ean **T**ime **T**o **F**ailure (dangerous)*
NMT	Network Management. One of the service elements in the application layer in the CAN reference model. Executes initialization, configuration and error handling in bus traffic.
PDO	Process Data Object. Object for data exchange among multiple devices.
PFD_{av}	***Av**erage **P**robability of **F**ailure on **D**emand* Average probability of failure of a safety function with low demand
PFH	***P**robability of **F**ailure per **H**our* Operating mode with high requirement rate or continuous demand. Probability of dangerous failure per hour.
S/UTP	***S**hielded/**U**nshielded **T**wisted **P**air*
SDO	Service Data Object. Point-to-point communication with access to the object data list of a device.
SCS	***S**afety **I**ntegrity **L**evel*: Four discrete levels (SIL1 to SIL4). The higher the SIL of a safety instrumented system, the lower the probability that the system cannot execute the required safety functions.
Slot	Timeslice
Repeat test (proof test)	Recurrent test for detecting hidden dangerous failures in a safety instrumented system.
XDD	XML device description file
XML	E***X**tensible **M**arkup **L**anguage*

1.4 Main features

- POWERLINK interface with openSAFETY protocol, for transfer of a safe position and velocity
- Fast process data channel via POWERLINK, not safety instrumented
- Variant 1 only:
  Additional incremental or SIN/COS interface, not safety instrumented
- Two-channel scanning system, for generation of safe 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, test system:
    Magnetic single- and multi-turn scanning
  - Variant 2:
    Channel 1, master system:
    Magnetic single- and multi-turn scanning

    Channel 2, test system:
    Magnetic single- and multi-turn scanning
- One common drive shaft

The data of the master system are provided in the non safety instrumented process data channel with normal POWERLINK protocol (untested) and short cycle time.

The inspection system is used for the internal safety check. The “safe data” that are obtained through two-channel data comparison are packed into the openSAFETY protocol and also transmitted to the POWERLINK control via POWERLINK. The data are also provided to the openSAFETY control through cross traffic.

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

1.5 Principle of the safety function

System safety is established as follows:

- 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 velocity in two channels and transfers the safe data to a downstream safety instrumented control in the openSAFETY protocol via POWERLINK.
- In the event of a failed channel comparison or other error detected through internal diagnostic mechanisms, the measuring system switches the openSAFETY channel to error state.
- Initialization of the measuring system and execution of the preset adjustment function are appropriately safeguarded.
- The control additionally checks whether the obtained position data are within the position window expected by the control. Unexpected position data are, e.g., position jumps, following error deviations and incorrect direction of travel.
- In case errors are detected, the control introduces appropriate safety measures defined by the system manufacturer
- The system manufacturer ensures, through correct attachment 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 safeguarded test during commissioning and whenever a parameter has been changed.

2 Safety instructions

2.1 Definition of symbols and notes

⚠ DANGER	means that death or serious injury will occur if the user fails to take the respective precautionary measures.
⚠ WARNING	means that death or serious injury may occur if the user fails to take the respective precautionary measures.
⚠ CAUTION	means that minor injuries may occur if the user fails to take the respective precautionary measures.
NOTICE	means that damage to property may occur if the user fails to take the respective precautionary measures.
	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, personnel assigned to handle the measuring system must
  - have read and understood the Safety Manual, in particular chapter ***"Basic safety instructions"***,
  - as well as this User Manual, in particular chapter ***"Safety instructions"***.

This is particularly applicable for personnel who handle the measuring system only occasionally, e.g., when the measuring system is parameterized.

2.3 Safety functions of the fail-safe processing unit

The measuring system does not decide on valid motion states of the system in which it is installed. The system must check the position information provided by the measuring system and the expected motion of the system for consistency.
The **safety control** to which the measuring system is connected, must perform the following safety checks.

To ensure the appropriate measures can be taken in the event of an error, the following applies:

If the measuring system detects an error and a safe position cannot be output, the openSAFETY channel is put into the `Pre-Operational` state and then automatically passed over to the fail-safe state; openSAFETY status LED = red. In this state, "forced variable values" are output via the openSAFETY channel. See also chapter "Output of forced variable values (substitute values)" on page 45.

Fail-safe state as seen by the measuring system:

- openSAFETY state: Pre-Operational
- openSAFETY frame: Data are set to 0
- openSAFETY module: SafeModuleOk: invalid

Upon receipt of forced data, the safety control must put the system into a safe state. It is only possible to leave this error state by eliminating the error and then switching the supply voltage of the measuring system off and on again!

This does not necessarily affect the process data channel that can be addressed via POWERLINK. If the internal diagnosis in the master channel does not detect an error, the process data are still output. Module status: `ModuleOk=valid`. However, these data are not safe in terms of a safety standard.

2.3.1 Mandatory safety checks / measures

Measures for commissioning, changes	Error response
Application-dependent parameterization of the openSAFETY parameters, see chapter "Safety instrumented parameters" on page 43.	–
In the event of parameter changes, check whether the measure is taken as desired.	STOP

Check by safety control	Error response
Cyclic check of the current safety instrumented openSAFETY data for consistency with the previous data.	STOP
Check of the openSAFETY position information of the measuring system for consistency with the motion of the system.	STOP
Monitoring of cycle openSAFETY data.	SafeModuleOk = false --> STOP
Timeout: Monitoring of the measuring system – response time. To check, e.g., for cable breakage, power failure, etc.	STOP

3 Technical data

3.1 Safety

Startup time... Time between POWER-UP and safe position output
Overall system................................. Approx. 17 s, B&R: X20CP1584 (1 ms) with X20SL8010

PFH, operating mode .... $3.96*10^{-10}$ 1/h
Scanning system, double magnetic ..$2.30*10^{-9}$ 1/h

PFD_{av} (T_1 = 20 a)...................................... $3.45\ 10^{-5}$

$MTTF_d$... 88 a, HIGH
Scanning system, double magnetic ..110 a

*** DC_{avg}** .... 98%, HIGH
Scanning system, double magnetic ..98.87%

Internal process safety time.................... Time elapsing between occurrence of a safety-relevant error and output of an alarm
Overall system................................. ≤ 6 ms

Process safety angle............................... Angle between error occurrence and output of an alarm
Via channel-internal self-diagnosis .. ± 100°, relating to the measuring system shaft, at 6000 min^{-1}
Through channel comparison.......... Parameterizable using the `Window Increments` parameter

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

* Was assessed according to Note 2 on Table 6 of EN ISO 13849-1

3.2 Electrical specifications

3.2.1 General

Supply voltage...................................... 13…27 V DC acc. to IEC 60364-4-41, SELV/PELV
Feed .... Common feed, however, electrically isolated from each other via two power supply units
Reverse polarity protection .... Yes
Short-circuit protection .... Yes, by internal 2 A safety fuse
Overvoltage protection.................. Yes, up to ≤ 36 V DC

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

3.2.2 Device-specific specifications

Total resolution...................................... ≤ 268 435 456 steps

Number of steps / revolution................ ≤ 8192

Number of revolutions .... ≤ 32768

Functional accuracy.............................. 8192 steps, single-turn
Scanning system, double magnetic.. 256 steps, single-turn

Accuracy, used for safety purposes
Scanning, optical/magnetic .... 256 steps, single-turn
Scanning, double magnetic .... 128 steps, single-turn

Safety principle..................................... 2 redundant scanning systems with internal triangulation

POWERLINK Interface........................... Acc. to IEC 61158 et seq. and IEC 61784-2
Safety Profile Specification .... EPSG WDP-304 V1.4.0 openSAFETY
Additional functions .... Preset
* Parameter
- Integration time Safe............... 50 ms…500 ms
- Integration time Unsafe........... 5 ms…500 ms
- Size of monitoring window...... 50…4000 increments
- Idleness Preset tolerance .... 1...5 increments/Integration time Safe
- Counting direction.................. Forward, backward
POWERLINK specification............ V2.0
Physical layer .... POWERLINK 100Base-TX, Fast Ethernet, ISO/IEC 8802-3
Communication profile.................. EPSG DS-301 V1.1.0
Output code .... Binary
Device profile................................. Based on CiA DS-406
Bus cycle time .... ≥ 400 µs
Transmission rate.......................... 100 Mbit/s
Transmission .... Cat5e cable S/UTP (netting), ISO/IEC 11801
* TR-specific functions.................. Velocity output in increments/Integration time Safe

Incremental interface For cable specification, see page 22
Availability .... Scanning system: optical/magnetic
Pulses / revolution .... 1024, 2048, 3072, 4096, 5120 or
4096, 8192, 12288, 16384, 20480, via factory setting
A, /A, B, /B, TTL .... RS422 (2-wire) according to EIA standard
A, /A, B, /B, HTL .... Optionally 13…27 V DC, see page 26
Output frequency, TTL .... ≤ 500 KHz
Output frequency, HTL.................. See page 26

SIN/COS interface, alternative For cable specification, see page 22
Availability .... Scanning system: optical/magnetic
Number of periods......................... 4096 / revolution
SIN+, SIN–, COS+, COS– .... 1 Vss ± 0.2 V at 100 Ω, differential
Short-circuit proof.......................... Yes

Cycle time
NOT safety instrumented .... 0.5 ms
Safety instrumented .... 5 ms

Preset write cycles .... ≥ 8 000 000

* parameterizable via POWERLINK

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

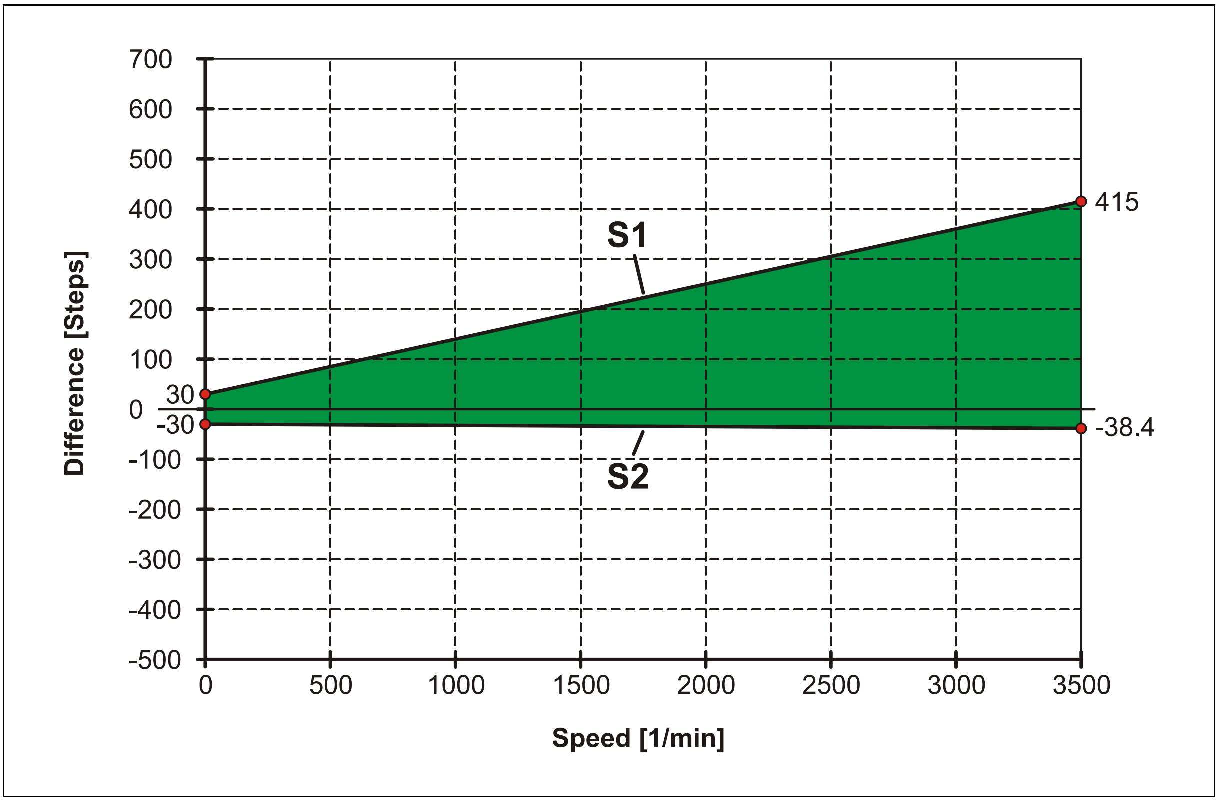


Figure 1: Dynamic view of the step deviation, in ascending counting direction (view onto flanging)

Function of straight line S1:

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

Function of straight line S2:

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

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

Example: Max. possible step deviation at 3500 1/min

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

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

4 Installation / preparation for commissioning

4.1 Basic rules

⚠ WARNING

The safety function may be deactivated by line-borne disturbance sources!

- All openSAFETY devices used on the bus must have a POWERLINK certificate and an openSAFETY certificate.
- All safety instrumented devices must also have a certificate from a “Notified Body” (e.g., TÜV, BIA, HSE, INRS, UL, etc.).
- The 24 V power supplies used must comply with the requirements of IEC 60364-4-41 SELV/PELV and be NEC Class 2 compliant for UL applications.
- The shielding effect of cables must also be ensured after installation (bending radii/tensile strength!) and after connector changes. In cases of doubt, use more flexible cables with a higher current carrying capacity.
- Only use M12 connectors for connecting the measuring system, which ensure good contact between the cable shield and the connector housing. Connect the cable shield to the connector housing over a large area.
- Compensating currents caused by differences in potential across the shield to the measuring system must be prevented.
- A shielded and stranded data cable must be used to ensure high electromagnetic interference stability of the system. The shield should be connected to protective ground in a well-conducting manner using large-scale shield clips, **if possible on either end**. The shielding should be grounded in the switch cabinet **on one end** 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, observe the applicable national safety and installation regulations for data and power cables.
- 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. Whenever possible, the quality of the network should be verified using a suitable bus analysis tool: no duplicate IP addresses, no reflections, no telegram repetitions, etc.

To ensure safe and fault-free operation,

- *ISO/IEC 11801, EN 50173 (European standard)*
- *ISO/IEC 8802-3*
- *EPSG DS 301, Communication Profile Specification, chapter "Physical Layer",*
- *IAONA Guide "Industrial Ethernet - Planning and Installation Guide" chapters "Cable" and "System Installation", www.iaona-eu.com,*
- *and the standards and directive referenced therein must be observed!*

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

4.2 POWERLINK transmission technology, cable specification

Safety instrumented openSAFETY communication is embedded in the POWERLINK standard protocol and transmitted via the same network.

S/UTP Cat5e must be used for transmission according to the 100Base-TX Fast Ethernet standard (overall shield with 2 x 2 twisted pair unshielded copper wires). 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 velocity is automatically detected by the measuring system and does not have to be set by means of switches.

Select half duplex operation for transmission, and deactivate the automatic detection function. We recommend that you use class 2 hubs for setting up the EPL network.

The cable length between two users may not exceed 100 m.

4.3 Connection

WARNING

NOTICE

The measuring system may be destroyed or damaged or its function be impaired by ingress of moisture!

- Connector plugs of the measuring system that are unused during storage and/or operation of the system have to be provided either with a mating connector or with a protective cap. The IP degree of protection is to be selected according to requirements.
- Protective cap with O-ring:
  When re-closing, check that the O-ring is present and seated properly.
- For suitable protective caps, see the chapter on accessories in the Safety Manual.

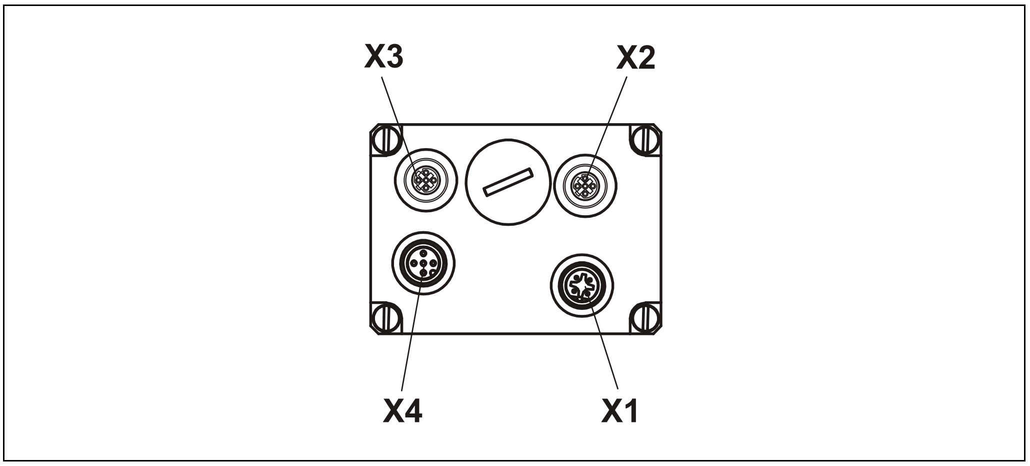


Figure 2: Connector assignment

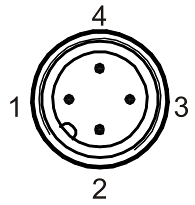
4.3.1 Supply voltage

NOTICE

The internal electronics may be damaged by impermissible overvoltages and this damage go unnoticed!

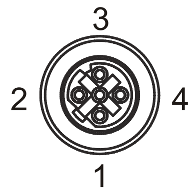
- If an overvoltage of >36 V DC is inadvertently applied, the measuring system must be checked at the factory. If overvoltage is applied for more than 200 ms, the measuring system will be permanently switched off for safety reasons.
  - ➢ The measuring system must be shut down immediately
  - ➢ When 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)

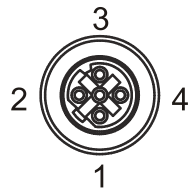
X1	Signal	Description	Pin, M12x1, 4 pole
1	+ 24 V DC (13…27 V DC)	Supply voltage	A-coded
2	n.c.	-	
3	0 V	GND	
4	n.c.	-	



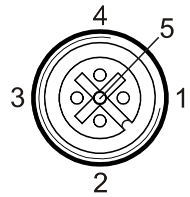
Cable specification: min. 0.34 mm² (recommended 0.5 mm²) and shielded.
Generally, the cable cross-section must be harmonized with the cable length.

4.3.2 POWERLINK

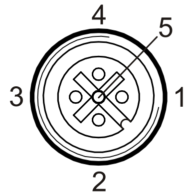
X2	Signal	Description	4-pin female connector, M12x1
1	TxD+, transmit data +	PORT 2	D-coded 
2	RxD+, receive data +		
3	TxD–, transmit data –		
4	RxD–, receive data –		

X3	Signal	Description	4-pin female connector, M12x1
1	TxD+, transmit data +	PORT 1	D-coded 
2	RxD+, receive data +		
3	TxD–, transmit data –		
4	RxD–, receive data –		

4.3.3 Incremental interface / SIN/COS interface

X4	Signal	Description	5-pin female connector, M12x1
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	

Alternative with SIN/COS signals

X4´	Signal	Description	5-pin female connector, M12x1
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.
To guarantee the signal quality and minimization of possible environmental influences, we urgently recommend to use a shielded twisted pair cable.

1) TTL/HTL level variant: see nameplate

4.4 EPL node ID

Every EPL node, MN/CN router, is addressed via an 8-bit EPL node ID on the EPL layer. This ID may be assigned only once within one EPL segment and is therefore only relevant to the local EPL segment. Node IDs 1...239 may be assigned to the measuring system.

4.4.1 Setting by means of hardware switches

⚠ WARNING

NOTICE

The measuring system may be destroyed or damaged or its function be impaired by penetration of foreign bodies and ingress of moisture!

- ➢ The access to the hardware switches must be firmly closed with the screw plug after the settings have been made.

The node ID is set using two HEX rotary switches which are read only at the starting moment. Subsequent settings during ongoing operation will no longer be detected.

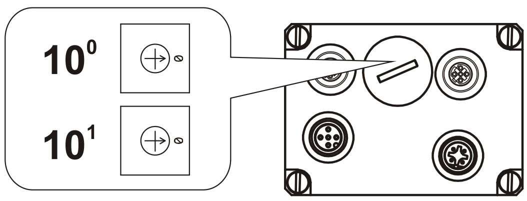


Figure 3: EPL node ID, switch assignment

4.4.2 Setting through POWERLINK SDO access, optional

This setting option can only be used if the housing variant does not feature any access to the hardware switches for tightness reasons.

Index	Subindex	Comment	Default value	Type	Attr.
2300h	0	No. of entries	3	UNSIGNED8	ro
	1	Current node ID	224 on delivery	UNSIGNED8	ro
	2	NodeIDByHW	0	BOOLEAN	ro
	3	SWNodeID	-	UNSIGNED8	rw

Procedure suggested:

- Initially, do not connect the measuring system to the actual automation net. Instead, connect the measuring system as a single component to a POWERLINK control or a PC featuring a standard Ethernet network card and POWERLINK SDO communication option (UDP/IP). Refer to chapter “IP addressing”, see page 30.
- Put the measuring system to the `NMT_CS_BASIC_ETHERNET` state
- Write the desired EPL node IP to index 2300h, subindex 3
- Turn the supply voltage to the measuring system off and on again
  - – The desired EPL node IP is applied to subindex 1 as the current EPL node ID and stored permanently
- Take the same steps to set other measuring systems.
- Finally, connect all measuring systems to the automation net.

4.5 Incremental interface / SIN/COS interface

In addition to the POWERLINK interface for output of the absolute position, the measuring system in the standard version features an incremental interface.

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

⚠ WARNING

This additional interface is not evaluated in relation to safety and may not be used for safety instrumented purposes!

- ➢ The measuring system checks the outputs of this interface for infeed of external voltages. In the event of voltages > 5.7 V, the measuring system is switched off for safety reasons. In this state, the measuring system behaves as if it were not connected.
- ➢ In motor control applications, the interface is generally used as position feedback.

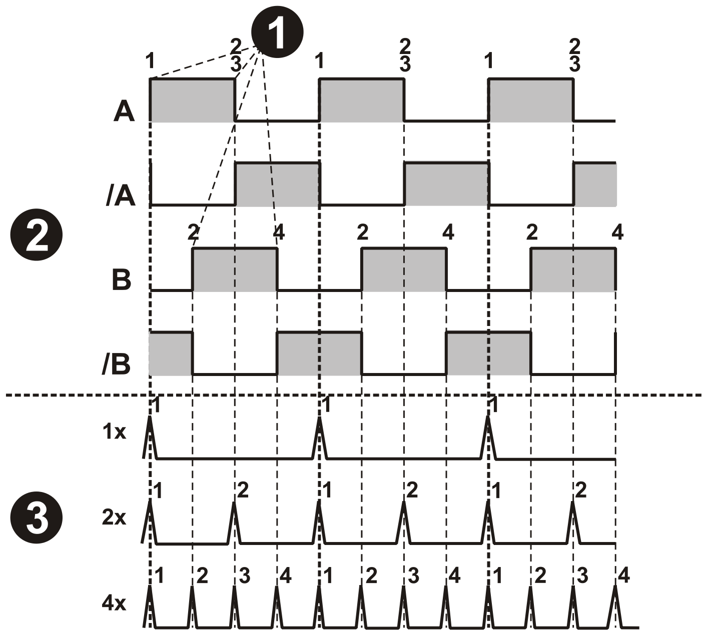
NOTICE

In the event of overvoltages, caused by a missing ground reference point, there is the danger of damage to the subsequent electronics!

- If the ground reference point is completely missing, e.g., 0 V of the power supply are 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 all times,
  - ➢ or the organization responsible for the system must provide appropriate protective measures for subsequent electronics.

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

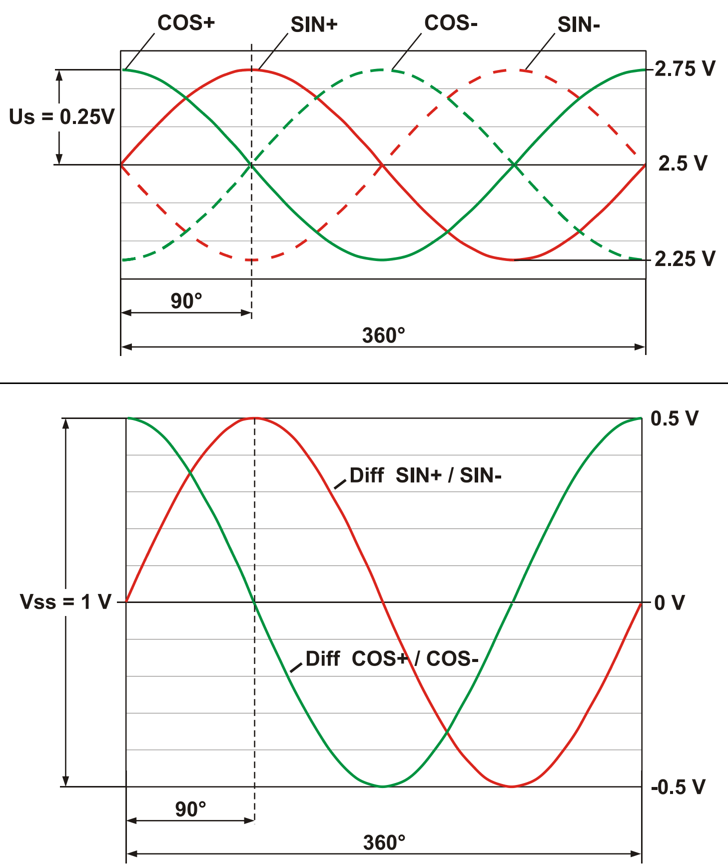
4.5.1 Signal characteristics



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

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

Optionally, the incremental interface is also available with HTL levels. For technical reasons, the user has to take the following general conditions into account with this version: ambient temperature, cable length, cable capacitance, supply voltage, and output frequency.
In this case, the maximum output frequencies that can be reached via the incremental interface are a function of the cable capacitance, the supply voltage and the ambient temperature. Therefore, the use of this interface is reasonable only if the interface characteristics meet the technical requirements.

From the view of the measuring system, the transmission cable represents a capacitive load which must be reloaded with each impulse. The load quantity required varies strongly depending on the cable capacitance. It is this reloading of the cable capacitances that is responsible for the high power dissipation and heat, which result in the measuring system.

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

Due to the developing heat, the measuring system may only be operated with approx. 80 % of the working temperature specified.

The following diagram shows the different dependencies with respect to three different supply voltages.

Fixed variables are
- Cable capacitance: 75 pF/m
- Ambient temperature: 40 °C and 70 °C

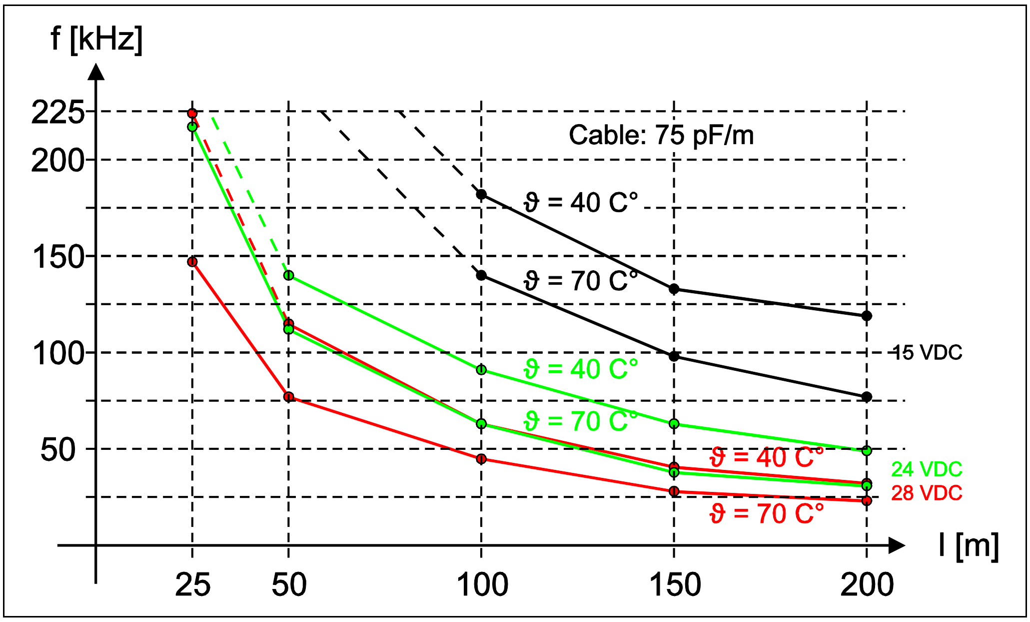


Figure 6: Cable lengths / limit frequencies

Other cable parameters, frequencies and ambient temperatures as well as bearing heat and temperature increase via the shaft and flange, can yield a considerably poorer result in practice.

Therefore, the fault-free function of the incremental interface with the application-dependent parameters has to be checked prior to productive operation.

5 Commissioning

5.1 POWERLINK / openSAFETY

For a description of the functional principle of POWERLINK and of the complete communication processing, please refer to the EPSG specification *DS 301 Communication Profile Specification*.
For the safety protocol of openSAFETY, please refer to the EPSG specification *WDP 304 Safety Profile Specification*.

On request, this and more information about POWERLINK and openSAFETY are available from the ***Ethernet POWERLINK Standardization Group*** (EPSG) at the following address:

POWERLINK-OFFICE EPSG
Bonsaiweg 6
15370 Fredersdorf
Germany

Phone:	+ 49 (0) 33439 - 539270
Fax:	+ 49 (0) 33439 - 539272
Email:	info@ethernet-powerlink.org
Internet:	www.ethernet-powerlink.org
	www.open-safety.org

5.2 Device description file

As from Automation Studio version V4.0 up to V4.4

Due to the control used (projecting software), it is not possible to directly import the POWERLINK object directory or the openSAFETY object directory to the control via a device description file (XML file). Instead, the device description files are replaced with a proprietary hwx file. This hwx file contains the complete device description and can be incorporated in “Automation Studio” by updating the firmware:

As from Automation Studio V4.5 and rotary encoder with openSAFETY V1.5 (name plate)

The XML-based XDD-file (not safety related) and XOSDD-file (safety related) contain together all information on the measuring system-specific parameters and the operating modes of the measuring system. The XML files are integrated by the POWERLINK network configuration tool, in order to enable correct configuration and commissioning of the measuring system.

Observe sequence

*Import first the file with extension *.xosdd, then the file with extension *.XDD*

Download

- Model range 75 / 115: www.tr-electronic.de/f/TR-ECE-ID-MUL-0046
- Model range 88: www.tr-electronic.de/f/TR-ECE-ID-MUL-0047

5.3 Bus status display

⚠ WARNING

NOTICE

The measuring system may be destroyed or damaged or its function be impaired by penetration of foreign bodies and ingress of moisture!

- ➢ The access to the LEDs must be firmly closed with the screw plug after the settings have been made.

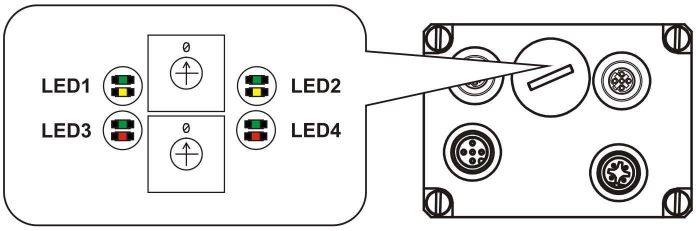


Figure 7: Bus status display

5.3.1 Indicator states and flashing frequency

LED	Description
ON	Constantly ON
OFF	Constantly OFF
Flickering	Identical ON and OFF times with a frequency of approx. 10 Hz: ON = 50 ms, OFF = 50 ms.
Blinking	Identical ON and OFF times with a frequency of approx. 2.5 Hz: ON = 200 ms, OFF = 200 ms.
Single flash	Single brief flash, approx. 200 ms ON followed by a long OFF period, approx. 1000 ms
Double flash	Double brief flash, approx. 200 ms /ONOFF followed by a long OFF period, approx. 1000 ms
Triple flash	Triple brief flash, approx. 200 ms /ONOFF followed by a long OFF period, approx. 1000 ms

5.3.2 Link / data activity LEDs

LED	Description
OFF	No Ethernet connection
Green	Ethernet connection established
Yellow	Data transfer TxD/RxD

For appropriate measures to be taken in the event of a fault, please refer to chapter “Troubleshooting and diagnosis options”, page 47.

5.3.3 POWERLINK status LED

The function of the status LED (green) is controlled via the states of the *NMT State Machine*.

LED	State
OFF	NMT_GS_OFF, NMT_GS_INITIALISATION, NMT_CS_NOT_ACTIVE
Flickering	NMT_CS_BASIC_ETHERNET
Single flash	NMT_CS_PRE_OPERATIONAL_1
Double flash	NMT_CS_PRE_OPERATIONAL_2
Triple flash	NMT_CS_READY_TO_OPERATE
ON	NMT_CS_OPERATIONAL
Blinking	NMT_CS_STOPPED

The function of the status LED (red) is controlled via the *NMT State Machine* and its state transitions.

LED	State
ON	POWERLINK error

For appropriate measures to be taken in the event of a fault, please refer to chapter “Troubleshooting and diagnosis options”, page 47.

5.3.4 openSAFETY status LED

The function of the status LED (green) is controlled via the states of the *SNMT State Machine*.

LED	State
OFF	Initialization, device off
Single flash	PRE_OPERATIONAL
Double flash	OPERATIONAL – no valid connection
ON	OPERATIONAL

The function of the status LED (red) is controlled via the *SNMT State Machine* and its state transitions.

LED	State
ON (green = OFF)	System or safety relevant error

For appropriate measures to be taken in the event of a fault, please refer to chapter “Troubleshooting and diagnosis options”, page 47.

5.4 IP addressing

Each IP-capable EPL node has an Ipv4 address, a subnet mask and a default gateway. These attributes are called IP parameters.

Ipv4 address

The private class-C network ID **192.168.100.0** is used for an EPL network. A class-C network supports IP addresses 1...254 and corresponds to the number of valid EPL node IDs. The host ID of the private class-C network ID is identical to the set EPL node ID. Accordingly, the last byte of the IP address (host ID) contains the value of the EPL node ID:

IP address	
192.168.100.	Set EPL node ID
Network ID	Host ID

Subnet mask

The subnet mask of an EPL node is 255.255.255.0. This is the subnet mask of a class-C network.

Default gateway

A default gateway is a node (router/gateway) in the EPL network and allows access to another network outside the EPL network.

IP address 192.168.100.254 can be used for the default gateway setting. This value can be adjusted to valid IP addresses. If the EPL network features a router/gateway, the IP address used there has to be applied.

The following table summarizes the default IP parameters:

IP parameter	**IP address**
IP address	192.168.100.<EPL node ID>
Subnet mask	255.255.255.0
Default gateway	192.168.100.254, can be adjusted

5.5 Commissioning using the B&R X20 CPU

Download

- Technical Information: www.tr-electronic.de/f/TR-ECE-TI-DGB-0264

6 Process data structure

6.1 Safety instrumented data

Input data structure
[*]: I/O channel name

Byte	Bit	Input data	
X+0	2^7-2^0	TR status	UNSIGNED8
X+1	2^7-2^0	Velocity [SafeTRInputVel]	INTEGER16
X+2	2^{15}-2^8		
X+3	2^7-2^0	Actual value, Multi-turn, 15-bit [SafeTRInputMulti]	UNSIGNED16
X+4	2^{15}-2^8		
X+5	2^7-2^0	Actual value, Single-turn, 13-bit [SafeTRInputSingle]	UNSIGNED16
X+6	2^{15}-2^8		
X+7	2^7-2^0	Scaled actual value, 28-bit [SafeTRInputScaled]	UNSIGNED32
X+8	2^{15}-2^8		
X+9	2^{23}-2^{16}		
X+10	2^{31}-2^{24}		

Structure of the output data

Byte	Bit	Output data	
X+0	2^7-2^0	TR control	UNSIGNED8
X+1	2^7-2^0	Preset, Multi-turn [SafeTRPresetMultiturn]	UNSIGNED16
X+2	2^{15}-2^8		
X+3	2^7-2^0	Preset, Single-turn [SafeTRPresetSingleturn]	UNSIGNED16
X+4	2^{15}-2^8		

Process data can only be accessed indirectly via the safety instrumented I/O channels; see chapter “Access to the openSAFETY object directory” on page 42.

6.1.1 Input data

6.1.1.1 TR status

WARNING

NOTICE

- **If the drive system starts uncontrolled and the `SafeState` bit 2^4 fails to be evaluated, there is the danger of death, serious physical injury and/or damage to property!**
  - ➢ The output actual values are only valid if the `SafeState` bit 2^4 = 1.
    We recommend to logically AND the `SafeState` bit with the `SafeModuleOk` module status:
    `SafeState` (1) **AND** `SafeModuleOk` (TRUE) = actual value is valid
    For access to the module status, see chapter 8.1 on page 42.

UNSIGNED8

Byte	**X+0**
Bit	7 – 0
Data	$2^7 - 2^0$

Bit	**Description**
2^0	[SafeSpeedError] Bit = 1, if the velocity value is outside the range –32768…+32767.
2^1	[SafePresetStatus] Bit = 1, if execution of the preset function is triggered via the [SafePresetRequest] control bit. After the preset function has been executed, the bit is reset automatically; see also page 46.
2^2	[SafePresetError] Bit = 1, if a preset request could not be executed because the velocity was excessively high. The current velocity must be within the range of the velocity set under Idleness Preset Tolerance. The bits can be reset using the [SafePresetRequest] and [SafePresetPreparation] preset control bits; see also page 46.
2^3	[SafePresetOK] Bit = 1, if a preset request was executed successfully.
2^4	[SafeState] Bit = 0, - in the initialization phase or, rather, if initialization was unsuccessful - if a preset request is initiated using the [SafePresetPreparation] control bit - if there is an exception error while the preset function is executed Bit = 1, - if initialization was completed successfully - if a preset request was completed successfully and the [SafePresetRequest] and [SafePresetPreparation] preset control bits were reset
$2^7…2^5$	Reserved

6.1.1.2 Velocity

[SafeTRInputVel], INTEGER16

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

The velocity is output as a signed two's complement value.

Direction of rotation set to = forward

– Looking at the flange connection, while the shaft rotates clockwise:
--> positive velocity output

Direction of rotation set to = backward

– Looking at the flange connection, while the shaft rotates clockwise:
--> negative velocity output

If the measured velocity exceeds the display range of –32768…+32767, there will be an overflow that is signaled in the status register via bit 2^0. At the time of overflow, the velocity stops at the respective +/- maximum value until the velocity has returned to within the display range. In this case, the message in the status register is cleared as well.
The velocity is specified in `Increments` per `Integration time Safe`.

6.1.1.3 Multi-turn / single-turn

[SafeTRInputMulti], UNSIGNED16

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

[SafeTRInputSingle], 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 `Multi-Turn` register while the current single-turn position is recorded in steps in the `Single-Turn` register. On this basis, the actual position can be calculated along with the resolution of the measuring system, the max. number of steps per revolutions as specified on the nameplate:

Position in steps = (steps per revolution * number of revolutions) + single-turn position

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

The output position is unsigned.

6.1.1.4 Scaled actual value

[SafeTRInputScaled], 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 Scaled Actual Value register is used to output the current scaled actual position.

The output position is unsigned.

6.1.2 Output data

6.1.2.1 TR control

UNSIGNED8

Byte	X+0
Bit	7 – 0
Data	$2^7 – 2^0$

Bit	Description
2^0	[SafePresetPreparation] The bit serves to prepare the preset adjustment function. The actual preset function can only be set using the [SafePresetRequest] control bit if this bit is set. This function can only be executed when the corresponding sequence is exactly followed; see chapter "Preset adjustment function" on page 46.
2^1	[SafePresetRequest] 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 Preset Multi-Turn/Preset Single-Turn registers. This function can only be executed when the corresponding sequence is exactly followed; see chapter "Preset adjustment function" on page 46.
$2^7…2^2$	reserved

6.1.2.2 Preset multi turn / Preset single turn

[SafeTRPresetMultiturn], UNSIGNED16

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

[SafeTRPresetSingleturn], UNSIGNED16

Byte	X+6	X+7
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 bits). On this basis, the corresponding values for Preset Multi-Turn/Preset Single-Turn can be calculated along with the resolution of the measuring system, the max. number of steps per revolution as specified on the nameplate (8192):

Number of revolutions = desired preset value / steps per revolution

The integer content from this division results in the number of revolutions and must be entered in the Preset Multi-Turn register.

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

The result of this calculation must be entered in the Preset Single-Turn register.

The preset value is set as new position when the preset adjustment function is executed; see chapter "Preset adjustment function" on page 46.

6.2 NON safety instrumented process data

Structure of the input data
[*]: I/O channel name

Byte	Bit	Input data	
X+0	2^7-2^0	Cams	UNSIGNED8
X+1	2^7-2^0	Velocity [Velocity]	INTEGER16
X+2	2^{15}-2^8		
X+3	2^7-2^0	Actual value, multi-turn, 15-bit [Multiturn]	UNSIGNED16
X+4	2^{15}-2^8		
X+5	2^7-2^0	Actual value, single-turn, 13-bit [SingleTurn]	UNSIGNED16
X+6	2^{15}-2^8		
X+7	2^7-2^0	Scaled actual value, 28-bit [Scaled]	UNSIGNED32
X+8	2^{15}-2^8		
X+9	2^{23}-2^{16}		
X+10	2^{31}-2^{24}		

For access to process data, please refer to chapter "Access to the POWERLINK object directory" on page 41.

6.2.1 Input data

6.2.1.1 Cams

UNSIGNED8

Byte	X+0
Bit	7 – 0
Data	2^7 – 2^0

Bit	Description
2^0	[Overflow] Bit = 1, if the velocity value is outside the range –32768…+32767.
2^7…2^1	Reserved

6.2.1.2 Velocity

[Velocity], INTEGER16

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

The velocity is output as a signed two's complement value.

Direction of rotation set to = forward

– Looking at the flange connection, while the shaft rotates clockwise:
--> positive velocity output

Direction of rotation set to = backward

– Looking at the flange connection, while the shaft rotates clockwise:
--> negative velocity output

If the measured velocity exceeds the display range of –32768…+32767, there will be an overflow that is reported in the cam register via bit 2^0. At the time of overflow, the velocity stops at the respective +/- maximum value until the velocity has returned to within the display range. In this case, the message in the cam register is cleared as well.
The velocity is specified in Increments per Integration time Unsafe.

6.2.1.3 Multi turn / single turn

[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 Multi-Turn register while the current single-turn position is recorded in steps in the Single-Turn register. On this basis, the actual position can be calculated along with the resolution of the measuring system, the max. number of steps per revolutions as specified on the nameplate:

Position in steps = (steps per revolution * number of revolutions) + single-turn position

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

The output position is unsigned.

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 Scaled Actual Value register is used to output the current scaled actual position.

The output position is unsigned.

7 POWERLINK object directory

The objects in the POWERLINK directory are used to transmit both the NON safety instrumented data and the safety instrumented data that are packed in openSAFETY frames. Using the safety instrumented data in the NON safety instrumented control, however, is not safe in terms of a safety standard.
The entire management is achieved via the NON safety instrumented part of the control.

7.1 Communication-specific standard objects, EPSG DS-301

Reference: EPSG specification *DS-301 Communication Profile Specification*

Supported communication-specific standard objects:

Index (h)	Name
1000	NMT_DeviceType_U32
1001	ERR_ErrorRegister_U8
1006	NMT_CycleLen_U32
1008	NMT_ManufactDevName_VS
1009	NMT_ManufactHwVers_VS
100A	NMT_ManufactSwVers_VS
1018	NMT_IdentityObject_REC
1020	CFM_VerifyConfiguration_REC
1030	NMT_InterfaceGroup_0h_REC
1050	NMT_RelativeLatencyDiff_AU32
1300	SDO_SequLayerTimeout_U32
1400	PDO_RxCommParam_00h_REC
1401	PDO_RxCommParam_01h_REC
1600	PDO_RxMappParam_00h_AU64
1601	PDO_RxMappParam_01h_AU64
1800	PDO_TxCommParam_00h_REC
1A00	PDO_TxMappParam_00h_AU64
1C0B	DLL_CNLossSoC_REC
1C0D	DLL_CNLossPReq_REC
1C0F	DLL_CNCRCError_REC
1C14	DLL_CNLossOfSocTolerance_U32
1E40	NWL_IpAddrTable_0h_REC
1E4A	NWL_IpGroup_REC
1F81	NMT_NodeAssignment_AU32
1F82	NMT_FeatureFlags_U32
1F83	NMT_EPLVersion_U8
1F8C	NMT_CurrNMTState_U8
1F8D	NMT_PResPayloadLimitList_AU16
1F93	NMT_EPLNodeID_REC
1F98	NMT_CycleTiming_REC
1F99	NMT_CNBasicEthernetTimeout_U32
1F9A	NMT_HostName_VSTR
1F9E	NMT_ResetCmd_U8

7.2 Manufacturer-specific objects

7.2.1 Object 2000h: DeviceConfiguration

The object contains the integration time for calculating the NON safety instrumented velocity and the value (MAC address) for the "Unique Device Identification" (UDID). The integration time is set using the parameterization options of the NON safety instrumented part of the control.

Index	Subindex	Comment	Default value	Type	Attr.	Page
2000h	0	No. of entries	3	UNSIGNED8	ro	-
	1	Integration_time_unsafe	20	UNSIGNED16	rw	
	2	UDID low	0x12xxxxxx	UNSIGNED32	ro	-
	3	UDID high	0x0003	UNSIGNED16	ro	-

7.2.2 Object 4000h: Indata_safe

The object contains the cyclic safety instrumented Input data; for their structure, refer to page 31 et seq. It is accessed via the I/O channels of the NON safety instrumented part of the control.

Index	Subindex	Comment	Default value	Type	Attr.	Page
4000h	0	No. of entries	1	UNSIGNED8	ro	-
	1	Indata_safe	-	Record	ro	

7.2.3 Object 4001h: Outdata_safe

The object contains the cyclic safety instrumented Output data; for their structure, refer to page 31 et seq. It is accessed via the I/O channels of the NON safety instrumented part of the control.

Index	Subindex	Comment	Default value	Type	Attr.	Page
4001h	0	No. of entries	1	UNSIGNED8	ro	-
	1	Outdata_safe	-	Record	rw	

7.2.4 Object 4010h: grayData

The object contains the cyclic NON safety instrumented Input data; for their structure, refer to page 36 et seq. It is accessed via the I/O channels of the NON safety instrumented part of the control. "Gray data" are completed by the profile-specific standard object 6004h which contains the scaled position.

Index	Subindex	Comment	Default value	Type	Attr.	Page
4010h	0	No. of entries	4	UNSIGNED8	ro	-
	1	input_cam	0	UNSIGNED8	ro	
	2	input_velocity	0	INTEGER16	ro	
	3	input_multiturn	0	UNSIGNED16	ro	
	4	input_singleturn	0	UNSIGNED16	ro	
6004	0	position_value	0x00000000	UNSIGNED32	ro	

7.3 Profile-specific standard objects, CiA DS-406

Reference: CiA specification *DS-406 Device profile for encoders*

Supported profile-specific standard objects:

Index (h)	Name	Type	Attr.
6000	operating_parameter	UNSIGNED16	ro
6004	position_value	UNSIGNED32	ro
6500	operating_status	UNSIGNED16	ro
6501	single_turn_resolution	UNSIGNED32	ro
6502	number_of_distinguishable_revolutions	UNSIGNED16	ro

Object 6004 contains the scaled actual position and is available both in the NON safety instrumented channel and the safety instrumented channel.

7.4 Access to the POWERLINK object directory

NON safety instrumented data are accessed via their channel name that has been assigned internally.
The following I/O channels are provided via the NON safety instrumented part of the control:

Channel name	I/O	Type	Description	Page
ModuleOk	***I***	***BOOLEAN***	***System parameter***	***14/45***
UDID_low	I	UNSIGNED32	Unique Device Ident, low	40
UDID_high	I	UNSIGNED16	Unique Device Ident, high	40
Overflow	I	BOOLEAN	Velocity overflow	36
Velocity	I	INTEGER16	Velocity value	37
Multiturn	I	UNSIGNED16	Actual value, multi-turn content	37
SingleTurn	I	UNSIGNED16	Actual value, single-turn content	37
Scaled	I	UNSIGNED32	Scaled actual value	38
SafeSpeedError	I	BOOLEAN	Velocity overflow	32
SafePresetStatus	I	BOOLEAN	Preset status bit	32
SafePresetError	I	BOOLEAN	Preset error bit	32
SafePresetOK	I	BOOLEAN	Preset execution OK	32
SafeState	I	BOOLEAN	Preset in process	32
SafeTRInputVel	I	INTEGER16	Velocity value	33
SafeTRInputMulti	I	UNSIGNED16	Actual value, multi-turn content	33
SafeTRInputSingle	I	UNSIGNED16	Actual value, single-turn content	33
SafeTRInputScaled	I	UNSIGNED32	Scaled actual value	34

8 openSAFETY object directory

The objects in the openSAFETY directory are used to transmit safety instrumented data. The entire management is achieved via the safety instrumented part of the control, the so-called *openSAFETY Configuration Manager* (SCM).

8.1 Access to the openSAFETY object directory

Safety instrumented data are accessed via their channel name that has been assigned internally.
The following I/O channels are provided via the openSAFETY Configuration Manager:

Channel name	I/O	Type	Description	Page
SafeModuleOk	***I***	***BOOLEAN***	***System parameter***	***14/45***
SafeSpeedError	I	BOOLEAN	Velocity overflow	32
SafePresetStatus	I	BOOLEAN	Preset status bit	32
SafePresetError	I	BOOLEAN	Preset error bit	32
SafePresetOK	I	BOOLEAN	Preset execution OK	32
SafeState	I	BOOLEAN	Preset in process	32
SafeTRInputVel	I	INTEGER16	Velocity value	33
SafeTRInputMulti	I	UNSIGNED16	Actual value, multi-turn content	33
SafeTRInputSingle	I	UNSIGNED16	Actual value, single-turn content	33
SafeTRInputScaled	I	UNSIGNED32	Scaled actual value	34
SafePresetPreparation	O	BOOLEAN	Preset preparation bit	35
SafePresetRequest	O	BOOLEAN	Preset execution bit	35
SafeTRPresetMultiturn	O	INTEGER16	Preset value, multi-turn content	35
SafeTRPresetSingleturn	O	INTEGER16	Preset value, single-turn content	35

9 Parameterization

Usually, controls feature input masks which allow the user to enter parameter data or select them from a list. The structure of the input masks is stored in the device master files.

⚠ DANGER

NOTICE

- **Malfunctions which are caused by improper parameterization result in the danger of death, serious physical injury and/or damage to property!**
  - ➢ The system manufacturer must ensure proper functioning by carrying out a protected test run during commissioning and whenever parameters have been changed.

9.1 Safety instrumented parameters

Safety instrumented parameters are used to define application-dependent device properties and provide them via the openSAFETY Configuration Manager.

Parameter	Type	Description
VIT Rotary Direction	BOOLEAN	0: backward 1: forward [default]
Integration Time	UNSIGNED16	Default = 2 Range: 1-10
Window Increments	UNSIGNED16	Default = 1000 Range: 50-4000
Idleness Preset Tolerance	UNSIGNED16	Default = 1 Range: 1-5

9.1.1 VIT Rotary Direction

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

forward = ascending counting direction
backward = descending counting direction

Default value = forward

9.1.2 Integration Time

This parameter is used to calculate the safe velocity that is output via the process data of the openSAFETY channel. Long integration times allow high-resolution measurements at low velocities. Short integration times show velocity changes more quickly and are suitable for high speeds and high dynamics. The time basis is set to a fixed value of to 50 ms. The value range of 1...10 can therefore be used to set 50...500 ms.

Standard value = 100 ms.

9.1.3 Window Increments

This parameter defines the maximum permissible position deviation in increments of the master / slave scanning systems integrated in 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. Values are within a range of 50…4000 increments.

Standard value = 1000 increments.

The larger the window increments, the larger the angle until an error will be detected.

9.1.4 Idleness Preset Tolerance

This parameter defines the maximum permissible speed in `increments` per `Integration Time` for executing the preset function, see page 46. The permissible velocity is dependent on the bus behavior and the system velocity, and must first be determined by the system operator. Values are within a range from 1 increment per `Integration Time` to 5 increments per `Integration Time`. That means that the shaft of the measuring system must be nearly at rest to ensure that the preset function can be executed.

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

9.2 NON safety instrumented parameters

These parameters are provided via the NON safety instrumented part of the control.

Parameter	Type	Description
Integration time (unsafe)	UNSIGNED16	Default = 20 Range: 1-100

9.2.1 Integration time (unsafe)

This parameter is used to calculate the unsafe velocity that is output via the process data of the NON safety instrumented data channel. Long integration times allow high-resolution measurements at low speeds. Short integration times show velocity changes more quickly and are suitable for high speeds and high dynamics. The time basis is set to a fixed value of to 5 ms. The value range of 1...100 can therefore be used to set 5...500 ms.

Standard value = 100 ms.

10 Output of forced variable values (substitute values)

The safety function requires that, in the event of an error in the safety instrumented openSAFETY channel, **forced values (0)** should be used instead of the cyclically output values in the following cases. The openSAFETY Configuration Manager signals this state using the `SafeModuleOk=FALSE` module status.

- When the safety instrumented system is started
- In the event of errors in the safety instrumented communication between the control and the measuring system via the openSAFETY protocol
- If the `Window Increments` value set under safety instrumented parameters has been exceeded and/or the internally calculated openSAFETY telegram is faulty
- If the ambient temperature, as defined under the corresponding article number, falls below or exceeds the permissible value range
- If the measuring system is supplied with >36 V DC for more than 200 ms
- If there are hardware related errors in the measuring system
- Scanning system, double magnetic: if the electrically permissible speed has been exceeded which is defined in the safety manual. Since up to this limit value a fault-free operation is guaranteed, the real output of safe data is performed therefore only explicitly above the given limit value

This does not necessarily affect the process data channel that can be addressed via POWERLINK. If the internal diagnosis in the master channel does not detect an error, the process data are still output. The NON safety instrumented part of the control signals this state using the `ModuleOk=TRUE` module status. However, these data are not safe in terms of a safety standard.

If the internal diagnosis in the master channel detects an error, **forced values (1)** are used for the NON safety instrumented channel as well and signaled with the `ModuleOk=FALSE` module status.

11 Preset adjustment function

WARNING

NOTICE

- **If the drive system starts uncontrolled while the preset adjustment function is executed, there is the danger of death, serious physical injury and/or damage to property!**
  - ➢ Execute the preset function only at standstill, see chapter "Idleness Preset Tolerance" on page 44
  - ➢ The relevant drive systems must be locked to prevent automatic start-up
  - ➢ We recommend to protect triggering of the preset adjustment function via the safety control by taking additional safety measures, such as key-operated switch, password, etc.
  - ➢ It is absolutely necessary to follow the operational sequence described below, particularly to evaluate the status bits by means of the safety control, in order to check whether the preset adjustment function has been executed successfully or unsuccessfully
  - ➢ 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. This allows setting the displayed position to a machine reference position electronically.

11.1 Sequence using the safety control

- ➢ Requirement: The measuring system is in cyclical data exchange mode.
- ➢ Write the desired preset value to the `SafeTRPresetMultiturn` and `SafeTRPresetSingleturn` registers to the output data of the safety control.
- ➢ Set the `SafePresetPreparation` and `SafePresetRequest` control bits to 0.
- ➢ Set the `SafePresetPreparation` control bit to 1. In response, the `SafeState` status bit is set to 0, whereupon the safety control must transfer the system to the safe state. The output position value is not safe any longer!
- ➢ The preset value is applied with a rising edge of the `SafePresetRequest` edge. Receipt of the preset value is acknowledged by setting (= 1) the `SafePresetStatus` status bit. Once execution of the preset function has been completed, the `SafePresetStatus` status bit is reset to 0.
- ➢ After receipt of the preset value, the measuring system checks whether all prerequisites for execution of the preset adjustment function are fulfilled. If yes, the preset value is written as the new position value. If no, execution is rejected and an error message is output by setting the `SafePresetError` status bit.
- ➢ After successful execution of the preset adjustment function, the measuring system sets the `SafePresetOK` status bit to 1, thus signaling to the safety control that execution of the preset adjustment function has been completed.
- ➢ Set the `SafePresetRequest` control bit to 0.
- ➢ Set the `SafePresetPreparation` control bit to 0. In response, the `SafeState` status bit is set to 1 again.
- ➢ Finally, the safety control must check that the new position corresponds to the new command position.

12 Troubleshooting and diagnosis options

12.1 Optical displays

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

12.1.1 Link status, PORT1: LED1; PORT2: LED2

Green LED	Cause	Remedy
Off	Voltage supply absent or too low	- Check voltage supply and wiring - Is the voltage supply within the allowed range?
	No Ethernet connection	Check Ethernet cable
	Hardware error, measuring system defective	Replace measuring system
On	Measuring system ready for operation, Ethernet connection established	-

12.1.2 POWERLINK status, LED3

Red LED	Cause	Remedy
Off	Everything is OK; node is in *NMT_CS_OPERATIONAL* state (NMT_CT7)	Normal operating state
	If the node, after having entered the *NMT_CS_NOT_ACTIVE* state, fails to receive a SoC, PReq, PRes or SoA frame within the defined timeout, it enters the *NMT_CS_BASIC_ETHERNET* state (NMT_CT3).	The timeout is defined in object 1F99h: NMT_CNBasicEthernetTimeout_U32. Default value = 5 s. The instructions given there must be followed.
	A hardware or local software RESET has been made. The node is re-initialized and enters the *NMT_GS_INITIALISING* state (NMT_GT2).	The node must be re-commissioned according to the state machine.
On	The node was put to the "Error Condition" state (NMT_CT11) by an internal error. This can be a CRC error or the loss of a frame.	- To localize the error, the fedback error code must be evaluated in the StatusResponse frame. If necessary, the limit value (threshold) must be adjusted in the associated objects.
	The node was put to the "Internal Communication Error" state (NMT_GT6) by an internal error. This can be a Tx/Rx buffer underrun/overflow error or a collision error.	- To localize the error, the fedback error code must be evaluated in the StatusResponse frame. If necessary, the limit value (threshold) must be adjusted in the associated objects.

12.1.3 openSAFETY status, LED4

Green LED	Cause	Remedy
Off	The measuring system is in the initialization phase or is switched off	-
	Voltage supply absent or too low	- Check voltage supply and wiring - Is the voltage supply within the allowed range?
	Hardware error, measuring system defective	Replace measuring system
Single flash	The measuring system is in PRE-OPERATIONAL state, which may also happen while it is running up	- Life guarding timeout? -> Check the life guarding parameter (100Ch) - Failed configuration or parameterization? -> Check parameter; restart - Node ID incorrectly configured? -> Check node ID
Double flash	The existing network connection (OPERATIONAL) to the safety control has been interrupted -> the ConnectionValid bit has been reset	Check the complete wiring between measuring system and safety control
On	OPERATIONAL	Normal operating state

Red LED	Cause	Remedy
On **(green = off)**	**A safety-relevant error was detected, the measuring system was put into fail-safe status and outputs forced data:**	**In order to restart the measuring system after a safety-relevant error has occurred, the error must first be eliminated and then the supply voltage has to be switched OFF/ON.**
	– Error in safety instrumented communication	– Try to localize the error using diagnostic mechanisms (depending on the control) – Check whether the set timeout values are appropriate for the automation task – Check whether the connection between safety control and measuring system is faulty
	– The value set for the `Window Increments` parameter has been exceeded	– Check that the set value for the `Window Increments` parameter is appropriate for the automation task; see chapter “” on page 43
	– The ambient temperature, as defined under the corresponding article number, has fallen below or exceeded the permissible value range	– Take appropriate measures to ensure that the permissible ambient temperature range can be maintained at all times
	– The measuring system was supplied with >36 V DC for more than 200 ms	– The measuring system must be shut down immediately and checked at the factory. When sending the measuring system to the factory, the reasons and circumstances relating to the overvoltage must be specified
	– The internally calculated openSAFETY telegram is faulty	– Power supply OFF/ON. If the error persists after this measure, the measuring system must be replaced
	– Scanning system, double magnetic: the electrically permitted speed which is defined in the safety manual was exceeded	– Bring speed into the permissible range. Error-acknowledgement about power supply OFF/ON.

12.2 Manufacturer-specific diagnosis (Powerlink 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

The OCTET STRINGs are single UNSIGNED8 arrays each having a length of 32 bytes.

Trouble-shoot as described in chapter “Optical displays”. If the error cannot be eliminated, the diagnostic codes along with the article number can be transmitted for evaluation to TR-Electronic.

13 Checklist, part 2 of 2

We recommend that you print out and work through the checklist for commissioning, 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 reason	Date	Processed	Checked

Sub-item	To note	Can be found under	Yes
The present User Manual has been read and understood	–	Document no.: TR-ECE-BA-GB-0110	☐
Verify 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	☐
Power supply requirements	• The power supply unit used must meet the requirements of SELV/PELV (IEC 60364-4-41:2005)	• Chapter Supply voltage, page 21	☐
Correct – electric installation (shielding) – network installation	• Comply with general installation rules • Comply with wiring standards and directives specified by the POWERLINK User Organization	• Chapter Installation / preparation for commissioning, page 18 et seq. • Chapter Commissioning, page 27	☐
System test according to commissioning and parameter changes	• During commissioning and whenever parameters have been changed, all safety functions involved must be checked	• Chapter Parameterization, page 43 et seq.	☐
Preset adjustment function	• The preset adjustment function may only be executed when the axis in question is at standstill • Ensure that the preset adjustment function is prevented from being triggered accidentally • After execution of the preset adjustment function, the new position must be checked before restarting	• Chapter Preset adjustment function, page 46	☐
Device replacement	• Ensure 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, page 43 et seq.	☐

14 Appendix

14.1 TÜV certificate

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

14.2 POWERLINK certificate

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- www.tr-electronic.de/f/TR-ECE-TI-GB-0248

14.3 openSAFETY certificate

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- www.tr-electronic.de/f/TR-ECE-TI-GB-0267

14.4 EU Declaration of Conformity

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

14.5 Drawings

See subsequent pages

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- www.tr-electronic.de/f/04-CDV75M-M0015
- www.tr-electronic.de/f/04-CDV75M-M0021
- www.tr-electronic.de/f/04-CDH75M-M0005