Original manual

Absolute Encoder CD_582 EtherNet/IP™ / CIP Safety™

– OPTION: Optional interface

CDV582

CDS582 / CDH582

Pictures are similar

DIN EN 61508 / DIN EN 62061:	**SIL2 / SIL CL 2, SIL3 / SIL CL 3**
DIN EN ISO 13849:	**PL d / PL e**

- _Safety instructions
- _Installation
- _Commissioning
- _Parameterization
- _Error causes and remedies

User Manual Interface

TR-ECE-BA-GB-0163 v06 01/27/2022

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Brand names

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Modification	Datum	Index
First release	10/06/2020	02
Adaptation of the procedure in chapter “Resetting the safety-related device parameters”	10/07/2020	03
Parameter for the second interface added	12/11/2020	04
- EtherNet/IP + CIP-Safety: Declaration of conformity added - ODVA Conformant - Logo added	01/11/2021	05
Chapter “Miscellaneous faults” no twisted pair wires for supply	01/27/2022	06

1 General information

This interface-specific user manual contains the following topics:

- Safety instructions
- 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 applies exclusively to measuring system series according to the following keys for article numbers and types with ***EtherNet/IP***™ interface and ***CIP Safety***™ profile:

Article number

* 1	* 2	* 3	* 4	* 5	–	* 6	* 6	* 6	* 6	* 6

Position	Designation	Description
* 1	A C	Explosion protection enclosure (ATEX); Ex Absolute encoder, programmable
* 2	D	Redundant dual scanning unit
* 3	V H S	Solid shaft Hollow shaft Blind shaft
* 4	582	Outer diameter ∅ 58 mm, Generation 2
* 5	M S	Multi-turn Singleturn
* 6	–	Consecutive number

* = placeholder

Type key

See Revision List:
CD_582M +FS02: www.tr-electronic.de/f/TR-ECE-TI-D-0343
CD_582M +FS03: www.tr-electronic.de/f/TR-ECE-TI-D-0349

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

The following documentations therefore apply as well:

- See the Chapter "Other Applicable Documents" in the Safety Manual www.tr-electronic.de/f/TR-ECE-BA-GB-0142
- Product data sheets www.tr-electronic.com/s/S022978

1.2 References

1.	IEC 61158:2003, Type 2 Defines (among other things) the CIP™ Application Layer that uses EtherNet/IP™
2.	IEC 61784-1:2003, Defines the communication profile of EtherNet/IP™ CP 2/2 Type 2
3.	ISO/IEC 8802-3 Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
4.	RFC768 Defines the User Datagram Protocol (UDP)
5.	RFC791 Defines the Internet Protocol (IP)
6.	RFC792 Defines the Internet Control Message Protocol (ICMP)
7.	RFC793 Defines the Transmission Control Protocol (TCP)
8.	RFC826 Defines the Ethernet Address Resolution Protocol (ARP)
9.	RFC894 IP datagram transmission standard for Ethernet networks
10.	RFC1112 Host extensions for IP multicasting
11.	RFC2131 Defines the Dynamic Host Configuration Protocol (DHCP)
12.	RFC2236 Defines the Internet Group Management Protocol (ICMP) Version 2
13.	ODVA™ The CIP Networks Library Vol. 1 to 9

1.3 Abbreviations used / Terminology

0x	Hexadecimal representation
CAT	Category Cable classification also used for Ethernet
CIP™	***C***ommon ***I***ndustrial ***P***rotocol, transmission protocol for real-time data and configuration data.
CRC	***C***yclic ***R***edundancy ***C***heck (redundancy check)
DHCP	***D***ynamic ***H***ost ***C***onfiguration ***P***rotocol, dynamic IP address assignment
DNS	***D***omain ***N***ame ***S***ystem, name resolution resulting in an IP address
EDS	***E***lectronic ***D***ata ***S***heet
EMC	***E***lectro ***M***agnetic ***C***ompatibility
Gateway	Connection point between two networks
Half duplex	Two-way alternate communication
IGMP	***I***nternet ***G***roup ***M***anagement ***P***rotocol, protocol for managing groups
MAC ID	***M***edia ***A***ccess ***C***ontrol ***Id***entifier
Multicast	Multipoint connection; the message is sent to a specific group of participants.
Node ID	Node address (IP address)
ODVA™	***O***pen ***D***eviceNet ***V***endor ***A***ssociation (CAN user organization, specifically for DeviceNet™, EtherNet/IP™)
Originator	Originator (control system) Type 1: A device capable of configuring target devices (targets) and simultaneously connect to the targets. Type 2: A device not capable of configuring target devices (targets). Safety-related parameters, SNN and SCID are configured using the SNCT program.
Passivation	In a safety-related peripheral equipment with outputs, the safety controller does not transmit the output values provided by the safety program in the process image to the fail-safe outputs in the event of a passivation but sends substitute values (e.g. 0) instead.
Port	Connection Address part that assigns data segments to a network protocol.
Router	Network component for coupling several subnets.
SCCRC	Safety Configuration CRC CRC that checks the Safety Open device configuration data.
SCID	***S***afety ***C***onfiguration ***Id***entifier SCCRC and SCTS combination used to uniquely identify a target and originator configuration.
SCTS	***S***afety ***C***onfiguration ***T***ime ***S***tamp Time/date stamp, identifies the time and date when a configuration was created or changed.
SIL	***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.

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SNCT	***S**afety **N**etwork **C**onfiguration **T**ool*
SNN	***S**afety **N**etwork **N**umber* Safety network number uniquely identifying a network across all networks in the safety system.
SSI	***S**ynchronous **S**erial **I**nterface*
Switch	Network component used to connect several computers or network segments in a local network, prevents collisions.
Target	Target device (measuring system)
TCP/IP	***T**ransmission **C**ontrol **P**rotocol/**I**nternet **P**rotocol*
TUNID	***T**arget **U**nique **N**etwork **Id**entifier*, see UNID
UDP	***U**ser **D**atagram **P**rotocol*
UNID	***U**nique **N**etwork **Id**entifier* Combination of SNN and device node ID used to uniquely identify a node across all networks in a safety system.
Full duplex	Two-way simultaneous communication

1.4 Main features

- EtherNet/IP™ – interface with CIP Safety™ protocol, used to transfer a safe position and a safe velocity
- Fast process data channel via EtherNet/IP™, non-safety-related
- Variant 1 only:
  Additional incremental or SIN/COS or SSI interface, non-safety-related
- 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 disc 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 untested Channel 1 Master System data and the Channel 2 Test System data are separately provided in the non-safety-related process data channel with normal EtherNet/IP™ protocol and short cycle time.

The inspection system is used for the internal safety check. "Safe data" obtained through two-channel data comparison are packed into the CIP Safety™ protocol and transmitted to the controller via EtherNet/IP™.

The optional incremental interface in Variant 1, or its alternative SIN/COS interface, are derived from the master system and are not evaluated with respect to safety.
Instead of the incremental interface, a synchronous-serial absolute-value interface (SSI) is available, which is also not evaluated with respect 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 and determines the velocity in two channels and transfers the safe data in the CIP Safety™ protocol via EtherNet/IP™.
- In the event of a failed channel comparison or if another error is detected through the internal diagnostic mechanisms, the measuring system switches the CIP Safety™ channel to error status.
- 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, tracking 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

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

⚠ CAUTION	means that minor injuries can occur if the required precautions are not met.

NOTICE	means that damage to property can occur if the required precautions are not met.

	indicates important information or features and application tips for the product used.

2.2 Safety-related requirements when using CIP Safety™ devices

- Exchanging the measuring system requires the backup device to be configured correctly and the user to verify its correct function by a test run in safe mode before recommissioning the replaced measuring system. See also Safety Manual TR-ECE-BA-GB-0142, Chapter 6 “Replacing the measuring system”.

- The user must ensure the originator and measuring system are correctly configured when a safety connection of the measuring system has been configured with a safety configuration ID `SCID = 0`. However, we strongly advise against this operating mode, as it bypasses an automated security check. See Chapter 4.5 from Page 36.

- Unique `SNN numbers` must be assigned for each safety network or safety subnet across the entire system. See Chapter 3.5 on Page 29.

- The transmitted SCID and configuration data must be compared with the SCID and configuration data originally displayed on the PC if the measuring system is configured using a PC (workstation). See Chapter 4.5 from Page 36.

- The user must validate all downloads to the measuring system. See Chapter 4.5 from Page 36.

- A user test is required to ensure a signature is verified (and the configuration locked). See Chapter 4.5 from Page 36.

- Connection data and measuring system configuration data must be downloaded to the measuring system first for an originator configuration to be tested and verified with such data. This is the only way to confirm the measuring system SCID. See Chapter 4.5 from Page 36.

- The lock attribute can be set in the measuring system only after the user has verified the correct function of the measuring system by a test run in safe mode. See Chapter 4.5 from Page 36.

- A configuration received by the measuring system from a Safety Network Configuration Tool (SNCT) must afterwards be uploaded from the measuring system to the SNCT and be compared. The lock attribute can only be set if the data match perfectly. See Chapter 4.5 from Page 36.

- An existing configuration must be deleted before installing a measuring system in a safety network. See Chapter 4 on Page 32.

- A measuring system must be programmed with the intended Target Unique Network Identifier (TUNID) before it can be installed in a safety network. See Chapter 3.5 on Page 29.

- A safety function user must carefully consider the effects of mixing different SIL level devices in the network. See Chapter 9.1.26 on Page 71.

- Safety connection configurations must be verified after they have been applied in an originator to confirm that a target connection is working as intended. See Chapter 8 from Page 49.

- The measuring system status LEDs are not reliable indicators and no guarantee can be given that they will provide accurate information. LEDs may thus only be used for the purpose of general diagnosis during commissioning or troubleshooting but may not be used as an operational display. See Chapter 4.3 on Page 34.

- The automatic SNN setting function of originator devices may only be used if the safety system does not rely on it. See Chapter 3.5.2 on Page 30.

- The measuring system must always be locked after the configuration data have been verified. See Chapter 4.5 from Page 36.

- As part of the final verification process, users must verify that the measuring system has received its ownership assignment from the relevant originator if the measurement system has been configured via a Type 1 SafetyOpen.

- Visually verify that all configuration data have been correctly downloaded to the measuring system. See Chapter 4.5 from Page 36.

The measuring system cannot receive configuration data from another originator in the presence of an ownership assignment by another originator. In this case you must reset the measuring system to remove the ownership assignment. See Chapter “Resetting the safety-related device parameters“ on Page 39.

2.3 Safety functions of the fail-safe processing unit

The **originator** connected to the measuring system must perform the safety checks listed below.

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

1. The CIP Safety™ data channel is automatically put into the fail-safe state if the measuring system detects an error and a safe position cannot be output. In this state, so-called “passivated data” are output via CIP Safety™.

   Passivated data as seen by the measuring system:

CIP Safety™ data channel:	all outputs are set to 0
CIP Safety™ Device Status:	in `ABORT` state
CIP Mode Byte:	Run/Idle-Bit is set to Idle
CIP Safety™ CRC:	valid
TR Safety status:	Safe State-Bit 2^4 = 0

   Upon receipt of passivated data, the Originator must put the system into a safe state. The error state can be terminated only by eliminating the error and exiting the `ABORT` state!

2. The CIP Safety stack is stopped if a safe position cannot be output due to a critical error (memory error) recognized by the measuring system. This state doesn’t permit any safety-related communication; a connection timeout error is output.

   Again, the Originator must put the system into a safe state if this occurs. To exist this error state, try switching the supply voltage off and then on again. The measuring system must be replaced if this doesn’t work.

This does not necessarily affect the process data channel that can be addressed via EtherNet/IP™. The process data continue to be output if an internal non-safety-related channel diagnosis does not detect an error. 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 by originator
Application-dependent parameterization or definition of the necessary safety-related parameters.	–
In the event of parameter changes, check whether the measure is taken as desired.	STOP

Verification by originator	Error response by originator
Cyclic check of the current safety-related data for consistency with the previous data.	STOP
Monitoring of non-safety-related and safety-related cyclic data.	Receipt of passivated data -> STOP
Timeout: Monitoring of the measuring system – response time. To check, e.g., for critical errors, cable breakage, power failure, etc.	STOP

3 Installation / Preparation for Commissioning

3.1 Basic rules

⚠ WARNING ***The safety function may be deactivated by wire-based disturbance sources!***

- All CIP Safety™ devices used on the bus must be EtherNet/IP™ and CIP Safety™ certified.
- All safety 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.
- Recommendation: Check the EtherNet/IP network for sufficient bandwidth reserves (determination of network load) before starting serial operation.

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

To ensure safe and fault-free operation, do observe

- the ODVA directive “Media Planning and Installation Manual” (Pub 148)
- the ODVA directive “EtherNet/IP™ Network Infrastructure Guide” (Pub 35)
- and the publications referenced therein!

In particular, do observe the EMC directive 2014/30/EU as amended!

For further technical ODVA guidelines see
https://www.odva.org/technology-standards/document-library/

Further information on EtherNet/IP™ and CIP Safety™ are available on request from the Open DeviceNet Vendor Association (ODVA™) at the following address:

ODVA, Inc.
4220 Varsity Drive, Suite A
Ann Arbor, MI 48108-5006 USA
Phone +1 734.975.8840
Fax +1 734.922.0027
www.odva.org
e-mail: mailto:odva@odva.org

More literature download options:

http://literature.rockwellautomation.com/
www.rockwellautomation.com/knowledgebase/

3.2 EtherNet/IP™ transmission technology, cable specification

EtherNet/IP™ networks generally use an active star topology where a point-to-point connection links the devices to a switch. One star topology advantage is that star topology supports devices with a transmission rate of 10 Mbit/s as well as 100 Mbit/s. Devices using either of the two transmission rates can also be combined, as most Ethernet switches automatically negotiate the transmission rate.

The measuring system also supports the Line (daisy chain) and Ring (DLR, optional) topologies.

Use category STP CAT5e patch cables (2 x 2 copper wire cables twisted in pairs and shielded) for transmissions using the 100Base-TX Fast Ethernet standard. The cables are designed for bit rates of up to 100 Mbit/s. The transmission velocity is automatically detected by the measuring system. The shield needs to be earthed on one side only.

Transmit in full duplex mode. We recommend using switches with the following properties when setting up the EtherNet/IP™ network:

- for the I/O communication:
- full duplex capability, on all ports
- IGMP snooping – restricts multicast data traffic to ports with an associated IP multicast group.
- IGMP Query – Routers (or switches) with active IGMP function periodically send queries to find out which IP multicast group members are connected in the LAN.
- Port Mirroring – allows data traffic on one port to be mirrored to another port, important for troubleshooting.
- other switch functions:
- e.g. redundant power supply
- Remote diagnostic capabilities

The EtherNet/IP™ Node ID can be set either via two rotary switches, flash configuration or DHCP.

The cable length between two nodes may be max. 100 m.

3.3 Connection – Notes

The pin assignment depends on the device version and is therefore noted on every connector as a pin assignment number. When the measuring system is delivered, a printed device-specific pin assignment form is enclosed.

Download
- TR-ECE-TI-DGB-0362, basic device
- TR-ECE-TI-DGB-0329, optional interface SIN/COS
- TR-ECE-TI-DGB-0330, optional interface TTL
- TR-ECE-TI-DGB-0331, optional interface HTL
- TR-ECE-TI-DGB-0332, optional interface SSI

https://www.tr-electronic.com/service/downloads/pin-assignments.html

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⚠ 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 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.

3.3.1 Supply voltage

NOTICE

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

- The power supply used must meet the requirements of
  – SELV/PELV (IEC 60364-4-41:2005)
  – and be designed according to NEC Class 2,
  see also Chapter “UL/CSA Approval” in the safety manual

Cable specification: min. 0.34 mm² (recommended 0.5 mm²). Always coordinate cable cross-section and cable length. We recommend using shielded cables, particularly in sensitive EMC environments.

3.3.2 Optional additional interfaces (Incremental, SSI)

Cable specification: min. 0.25 mm² and shielded.
To guarantee the signal quality and minimization of possible environmental influences, we urgently recommend to use a shielded twisted pair cable.

3.4 Additional interfaces – Hardware description

3.4.1 Incremental interface / SIN/COS interface (optional)

The measuring system can be equipped with an additional incremental interface in addition to the EtherNet/IP™ interface used for outputting the absolute position.

Alternatively, this interface can also be designed as a SIN/COS interface. This interface cannot be parameterized.

⚠ WARNING

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

- ➢ In motor control applications, the interface is generally used as position feedback.

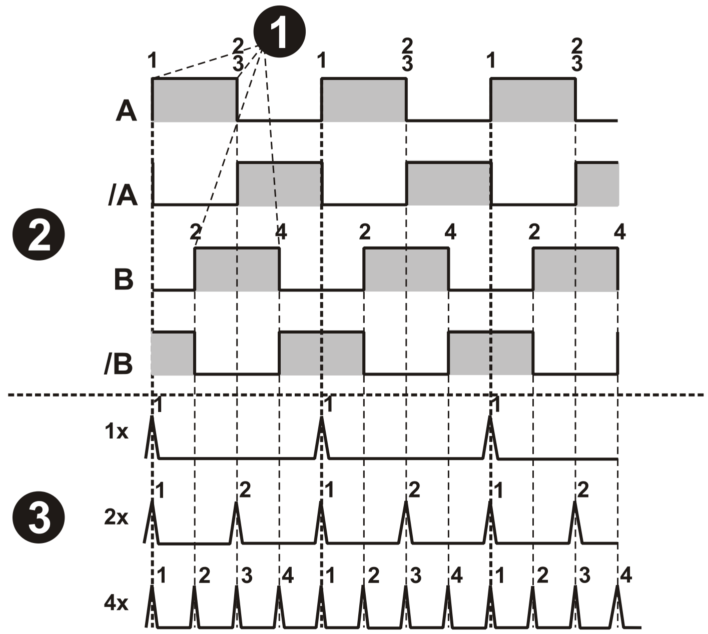
NOTICE

In the event of overvoltage, caused by a missing ground reference point, there is a danger of damage to the downstream electronic devices!

- If the ground reference point is completely missing, e.g., 0 V of the power supply is not connected, voltages equal to the supply voltage can occur at the outputs of this interface.
  - ➢ Ensure that a ground reference point is present at all times,
  - ➢ or the organization responsible for the system must provide appropriate protective measures for downstream electronic devices.

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

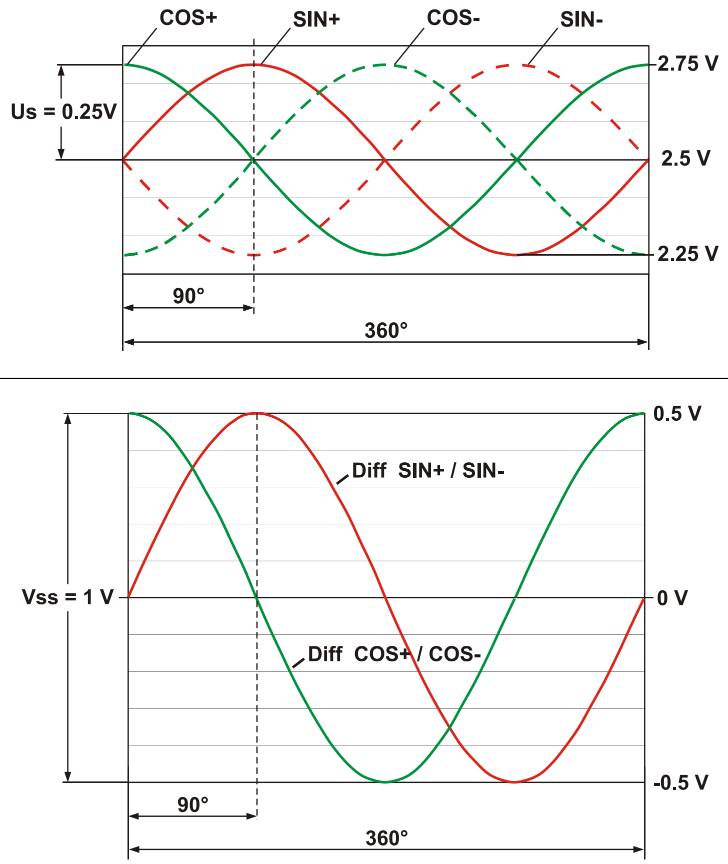
3.4.1.1 Signal characteristics



1: Edge evaluation
2: Measuring system with 1024 pulses/rev.
3: Counter evaluation

1x: 1024 counter pulses/rev.
2x: 2048 counter pulses/rev.
4x: 4096 counter pulses/rev.

Figure 1: Counter evaluation, incremental interface



Measurement of signals tending to 0 V

Differential measurement

Figure 2: Level definition, SIN/COS interface

3.4.1.2 HTL/TTL Level (optional)

Optionally, the incremental interface is also available with HTL and TTL levels. For technical reasons, the user using this version has to take the following general conditions into account: 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.

The following diagrams show, separated by TTL and HTL version, the different dependencies with respect to three different supply voltages.

TR's own hybrid cable (part number: 64-200-021) was used for the measurements.

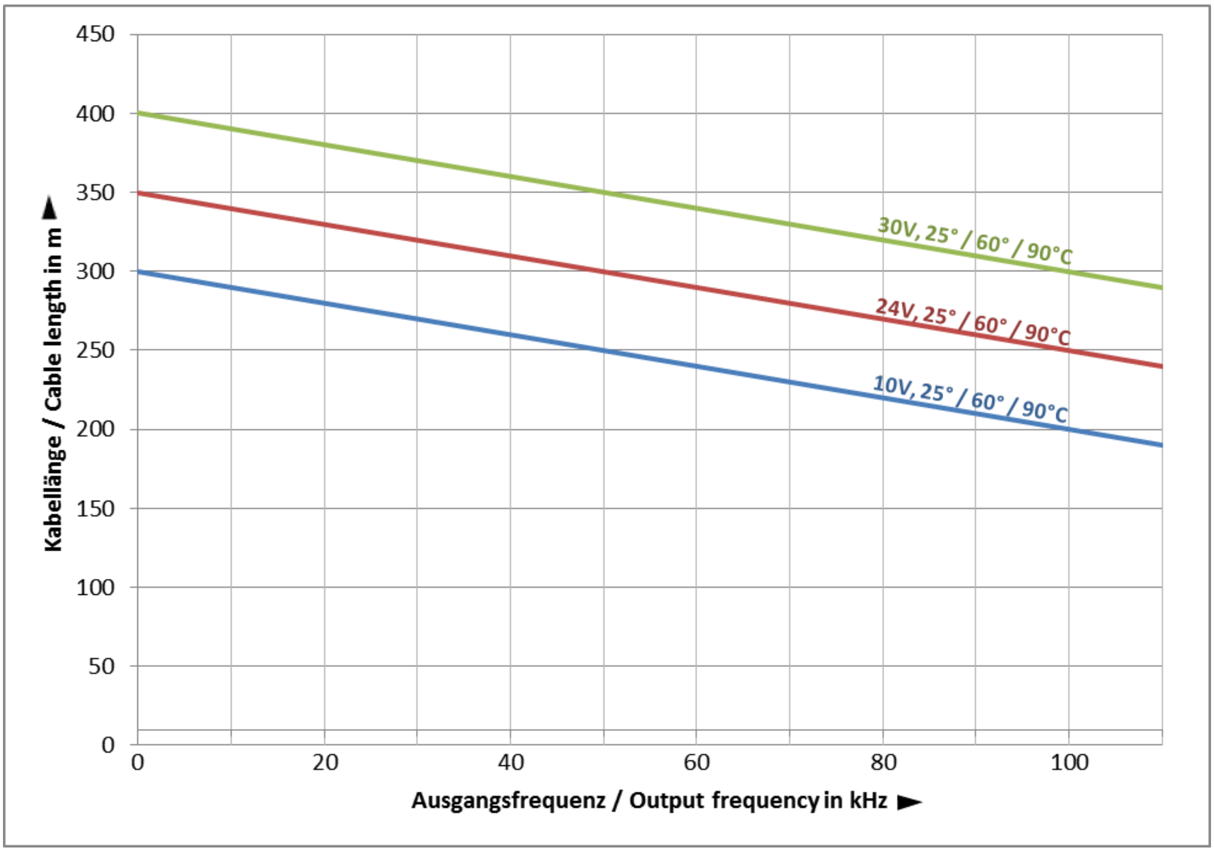


Figure 3: Cable lengths / cutoff frequencies, TTL version

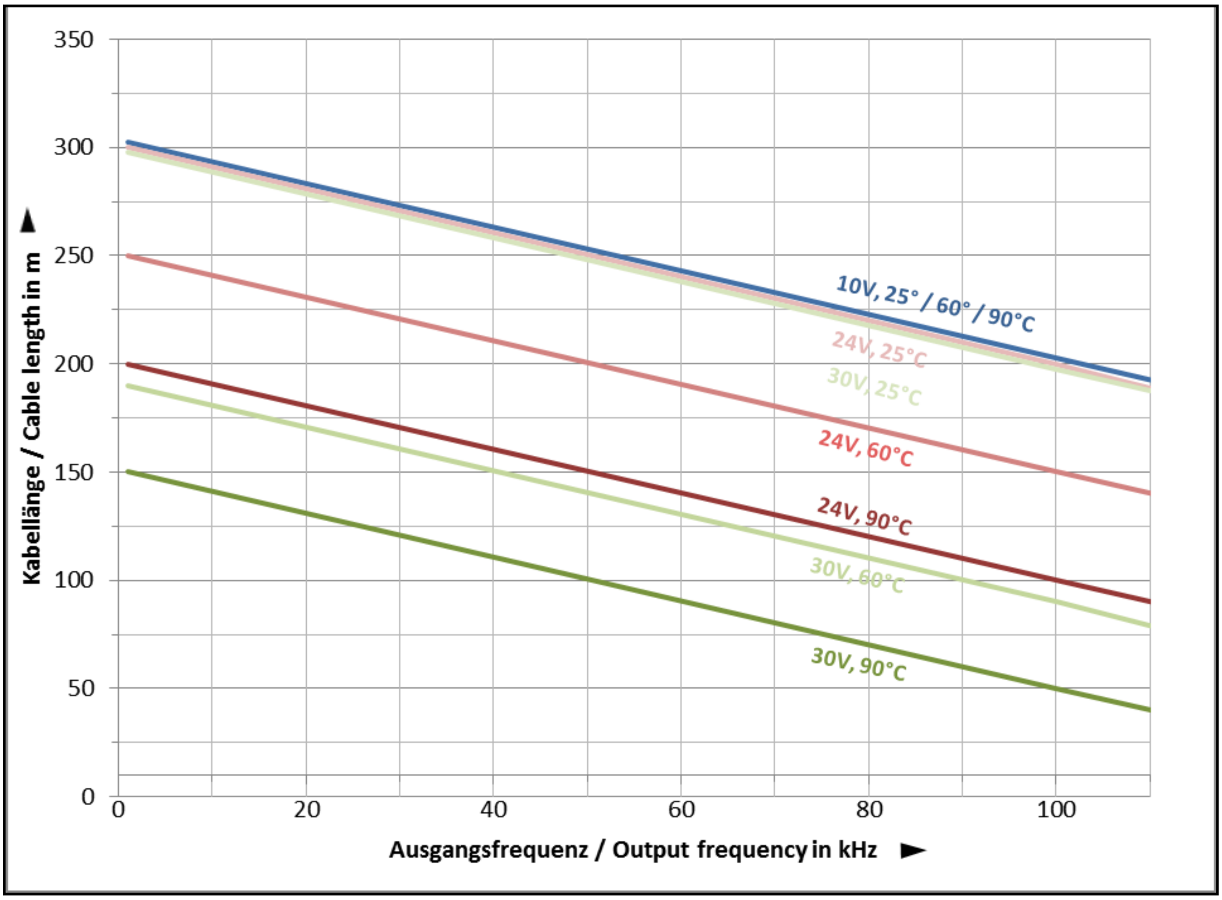


Figure 4: Cable lengths / cutoff frequencies, HTL version

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.

3.4.2 SSI interface (optional)

In addition to the EtherNet/IP™ interface, the measuring system can be equipped with a synchronous-serial absolute-value interface instead of an incremental interface.

⚠ WARNING ***This additional interface is not evaluated in relation to safety and may not be used for safety-related purposes!***

- The interface is typically used for control purposes when transferring absolute value data to a second non-safety-related controller.

3.4.2.1 Signal characteristics

In power-down mode, Data+ and Clock+ are set to high. In the diagram below, this corresponds to the Time before point (1).

When the clock signal changes from High to Low (1) for the first time, the device-internal re-triggerable monoflop is set to monoflop time t_M.
The time t_M determines the lowest transmission frequency ($T = t_M / 2$). The upper cutoff frequency results from the sum of all signal propagation times and is additionally limited by the built-in filter circuits.

With each further falling clock edge, the active state of the monoflop is extended by the time t_M – this happens last at point (4).
Setting the monoflop (1) causes the bit-parallel data pending at the internal parallel-to-serial converter to be stored by an internally generated signal in an input latch of the shift register. This ensures that the data does not change during the transmission of an actual position value.

When the clock signal changes from Low to High (2) for the first time, the most significant device information bit (MSB) is applied to the serial data output. With each further rising edge, the next lower-order bit is pushed to the data output.
When the clock rate has ended, the data lines are kept at 0 V (low) for the duration of the monoflop time t_M (4). This also results in the minimum pause time t_p, which must be maintained between two consecutive clock sequences and is $2 * t_M$.

The evaluation electronics read the data already at the first rising clock edge. Various factors result in a delay time t_V >100 ns, without cables. The measuring system data push to the output is thus delayed by the time t_V. Therefore, a “Pause-1” is read at time (2). This must be discarded or used for line break monitoring in conjunction with a “0” after the LSB data bit. The MSB data bit is read only at time (3). Therefore, the clock number must always be one higher (n+1) than the number of data bits to be transmitted.

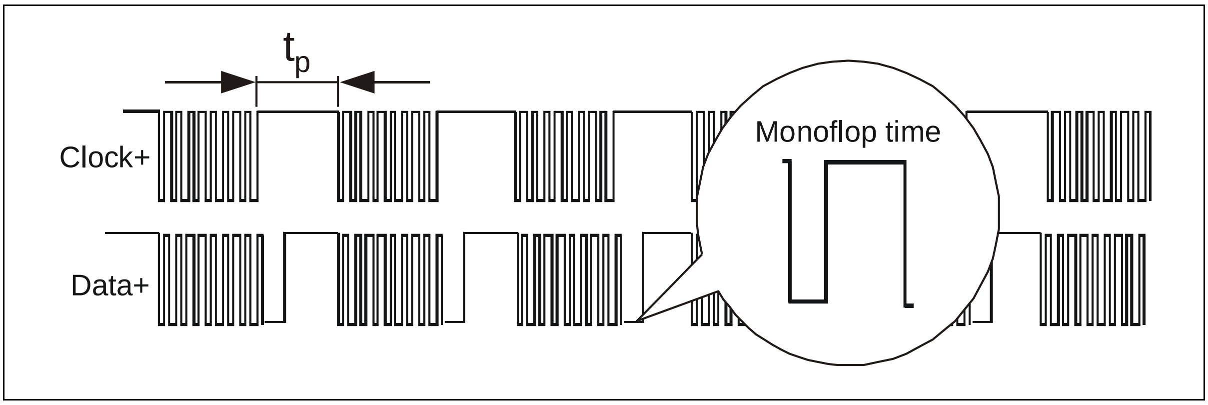


Figure 5: Typical SSI transmission sequences

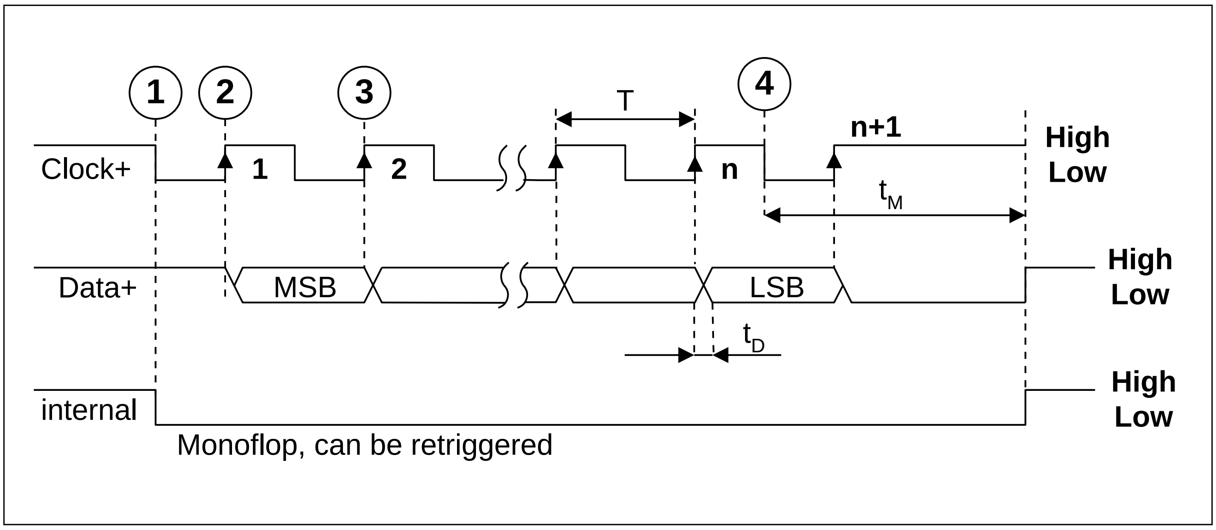


Figure 6: SSI transmission format

3.4.2.2 Cable lengths

SSI clock frequency and cable quality determine the maximum cable length.

TR's own hybrid cable (part number: 64-200-021) was used for the measurements.

SSI clock frequency [kHz]	1000	500	250	125	125	125
Cable length [m]	ca. 25	ca. 50	ca. 100	ca. 150	ca. 200	ca. 250

Table 1: **SSI clock frequency / cable lengths**

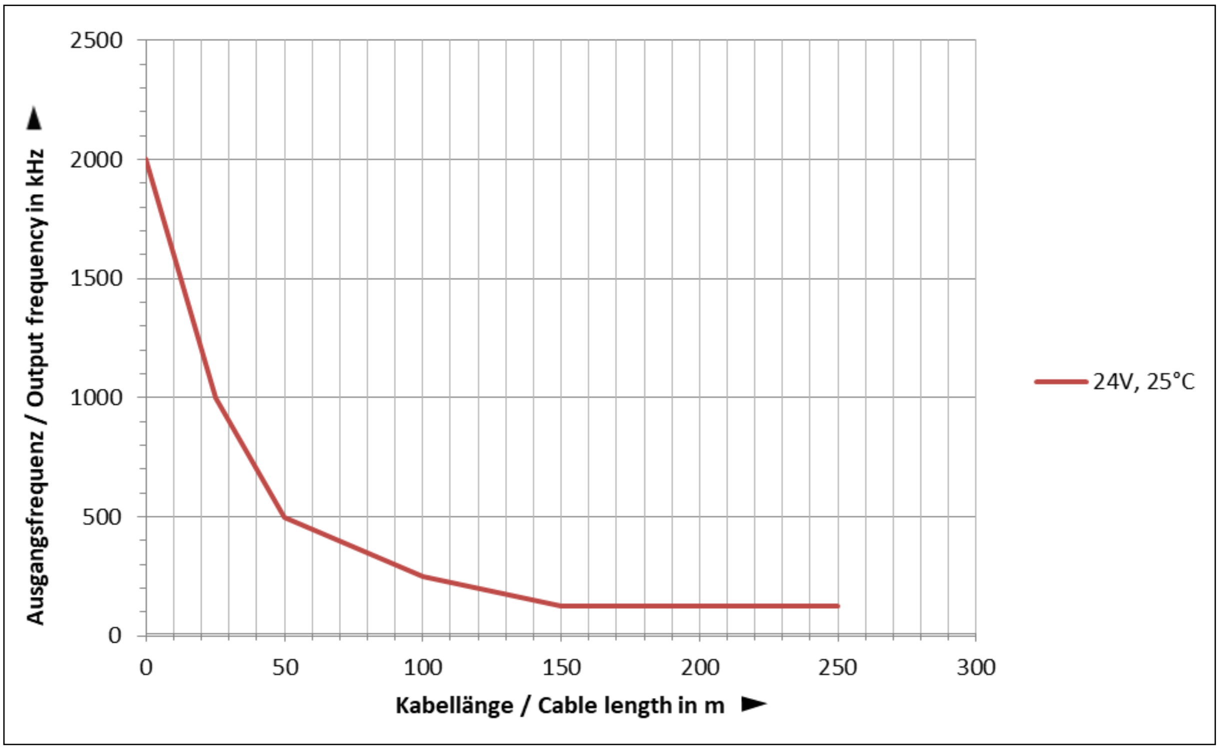


Figure 7: SSI clock frequency / cable lengths

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 SSI interface with the application-dependent parameters must be checked prior to productive operation.

3.5 Defining the Target Unique Network Identifier (TUNID)

The `TUNID` uniquely identifies the measuring system across all networks in the safety system and is a combination of "Safety Network Number" `SNN` (6 bytes) and the measuring system's IP address (4 bytes).

At delivery, the measuring system is assigned a default value of `FFFF_FFFF_FFFF`. Thus, the user must assign a valid value. The `TUNID` can be assigned by the TR program `TR SNCT Device Applet` or by an originator using the services `Propose` and `Apply TUNID`.
The measuring system performs a self-test when the supply voltage is ON, provided the supply voltage is switched on in this state. When the self-test completes successfully, the measuring system changes to the status `WAITING FOR TUNID` and waits for a `TUNID` to be assigned. This state is exited only after a valid assignment has been made.

The user must assign unique `SNN` numbers for each safety network or safety subnet across the entire system.

Establishing a `TUNID` is a prerequisite for the measuring system to be installed in a safety network.

3.5.1 Setting the Node ID or IP address

⚠ WARNING

NOTICE

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

- Firmly close the access to the address switches with the screw plug after the settings have been made.

Every EtherNet/IP™ node in an EtherNet/IP™ segment is addressed by an 8-bit node ID (node address). This address may be assigned only once within an EtherNet/IP™ segment and is therefore only relevant to that local EtherNet/IP™ segment. The preset node ID corresponds to the host ID and is part of the IP address.

Default IP address if hardware switch is active	
192.168.1.	**<preset EtherNet/IP™ node ID>**
Network ID	**Host ID**

Table 2: IPv4 address assembly

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. See also Chapter "Obtaining IP Parameters" on Page 83.

Hardware switch	* Configuration Control	Action
0x00	0x00	Configuration from FLASH
	0x02	Configuration via DHCP
0x01 … 0xFE	not relevant	**Hardware switch active**
0xFF	not relevant	Configuration via DHCP

Table 3: Switch activation

* See "Attribute 3, Configuration Control" from "TCP/IP Interface Object" on Page 82.

Node IDs 1 to 254 may be assigned to the measuring system.

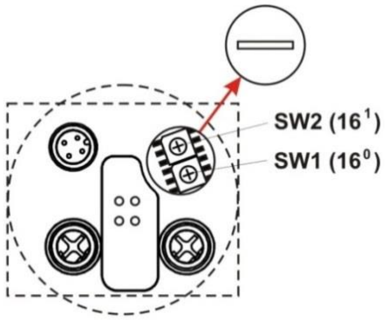


Figure 8: EtherNet/IP™ node ID, switch assignment

The following provisions apply when the HEX rotary switches are activated:

- IP address = 192.168.1.<preset node ID>
- Subnet mask = 255.255.255.0
- Default Gateway = 192.168.1.254

For obtaining the configuration from a FLASH or via a DHCP server, please refer to “Attribute 5, Interface Configuration” as from Page 83.

3.5.2 Programming the Safety Network Number (SNN)

TR-Electronic provides the WINDOWS® program `TR SNCT Device Applet` to configure the measuring system according to the “SNCT-to-Originator and SNCT-to-Target” scheme and to configure firmware updates and diagnostic options:

Download program description:

- www.tr-electronic.de/f/TR-ECE-TI-DGB-0364

Download TR SNCT Device Applet:

- www.tr-electronic.de/f/zip/TR-ECE-SW-MUL-0016

See the program description for program installation, system requirements, device connection and possible use cases.

Ensure that no controller is connected to the measuring system and that there is no EtherNet/IP™ communication during programming.
The following procedure assumes that the corresponding network interface and IP address of the measuring system have been set in the `TR SNCT Device Applet` and that there is communication.

`SNN` input format: „****_****_****“ (6 Byte); ´*´ = 4 Bit, HEX coded (0-9, A-F)

To improve readability, the separator “_” is required after every 2 bytes.

CIP data type for `DATE_AND_TIME`: [DATE_WORD]_[TIME_HI_WORD]_[TIME_LO_WORD]

Ensure the correct measuring system has been programmed with the preset `SNN` before writing the `SNN`. Use one of the following verification options found under the program tab `Device ID`:

Displayed article number and serial number in the field `Device ID` and MAC address displayed in the field `MAC address`. These data are noted on the nameplate of the measuring system.

The button `Identify` triggers the status LEDs of the relevant measuring system to flash, which makes assignments simple and easy.

Execute the function `Apply` after verifying that the correct measuring system has being addressed. The measuring system immediately applies these settings.
Several devices can be integrated into the LAN network via a switch if several devices have to be programmed. Select the devices by entering the corresponding IP address in the `TR SNCT Device Applet`.

Originators that support Type 1 SafetyOpen configurations can also program the `TUNID`. These originator devices support the “SNCT-to-Originator-to-Target” configuration scheme.

The user must ensure the uniqueness of an automatically assigned `SNN` if an originator programmed the `TUNID` with an automatic `SNN` setting function.

---

4 Commissioning

The measuring system must have a **safety-related configuration** before it can establish a connection to an originator. When the measuring system is delivered, it does not have a safety-related configuration and must therefore first be configured accordingly.
The measuring system performs a self-test if the supply voltage is turned on in this state. After a successful self-test it is checked whether the measuring system was assigned a valid TUNID. After a successful self-test, the measuring system changes to the CONFIGURING status and waits for a configuration to be assigned. This state is exited only after a valid configuration has been made.

If the measuring system has already been put into operation and has a safety-related configuration, this safety-related configuration must be deleted for safety reasons before the measuring system can be installed in a safety network.
If this is the case, follow this procedure:

1. Reset the measuring system to factory settings
2. Assign a TUNID
3. write the safety-related configuration

The safety-related configuration can be deleted by using the TR SNCT Device Applet, by using the SNCT download and by using the function Reset.
Alternatively, delete the configuration by using the rotary switch, see Chapter 5 on Page 39. This sets the factory settings for TUNID, SCID, the Safety configuration, and the password. The measuring system is then reset to the as-delivered status and remains in the WAITING FOR TUNID state after the supply voltage was turned OFF/ON, see Chapter 3.5 on Page 29.

The measuring system supports both SafetyOpen connection frames of Type 1 and Type 2.

Originators that support Type 1 SafetyOpen connection frames can configure the measuring system completely and simultaneously establish connections to the measuring system. The originator performs the entire configuration process (download, test, and verification).
The description of the configuration process is not part of this manual. Please refer to the documentation associated with the control system instead. However, do observe the instructions in Chapter 2.2 on Page 14.

Originators that only support Type 2 SafetyOpen connection frames cannot configure the measuring system. The safety-related parameters SNN and SCID must be configured with TR-Electronic's own TR SNCT Device Applet. Apply the values calculated in this way to the control system configuration.
Appropriate downloading, testing, and verification functions have been implemented in the configuration tool. The safety configured measuring system can then be connected to the originator and establish connections.

The safety-related Type 2 SafetyOpen configuration with download process and verification process meets the CIP NETWORKS LIBRARY Volume 5, Alternative 3 requirements:
Download and function test with various subsequent comparison processes.

This method performs a delayed readback verification after the entire configuration has been downloaded and tested.

1. Initially, the measuring system configuration has not yet been verified in the system. The measuring system is configured and assigned a `SCID`, which the measuring system uses to verify data. At this point, the user verification of the uploaded data is not yet performed.
2. As soon as the user has functionally tested the entire system, it is verified by the SNCT on the PC (workstation). This verification step reads back all configuration data from the measuring system, compares the read-back data with the local drive copy and provides the data in a separate text editor for review by the user. The most important step is that the user must perform this verification and with it, the verification can be regarded as completed.

4.1 Device identification

The following attributes are used to identify the correct device when establishing a connection or replacing a device.

Controllers (connection originators) use the so-called “Electronic Keying” function to verify the attributes defined in the control project with the attributes of the connected or installed device. If the verification fails an appropriate error message is generated and the connection setup is rejected.

Attribute	**Entry for the measuring system**
Vendor ID	0x471 (TR-Electronic GmbH)
Device Type	0x22 (Encoder)
Product Code	CD_582_-EIP
Major Revision	≥ 1
Minor Revision	≥ 1

Table 4: Device identification attributes

The `TR SNCT Device Applet` also displays the attributes `Vender ID`, `Device type`, and `Product Code` of the connected measuring system.

4.2 EDS file

The EDS (Electronic Data Sheet) file contains all information about the measuring-system-specific parameters and the measuring system’s operating modes. The EtherNet/IP™ network configuration tool attaches the EDS file so that the measuring system can be properly configured and commissioned.

Download:

- www.tr-electronic.de/f/TR-ECE-ID-MUL-0067

4.3 Bus status display

The measuring system is equipped with bicolor diagnostic LEDs. A self-test is performed when the system is switched on and indicated by the red/green flashing (1 Hz) module status LED.

For safety reasons, status LEDs may only be used for general diagnosis during commissioning and troubleshooting but may not be used as an operational display!

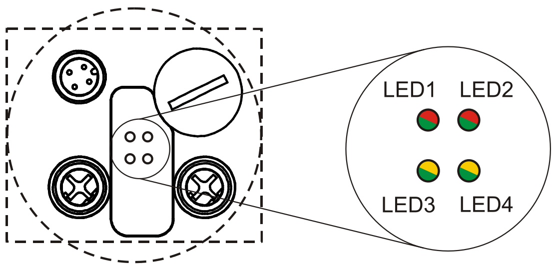


Figure 9: Measuring system diagnostic LEDs

LED1: Module status "Mod Stat"

green	Description
Off	– Voltage supply missing or too low – Hardware error, measuring system defective
On	Measuring system ready for operation (no error)
1 Hz	The measuring system is in Idle state

red	Description
On	a critical error has occurred
1 Hz	The measuring system is in Abort state

red/green	Description
red <-> green 1 Hz	The measuring system performs a self-test or must be configured

LED2: Network status "Net Stat"

green	Description
Off	– Voltage supply missing or too low – Hardware error, measuring system defective – Measuring system offline
On	Measuring system online, CIP connection established
1 Hz	Measuring system online, CIP connection not established

red	Description
On	Several identical IP addresses detected
1 Hz	I/O connections in Timeout state

red/green	Description
red <-> green 1 Hz	The measuring system is in Communication Error state
red <-> green 2 Hz	`Propose_TUNID` Service received

Identify function: Module status LED1, Network status LED2

green	red	Description
1 Hz, 5 s		The measuring system thereby indicates the receipt of a `TUNID-PROPOSE-REQUEST` service. This allows the user to verify that the correct device has been selected.

LED3/4: PORT1/2 – Link / Data Activity "Port 1 L/A" / "Port 2 L/A"

green	Description
Off	no Ethernet connection established
On	Ethernet connection established

yellow	Description
Off	No data exchange
On / flashing	Data exchange active

For appropriate measures in case of error, see Chapter "Error causes and remedies" on Page 88.

4.4 MAC address

TR-Electronic assigns every EtherNet/IP™ device a globally unique device identification used to identify the Ethernet node. This 6 bytes long device identification is the MAC address and cannot be changed.

The MAC address is divided into:
- 3 bytes manufacturer ID and
- 3 bytes device ID, consecutive number

The MAC address is usually noted on the nameplate of the device,
e.g. "00-03-12-04-00-60"

4.5 Downloading the safety-related configuration

4.5.1 Via the TR SNCT – SafetyOpen Type 2

The user must always validate all downloads to the measuring system.

A download of the safety-related configuration requires that the measuring system has a TUNID and that a communication has been established to the TR SNCT Device Applet.

Before downloading the configuration to the measuring system, verify that the correct measuring system receives the preset configuration. To do so, use the SNCT's verification option Device ID.

The safety-related measuring system parameters

```
SIL / PL
Direction of rotation
Measuring range
Revolutions numerator
Revolutions denominator
Velocity format
Velocity factor
Velocity integration time
Velocity filter type
Velocity filter strength
Window Increments
```

and the calculation/determination of the Safety Configuration CRC SCCRC and Safety Configuration Time Stamp SCTS are set/performed by the SNCT Safety configuration function.
The combination of SCCRC and SCTS serves as a clear ID of the set configuration and makes up the Safety Configuration Identifier SCID.

Once the settings have been made as required, press the button Calculate to calculate this configuration. The result is displayed in the fields SCTS: and SCCRC. Right-click in the relevant field to copy the calculated value to the clipboard to then paste it in the originator's engineering tool.

The configuration must be downloaded to the measuring system so the preset configuration can be tested and verified.

Switch to the SNCT function SNCT Download to meet this requirement. The previously calculated SCTS and SCCRC values are automatically applied and written into the corresponding fields of the Configuration Download section.

The Download button transfers the preset configuration to the measuring system, which applies it after a voltage OFF/ON cycle.

Now the measuring system is configured and the originator can put it into the cyclic data exchange (Execute State) state.

The lock attribute can be set in the measuring system only after the user has verified the correct function of the measuring system by a test run in safe mode.

To meet this requirement, the user must integrate the measuring system in this phase into the intended application and verify the correct function through a test run in safe mode.

If readjustments are necessary, perform the steps of

- setting parameters
- calculating (SCTS, SCCRC)
- downloading the configuration
- Function test

repeatedly as described above.

It is recommended to save the configuration of a successful test for further configuration transfers or later verifications via the menu item `File` ->`Save`.

Now upload the configuration from the measuring system to the SNCT and compare it as the measuring system has received the configuration from the SCNT. The configuration can be locked only if the data match.

To meet this requirement, the measuring system must be reconnected to the SNCT. Ensure that no controller is connected to the measuring system. that there is no EtherNet/IP™ communication, and that the correct configuration has been selected for the verification. Activate the SNCT function `SNCT Download` -> `Upload` for the upload.

The `Upload` button transfers the `SCCRC` and `SCTS` determined or saved by the measuring system and writes them into the appropriate fields in the `Configuration Verification` section.
The fields `SCCRC` and `SCTS` are highlighted in yellow if the values differ from the configuration download data.

The transmitted SCID and configuration data must be compared with the SCID and configuration data originally displayed on the PC.

Visually verify that all configuration data have been correctly downloaded to the measuring system.

Use the `Show` button to read in and display the data automatically saved on the hard drive after the upload and meet this requirement. The divers display uses an independent and separate editor. Compare the data displayed in the editor (`Device SCID`) with the configuration download data (`Tool SCID`). These must be identical to meet the requirements of a Safety configuration. Close the editor via the `Shut down` button.

Confirm the verification by pressing the `Verify` button after the correct measuring system function has been validated and the configuration data have been verified by the user. The configuration data are now considered verified. This is visually indicated by the tick in the `SCID verified` checkbox. The configuration data can now be locked to protect them from unintentional changes.

The measuring system must always be locked after the configuration data have been verified.

To do so, set a password. This relates to locking and unlocking a configuration.
A 16-character password can be set in the `Password:` field of `Lock/Unlock the configuration` section. The assigned password must be re-entered in the `Confirmation:` field to confirm the password. If no password protection is required, the configuration can be locked with the standard password (no entry).

The `Lock` button locks the current configuration. The configuration cannot be changed in this state.

Now, the configuration can only be changed with the correct password (if assigned) and by unlocking it via the `Unlock` button or by resetting the measuring system to the factory settings.

The signature can only be considered verified after a user test and a completed configuration.

Now, the safety-related configuration is complete, the measuring system can be integrated into the CIP Safety™ network, and connections to the originators can be established with the Type 2 SafetyOpen configuration options.

The user must ensure the originator and measuring system are correctly configured when a safety connection of the measuring system has been configured with a safety configuration ID `SCID = 0`. However, we strongly advise against this operating mode, as it bypasses an automated security check.

4.6 Commissioning via SCHNEIDER M580 SIL3 (BME P58) – Type 2

Download, technical information: www.tr-electronic.de/f/TR-ECE-TI-DGB-0363

4.7 Commissioning via Allen-Bradley Compact GuardLogix 5370 – Type 1

Download, technical information: www.tr-electronic.de/f/TR-ECE-TI-DGB-0370

5 Resetting the safety-related device parameters

⚠ WARNING

NOTICE

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

- Firmly close the access to the address switches with the screw plug after the settings have been made.

Use the two HEX rotary switches SW1 and SW2 for resetting the device parameters. See Figure 8 on Page 30 for details on the position and assignment of the HEX rotary switches.

The device parameters can only be reset if no IO connection is active.

<u>Procedure:</u>

1. Unscrew the screw plug
2. Condition 1; at least one switch or both switches are set to ≠ 0:
   In this case both switches must be set to 0
   -> wait for feedback under point 3

   Condition 2; both switches are set to 0:
   In this case, set at least one switch temporary to ≠ 0, then set both switches to 0
   -> wait for feedback under point 3
3. Wait 3 s, the green NET- and green MODULE-status - LEDs flash alternately with 2 Hz
4. Set switch SW2 to 5 and switch SW1 to 2, corresponds to 0x52 = “R” (RESET)
5. Wait 3 s, the green NET- and green MODULE-status - LEDs flash alternately with 2 Hz
6. Set both switches to 0
7. Now, the safety-related configuration is reset, the `TUNID` and `SCID` are deleted and the ownership assignment of the measuring system/originator is cancelled.
8. The measuring system reboots to apply the settings
9. The process is complete, and the screw plug can be screwed back in again

<u>Resetting via the network:</u>

Alternatively, also you can use the `Safety Supervisor Object 0x39` to reset the device parameters. To do so, use the `Service Code 0x54` to trigger a so-called `Safety Reset` of Type 1 or 2.
Ensured the configuration is not locked as a precaution against changes when executing this command. The `Password` and the `TUNID` of the measuring system are required to prevent an unintentional deletion.
In contrast to a Type 1 Safety Reset, a Type 2 Safety Reset allows the selection of which parameters will not be reset, e.g. the password.

6 Structure of the configuration data – Configuration assembly

6.1 Instance 103, Grey Config Channel 1

Only the mandatory position sensor object (0x23) attribute for switching the counting direction `DirectionCountingToggle` (`DCT`) is supported in the non-safety-related **profile related configuration assembly** (Instance 103, Attribute 3). The setting is transferred to the measuring system during startup after a connection has been established.

Instance	Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
103	0	–	–	–	–	–	–	–	DCT	55
	1-3	reserved								–

6.2 Instance 104, Grey Config Channel

All TR Grey attributes from the position sensor object (0x23) are combined in the non-safety-related **TR-Electronic related configuration assembly** (Instance 104, Attribute 3) and transferred to the measuring system during startup after a connection has been established.

The attributes are described with their default values. All parameters must be written as "0" values if this is not desired.

Instance	Byte	Bit 7 … Bit 0	Page
104	0	TR Grey – Channel coupled	63
	1	TR Grey – Rotational Direction	58
	2	TR Grey – Measuring Range	59
	3		
	4		
	5		
	6	TR Grey – Revolutions Numerator	
	7		
	8		
	9		
	10	TR Grey – Revolutions Denominator	
	11		
	12		
	13		
	14	TR Grey – Velocity Format	62
	15	TR Grey – Velocity Filter Intensity	70
	16	TR Grey – Velocity Filter Type	71
	17	TR Grey – Velocity Factor	62
	18		
	19	TR Grey – Velocity Integration Time	70
	20		
	21	TR Grey – Position substitution	64
	22-23	reserved	–

6.3 Instance 123, Safety Config

All TR safety attributes from the position sensor object (0x23) are combined in the safety-related configuration assembly (Instance 123, Attribute 3). These are required to calculate the `SCID` as well as for downloading the safety-related configuration, see also Chapter 4.5 on Page 36.

<table>
<tr><th>Instance</th><th>Byte</th><th>Bit 7</th><th>Bit 6</th><th>Bit 5</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th><th>Page</th></tr>
<tr><td rowspan="24">123</td><td>0</td><td colspan="8" rowspan="2">TR Safety – SIL / PL</td><td rowspan="2">71</td></tr>
<tr><td>1</td></tr>
<tr><td>2</td><td colspan="8">TR Safety – Rotational Direction</td><td>65</td></tr>
<tr><td>3</td><td colspan="8" rowspan="4">TR Safety – Measuring Range</td><td rowspan="12">66</td></tr>
<tr><td>4</td></tr>
<tr><td>5</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td colspan="8" rowspan="4">TR Safety – Revolutions Numerator</td></tr>
<tr><td>8</td></tr>
<tr><td>9</td></tr>
<tr><td>10</td></tr>
<tr><td>11</td><td colspan="8" rowspan="4">TR Safety – Revolutions Denominator</td></tr>
<tr><td>12</td></tr>
<tr><td>13</td></tr>
<tr><td>14</td></tr>
<tr><td>15</td><td colspan="8">TR Safety – Velocity Format</td><td>69</td></tr>
<tr><td>16</td><td colspan="8" rowspan="2">TR Safety – Velocity Factor</td><td rowspan="2">69</td></tr>
<tr><td>17</td></tr>
<tr><td>18</td><td colspan="8" rowspan="2">TR Safety – Velocity Integration Time</td><td rowspan="2">70</td></tr>
<tr><td>19</td></tr>
<tr><td>20</td><td colspan="8">TR Safety – Velocity Filter Type</td><td>71</td></tr>
<tr><td>21</td><td colspan="8">TR Safety – Velocity Filter Intensity</td><td>70</td></tr>
<tr><td>22</td><td colspan="8" rowspan="2">TR Safety – Window Increments</td><td rowspan="2">71</td></tr>
<tr><td>23</td></tr>
</table>

7 Structure of the cyclic process data – IO Assembly

`IO Assembly` transfers the process data of the measuring system. Only the static configuration called `Static Assembly` is supported. The number of instances and attributes is therefore fixed and cannot be changed.

Instance	Attr.	Type	Name	Description
1	3	Input	**Grey Default Input** – Position Value Unsigned	NON-safety-related (PROFILE) 32-bit unsigned position value
100	3	–	Heartbeat	Heartbeat
101	3	Input	**TR Grey Input** – TR Grey – Encoder Status – Position Value Unsigned – TR Grey – Velocity	NON-safety-related (TR-Electronic) 16-bit status information 32-bit unsigned position value 32-bit signed velocity value
102	3	Output	**Grey Output Channel 1** – TR Grey – Preset Control – Preset Value	NON-safety-related 16-bit preset control Set 32-bit preset value
121	3	Input	**Safety Input** – TR Safety – Status – TR Safety – Position – TR Safety – Velocity	Safety-related 16-bit status information 32-bit unsigned position value 32-bit signed velocity value
122	3	Output	**Safety Output** – TR Safety – Controlword – TR Safety – Presetout	Safety-related 16-bit preset control Set 32-bit preset value

Table 5: Overview of I/O assembly instances

7.1 Instance 1, Grey Default Input

The current, non-safety-related, ***scaled*** absolute actual position of the measuring system is output as an unsigned 32-bit binary value via Instance 1, Member `Position Value Unsigned`.

Input byte IB0 to IB3, UDINT

Byte	0	1	2	3
Bit	7-0	15-8	23-16	31-24
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

Link path, `Packed EPATH` with 8-bit class

0x20	0x04	0x24	0x01	0x30	0x03
Logical Type = Class	Class #4	Logical Type = Instance	Instance #1	Logical Type = Attribute ID	Attribute ID #3

7.2 Instance 101, TR Grey Input

All non-safety-related data of the measuring system are output via Instance 101, Members 1 to 3.

Input word structure 0 to 4, Measuring system -> Originator

IW 0	IW 1	IW 2	IW 3	IW 4
TR Grey – Encoder Status	Position Value Unsigned		TR Grey – Velocity	

Link path, `Packed EPATH` with 8-bit class

0x20	0x04	0x24	0x65	0x30	0x03
Logical Type = Class	Class #4	Logical Type = Instance	Instance #65	Logical Type = Attribute ID	Attribute ID #3

7.2.1 Input TR Grey – Encoder Status

The current, non-safety-related measuring system status is output via the Member `TR Grey – Encoder Status`:

Input word IW 0, WORD

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

Bit	Function
0	Adjustment execution – positive feedback 0: Normal operation, no error 1: Adjustment was carried out For the execution of the adjustment function, see Chapter 7.3 on Page 45.
1	Output of the original position 0: Position incorrect, channel in error status 1: Output of the original position
2	Output of the substitute position 0: no substitute position output 1: Output of the substitute position The substitute position (`Position substitution` = `On`) must be set accordingly, see Chapter 9.1.15, Page 64.
3-6	unused
7	Adjustment execution – Negative feedback 1: Adjustment was not carried out For the execution of the adjustment function, see Chapter 7.3 on Page 45.
8-15	unused

7.2.2 Input Position Value Unsigned

The current, non-safety-related, ***scaled*** absolute actual position of the measuring system is output as an unsigned 32-bit binary value via Member `Position Value Unsigned`.

Input words IW 1 to IW 2, UDINT

Byte	2	3	4	5
Bit	23-16	31-24	39-32	47-40
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

7.2.3 Input TR Grey – Velocity

The current ***scaled*** non-safety-related velocity of the measuring system is output as a signed 32-bit two's complement value via the Member `TR Grey – Velocity`. Default setting: `RPM`, see Attribute `TR Grey – Velocity Format` on Page 62.

Input words IW 3 to IW 4, DINT

Byte	6	7	8	9
Bit	55-48	63-56	71-64	79-72
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

7.3 Instance 102, Grey Output Channel 1 (adjustment function)

WARNING

NOTICE

Danger of physical injury and material damage due to an actual value jump during execution of the adjustment function!

- ➢ The adjustment function should only be executed when the measuring system is stationary, or the resulting actual value jump must be permitted by both the program and the application!

A 32-bit adjustment value can be transferred and set as a new position value in `Instance 1` and `Instance 101` (`Position Value Unsigned`) via Instance 102, Member `TR Grey – Preset Control` (Control word) and Member `Preset Value` (Adjustment value). The adjustment value must be within the programmed measuring range –1. An invalid adjustment value transmitted is not accepted and error code 0x0080 is indicated in the status word `TR Grey – Encoder Status`. Control word = 0x0000 deletes the error code in the status word `TR Grey – Encoder Status`.

The adjustment value is set with a rising edge 0->1 of bit 2^0 (0x0001) in the control word. Execution of the adjustment is acknowledged in the status word `TR Grey – Encoder Status` by setting bit 2^0 (0x0001). Cancelling bit 2^0 (0x0000) in the control word automatically resets bit 2^0 (0x0000) in the status word `TR Grey – Encoder Status`.

Source data structure, originator -> measuring system
WORD / DINT

Byte	0	1	2	3	4	5
Bit	7-0	15-8	23-16	31-24	39-32	47-40
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$
Function	Control word (2^0)		32-bit adjustment value (binary)			

Adjustment value lower limit	0
Adjustment value upper limit	Programmed total measuring range in steps – 1

Link path, `Packed EPATH` with 8-bit class

0x20	**0x04**	**0x24**	**0x66**	**0x30**	**0x03**
Logical Type = Class	Class #4	Logical Type = Instance	Instance #66	Logical Type = Attribute ID	Attribute ID #3

7.4 Instance 121, Safety Input

All safety-related data of the measuring system are output via Instance 121, Members 1 to 3.

Input word structure 0 to 4, Measuring system -> Originator

IW 0	**IW 1**	**IW 2**	**IW 3**	**IW 4**
TR Safety – Status	TR Safety – Position		TR Safety – Velocity	

Link path, `Packed EPATH` with 8-bit class

0x20	**0x04**	**0x24**	**0x79**	**0x30**	**0x03**
Logical Type = Class	Class #4	Logical Type = Instance	Instance #79	Logical Type = Attribute ID	Attribute ID #3

7.4.1 Input TR Safety – Status

The safety-related measuring system status is output via the Member `TR Safety – Status`.

⚠ WARNING

NOTICE

Danger of death, serious physical injury and/or damage to property if the drive system starts uncontrolled and the `Safe State` bit 2^4 fails to be evaluated!

- ➢ The output actual values are only valid if the `Safe State` bit 2^4 = 1.

Input UINT IW 0, UINT

Bit	Description
0	`Speed Error` Bit = 1, if the velocity value is outside the range –2147483648…+2147483647. The bit is automatically reset when the velocity coefficient is within the permissible range.
1	reserved
2	`Preset OK` Bit = 1, if a preset request was executed successfully.
3	`Preset Error` Bit = 1, if a preset request was not executed because of an error. The bits can be reset using the `Preset Request` and `Preset Preparation` preset control bits; see also Chapter 7.5.1 on Page 48.
4	`Safe State` Bit = 0, - in the initialization phase or, rather, if initialization was unsuccessful - if a preset request is initiated using the `Preset Preparation` control bit - if the measuring system is in Safe state Bit = 1, - if initialization was completed successfully - if the preset control bits `Preset Request` and `Preset Preparation` were reset.
5	`Preset Active` Bit = 1, if execution of the preset function is triggered via the `Preset Request` control bit. After the preset function has been executed, the bit is reset automatically; see also page 74.
6	reserved
7	`Scaling Error` Bit = 1, if the measuring system was run in de-energized state. As it is impossible to verify whether a zero transition has been generated in this case, the issued position must first be verified with the desired mechanical position before the application is started. After positive verification, the bit can be cleared by executing the preset adjustment function, see Chapter 9.2 on Page 74.
8	`Error Ack Request` Bit = 1 if the measuring system is in Safe state This bit can only be acknowledged when exiting the `Abort` status. You may try to perform a Type 0 `Safety Reset` via `Safety Supervisor Object 0x39` (Service Code = 0x54) or perform a supply voltage OFF/ON cycle.
9	`Preset Locked` Bit = 1 if a preset is already being executed under another Safety IO connection (application). In order to avoid inconsistencies, this application will not be able to run a preset until the preset operation has been completed in the other application.
10…15	reserved

7.4.2 Input TR Safety – Position

The current ***scaled*** absolute actual safety-related position of the measuring system is output as an unsigned 32-bit binary value via the Member `TR Safety – Position`.

Input words IW 1 to IW 2, UDINT

Byte	2	3	4	5
Bit	23-16	31-24	39-32	47-40
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

7.4.3 Input TR Safety – Velocity

The current ***scaled*** safety-related velocity of the measuring system is output as a signed 32-bit two's complement value via the Member `TR Safety – Velocity`. Default setting: `RPM`, see Attribute `TR Safety – Velocity Format` on Page 69.

Input words IW 3 to IW 4, DINT

Byte	6	7	8	9
Bit	55-48	63-56	71-64	79-72
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

7.5 Instance 122, Safety Input

The safety-related preset adjustment function is controlled via Instance 122, Members 1 to 2, and the associated preset value is transferred to the measuring system.

Structure of the output words 0 to 2, Originator -> Measuring system

OW 0	OW 1	OW 2
TR Safety – Controlword	TR Safety – Presetout	

Link path, `Packed EPATH` with 8-bit class

0x20	0x04	0x24	0x7A	0x30	0x03
Logical Type = Class	Class #4	Logical Type = Instance	Instance #7A	Logical Type = Attribute ID	Attribute ID #3

7.5.1 Output TR Safety – Controlword

The safety-related preset adjustment function is triggered and a new position value is sent to Instance 121, Member `TR Safety – Position` via Members `TR Safety – Controlword`

Output word OW 0, UINT

Bit	Description
0	`Preset Preparation` This bit serves to prepare the preset adjustment function. The actual preset function can only be set using the `Preset Request` control bit if this bit is set. This function can only be executed when the corresponding sequence is exactly followed; see Chapter "TR Safety – Preset Adjustment Function" on Page 79.
1	`Preset Request` This bit serves to control the preset adjustment function. When this function is executed, the measuring system is set to the position value set in Member `TR Safety – Presetout`. This function can only be executed when the corresponding sequence is exactly followed; see Chapter "TR Safety – Preset Adjustment Function" on Page 79.
2…15	reserved

7.5.2 Output TR Safety – Presetout

The zero point of the measuring system can be adjusted to the mechanical zero point via the Member `TR Safety – Presetout`. The desired preset value must be in the range of 0 to (measuring range in steps – 1), otherwise the preset adjustment function will not be executed and Bit 3 `Preset Error` in `TR Safety – Status` is set to = 1.

The preset value is set as a new position when the preset adjustment function is executed; see chapter "TR Safety – Preset Adjustment Function" on Page 79.

Output words OW 1 to OW 2, UDINT

Byte	2	3	4	5
Bit	23-16	31-24	39-32	47-40
Data	$2^{7} – 2^{0}$	$2^{15} – 2^{8}$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

8 Connection Types – Connection Points

The connection type defines the type of connection between the sender = control system (originator) and the target = measuring system (target).

A distinction is also made between the data flow:

- O -> T: Data packets from `Originator` to `Target`
- T -> O: Data packets from `Target` to `Originator`

The measuring system supports the following connection types:

Exclusive Owner

Refers to an independent connection where a single device controls the output states in the target device. If an `Exclusive Owner` connection already exists to a target device `no further Exclusive Owner` connection can be defined to this target device.

Input Only

Refers to an independent connection where a device receives inputs from the target device and sends configuration data to the network. An `Input Only` connection does not send any outputs, only inputs can be received. But several `Input Only` connections can be defined from various senders to the target device.

NON-safety-related connections

Grey Channel 1, Exclusive Owner, Client

O -> T

Connection Point	Class	Attribute	Data size	Description
103 (instance)	0x04	3	4 bytes	Configuration data
102	0x04	–	6 bytes	– TR Grey – Preset Control, 16 bit – Preset Value, 32 bit

T -> O (SINGLE-CAST / MULTICAST)

Connection Point	Class	Attribute	Data size	Description
1	0x04	–	4 bytes	– Position Value Unsigned, 32 bit

TR Grey Channel 1, Exclusive Owner, Client

O -> T

Connection Point	Class	Attribute	Data size	Description
104 (instance)	0x04	3	24 bytes	Configuration data
102	0x04	–	6 bytes	– TR Grey – Preset Control, 16 bit – Preset Value, 32 bit

T -> O (SINGLE-CAST / MULTICAST)

Connection Point	Class	Attribute	Data size	Description
101	0x04	–	10 bytes	– TR Grey - Encoder Status, 16 bit – Position Value Unsigned, 32 bit –TR Grey – Velocity, 32 bit

Safety-related connections

Safety Output, Exclusive Owner, Server
O -> T

Connection Point	Class	Attribute	Data size	Description
123 (instance)	0x04	3	24 bytes	Safety configuration data
122	0x04	–	6 bytes	– TR Safety – Controlword, 16 bit – TR Safety – Presetout, 32 bit

Safety Input, Input Only, Client
O -> T

Connection Point	Class	Attribute	Data size	Description
123 (instance)	0x04	3	24 bytes	Safety configuration data

T -> O (SINGLE-CAST / MULTICAST)

Connection Point	Class	Attribute	Data size	Description
121	0x04	–	10 bytes	– TR Safety – Status, 16 Bit – TR Safety – Position, 32 Bit – TR Safety – Velocity, 32 Bit

Safety connection configurations must be verified after they have been applied in an originator to confirm that a target connection is working as intended.

9 Parameter description

Object description terms

Term	**Description**
Attribute-ID (Attr. ID)	Integer value assigned to the corresponding attribute
Access	Access rule **Set:** The attribute can be accessed via the `Set_Attribute` service and corresponds to a writing service. Note: All Set Attributes can also be addressed via the `Get_Attribute` services. **Get:** The attribute can be accessed via the `Get_Attribute` service and corresponds to a reading service.
NV (nonvolatile), V (volatile)	Saving the attributes (parameters) **NV:** The attribute is permanently saved in the non-volatile memory. **V:** The attribute is temporarily saved in the volatile memory.
Name	Attribute name
Data type	Data type of the Attribute
Description	Attribute description
Default	Attribute default value

Table 6: Definition of terms

9.1 Object 0x23 (Instance 1), Position Sensor

The `Position sensor object` contains all measurement-system-specific attributes. The attributes are accessed via the Configuration Assembly or via the IO Assembly, see Chapter 6 on Page 40 or Chapter 7 on Page 42.
Currently only the mandatory `Attribute 0x0C` for switching the counting direction `DirectionCounting Toggle` is provided for the write access (`Set_Attribute Service`) across the network.

The attribute is permanently (NV) saved with the write access to a writable attribute.

Attr. ID	Access	Name	Data type	Description	Default	Page
0x01	Get	Number of Attributes	USINT	Number of all supported attributes	Depending on the measuring system	55
NON-safety-related attributes						
–	Get	Position Value Unsigned	UDINT	Current unsigned position value	–	55
0x0B	Get	Position Sensor Type	UINT	Defines the device type	0x00 02: Multi-turn absolute encoder	55
0x0C	Set	Direction Counting Toggle	BOOL	Counting direction of the position value (profile parameter)	0: Counting direction increasing	55
–	Set	Preset Value	DINT	Preset value, 32 bit	0	56
–	Set	TR Grey – Preset Control	WORD	Adjustment function	0	56
–	Get	TR Grey – Encoder Status	WORD	Measuring system status (preset, position ...)	0	57
–	Get	TR Grey – Velocity	DINT	Current signed velocity	–	57
–	Set	TR Grey – Rotational Direction	BOOL	Counting direction of the position value (TR parameter)	1: Counting direction increasing	58
–	Set	TR Grey – Measuring Range	UDINT	Total measuring range in steps	536870912	59
–	Set	TR Grey – Revolutions Numerator	UDINT	Number of numerator revolutions	65536	59
–	Set	TR Grey – Revolutions Denominator	UDINT	Number of denominator revolutions	1	59
–	Get	TR Grey – Revolutions	UDINT	For internal use only	–	–
–	Get	TR Grey – Resolution	UDINT	For internal use only	–	–
–	Get	TR Grey – Sensor Null Offset	UDINT	For internal use only	–	–

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Attr. ID	Access	Name	Data type	Description	Default	Page
–	Set	TR Grey – Velocity Format	USINT	Velocity format	1: RPM	62
–	Set	TR Grey – Velocity Factor	UINT	Velocity factor	1	62
–	Set	TR Grey – Velocity Integration Time	UINT	Velocity integration time	100 ms	63
–	Set	TR Grey – Channel coupled	BOOL	Linked channel	0: off	63
–	Set	TR Grey – Position substitution	BOOL	Substitute position	0: off	64
–	Set	TR Grey – Velocity Filter Intensity	USINT	Velocity filter strength	0	64
–	Set	TR Grey – Velocity Filter Type	BOOL	Velocity filter type	0: static	64
Safety-related attributes						
–	Set	TR Safety – Rotational Direction	BOOL	Counting direction of the position value	1: Counting direction increasing	65
–	Set	TR Safety – Measuring Range	UDINT	Total measuring range in steps	536870912	66
–	Set	TR Safety – Revolutions Numerator	UDINT	Number of numerator revolutions	65536	66
–	Set	TR Safety – Revolutions Denominator	UDINT	Number of denominator revolutions	1	66
–	Set	TR Safety – Velocity Format	USINT	Velocity format	1: RPM	69
–	Set	TR Safety – Velocity Factor	UINT	Velocity factor	1	69
–	Set	TR Safety – Velocity Integration Time	UINT	Velocity integration time	100 ms	70
–	Set	TR Safety – Velocity Filter Intensity	USINT	Velocity filter strength	0	70
–	Set	TR Safety – Velocity Filter Type	BOOL	Velocity filter type	0: static	71
–	Set	TR Safety – Window Increments	UINT	Window Increments	1000 increments	71

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Attr. ID	Access	Name	Data type	Description	Default	Page
–	Set	TR Safety – SIL / PL	UINT	SIL / PL Level	2: SIL 2	71
–	Get	TR Safety – Position	UDINT	Current unsigned position value	–	72
–	Get	TR Safety – Velocity	DINT	Current signed velocity	–	72
–	Get	TR Safety – Status	UINT	Measuring system status (preset, position ...)	0	72
–	Set	TR Safety – Controlword	UINT	Adjustment function	0	72
–	Set	TR Safety – Presetout	UDINT	Preset value, 32 bit	0	73

Table 7: Overview of measuring system parameters

9.1.1 Attribute 1, Number of Attributes

`Number of Attributes` returns the number of supported `Position Sensor Object` attributes.

Link path, `Packed EPATH` with 8-bit class

0x20	0x23	0x24	0x01	0x30	0x01
Logical Type = Class	Class #35	Logical Type = Instance	Instance #1	Logical Type = Attribute ID	Attribute ID #1

9.1.2 Position Value Unsigned

The current, non-safety-related, ***scaled*** absolute actual position of the measuring system is output as an unsigned 32-bit binary value via the Attribute `Position Value Unsigned`.

UDINT, read only

Byte	0	1	2	3
Bit	7-0	15-8	23-16	31-24
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

9.1.3 Attribute 11, Position Sensor Type

`Position Sensor Type` returns the device type:

UINT, read only

Value	Definition
02	Absolute multi-turn encoder

Link path, `Packed EPATH` with 8-bit class

0x20	0x23	0x24	0x01	0x30	0x0B
Logical Type = Class	Class #35	Logical Type = Instance	Instance #1	Logical Type = Attribute ID	Attribute ID #11

9.1.4 Attribute12, Direction Counting Toggle

⚠ WARNING

NOTICE

Danger of death, severe personal injury and/or material damage due to a jump in the absolute value when changing the counting direction function!

- The internal calculation algorithm results in different absolute positions for the counting direction settings `ascending` and `descending`. Verify the correct function by a test run in safe mode after changing the counting direction. Under certain circumstances, the output position must be adjusted via the preset function.

BYTE, BOOL

Value	Description	Default
0	Measuring system – position ascending clockwise (looking at shaft, flange connection)	**X**
1	Measuring system – position descending clockwise (looking at shaft, flange connection)	

Link path, `Packed EPATH` with 8-bit class

0x20	0x23	0x24	0x01	0x30	0x0C
Logical Type = Class	Class #35	Logical Type = Instance	Instance #1	Logical Type = Attribute ID	Attribute ID #12

9.1.5 Preset Value

The Attribute `Preset Value` contains the adjustment value, which is set as the new position value if the adjustment function is triggered via the Attribute `TR Grey – Preset Control`. The attribute is integrated into the cyclic data traffic via the IO Assembly `Instance 102, Grey Output Channel 1 (adjustment function)`,
see Chapter 7.3 on Page 45.

DINT, Default: 0

Byte	0	1	2	3
Bit	7-0	15-8	23-16	31-24
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

9.1.6 TR Grey – Preset Control

The Attribute `TR Grey – Preset Control` (control word) contains the control bit for the adjustment function and is integrated into the cyclic data traffic via the IO Assembly `Instance 102, Grey Output Channel 1 (adjustment function)`,
see Chapter 7.3 on Page 45.

WORD

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

9.1.7 TR Grey – Encoder Status

The Attribute `TR Grey – Encoder Status` (status word) contains the measuring system-related status bits and is integrated into the cyclic data traffic via the IO Assembly `Instance 101, TR Grey Input`, see Chapter 7.2 from Page 43.

WORD

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

Bit	Function
0	Adjustment execution – positive feedback 0: Normal operation, no error 1: Adjustment was carried out For the execution of the adjustment function, see Chapter 7.3 on Page 45.
1	Output of the original position 0: Position incorrect, channel in error status 1: Output of the original position
2	Output of the substitute position 0: no substitute position output 1: Output of the substitute position The substitute position (`Position substitution` = `On`) must be set accordingly, see Chapter 9.1.15, Page 64.
3-6	unused
7	Adjustment execution – Negative feedback 1: Adjustment was not carried out For the execution of the adjustment function, see Chapter 7.3 on Page 45.
8-15	unused

9.1.8 TR Grey – Velocity

The current ***scaled*** non-safety-related velocity of the measuring system is output as a signed 32-bit two's complement value via the Attribute `TR Grey – Velocity`. Default setting: `RPM`, see Parameters `TR Grey – Velocity Format` on Page 62.

DINT, read only

Byte	0	1	2	3
Bit	7-0	15-8	23-16	31-24
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

9.1.9 TR Grey – Rotational Direction

⚠ WARNING

NOTICE

Danger of death, severe personal injury and/or material damage due to a jump in the absolute value when changing the counting direction function!

- The internal calculation algorithm results in different absolute positions for the counting direction settings `ascending` and `descending`. Verify the correct function by a test run in safe mode after changing the counting direction. Under certain circumstances, the output position must be adjusted via the preset function.

BYTE, BOOL

Value	Description	Default
0	Measuring system – position descending clockwise (looking at shaft, flange connection)	
1	Measuring system – position ascending clockwise (looking at shaft, flange connection)	**X**

9.1.10 TR Grey – Scaling parameter

⚠ WARNING

NOTICE

Risk of physical injury and material damage due to shifting of the zero point when the measuring system is switched on again after positioning in de-energized state!

The zero point of the multiturn measuring system may be lost if more than 32767 revolutions are executed in de-energized state!

- Make sure that positioning operations in de-energized state take place within 32767 revolutions on a multiturn measuring system.
- If this cannot be ensured, the issued position must first be verified with the desired mechanical position before the application can be started.

The physical resolution of the measuring system can be changed by using the scaling parameters

– TR Grey – Measuring Range
– TR Grey – Revolutions Numerator
– TR Grey – Revolutions Denominator

The measuring system supports the gear function for rotary axes.

This means that the ***number of steps per revolution*** and the quotient of `Revolutions numerator / Revolutions denominator` can be a decimal number.

The output actual position value is offset by a zero-point correction, the set counting direction and the entered gearbox parameter.

MEASURING RANGE

Defines the total number of steps of the measuring system, before the measuring system restarts at 0.

UDINT

Lower limit	2 steps
Upper limit	536 870 912 steps (30 bits)
Default	**536870912**

The actual upper limit value to be entered for the `measuring range` in steps depends on the measuring system design and can be calculated using the formula below. As the value "0" is already counted as a step, the end value = measuring range in steps – 1.

Measuring range = steps per revolution * number of revolutions

For the purposes of calculation, the parameters ***Steps/Revolution*** and ***Number of Revolutions*** can be taken from the measuring system nameplate.

REVOLUTIONS NUMERATOR / REVOLUTIONS DENOMINATOR

These two parameters together define the ***number of revolutions***, before the measuring system starts at 0 again.

As decimal numbers are not always finite (such as 3.4), but may have an infinite number of digits after the decimal point (such as 3.43535355358774...) the number of revolutions is entered as a fraction.

UDINT

Numerator lower limit	1
Numerator upper limit	256000
Numerator default	65536

UDINT

Denominator lower limit	1
Denominator upper limit	16384
Denominator default	**1**

Formula for gearbox calculation:

$$\text{Measuring range in steps} = \text{number of steps per revolution} * \frac{\text{Number of numerator revolutions}}{\text{Number of denominator revolutions}}$$

If it is not possible to enter parameter data in the permitted ranges of numerator and denominator, the attempt must be made to reduce these accordingly. If this is not possible, it may only be possible to represent the relevant decimal number approximately. The resulting minor inaccuracy accumulates for real round axis applications (infinite applications with motion in one direction).
A solution is e.g. to perform adjustment after each revolution or to adapt the mechanics or gear ratio accordingly.

The parameter **Number of steps per revolution** may also be a decimal number, however the `measuring range` may not. The result of the above formula must be rounded up or down. The resulting error is distributed over the total number of revolutions programmed and is therefore negligible.

Preferably for linear axes (forward and backward motion):

The parameter `Revolutions denominator` can be programmed as a fixed value of “1” for linear axes. The parameter `Revolutions numerator` is programmed slightly higher than the required number of revolutions. This ensures that the measuring system does not generate an actual value jump (zero transition) if the travel is slightly exceeded. For the sake of simplicity, the full revolution range of the measuring system can also be programmed.

The following example serves to illustrate the approach.

Given:

- Measuring system with 4096 steps/rev. and max. 4096 revolutions
- Resolution 1/100 mm

- Make sure that the measuring system is programmed in its full resolution and measuring range (4096x4096):
  Measuring range in steps = 16777216,
  Revolutions numerator = 4096
  Denominator revolutions = 1
  Set the mechanics to be measured to the left stop position
- Set measuring system to "0" by adjustment
- Set the mechanics to be measured to the end position
- Measure the mechanical distance covered in mm
- Read off the actual position of the measuring system on the connected control

Assumption:

- Distance covered = 2000 mm
- Measuring system actual position after 2000 mm = 607682 steps

Consequently:

Number of revolutions covered = 607682 steps / 4096 steps/rev.
= **148.3598633 revolutions**

Number of mm/revolution = 2000 mm/148.3598633 revs. = **13.48073499 mm/rev.**

For a resolution of 1/100 mm, this equates to **1348.073499 steps/revolution**

required programming:

Number of numerator revolutions = ***4096***
Number of denominator revolutions = ***1***

$$\text{Measuring range in steps} = \text{number of steps per revolution} * \frac{\text{Number of numerator revolutions}}{\text{Number of denominator revolutions}}$$

$$= 1348.073499 \text{ steps / rev.} * \frac{4096 \text{ numerator revolutions}}{1 \text{ denominator revolution}}$$

= ***5521709 steps*** *(rounded)*

9.1.11 TR Grey – Velocity Format

The Attribute indicates the resolution at which the velocity is calculated and output.

The velocity is output as a signed two's complement:

- Counting direction setting = ascending
  - Output positive, with clockwise rotation (looking at flange connection)

- Counting direction setting = descending
  - Output negative, with clockwise rotation (looking at flange connection)

The limit values (0x7FFF FFFF or 0x8000 0000) are output if the velocity value range (-2147483648…+2147483647) has been exceeded or not reached.

USINT

Value	Allocation	Description	Default
0	RPS * Factor	Output in [rev./second], multiplied by the factor set under the *TR Grey – Velocity Factor* parameter, see Page 62	
1	U/min * Factor	Output in [rev./min], multiplied by the factor set under the *TR Grey – Velocity Factor* parameter, see Page 62	X
2	Rev/hour * factor	Output in [rev./hour], multiplied by the factor set under the *TR Grey – Velocity Factor* parameter, see Page 62	
3	(Steps/integration time)	Output in [steps/ms], see Page 62 Resolution: scaled steps/rev.	

9.1.12 TR Grey – Velocity Factor

The Attribute specifies the factor value for the parameter `TR Grey – Velocity Format`, see Page 62.

UINT

Lower limit	1
Upper limit	1000
Default	**1**

9.1.13 TR Grey – Velocity Integration Time

The Attribute specifies the integration time in [ms] for the parameter `TR Grey – Velocity Format`, see Page 62.

The parameter serves to calculate the velocity, which is output via the cyclic process data. The velocity is specified in steps/integration time. Long integration times allow high-resolution measurements at low speeds. Low integration times show velocity changes more quickly and are suitable for high velocities and high dynamics.

UINT

Lower limit	1 ms
Upper limit	1000 ms
Default	**100 ms**

Example

Given:
- Programmed resolution = 8192 steps per revolution
- Speed = 4800 revolutions per minute
- Integration time t_i = 50 ms = 0.05 s

Determine:
- Output value in steps/integration time

$$\text{Number of steps / s} = \frac{8192 \text{ steps} * 4800 \text{ ~~rev.~~}}{\text{~~Rev.~~} * 60 \text{ s}} = \frac{655360 \text{ steps}}{1 \text{ s}}$$

$$\text{Number of steps/t} = \frac{655360 \text{ steps}}{1 \text{ s}} * 0.05 \text{ s} = 32768 \text{ steps}$$

Steps/integration time = <u>32768 steps / 50 ms</u>

9.1.14 TR Grey – Channel coupled

BYTE, BOOL

Value	Allocation	Description	Default
0	Off	Function switched off	X
1	On	Use the setting `Channel coupled` = `on` to specify whether the non-safety-related channel `TR Grey` should be linked to the safety-related `TR Safety` channel. The position and velocity settings are used by the safety-related channel `TR Safety` and the current settings in the channel `TR Grey` are ignored. The preset function can only be performed in the safety-related `TR Safety` channel, but the preset function in the non-safety-related `TR Grey` channel is disabled.	

9.1.15 TR Grey – Position substitution

BYTE, BOOL

Value	Allocation	Description	Default
0	Off	Function switched off	X
1	On	Output of the substitute position if the position channel is in the error status, see also Attribute `TR Grey – Encoder Status` on Page 57.	

9.1.16 TR Grey – Velocity Filter Intensity

Use the Attribute `TR Grey – Velocity Filter Intensity` to average the output velocity. The strength of averaging can be specified. You can also select whether the filtering should be switched off dynamically during the acceleration phases, see the Attribute `TR Grey – Velocity Filter Type` described below. Thus the velocity signal can quickly follow the actual course in the event of changes and is stable in the stationary range.

USINT

Lower limit	0
Upper limit	10
Default	**0**

0: no filtering

1: weak filtering, high cutoff frequency

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10: strong filtering, low cutoff frequency

9.1.17 TR Grey – Velocity Filter Type

See also Attribute `TR Grey – Velocity Filter Intensity` on Page 64.

BYTE, BOOL

Value	Allocation	Description	Default
0	static	The low-pass filter characteristic acts on the actual value velocity output, regardless of the current movement or acceleration status of the drive.	X
1	dynamic	The low-pass filter characteristic is deactivated as soon as the measuring system detects a significant change in the acceleration of the velocity signal. The low-pass filter is reactivated as soon as the measuring system detects a uniform movement.	

9.1.18 TR Safety – Rotational Direction

⚠ WARNING

NOTICE

Danger of death, severe personal injury and/or material damage due to a jump in the absolute value when changing the counting direction function!

- The internal calculation algorithm results in different absolute positions for the counting direction settings `ascending` and `descending`. Verify the correct function by a test run in safe mode after changing the counting direction. Under certain circumstances, the output position must be adjusted via the preset function.

BYTE, BOOL

Value	Description	Default
0	Measuring system – position descending clockwise (looking at shaft, flange connection)	
1	Measuring system – position ascending clockwise (looking at shaft, flange connection)	**X**

9.1.19 TR Safety – Scaling parameter

WARNING

NOTICE

Risk of physical injury and material damage due to shifting of the zero point when the measuring system is switched on again after positioning in de-energized state!

If the scaling parameter settings listed below deviate from the default settings, the zero point of the multi-turn measuring system may be lost if more than the permissible revolutions are performed in the de-energized state!

- SIL2 – measuring system: Make sure that positioning operations in de-energized state take place within 3200 revolutions on a multiturn measuring system.
- SIL3 – measuring system: Make sure that positioning operations in de-energized state take place within 320 revolutions on a multiturn measuring system.
- If this cannot be ensured, the issued position must first be verified with the desired mechanical position before the application can be started. Too high revolutions are indicated by the cyclic process input data in `TR Safety – Status`, Bit 7 `Scaling Error` = 1 when the measuring system is restarted in case the actual revolutions exceed the permissible revolutions. After positive verification, the `Scaling Error` bit can be cleared by executing the preset adjustment function, see Chapter 9.2 on Page 74.

The physical resolution of the measuring system can be changed by using the scaling parameters

– TR Safety – Measuring Range
– TR Safety – Revolutions Numerator
– TR Safety – Revolutions Denominator

The measuring system supports the gear function for rotary axes.

This means that the ***number of steps per revolution*** and the quotient of `Revolutions numerator / Revolutions denominator` can be a decimal number.

The output actual position value is offset by a zero-point correction, the set counting direction and the entered gearbox parameter.

MEASURING RANGE

Defines the total number of steps of the measuring system, before the measuring system restarts at 0.

UDINT

Lower limit	2 steps
Upper limit	536 870 912 steps (30 bits)
Default	**536870912**

The actual upper limit value to be entered for the `measuring range` in steps depends on the measuring system design and can be calculated using the formula below. As the value "0" is already counted as a step, the end value = measuring range in steps – 1.

Measuring range = steps per revolution * number of revolutions

For the purposes of calculation, the parameters ***Steps/Revolution*** and ***Number of Revolutions*** can be taken from the measuring system nameplate.

REVOLUTIONS NUMERATOR / REVOLUTIONS DENOMINATOR

These two parameters together define the ***number of revolutions***, before the measuring system starts at 0 again.

As decimal numbers are not always finite (such as 3.4), but may have an infinite number of digits after the decimal point (such as 3.43535355358774...) the number of revolutions is entered as a fraction.

UDINT

Numerator lower limit	1
Numerator upper limit	256000
Numerator default	65536

UDINT

Denominator lower limit	1
Denominator upper limit	16384
Denominator default	**1**

Formula for gearbox calculation:

$$\text{Measuring range in steps} = \text{number of steps per revolution} * \frac{\text{Number of numerator revolutions}}{\text{Number of denominator revolutions}}$$

If it is not possible to enter parameter data in the permitted ranges of numerator and denominator, the attempt must be made to reduce these accordingly. If this is not possible, it may only be possible to represent the relevant decimal number approximately. The resulting minor inaccuracy accumulates for real round axis applications (infinite applications with motion in one direction).
A solution is e.g. to perform adjustment after each revolution or to adapt the mechanics or gear ratio accordingly.

The parameter **Number of steps per revolution** may also be a decimal number, however the `measuring range` may not. The result of the above formula must be rounded up or down. The resulting error is distributed over the total number of revolutions programmed and is therefore negligible.

Preferably for linear axes (forward and backward motion):

The parameter `Revolutions denominator` can be programmed as a fixed value of “1” for linear axes. The parameter `Revolutions numerator` is programmed slightly higher than the required number of revolutions. This ensures that the measuring system does not generate an actual value jump (zero transition) if the travel is slightly exceeded. For the sake of simplicity, the full revolution range of the measuring system can also be programmed.

The following example serves to illustrate the approach.

Given:

- Measuring system with 4096 steps/rev. and max. 4096 revolutions
- Resolution 1/100 mm

- Make sure that the measuring system is programmed in its full resolution and measuring range (4096x4096):
  Measuring range in steps = 16777216,
  Revolutions numerator = 4096
  Denominator revolutions = 1
  Set the mechanics to be measured to the left stop position
- Set measuring system to "0" by adjustment
- Set the mechanics to be measured to the end position
- Measure the mechanical distance covered in mm
- Read off the actual position of the measuring system on the connected control

Assumption:

- Distance covered = 2000 mm
- Measuring system actual position after 2000 mm = 607682 steps

Consequently:

Number of revolutions covered = 607682 steps / 4096 steps/rev.
= **148.3598633 revolutions**

Number of mm/revolution = 2000 mm/148.3598633 revs. = **13.48073499 mm/rev.**

For a resolution of 1/100 mm, this equates to **1348.073499 steps/revolution**

required programming:

Number of numerator revolutions = ***4096***
Number of denominator revolutions = ***1***

$$\text{Measuring range in steps} = \text{number of steps per revolution} * \frac{\text{Number of numerator revolutions}}{\text{Number of denominator revolutions}}$$

$$= 1348.073499 \text{ steps / rev.} * \frac{4096 \text{ numerator revolutions}}{1 \text{ denominator revolution}}$$

= ***5521709 steps*** *(rounded)*

9.1.20 TR Safety – Velocity Format

The Attribute indicates the resolution at which the velocity is calculated and output.

The velocity is output as a signed two's complement:

- Counting direction setting = ascending
  - Output positive, with clockwise rotation (looking at flange connection)

- Counting direction setting = descending
  - Output negative, with clockwise rotation (looking at flange connection)

The limit values (0x7FFF FFFF or 0x8000 0000) are output if the velocity value range (-2147483648…+2147483647) has been exceeded or not reached.

USINT

Value	Allocation	Description	Default
0	RPS * Factor	Output in [rev./second], multiplied by the factor set under the *TR Safety – Velocity Factor* parameter, see Page 69	
1	U/min * Factor	Output in [rev./min], multiplied by the factor set under the *TR Safety – Velocity Factor* parameter, see Page 69	X
2	Rev/hour * factor	Output in [rev./hour], multiplied by the factor set under the *TR Safety – Velocity Factor* parameter, see Page 69	
3	Steps/integration time	Output in [steps/ms], see Page 69 Resolution: scaled steps/rev.	

9.1.21 TR Safety – Velocity Factor

The Attribute specifies the factor value for the parameter `TR Safety – Velocity Format`, see Page 69.

UINT

Lower limit	1
Upper limit	1000
Default	**1**

9.1.22 TR Safety – Velocity Integration Time

The Attribute specifies the integration time in [ms] for the parameter `TR Safety – Velocity Format`, see Page 69.

The parameter serves to calculate the velocity, which is output via the cyclic process data. The velocity is specified in steps/integration time. Long integration times allow high-resolution measurements at low speeds. Low integration times show velocity changes more quickly and are suitable for high velocities and high dynamics.

UINT

Lower limit	1 ms
Upper limit	1000 ms
Default	**100 ms**

Example

Given:

- Programmed resolution = 8192 steps per revolution
- Speed = 4800 revolutions per minute
- Integration time t_i = 50 ms = 0.05 s

Determine:

- Output value in steps/integration time

$$\text{Number of steps / s} = \frac{8192 \text{ steps} * 4800 \text{ rev.}}{\text{Rev.} * 60 \text{ s}} = \frac{655360 \text{ steps}}{1 \text{ s}}$$

$$\text{Number of steps/t} = \frac{655360 \text{ steps}}{1 \text{ s}} * 0.05 \text{ s} = 32768 \text{ steps}$$

Steps/integration time = <u>32768 steps / 50 ms</u>

9.1.23 TR Safety – Velocity Filter Intensity

Use the Attribute `TR Safety – Velocity Filter Intensity` to average the output velocity. The strength of averaging can be specified. You can also select whether the filtering should be switched off dynamically during the acceleration phases, see the Attribute `TR Safety – Velocity Filter Type` described below. Thus the velocity signal can quickly follow the actual course in the event of changes and is stable in the stationary range.

USINT

Lower limit	0
Upper limit	10
Default	**0**

0: no filtering

1: weak filtering, high cutoff frequency

. . .

10: strong filtering, low cutoff frequency

9.1.24 TR Safety – Velocity Filter Type

See also Attribute `TR Safety – Velocity Filter Intensity` on Page 70.

BYTE, BOOL

Value	Allocation	Description	Default
0	static	The low-pass filter characteristic acts on the actual value velocity output, regardless of the current movement or acceleration status of the drive.	X
1	dynamic	The low-pass filter characteristic is deactivated as soon as the measuring system detects a significant change in the acceleration of the velocity signal. The low-pass filter is reactivated as soon as the measuring system detects a uniform movement.	

9.1.25 TR Safety – Window Increments

This Attribute 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.

UINT

Lower limit	50
Upper limit	4000
Default	**1000**

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

The position deviation in increments is always based on the non-scaled resolution of 13 bits = 8192 steps/revolution.

9.1.26 TR Safety – SIL / PL

The Attribute `TR Safety – SIL / PL` indicates the SIL the user expects from the respective safety-related device. It is compared with the manufacturer's fixed setting in the device. The measuring system supports the safety classes SIL2 to SIL3.

UINT

Value	Description	Default
2	Safety class SIL2	X
3	Safety class SIL3	

The user must carefully consider the effects of mixing different SIL level devices in the network.

9.1.27 TR Safety – Position

The current, ***scaled*** absolute actual position of the measuring system is output as an unsigned 32-bit binary value via the Attribute `TR Safety – Position`.

UDINT, read only

Byte	0	1	2	3
Bit	7-0	15-8	23-16	31-24
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

9.1.28 TR Safety – Velocity

The current ***scaled*** safety-related velocity of the measuring system is output as a signed 32-bit two's complement value via the Attribute `TR Safety – Velocity`. Default setting: `RPM`, see Attribute `TR Safety – Velocity Format` on Page 69.

DINT, read only

Byte	0	1	2	3
Bit	7-0	15-8	23-16	31-24
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

9.1.29 TR Safety – Status

The Attribute `TR Safety – Status` (status word) contains the status bits for the adjustment function, position output, etc. and is integrated into the cyclic data traffic via the IO assembly `Instance 121, Safety Input`, see Chapter 7.4 from Page 45.

UINT

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

9.1.30 TR Safety – Controlword

The safety-related preset adjustment function is triggered, and a new position value is sent to Instance 121, Member `TR Safety – Position` via the Attribute `TR Safety – Controlword`. The attribute is integrated into the cyclic data traffic via the IO Assembly `Instance 122, Safety Input`, see Chapter 7.5 from Page 48.

UINT

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

9.1.31 TR Safety – Presetout

The Attribute `TR Safety – Presetout` contains the adjustment value, which is set as the new position value if the Preset Adjustment function is triggered via the Attribute `TR Safety – Controlword`. The attribute is integrated into the cyclic data traffic via the IO Assembly `Instance 122, Safety Input`, see Chapter 7.5 from Page 48.

DINT, Default: 0

Byte	0	1	2	3
Bit	7-0	15-8	23-16	31-24
Data	$2^7 – 2^0$	$2^{15} – 2^8$	$2^{23} – 2^{16}$	$2^{31} – 2^{24}$

9.2 OPTION: Additional interface

Optionally, the measuring system can be equipped with a second interface in addition to the EtherNet/IP interface. The setting of the attributes can be done either directly via the EtherNet/IP network, or via the SNCT.

The standard EtherNet/IP services are used to access the parameters:
0x0E: `Get_Attribute_Single` returns the content of the corresponding attribute
0x10: `Set_Attribute_Single` modifies the content of the corresponding attribute
0x01: `Get_Attributes_All` returns the content of all attributes
0x02: `Set_Attributes_All` modifies the value of a list of attributes
0x0D: `Apply_Attributes` activates with "1" the modified attributes and saves them permanently

The attributes can be parameterized user-friendly via the GUI of the `TR SNCT Device Applet`:

Download program description:

- www.tr-electronic.de/f/TR-ECE-TI-DGB-0364

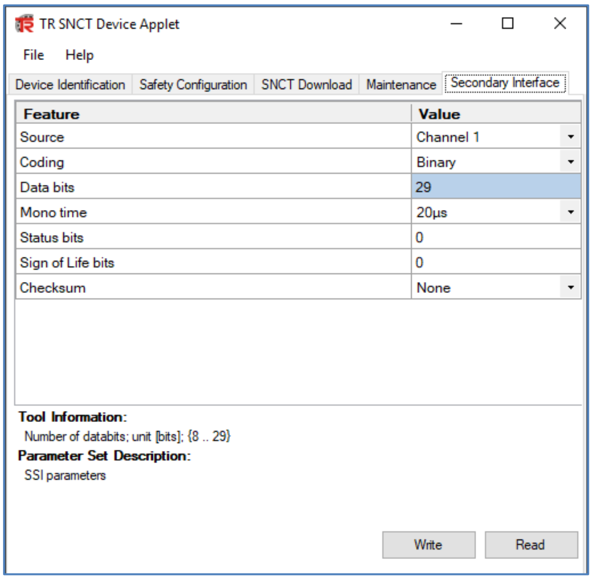
Download TR SNCT Device Applet:

- www.tr-electronic.de/f/zip/TR-ECE-SW-MUL-0016

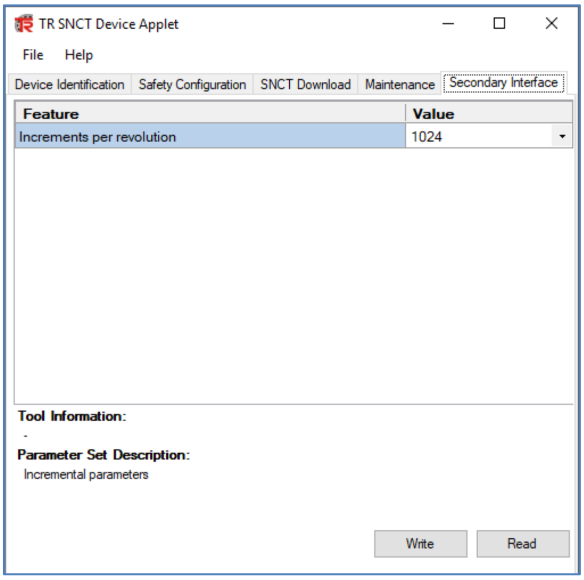
See the program description for program installation, system requirements, device connection and possible use cases.

Ensure that no controller is connected to the measuring system and that there is no EtherNet/IP™ communication during programming.
The following procedure assumes that the corresponding network interface and IP address of the measuring system have been set in the `TR SNCT Device Applet` and that there is communication.

Under the program tab `Device ID` you can use the `Identify` button to determine whether and which secondary interface is supported by the measuring system. If a secondary interface is supported by the measuring system, an additional program tab `Secondary Interface` is added to the program interface. This tab then contains a suitable table with the possible settings for each secondary interface:



Example of a SSI interface for the second interface



Example of an incremental interface for the second interface

9.2.1 Class 0x545247 - Instance 1, TR SSI Sensor

Optionally, the measuring system can be equipped with a synchronous serial absolute SSI interface in addition to the EtherNet/IP interface.

SSI Data transmission format:

MSB LSB

Position	Status	Sign of life	Checksum
max. 8…29 bits	max. 0…2 bits	max. 0…5 bits	max. 0…8 bits

Object 0x545247 and the following attributes are only available if the measuring system is equipped with an additional SSI interface.

Attr.-ID	Access	Name	Data type	Description	Default	Page
0x01	Set	Source	BOOL	Selection of the channel 0: Channel 1 1: Channel 2	0: Channel 1	76
0x02	Set	Coding	BYTE	SSI output code 0: Binary 1: Gray	0: Binary	76
0x03	Set	Data bits	BYTE	Number for SSI data bits (8…29) 0000 1000: 8 0000 1001: 9 . . . 0001 1101: 29	29 Data bits	76
0x04	Set	Mono time	BYTE	Selection of the SSI monoflop time t_M 0000 0000: 15 µsec 0000 0001: 20 µsec 0000 0010: 35 µsec 0000 0011: 50 µsec 0000 0100: 500 µsec	0x01: 20 µsec	76
0x05	Set	Status bits	BYTE	Number of the status bits 0000 0000: 0 0000 0001: 1 0000 0010: 2	0x00: 0	77
0x06	Set	Sign of Life bits	BYTE	Number of the sign of life bits 0000 0000: 0 0000 0001: 1 0000 0010: 2 0000 0011: 3 0000 0100: 4 0000 0101: 5	0x00: 0	77
0x07	Set	Checksum	BYTE	0000 0000: None 0000 0001: Parity even 0000 0010: Parity odd 0000 0011: CRC8	0x00: None	78

9.2.1.1 Attribute 1, Source

BYTE, BOOL

Selection	Value	Description	Default
Channel 1	0	SSI output: Actual position from the master system	X
Channel 2	1	SSI output: Actual position from the test system	

9.2.1.2 Attribute 2, Coding

BYTE

Selection	Value	Description	Default
Binary	0	SSI output binary coded	X
Gray	1	SSI output gray coded	

9.2.1.3 Attribute 3, Data bits

The attribute *`Data bits`* define the number of reserved bits for the output of the measuring system position. Special bits such as status bits, sign of Life bits or the checksum are not contained in it and will be output in this order after the data bits.

BYTE

Lower limit	8
Upper limit	29
Default	**29**

9.2.1.4 Attribute 4, Mono time

BYTE

Selection	Value	Description	Default
15 µsec	0	SSI monoflop time = 15 µs	
20 µsec	1	SSI monoflop time = 20 µs	X
35 µsec	2	SSI monoflop time = 35 µs	
50 µsec	3	SSI monoflop time = 50 µs	
500 µsec	4	SSI monoflop time = 500 µs	

9.2.1.5 Attribute 5, Status bits

The attribute `Status bits` define the number of reserved bits for the status output.

BYTE

Value	Description	Default
0	No output of status bits	X
1	Output of one status bit 0: No error 1: Error in the master system or test system; depending on the source	
2	Output of two status bits MSB bit = 0: No error MSB bit = 1: Error in the master system LSB bit = 0: No error LSB bit = 1: Error in the test system	

9.2.1.6 Attribute 6, Sign of Life bits

The attribute `Sign of Life bits` define the number of reserved bits for the sign of life output.

The sign of life counter is incremented in dependence of the scanning procedures and is inserted into the SSI telegram. The control of this incrementing event by the control guarantees that the newly transferred position value comes from a current scanning procedure.

BYTE

Value	Description	Default
0	no output of sign of life bits	X
1	1 bit sign of life (toggle bit)	
2	2 bit sign of life	
3	3 bit sign of life	
4	4 bit sign of life	
5	5 bit sign of life	

9.2.1.7 Attribute 7, Checksum

In general, the checksum is calculated via all user data (position, status and sign of life) in the SSI telegram and is always inserted into the SSI telegram at the last position (LSB).

An incorrect CRC checksum is not a reference to a measuring system error, but to a communication problem. A cause for it can be an EMC interference signal. Communication problems at SSI interfaces can also occur by too long cable lengths or to high SSI sampling rates.

BYTE

Selection	Value	Description	Default
None	0	no output of a checksum	X
Parity even	1	The parity represents the checksum of the bits in the SSI data word. If the SSI data word contains an odd number of "1", this bit = "1" and supplements the checksum to even parity.	
Parity odd	2	The parity represents the checksum of the bits in the SSI data word. If the SSI data word contains an even number of "1", this bit = "1" and supplements the checksum to odd parity.	
CRC8	3	8 bit CRC checksum Polynomial: $X^8 + X^5 + X^4 + 1$ (Maxim/Dallas) Start value: 0xFF Min. Hamming distance: 4	

9.2.2 Class 0x545248 - Instance 1, TR Incremental Sensor

Optionally, the measuring system can be equipped with an incremental interface in addition to the EtherNet/IP interface.

Object 0x545248 or the following attribute is only available if the measuring system is equipped with an additional incremental interface.

9.2.2.1 Attribute 1, Pulses/Rev.

BYTE

Selection	Value	Description	Default
1024	0	The number of pulses is set to 1024	X
2048	1	The number of pulses is set to 2048	
3072	2	The number of pulses is set to 3072	
4096	3	The number of pulses is set to 4096	
5120	4	The number of pulses is set to 5120	

10 TR Safety – Preset Adjustment Function

WARNING

NOTICE

Risk of death, serious physical injury and/or damage to property if the drive system starts uncontrolled while executing the Preset Adjustment function!

- The relevant drive systems must be locked to prevent automatic start-up
- Use the Originator to protect the preset adjustment function from being triggered by taking additional safety measures, such as key-operated switches, passwords, etc.
- You must follow the operational sequence described below and the Originator must evaluate the status bits to verify whether the preset adjustment function has been executed successfully or unsuccessfully
- Ensure the settings are made for the correct axis
- Verify the new position on the relevant axis after executing the preset function

The preset adjustment function is used to set the currently output actual position value to any actual position value within the scaled measuring range. This allows setting the displayed position to a machine reference position electronically.

10.1 Procedure

- Requirement: The measuring system is in Cyclical Data Exchange mode.
- Set the `Preset` register in the source data of the safety-related submodule to the desired preset value.
- Set the control bits `Preset Preparation` and `Preset Request` to 0.
- Set the `Preset Preparation` control bit to 1. In response, the `Safe State` status bit is set to 0, whereupon the Originator must transfer the system to the safe state. The output actual position value is no longer safe!
- A rising edge of the `Preset Request` control bit applies the preset value. Receipt of the preset value is acknowledged by setting (= 1) the `Preset Active` status bit. Once execution of the preset function has been completed, the `Preset Active` 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 actual position value. If no, 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, thus signaling to the Originator that execution of the preset adjustment function has been completed.
- Reset the `Preset Request` control bit to 0.
- Reset the `Preset Preparation` control bit to 0. In response, the `Safe State` status bit is set to 1 again.
- Finally, the Originator must verify that the new position corresponds to the new target position.

10.2 Timing – Diagram

Blue area: Output signals Originator -> Measuring system
Orange area: Input signals measuring system -> Originator

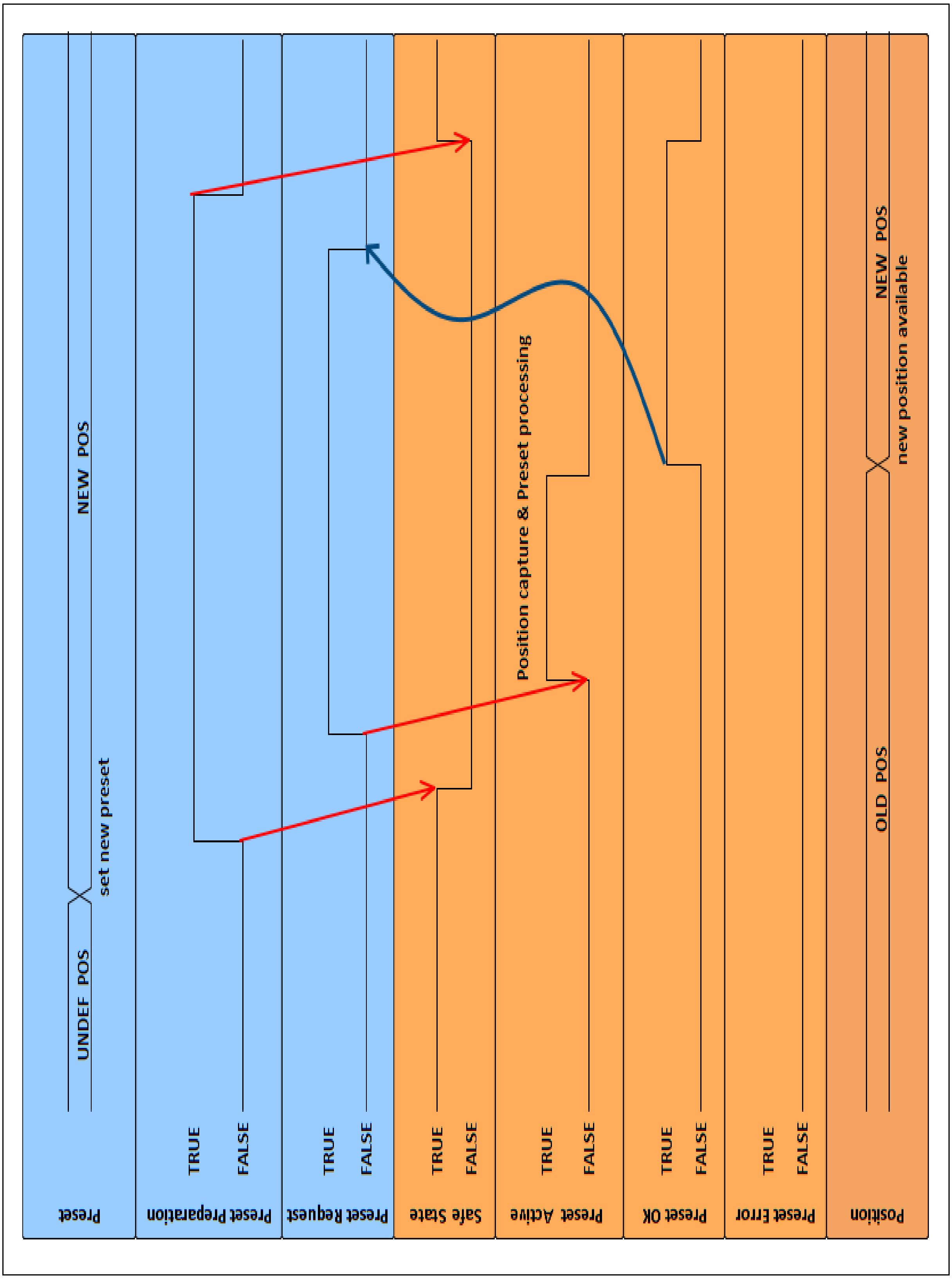


Figure 10: Preset Timing Diagram

10.3 Calculating the delay for a moving axis

If the preset adjustment function is executed while the axis is in motion, processing and run-times in the control system and the speed of the measuring system play a major role for the delay between preset execution and actually setting the value. The faster the axis moves, the greater the delay, measured in revolutions.
The delay can also be expressed in steps when using the programmed `Number of steps per revolution`.

The following example explains these facts in more detail.

Given:

- Programmed resolution = 8192 steps per revolution
- Speed: n = 3000 revolutions per minute
- Processing time in the controller: $t_{Control}$ = 100 ms (application-specific)
- Transmission time via EtherNet/IP™ network: $t_{EtherNet/IP}$ = 10 ms (application specific)
- Processing time in the measuring system: $t_{measuring\ system} \leq 10$ ms

Wanted:

- Delay in revolutions and steps

The static delay time t_{static} [ms] is a result of adding the processing times and the EtherNet/IP™ transmission time:

$$t_{static} = t_{Controller} + t_{EtherNet/IP} + t_{Measuring\ system} = 100\ \text{ms} + 10\ \text{ms} + 10\ \text{ms} = \underline{\mathbf{120\ ms}}$$

The dynamic delay in revolutions $V_{dynamic}$ results from the static delay time multiplied by the speed:

$$V_{dynamic} = t_{static} * n \quad = \frac{0.120\ \cancel{\text{s}} * 3000\ \text{rev.}}{60\ \cancel{\text{s}}} = \underline{\mathbf{6\ rev.}}$$

The steps taken result from:

$$V_{dynamic} * \text{Resolution} \quad = \frac{6\ \cancel{\text{Rev.}} * 8192\ \text{steps}}{\cancel{\text{Rev.}}} = \underline{\mathbf{49152\ steps}}$$

11 Obtain IP parameters via Flash or DHCP

The `TCP/IP Interface Object` is used to configure the TCP/IP network interface; it contains, among other things, device IP address, network mask, and gateway address. The settings are made via the Object `0xF5`, `Instance 1`, and the Attributes 3 `Configuration Control` and 5 `Interface Configuration`. The attributes are generally controlled via a DHCP server program, see 85.

11.1 Object 0xF5, Instance 1

Attr. ID	Access	Name	Data type	Description	Default	Page
3	Set/Get	Configuration Control	DWORD	Interfaces Control flags set the configuration options.	0x0000 0002 The device obtains the IP parameters via DHCP if the hardware switch = 0x00	82
5	Set/Get	Interface Configuration	STRUCT of:	Configuration of the TCP/IP network interface.		83
		IP Address	UDINT	configures the device IP address	FLASH content	83
		Network Mask	UDINT	configures the device subnet mask	FLASH content	83
		Gateway Address	UDINT	configures the device gateway address	FLASH content	83
		Name Server	UDINT	not implemented	0x0000 0000	–
		Name Server	UDINT	not implemented	0x0000 0000	–
		Domain Name	STRING	configures the domain name	0	83
6	Set/Get	Host Name	STRING	configures the Host name	0	–

Table 8: TCP/IP interface object 0xF5, Instance 1, Attributes 3 and 5

11.1.1 Attribute 3, Configuration Control

The `Configuration Control` attribute is bit-coded and defines how the IP parameters are assigned to the measuring system during the start-up phase, see also "Obtaining IP Parameters" on Page 83.

Bit	Function	Description
0-3	Startup Configuration	**Switch position 0x00** Value = 0: A FLASH provides the IP parameters to the measuring system. Value = 2: A DHCP provides the IP parameters to the measuring system. Attribute 3 is not evaluated if the switch positions are different; hardware switch specifications apply.
4	DNS Enable	0 (FALSE): is not supported
5-31	Reserved	0

11.1.2 Attribute 5, Interface Configuration

The `Interface Configuration` attribute contains the configuration parameters (IP parameters) required to operate the measuring system as a TCP/IP node. IP parameters cannot be set individually to avoid incomplete or incompatible configurations. Perform changes as follows: read the Get service with the `Interface Configuration Attribute`, change the desired parameters, and then write the parameters with the Set service.

Name	Description
IP address	Sets the IP address, e.g. 0x0501A8C0 for 192.168.1.5
Network mask	Set the subnet mask
Gateway address	Sets the IP address for the default gateway
Name server	0, is not supported
Name server 2	0, is not supported
Domain name	Sets the domain name, max. 48 characters

11.1.2.1 Obtaining IP Parameters

During the start-up phase of the measuring system, the saved configuration is read from “Attribute 5, Interface Configuration” (Page 83), the saved value is read from “Attribute 3, Configuration Control” (Page 82) and the hardware switch value is read from (Page 29) and evaluated as follows:

Config. Control	Hardware switch	Action	Description
0x00	0x00	FLASH active	A FLASH provides the configuration.
not relevant	0x01 … 0xFE	Switch active	IP Address: 192.168.1.<Switch position> Subnet mask: 255.255.255.0 Default Gateway: 192.168.1.254
not relevant	0xFF	DHCP request	The configuration is obtained from a DHCP server. DHCP requests are sent until a response is received.
0x02	0x00		
other	–	none	Inadmissible! The request is responded to with error code 0x20.

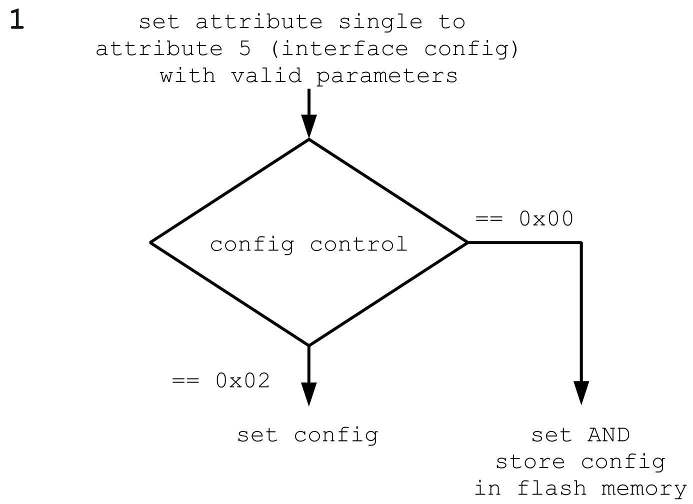
11.1.2.2 Setting and saving IP parameters

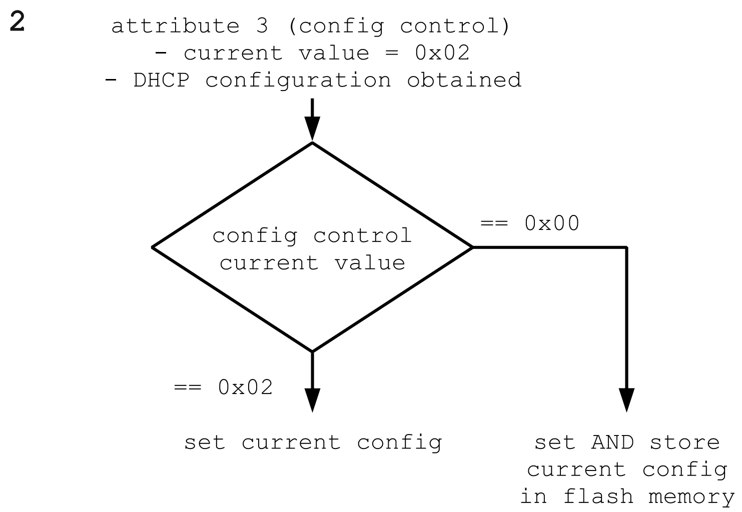
The IP parameters can be set or saved via the `TCP/IP Interface Object`, Class code 0xF5, in two ways:

1. A `Set_Attribute_Single` service on Attribute 5 `Interface Configuration` causes the values transferred as parameters to be set. The configuration is also permanently stored in the FLASH if the value of Attribute 3 `Configuration Control` = 0x00 during executing of the action.

2. The current configuration is permanently saved in the FLASH if the measuring system has received a configuration via DHCP, the current value of Attribute 3 Configuration Control = 0x02, and the Configuration Control value is set to 0x00.

Flowcharts





11.2 Example, obtaining IP parameters via DHCP server

11.2.1 Requirements

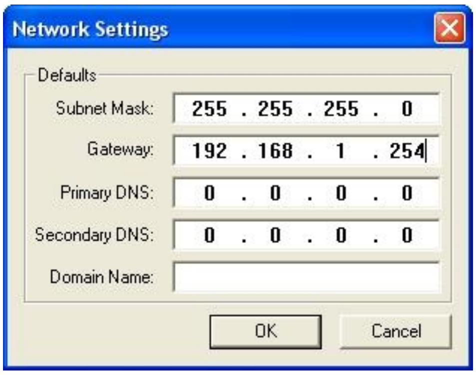
- An appropriate software is required for the DHCP server, which can be obtained free of charge from Rockwell Automation:
  - – Program: BootP DHCP EtherNet/IP™ Tool
  - – Download: Rockwell Automation - Compatibility & Downloads
  - – The tool is part of the control software if the Rockwell control system "Logix" is used.
- The program can be installed on a PC running under a WINDOWS® operating system. The PC acting as DHCP server must be in the same network as the measuring system to be parameterized.

11.2.2 Procedure

1. Connect the measuring system with the DHCP server
   - ➢ Ensure the measuring system functions as a DHCP client:
     - – Hardware switch = 0x00; 0xFF if `Configuration Control` state = unknown
     - – Instance Attribute 3 `Configuration Control` = 0x0000 0002
       -> matches the as-delivered status!

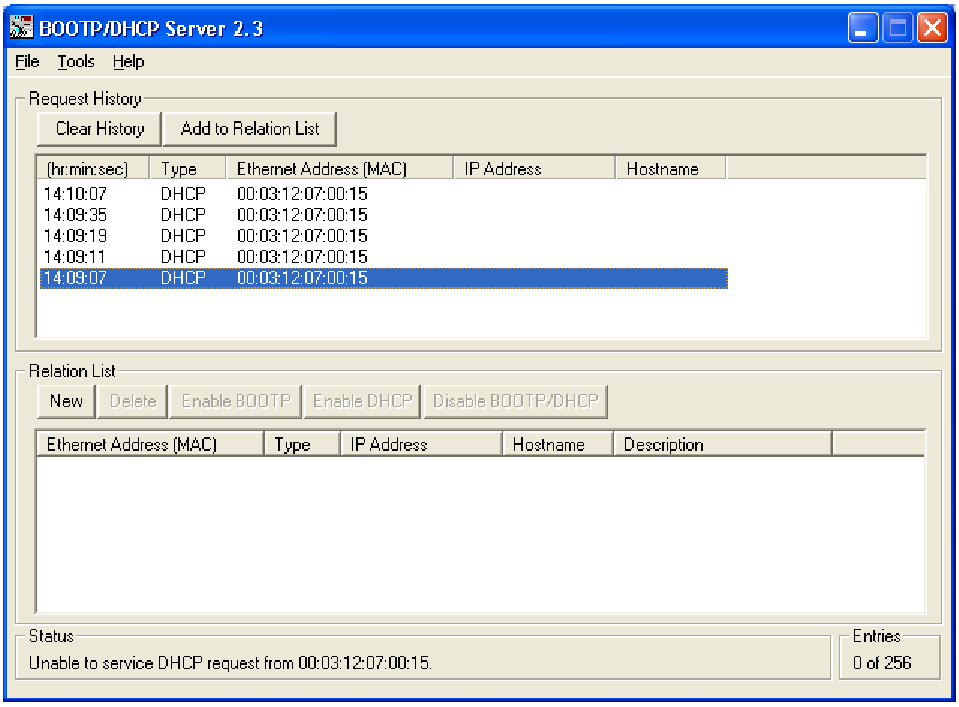
2. Start BOOTP/DHCP Server Utility

3. Make the following entries in the `Tools` -> `Network Settings` menu:
   - ➢ `Subnet mask`: desired subnet mask
   - ➢ `Gateway`: desired Default Gateway IP address
   - ➢ `Primary DNS`, `Secondary DNS`, and `Domain name`: are not supported



4. Switch on the supply voltage

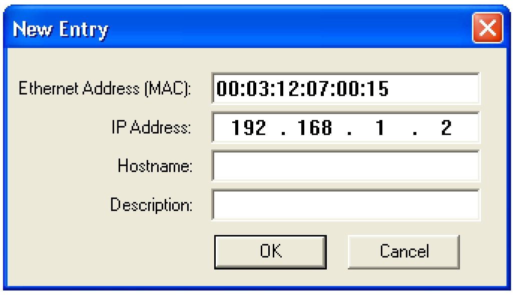
– The measuring system starts cyclical DHCP requests, which are entered into the `Request History`:



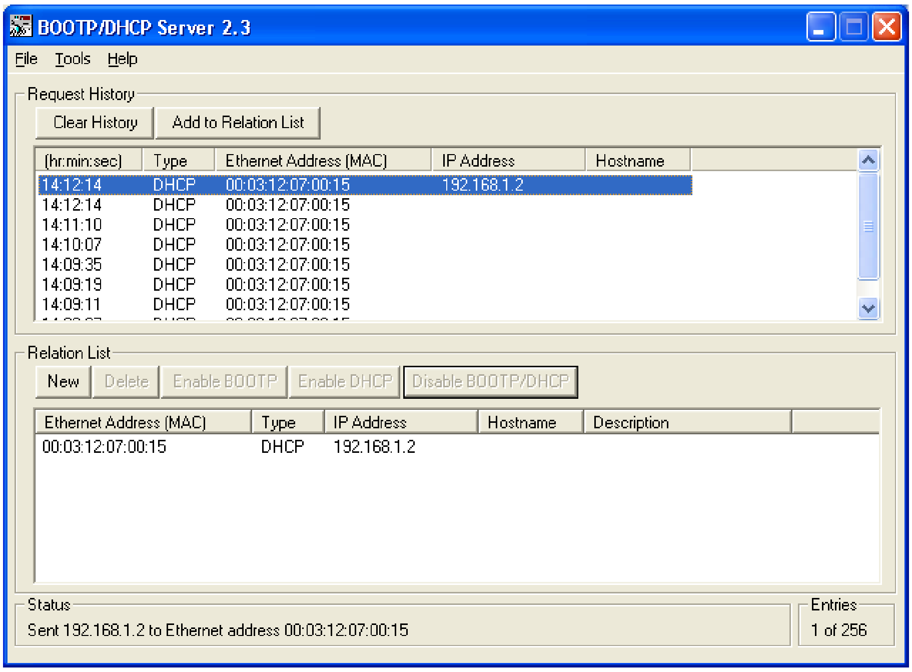
5. Double click on one of the entries:

– The New `Entry Dialog` box allows the following entries to be made:

- `Ethernet Address (MAC)`: is automatically applied!
- `IP address`: desired IP address
- `Hostname`: is not supported
- `Description`: description is optional



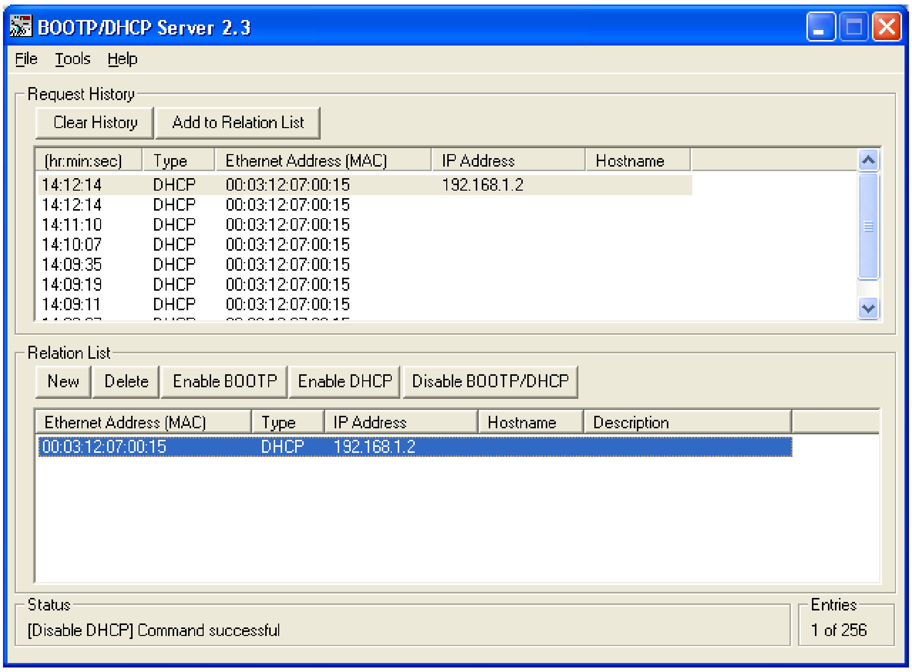
The new entry is displayed in the `Relation List` and the specified IP parameters are assigned to the measuring system with the next DHCP request. The result of this assignment is written to the `Request History`:



6. Use the `Disable BOOTP/DHCP` button to save the IP parameters to the FLASH.

– The successful execution is confirmed with the status report (Disable DHCP) `Command successful`, which completes the configuration.

– `Disable BOOTP/DHCP` sets the Instance Attribute 3 `Configuration Control` to 0x0000 0000
-> the measuring system does not send any more DHCP requests after POWER ON if the hardware switch = 0x00.



12 Error causes and remedies

12.1 Optical displays

For the assignment of LEDs, see Chapter “Bus status display”, Page 34.

12.1.1 Module status, bicolor LED

green	Cause	Solution
OFF	Voltage supply absent or too low	- Check power supply, wiring - Is the voltage supply in the permissible range?
	Connector incorrectly wired or screwed down	Check wiring and connector position
	Hardware error, measuring system defective	Replace measuring system
ON	- Device status: `EXECUTING` - The measuring system is fully configured - The measuring system is ready for operation, no error	–
1 Hz	- Device status: `IDLE` - Self-test completed successfully - valid configuration available	–
red	**Cause**	**Solution**
ON	- Device status: `CRITICAL FAULT`; CIP Safety – Stack is stopped and causes a connection timeout - Unrecoverable error occurred, passivated data cannot be output	Power supply OFF/ON. If the error persists after this measure, the measuring system must be replaced
1 Hz	- Device status: `ABORT` - A recoverable error has occurred. -> CIP Safety™ channel in error state, passivated data are output	Try to execute a `Safety Reset Service` 0x54 (Type 0) on Object 0x39 `Safety Supervisor` to put the measurement system in the `IDLE` state.
red/green	**Cause**	**Solution**
1 Hz	- Device status: `SELF-TESTING` - The measuring system is still self-testing after the supply is ON	Read out the device status of the `Safety Supervisor Object` 0x39, Attribute 11 = 1. The self-test takes ca. < 10 s.
	- Device status: `SELF-TEST EXCEPTION` - Self-test was not successful	Read out the device status of the `Safety Supervisor Object` 0x39, Attribute 11 = 3. Try to execute a `Safety Reset Service` 0x54 (Type 0) on Object 0x39 `Safety Supervisor`. Switch the supply OFF/ON and restart the measuring system if the above measure was unsuccessful.
	- Device status: `WAITING FOR TUNID` - Measuring system needs a `TUNID` assignment	Read out the device status of the `Safety Supervisor Object` 0x39, Attribute 11 = 8. See Chapter “Defining the Target Unique Network Identifier (TUNID)” on Page 29.
	- Device status: `CONFIGURING` - Measurement system must be configured	Read out the device status of the `Safety Supervisor Object` 0x39, Attribute 11 = 7. See Chapter „Downloading the safety-related configuration” on Page 36.

12.1.2 Network Status, Bicolor LED

green	Cause	Solution
OFF	Measuring system is offline, IP address was not assigned	See Chapter "Setting the Node ID or IP address" on Page 29.
	Voltage supply absent or too low	See measures under `Module Status`
ON	Measuring system online, CIP connection was established	Measuring system is ready for operation, normal operating state
1 Hz	Measuring system is online, CIP connection not established, IP address was assigned.	- Try to read out the status of the `Identity Object` 0x01 to isolate the error. - The controller was unable to establish a connection due to incorrect IP parameters. Coordinate IP address, subnet mask, and default gateway settings between the controller and the measuring system. - Incorrect connection parameters prevented the controller from establishing a connection, see Chapter "Connection Types – Connection Points" on Page 49.
red	**Cause**	**Solution**
ON	The `Address Conflict Detection` (ACD) function determined that the same IP address was assigned several times in the network.	Ensure an IP address is only assigned once within an EtherNet/IP™ segment.
1 Hz	One or more I/O connections (`Exclusive Owner`) to the measuring system are in timeout state.	This state is exited only when all connections have been re-established or a device RESET has been carried out.
red/green	**Cause**	**Solution**
1 Hz	Communication error, existing network connection was interrupted	- Check network connections - Ensure accessibility via the (DOS prompt) `PING` command
2 Hz	- Device status: `PROPOSED TUNID RCVD` - The measuring system received the intended `TUNID`. The LED flashes until the measuring system received the `APPLY_TUNID` service and the validation was completed successfully.	–

12.2 General status codes

This table lists the general status codes that are entered in the General Status Code Field of an Error Response.

General Status Code	Name	Description
0x00	Success	The service specified by the object was executed successfully.
0x01	Connection failure	The connection related service failed.
0x02	Resource unavailable	The resources required to perform the requested service are not available.
0x03	Invalid parameter value	see Status Code 0x20, which is the preferred value for this state.
0x04	Path segment error	The path segment name or the segment syntax was not understood by the node being executed.
0x05	Path destination unknown	The path refers to an object class, instance, or structure element, which the node does not know or does not contain.
0x06	Partial transfer	Only a part of the expected data was transferred.
0x07	Connection lost	The communication link has been lost.
0x08	Service not supported	The service requested for this object class or instance was not implemented or not defined.
0x09	Invalid attribute value	Invalid attribute data detected.
0x0A	Attribute list error	An attribute in the feedback of the Get_Attribute_List or Set_Attribute_List reported a Status ≠0.
0x0B	Already in requested mode/state	The object is already in the requested mode or state.
0x0C	Object state conflict	The requested service cannot be executed by the object in the current mode or status.
0x0D	Object already exists	The requested instance of the object to be created already exists.
0x0E	Attribute not settable	Only a Get Service can be executed for this attribute.
0x0F	Privilege violation	Access right violated.
0x10	Device state conflict	The current mode or status of the device prevents the requested service from being carried out.
0x11	Reply data too large	The data in the input buffer to be transferred is larger than the allocated buffer.
0x12	Fragmentation of a primitive value	The service specifies a procedure which fragments a simple data value, i.e. halves a REAL data type.

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General Status Code	Name	Description
0x13	Not enough data	The service does not support enough data to perform the requested operation.
0x14	Attribute not supported	The attribute specified in the request is not supported.
0x15	Too much data	The service provides more data than expected.
0x16	Object does not exist	The specified object is not implemented in the device.
0x17	Service fragmentation sequence not in progress	The fragmentation sequence for this service is currently not active for this data.
0x18	No stored attribute data	The attribute data for this object was previously not saved for the requested service.
0x19	Store operation failure	An error caused the attribute data for this object not to be saved.
0x1A	Routing failure, request packet too large	The service request packet in the path to the target was too large for transmission on the network.
0x1B	Routing failure, response packet too large	The service response packet in the path from the target was too large for transmission on the network.
0x1C	Missing attribute list entry data	An attribute in the attribute list is not supported by the service but is required by the service to perform the requested behavior.
0x1D	Invalid attribute value list	The service returns an attribute list with invalid status information for this data.
0x1E	Embedded service error	An error has occurred in an embedded service.
0x1F	Vendor specific error	–
0x20	Invalid parameter	A parameter associated with the request was invalid. This code is used when a parameter does not meet the ODVA™ or Application Object Specifications.
0x21	Write-once value or medium already written	An attempt was made to write to a medium that can only be written once, e.g. WORM Drive, PROM. Or an attempt was made to change a value that can only be set once.
0x22	Invalid Reply Received	An invalid response was received, e.g. the Response Service Code does not match the Requested Service Code, or the returned message is smaller than the expected size.
0x23	Buffer Overflow	The received message is larger than the receive buffer can process. The entire message was discarded.

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General Status Code	Name	Description
0x24	Message Format Error	The server does not support the format of the received message.
0x25	Key Failure in path	The key segment (included as the first segment in the path) does not match the target module. The object-specific status indicates the defective part.
0x26	Path Size Invalid	The path size sent with the service request is either not large enough to enable the service or too much routing data have been added.
0x27	Unexpected attribute in list	An attempt was made to set an attribute which cannot be set at that moment.
0x28	Invalid Member ID	The Member ID specified in the request does not exist in the specified class / instance / attribute.
0x29	Member not settable	An attempt was made to write to a read-only member.

12.3 Miscellaneous faults

Fault	Cause	Solution
Position jumps of the measuring system	strong vibrations	So-called “shock modules dampen vibrations, impacts, and shocks, e.g. on presses. The measuring system must be replaced if this error reappears despite these measures.
	electrical interference, EMC	Isolated flanges and couplings made of plastic may help against electrical faults, as well as cables with twisted pair wires for data lines. Shielding and cable routing must follow the installation guidelines and the specification.
	extreme axial and radial load on the shaft or a scanning defect.	Couplers prevent mechanical stress on the shaft. If the error occurs repeatedly despite these measures, the measuring system must be replaced.

13 Elementary data types

Data type	Code	Description
BOOL	0xC1	Boolean variable with the values TRUE and FALSE
SINT	0xC2	Signed 8 Bit Integer
INT	0xC3	Signed 16 Bit Integer
DINT	0xC4	Signed 32 Bit Integer
LINT	0xC5	Signed 64 Bit Integer
USINT	0xC6	Unsigned 8 Bit Integer
UINT	0xC7	Unsigned 16 Bit Integer
UDINT	0xC8	Unsigned 32 Bit Integer
ULINT	0xC9	Unsigned 64 Bit Integer
REAL	0xCA	32 Bit Floating Point
LREAL	0xCB	64 Bit Floating Point
STRING	0xD0	Character string, 1 byte / character
BYTE	0xD1	Bit string, 8 bit
WORD	0xD2	Bit string, 16 bit
DWORD	0xD3	Bit string, 32 bit
LWORD	0xD4	Bit string, 64 bit
SHORT_STRING	0xDA	Character string, 1 byte / character, 1 byte length index
EPATH	0xDC	CIP path segment
STRINGI	0xDE	International Character String

14 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	Datum	edited	checked

Sub-item	Note	Reference	yes
–	Checklist, part 1 of 2	Document no.: TR-ECE-BA-GB-0142	☐
This User Manual was read and understood	–	Document no.: TR-ECE-BA-GB-0163	☐
Verify that the measuring system can be used for the present automation task based on 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 16 • Product data sheets www.tr-electronic.com/s/S022978	☐
Supply voltage	• The power supply unit used must meet the requirements of	• Chapter Supply voltage, Page 21	☐
Proper EtherNet/IP™ installation	• Compliance with valid international standards or ODVA guidelines specified for EtherNet/IP™	• Chapter Installation / Preparation for Commissioning, from Page 18	☐
Compliance with the safety-related requirements when using CIP Safety™ devices according to ODVA EtherNet/IP™ Specification V2.20, Volume 5, CIP™ Safety, Table "TST97 – Safety Manual Inspection Requirement"	Applicable to • Device replacement • Security connections with SCID = 0 • SNN No. – Assignment • SNCT configuration – comparison of SCID and configuration data • Validation of all downloads • Verification of the signature • Verification of configuration data • Function test • Deletion of an existing configuration • Programming the TUNID • Various SIL levels in the network • Verification of safety connections • Status EDS • Automatic SNN assignment • Locking of configuration data • Ownership assignment for Type 1 SafetyOpen configurations • Visual review of configuration data	• Chapter Safety-related requirements when using CIP Safety™ devices, Page 14 and references	☐

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Sub-item	Note	Reference	yes
Preset adjustment function	• Ensured the preset adjustment function can not be triggered unintentionally • Ensure the settings are made for the correct axis • After execution of the preset adjustment function, check the new position at the relevant axis before restarting	• Chapter TR Safety – Preset Adjustment Function, Page 79	☐

15 Appendix

15.1 TÜV certificate

Download

- CD_582M +FS02: www.tr-electronic.de/f/TR-ECE-TI-DGB-0344
- CD_582M +FS03: www.tr-electronic.de/f/TR-ECE-TI-DGB-0350

15.2 EtherNet/IP™ / CIP Safety™ - Declaration of Conformity

Download

- www.tr-electronic.de/f/TR-ECE-TI-GB-0371

15.3 EU Declaration of Conformity

Download

- CD_582M +FS02: www.tr-electronic.de/f/TR-ECE-KE-DGB-0354
- CD_582M +FS03: www.tr-electronic.de/f/TR-ECE-KE-DGB-0358