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CANopen Safety

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Absolute Encoder CD_582
CANopen / CANopen Safety

- TR Encoder Profile
- CiA DS406 Encoder Profile, Class 3
- CANopen Safety EN 50325-5 (CiA DS304)
- OPTION: Second interface

CDV582

CDS582 / CDH582

Illustrations similar

DIN EN 61508: **SIL CL2 / SIL CL3**
DIN EN ISO 13849: **PL d / PL e**

_Safety information
_Installation
_Commissioning
_Configuration / Parametrization
_Troubleshooting / Diagnostic options

User Manual
Interface

TR-ECE-BA-GB-0171 v02 04/19/2024

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First release	03/04/2024	01
- Default values for objects 0x1029, 0x1302 and 0x13FF modified - New object 0x2222 added	04/19/2024	02

1 General information

This interface-specific user manual contains the following topics:

- Safety information
- Installation
- Commissioning
- Configuration / Parametrization
- Troubleshooting and diagnosis options

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

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

1.1 Applicability

This User Manual applies exclusively for measuring system series in accordance with the following keys for article numbers and types with ***CANopen*** interface and ***CANopen Safety*** protocol:

Article number

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

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

* = placeholder

Type keys

See revision lists:
CD_582M +FS02: www.tr-electronic.de/f/TR-ECE-TI-GB-0343
CD_582M +FS03: www.tr-electronic.de/f/TR-ECE-TI-GB-0349

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

The following documentation therefore also applies:

- See chap. "Other Applicable Documents" in the Safety Manual www.tr-electronic.de/f/TR-ECE-BA-GB-0142
- Product data sheets https://www.tr-electronic.com/s/S025893

1.2 References

1.	ISO 11898: Road vehicles, interchange of digital information - Controller Area Network (CAN) for high-speed communication, November 1993	
2.	Robert Bosch GmbH, CAN Specification 2.0 Part A and B, September 1991	
3.	CiA DS-201	V1.1, CAN in the OSI Reference Model, February 1996
4.	CiA DS-202-1	V1.1, CMS Service Specification, February 1996
5.	CiA DS-202-2	V1.1, CMS Protocol Specification, February 1996
6.	CiA DS-202-3	V1.1, CMS Encoding Rules, February 1996
7.	CiA DS-203-1	V1.1, NMT Service Specification, February 1996
8.	CiA DS-203-2	V1.1, NMT Protocol Specification, February 1996
9.	CiA DS-204-1	V1.1, DBT Service Specification, February 1996
10.	CiA DS-204-2	V1.1, DBT Protocol Specification, February 1996
11.	CiA DS-206	V1.1, Recommended Layer Naming Conventions, February 1996
12.	CiA DS-207	V1.1, Application Layer Naming Conventions, February 1996
13.	CiA DS-301	V4.2, CANopen communication profile based on CAL, February 2011
14.	CiA DS-302	V4.1, Additional application layer functions, February 2009
15.	CiA DR 303-1	CANopen cabling and connector pin assignment
16.	CiA DS-303-3	V1.4, Indicator specification, April 2012
17.	CiA DS-305	V3.0.0, Layer Setting Services (LSS) and protocols, May 2013
18.	CiA DS-319	V1.0.0, CANopen implementation and configuration guideline for safety-related devices
19.	CiA DS-406	V4.1, CANopen profile for encoders, June 2019
20.	DIN EN 50325-4	Industrial communications subsystem based on ISO 11898 (CAN) - Part 4: CANopen
21.	DIN EN 50325-5	Industrial communications subsystem based on ISO 11898 (CAN) - Part 5: Functional safety communication based on EN 50325-4
22.	DIN EN IEC 61918	Industrial communication networks. Installation of communication networks in industrial premises

1.3 Abbreviations used / Terminology

EMC	***E***lectro-***M***agnetic ***C***ompatibility
CAL	CAN Application Layer. The application layer for CAN-based networks is described in the CiA Draft Standard 201 ... 207.
CAN	Controller Area Network. Data Layer Protocol for serial communication, described in ISO 11898.
CiA	CAN in Automation. Internationale Anwender- und Herstellervereinigung e.V.: non-profit organization for the Controller Area Network (CAN).
CMS	CAN-based Message Specification. One of the service elements in the application layer in the CAN reference model.
COB	Communication Object (CAN Message). Transmission unit in the CAN network. Data must be transmitted through the CAN network in a COB.
COB-ID	COB Identifier. Unique assignment of the COB. The identifier defines the priority of the COB in the bus traffic.
CRC	***C***ylic ***R***edundancy ***C***heck
DBT	Distributor. One of the service elements in the application layer in the CAN reference model. The DBT is responsible for the distribution of COB-IDs to the COBs, which are used by the CMS.
EDS	***E***lectronic-***D***ata-***S***heet
FSA	Finite state automata. State machine for controlling LSS services
LSS	Layer Setting Services. Services and protocols for configuring the node-ID and baud rate via the CAN network.
NMT	Network Management. One of the service elements in the application layer in the CAN reference model. Executes initialization, configuration and troubleshooting in bus traffic.
PDO	Process Data Object. Object for data exchange between several devices.
SCT	Safeguard Cycle Time. Maximum time between two SRDO transmission cycles.
SDO	Service Data Object. Point-to-point communication with access to the object data list of a device.
SIL	***S***afety ***I***ntegrity ***L***evel: Four discrete levels (SIL1 to SIL4). The higher the SIL of a safety-related system, the lower the probability that the system cannot execute the required safety functions.
SRDO	Safety Related Data Object. Safety-related data object with cyclic data transfer and timeout monitoring.
SRVT	Safety Related Validation Time. Maximum time between the two SRDO CAN telegrams.
SSI	***S***ynchronous ***S***erial ***I***nterface

1.4 Main features

- CANopen interface with CANopen Safety protocol, for transfer of a safe position and speed (SRDO)
- Quick process data channel via CANopen, NOT safety-related (PDO)
- Only for variant 1:
  Additional incremental / SIN/COS or SSI interface, NON-safety-related
- Two-channel scanning system, for generation of reliable measured data through internal channel comparison
  - Variant 1:
    Channel 1, Master system:
    optical single-turn scanning via code disk with transmitted light and magnetic multi-turn scanning
    Channel 2, 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
- A common drive shaft

The data of the more precise measuring system are made available unchecked in the NON-safety-related process data channel (PDO) with normal CANopen protocol. As the process data do not have to be compared, these data are more up-to-date in variant 1 than the safety-related process data.

The inspection system serves for the internal safety check. The "safe data" obtained through two-channel data comparison are packed into the CANopen Safety protocol and also transmitted to the control via a safety-related data object (SRDO) with appropriate safety mechanisms.

The SSI interface and the incremental interface, or the optionally available SIN/COS interface, is derived from a single channel and is not evaluated from a safety viewpoint.

1.5 Principle of the safety function

System safety results when:

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

2 Safety information

2.1 Definition of symbols and notes

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

2.2 Safety functions of the fail-safe processing unit

The **safety control**, to which the measuring system is connected, must perform the following safety checks according to EN 50325-5.
In particular, the requirements for evaluating the `Safety Communication Layer Protocol` must be met with reference to the safety-related cyclic process data transfer (SRDO).

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

- "Passive Safe State" (see chap. 13 on page 141)

This state is supported in both `CiA DS406 Encoder Profile` and in `TR Mode`. If no safe position can be output due to an error detected by the measuring system, the cyclic transmission of safety-related data objects (SRDO) is interrupted, so that error detection is possible on the receiver side after expiry of the `Safeguard Cycle Time` (SCT).

- "Active Safe State" (see chap. 13 on page 141)

This state is only supported in `TR Mode`, if the value "1" has been set in object 0x2410 in subindex 11 `Error behavior` for the "Status bit behavior" function, see chap. 10.2.2.9 on page 96. In this case the cyclic transmission of safety-related data objects (SRDO) is continued. The `Safe State` bit 2^4 in object 0x2420 is set from "1" to "0" and enables error detection on the receiver side.

Data from the perspective of the measuring system in `Active Safe State` are:

- CANopen SRDO position:
  - cyclic output of the position, NOT safety-related
- CANopen SRDO speed:
  - cyclic output of the speed, NOT safety-related
- CANopen SRDO TR safety status:
  - Safe State bit 2^4 in object 0x2420 = 0

As the output position or speed in `Active Safe State` can only be generated in a single channel and without data comparison, these output data are not safe for the purposes of a safety standard, even if the transmission is executed via the CANopen Safety Protocol.

If the requirements on safety-related data transmission according to EN 50325-5 are not met or if in `Active Safe State` the `Safe State` bit is reset in object 0x2420, the safety control must put the system into a safe state. This error state can only be cleared by eliminating the error and then switching the measuring system off and on again, or through an `error acknowledgment`, see page 141!

The process data objects 1800h-1803h addressable via CANopen are not necessarily affected by this. If the internal diagnosis of the single-channel position acquisition does not detect an error, the process data are still output. However, these data are not safe for the purposes of a safety standard.

2.2.1 Mandatory safety checks / measures

Measures for commissioning, changes	Error reaction
Application-dependent parametrization of safety-related parameters: TR mode - Object 2410h: TR safety configuration parameter, see from page 89 CiA DS406 mode - Object 6100h: Safety position configuration parameters, - Object 6101h: Safety speed configuration parameters, see from page 121 and 123	–
In the event of parameter changes, check that the measure is executed as desired.	STOP

Check by safety control	Error reaction
Cyclic consistency check of the current CANopen Safety SRDOs with the associated inverse SRDOs according to EN 50325-5. Also see chap. 4 from page 32.	STOP
Monitoring of the `Safeguard Cycle Time` (SCT) timing requests for CANopen Safety SRDOs according to EN 50325-5. Also see chap. 4 from page 32.	STOP
Monitoring of the `Safety Related Validation Time` (SRVT) timing requests for CANopen Safety SRDOs according to EN 50325-5. Also see chap. 4 from page 32.	STOP
Only TR mode: Monitoring of the `Safe State` bit in object 0x2420 `TR safety status` when using the "Status bit behavior" function: Object 0x2410, subindex 11 `Error behavior` = "1"	Safe State bit 2^4 = 0 --> STOP

3 Basic CANopen functions

CANopen was developed by the CiA and has been standardized as European standard EN 50325-4 since the end of 2002.

CANopen uses layers 1 and 2 of the CAN standard originally developed for use in cars (ISO 11898-2) as a transmission technology. These are extended in automation technology by the recommendations of the CiA Industrial Association in respect of plug assignment and transmission rates.
CiA has developed the CAL standard (CAN Application Layer) for the application layer.

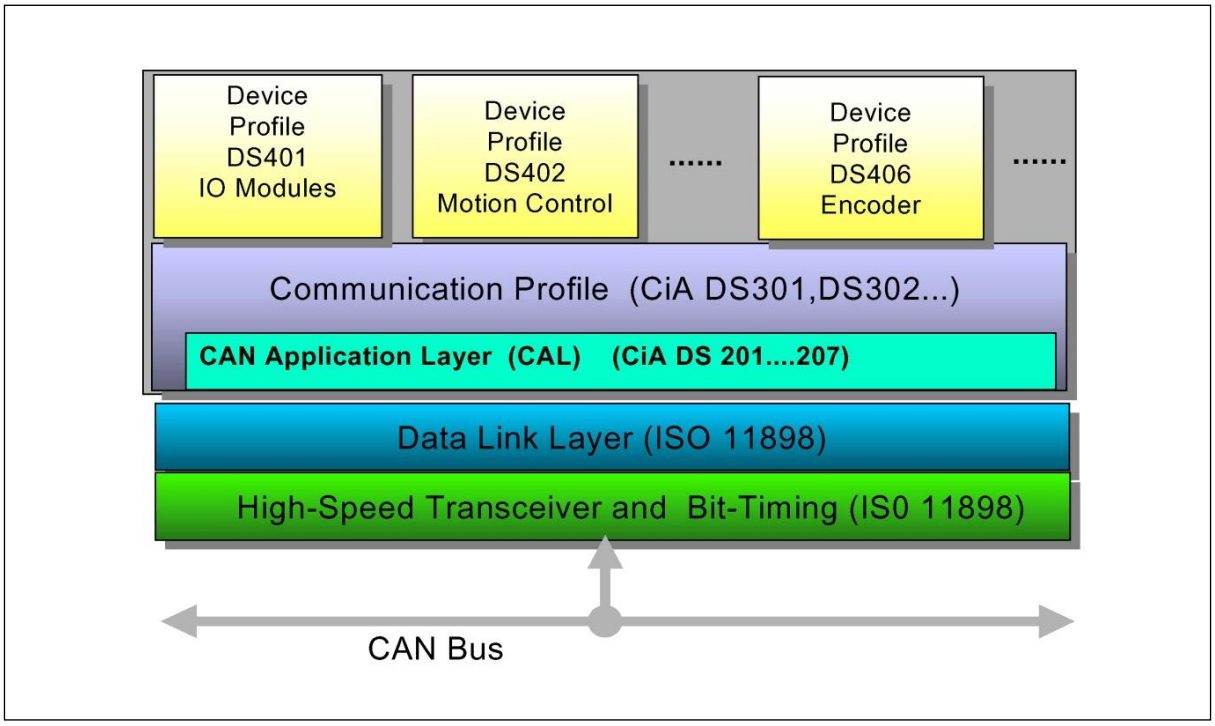


Figure 1: CANopen organized in the ISO/OSI layer model

The CANopen communication profile was developed first of all together with "building instructions" for device profiles, in which the common denominator of all device profiles is defined with the structure of the object dictionary and the general coding conventions.

3.1 CANopen communication profile

The CANopen communication profile (documented in CiA DS-301) regulates how devices exchange data with each other. A distinction is made between real time data (e.g. position value) and parameter data (e.g. counting direction). CANopen assigns appropriate communication elements to these data types, which are completely different in character.

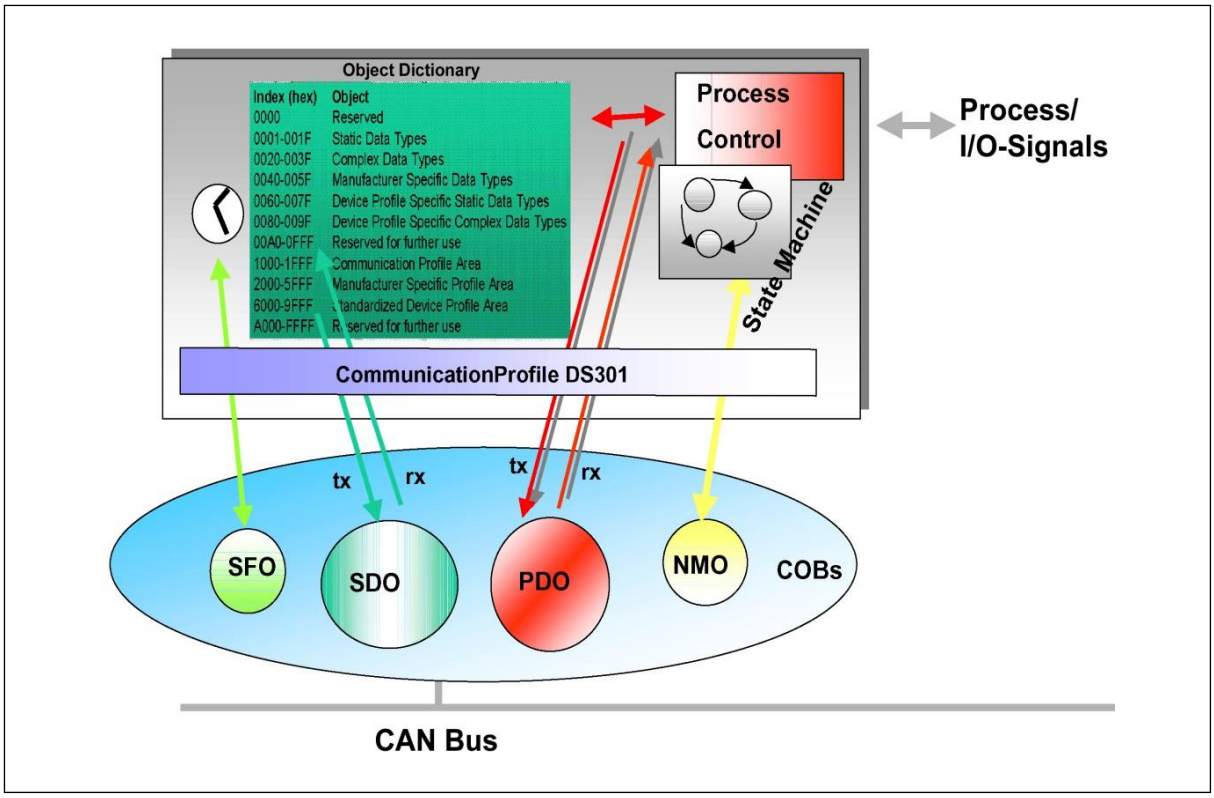


Figure 2: Communication profile

Special **F**unction **O**bject **(SFO)**

- Synchronization (SYNC)
- Emergency (EMCY) protocol

Network **M**anagement **O**bject **(NMO)**
e.g.

- Life / Node Guarding
- Boot-up,…
- Error Control protocol

3.2 Process and Service Data Objects

Process Data Object (PDO)

Process Data Objects manage the process data exchange, e.g. the cyclical transmission of the position value.
The process data exchange with the CANopen PDOs is "CAN pure", so without protocol overhead. All broadcast characteristics of CAN remain unchanged. A message can be received and evaluated by all devices at the same time.
The four Transmit Process Data Objects 1800h to 1803h are used by the measuring system. Depending on the setting, these can be used for asynchronous (event-controlled) transmission or synchronous (on request) transmission.

Service Data Object (SDO)

Service Data Objects manage the parameter data exchange, e.g. the acyclical execution of the preset function.
The SDO provides an efficient communication mechanism for parameter data of any size. A service data channel for parameter communication is formed between the configuration master and the connected devices for this purpose. The device parameters can be written to or read from the device object dictionary with a unique telegram handshake.

Important features of SDO and PDO

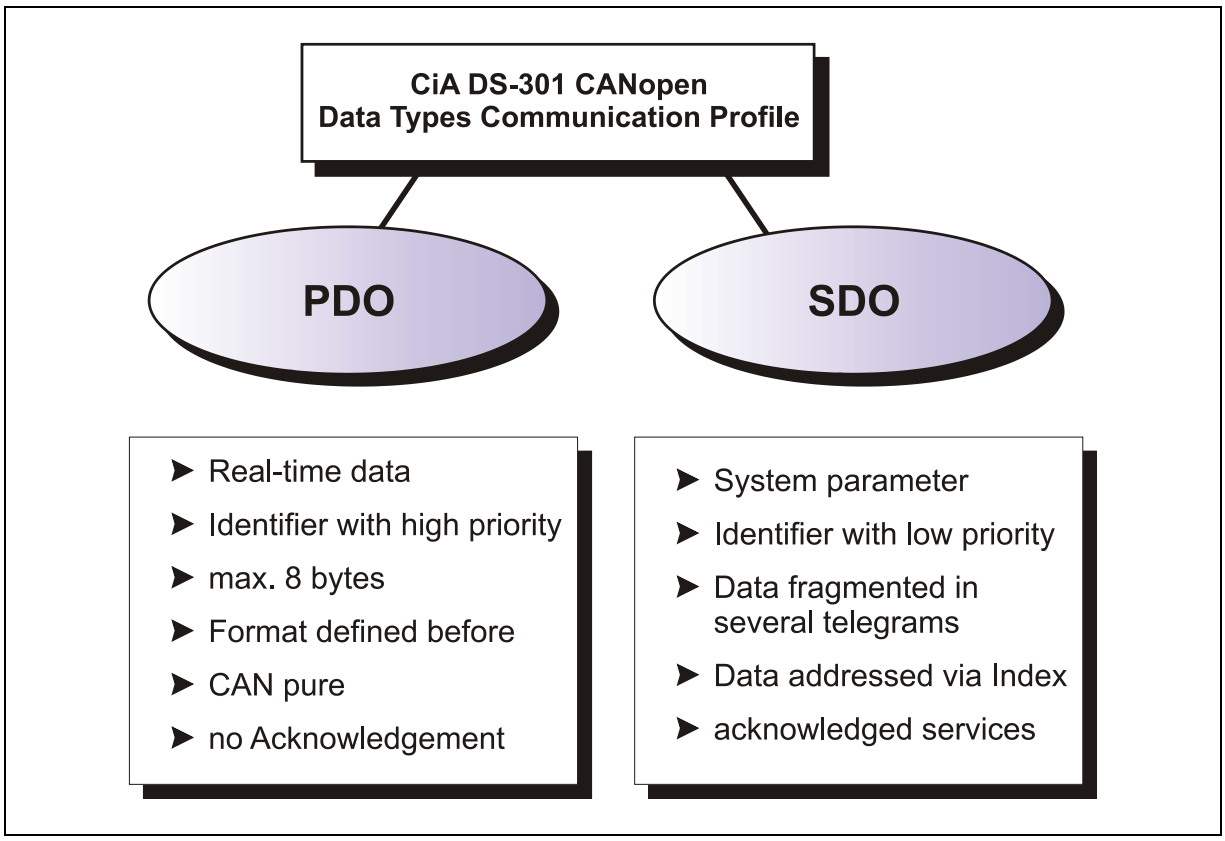


Figure 3: Comparison of PDO/SDO characteristics

3.3 Object Dictionary

The object dictionary structures the data of a CANopen device in a clear tabular arrangement. It contains all device parameters and all current process data, which are therefore also accessible via the SDO.

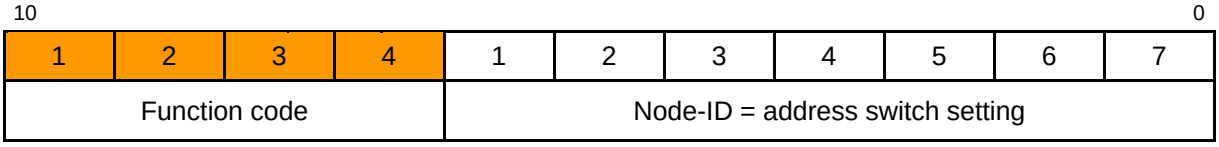
Index	Object	
0000_h	not used	Common to all devices
0001_h - $025F_h$	Data type definitions	
0260_h - $0FFF_h$	Reserved	
1000_h - $1FFF_h$	Communication profile area	
2000_h - $5FFF_h$	Manufacturer specific profile area	Device specific
6000_h - $9FFF_h$	Standardized device profile area	
$A000_h$ - $BFFF_h$	Standardized interface profile area	
$C000_h$ - $FFFF_h$	Reserved	

Figure 4: Structure of the object dictionary

3.4 CANopen Default Identifier, COB-ID

CANopen devices can be used in a CANopen network without configuration. Just the setting of a bus address and the baud rate is required. The identifier allocation for the communication channels is derived from this node address.

COB Identifier = Function Code + Node-ID



Examples

Object	Function code	COB-ID	Index Communication Parameter
NMT	0000bin	0h	–
SYNC	0001bin	80h	1005h
PDO1 (tx)	0011bin	181h – 1FFh	1800h
PDO2 (tx)	0101bin	281h – 2FFh	1801h
PDO3 (tx)	0111bin	381h – 3FFh	1802h
PDO4 (tx)	1001bin	481h – 4FFh	1803h

3.5 Transmission of SDO messages

The transmission of SDO messages occurs via the CMS "Multiplexed-Domain" protocol (CIA DS-202-2).
Objects can be read or written from the object dictionary with SDOs. This is a confirmed service. The so-called ***SDO Client*** specifies in its "Request" the parameter, the access type (read/write) and the value if applicable. The so-called ***SDO Server*** executes the write or read access and answers the request with a "Response". In the case of error, an error code provides information on the cause of the error. Transmit SDO and receive SDO are differentiated by their function codes.

The measuring system (Slave) corresponds to the SDO Server and uses the following function codes:

Function code	COB-ID	Meaning
`11 (1011 bin)`	`0x580 + Node ID`	**Slave → SDO Client**
`12 (1100 bin)`	`0x600 + Node ID`	**SDO Client → Slave**

Table 1: **COB-IDs for Service Data Object (SDO)**

3.5.1 SDO message format

The maximum 8-byte long data range of a CAN message is configured by an SDO as follows:

CCD	Index		Subindex	Data			
Byte 0	Byte 1, Low	Byte 2, High	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7

Table 2: **SDO message**

The ***command code (CCD)*** identifies whether the SDO request is of the read or write type. With a write command, the number of bytes to be written are also encoded in the CCD.
In the SDO response the CCD indicates whether the request was successful. In the case of a read command, the CCD also provides information on the number of bytes read:

CCD	Meaning	Valid for
0x22	Write n byte	SDO Request
0x23	Write 4 byte	SDO Request
0x2B	Write 2 byte	SDO Request
0x2F	Write 1 byte	SDO Request
0x60	Write successful	SDO Response
0x80	Error	SDO Response
0x40	Read request	SDO Request
0x43	4 byte of data read	SDO response to read request
0x4B	2 byte of data read	SDO response to read request
0x4F	1 byte of data read	SDO response to read request

Table 3: Command codes for SDO

In the case of an error (SDO response CCD = 0x80), the data range contains a 4- byte error code, which provides information on the cause of the error. The meaning of the error codes can be found in Table 11, page 147.

Segment protocol, data segmentation

Many objects contain data that are larger than 4 bytes. The "Segment protocol" must be used to read these data.
First of all the read process is initiated like a normal SDO service with the command code = 0x40. The response indicates how many data segments are concerned and how many bytes can be read. The individual data segments can then be read with subsequent read requests. A data segment comprises 7 bytes.

Example for reading a data segment:

Telegram 1

CCD	Meaning	Valid for
0x40	Read request, initiation	SDO Request
0x41	1 data segment present The number of bytes to be read is in bytes 4 to 7.	SDO Response

Telegram 2

CCD	Meaning	Valid for
0x60	Read request	SDO Request
0x01	No further data segments present. Bytes 1 to 7 contain the requested data.	SDO Response

3.5.2 Read SDO

Initiate "Domain Upload"

Request Protocol Format:

COB-Identifier = 600h + Node-ID

Read SDOs								
Byte	0	1	2	3	4	5	6	7
Contents	Code	Index		Sub-index	Data 0	Data 1	Data 2	Data 3
	40h	Low	High	Byte	0	0	0	0

The "Read SDO" telegram must be sent to the slave.

The slave answers with the following telegram:

Response Protocol Format:

COB-Identifier = 580h + Node-ID

Read SDOs								
Byte	0	1	2	3	4	5	6	7
Contents	code	Index		Sub-index	Data 0	Data 1	Data 2	Data 3
	4xh	Low	High	Byte	data	data	data	data

Format Byte 0:

MSB LSB

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	1	0	0	n		1	1

n = Number of data bytes (bytes 4-7), which do not contain any data.

If just 1 data byte (data 0) contains data, the value of byte 0 = "4Fh".

If byte 0 = 80h, the transmission is aborted.

3.5.3 Write SDO

Initiate "Domain Download"

Request Protocol Format:

COB-Identifier = 600h + Node-ID

Write SDOs								
Byte	0	1	2	3	4	5	6	7
Contents	code	Index		Sub-index	Data 0	Data 1	Data 2	Data 3
	2xh	Low	High	Byte	0	0	0	0

Format Byte 0:

MSB LSB

7	**6**	**5**	**4**	**3**	**2**	**1**	**0**
0	0	1	0	n		1	1

n = Number of data bytes (bytes 4-7), which do not contain any data.

If just 1 data byte (data 0) contains data, the value of byte 0 = "2Fh".

The "Write SDO" telegram must be sent to the slave.

The slave answers with the following telegram:

Response Protocol Format:

COB-Identifier = 580h + Node-ID

Read SDOs								
Byte	0	1	2	3	4	5	6	7
Contents	code	Index		Sub-index	Data 0	Data 1	Data 2	Data 3
	60h	Low	High	Byte	0	0	0	0

If byte 0 = 80h, the transmission is aborted.

3.6 Network Management, NMT

The network management supports a simplified boot-up of the network. For example, all devices can be set to Operational state with a single telegram.

After switch-on, the measuring system is initially in "Pre-operational state", (2).

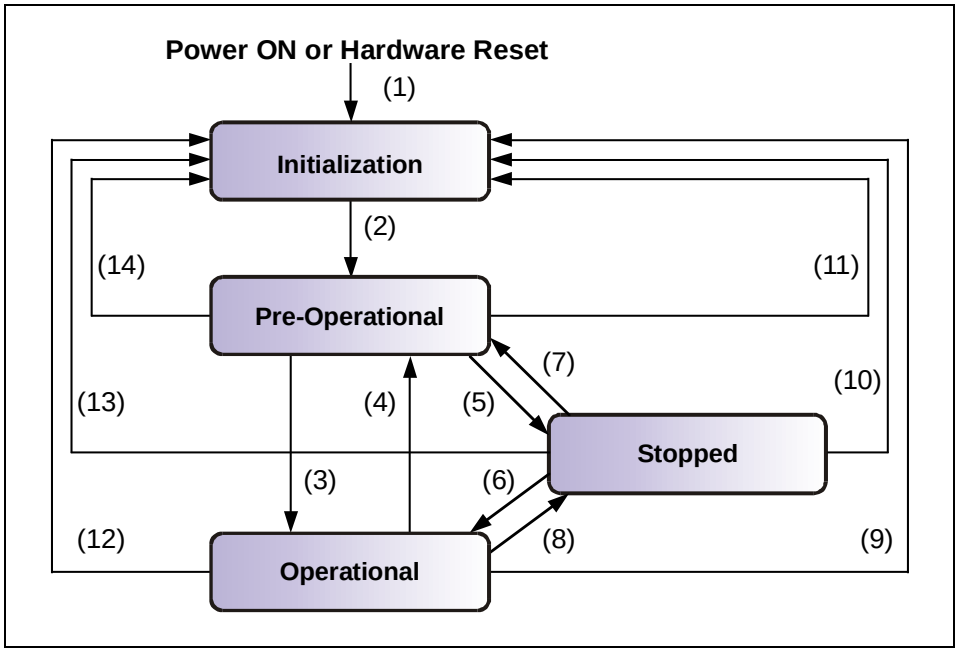


Figure 5: Network Management Boot-Up Mechanism

Status	Description
(1)	Automatic initialization after switch-on
(2)	End of initialization --> Pre-operational state
(3),(6)	Start_Remote_Node --> Operational state
(4),(7)	Enter_PRE-OPERATIONAL_State --> Pre-operational state
(5),(8)	Stop_Remote_Node --> Stop
(9),(10),(11)	Reset_Node --> Reset node
(12),(13),(14)	Reset_Communication --> Reset communication

3.6.1 Network Management Services

The ***Network Management (NMT)*** has the task of initializing nodes of a CANopen network, incorporating the nodes into the network, stopping them and monitoring them.

NMT services are initiated by an ***NMT master***, which addresses individual nodes (***NMT slave***) via their Node ID. An NMT message with Node ID 0 is addressed to **all** NMT slaves.

The measuring system corresponds to an NMT slave.

3.6.1.1 NMT Services for Device Control

The NMT services for device control use the **COB-ID 0** and thus receive the highest priority.

Only the first two bytes of the CAN message data field are used:

CCD	Node ID
Byte 0	Byte 1

The following commands are defined:

CCD	Meaning	Status
-	Automatic initialization after switch-on	(1)
-	End of initialization --> PRE-OPERATIONAL	(2)
0x01	**Start Remote Node** Node must change to OPERATIONAL status and start normal network operation	(3),(6)
0x02	**Stop Remote Node** Node must go to STOPPED status and stop communication. Any active connection monitoring will remain active.	(5),(8)
0x80	**Enter PRE-OPERATIONAL** Node must go into PRE-OPERATIONAL status. All messages except PDOs and SRDOs can be used.	(4),(7)
0x81	**Reset Node** Values of the objects 2xxxh to 9xxxh are reset to the switch-on values. Then transition to the RESET COMMUNICATION status.	(9),(10), (11)
0x82	**Reset Communication** Values of the objects 1xxxh are reset to the switch-on values. Then transition to the PRE-OPERATIONAL status.	(12),(13), (14)

Table 4: **NMT services for device control**

3.6.1.2 NMT Services for Connection Monitoring

Connection monitoring enables an NMT master to detect the failure of an NMT slave and/or an NMT slave to detect the failure of the NMT master:

- **Node Guarding and Life Guarding:**
  An NMT master monitors an NMT slave with these services

In the case of **Node Guarding**, the NMT master requests the status of an NMT slave at regular intervals. The toggle bit 2^7 in the "Node Guarding Protocol" toggles after each request:

Example:
0x85, 0x05, 0x85 … --> no error
0x85, 0x05, 0x05 … --> error

If **Life Guarding** is also active, the NMT slave expects such a status request from the NMT master within a defined time interval. If this is not the case, you can set how the slave should behave via `Object 1029h: Error behavior`.

The NMT services for connection monitoring use the function code **`1110 bin`**, so **COB-ID 0x700+Node ID**.

Index	Description	
0x100C	**Guard Time [ms]**	After expiry of the time interval at the latest **Life Time = Guard Time x Life Time Factor [ms]** the NMT slave expects a status request from the master. If the Life Time or Guard Time = 0, Life Guarding is switched off.
0x100D	**Life Time Factor**	

Table 5: **Parameters for NMT services**

3.7 Layer Setting Services (LSS) and protocols

LSS services and protocols are used to query and configure different parameters of the Data Link Layer and the Application Layer of an LSS slave by an LSS master via the CAN network.

The following parameters are supported:

- Node ID
- Baud rate
- LSS address, according to Identity Object 1018h

This means it is no longer necessary to set the Node-ID and baud rate via DIP switches. Access to the LSS slave occurs via its LSS address, comprising:

- Vendor-ID
- Product Code
- Revision Number and
- Serial Number

If the Node-ID is set via the LSS service and the HEX addressing switches simultaneously indicate the value 0x00, the COB-IDs are immediately reset to their default values and the system configuration is set via Object 13FEh to 00h = invalid:

- Process Data Objects (PDOs),
see subindex 1 chap. 7.1.1 on page *49*

- Safety Related Process Data Objects (SRDOs),
see subindex 5 and 6 chap. 7.2.1 from page *54*

- EMCY Messages,
see chap. 9.12 on page 67

- Validity of the system configuration,
see `Object 13FEh: Configuration valid` *chap. 9.23 on page 72*

LSS services and protocols are standardized and documented in CiA DS-305 V3.0.0 . The following description is therefore only intended to provide an overview of the functionalities supported by the measuring system. The services and command codes required for setting are integrated in the LSS master and are therefore not part of this description.

3.7.1 Finite State Automaton, FSA

The FSA corresponds to a state machine and defines the behavior of an LSS slave. The state machine is controlled by LSS COBs produced by an LSS master, or NMT COBs produced by an NMT master, or local NMT state transitions.

The LSS FSA supports the following states:
(0) Initial: Pseudo state, indicates activation of the FSA
(1) LSS waiting: Support of all services as specified below
(2) LSS configuration: Support of all services as specified below
(3) Final: Pseudo state, indicates deactivation of the FSA

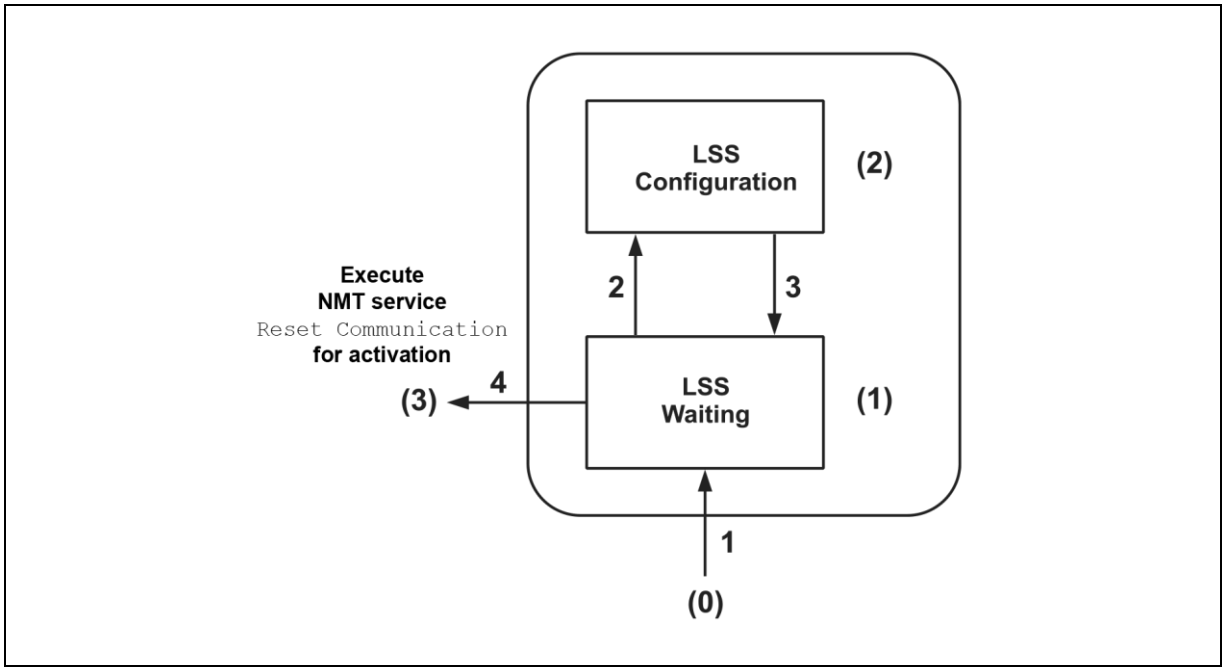


Figure 6: LSS FSA State Machine

State behavior of the supported services

Services	LSS Waiting	LSS Configuration
Switch state global	Yes	Yes
Switch state selective	Yes	No
Activate bit timing parameters	No	Yes
Configure bit timing parameters	No	Yes
Configure Node-ID	No	Yes
Store configured parameters	No	Yes
Inquire LSS address	No	Yes
Inquire Node-ID	No	Yes
LSS identify remote slave	Yes	Yes
LSS identify slave	Yes	Yes
LSS identify non-configured remote slave	Yes	Yes
LSS identify non-configured slave	Yes	Yes
LSS Fastscan	Yes	No

LSS FSA state transitions

Transition	Events	Actions
1	Automatic transition after initial entry into either NMT PRE-OPERATIONAL state or NMT STOPPED state, or NMT RESET COMMUNICATION state with Node-ID = FFh.	none
2	LSS 'switch state global' command with parameter 'configuration_switch' or 'switch state selective' command	none
3	LSS 'switch state global' command with parameter 'waiting_switch'	none
4	Automatic transition if an invalid Node-ID has been changed and the new Node-ID has been successfully stored in the non-volatile memory AND state switch to LSS waiting was requested.	none

Once the LSS FSA undergoes further transition states in the NMT FSA from NMT PRE-OPERATIONAL to NMT STOPPED state and vice-versa, this does not lead to re-entering the LSS FSA.

3.7.2 Transmission of LSS services

Via the LSS services, the LSS master requests individual services, which are then performed by the LSS slave. Communication between LSS master and LSS slave is carried out via the implemented LSS protocols.
Similarly to SDO transmission, here too, two COB-IDs are used for sending and receiving:

COB-ID	Meaning
0x7E4	**LSS slave → LSS master**
0x7E5	**LSS master → LSS slave**

Table 6: **COB-IDs for Layer Setting Services (LSS)**

3.7.2.1 LSS message format

The maximum 8-byte long data range of a CAN message is configured by an LSS service as follows:

CS	Data						
Byte 0	byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7

Table 7: **LSS message**

Byte 0 contains the ***Command Specifier*** (CS), followed by 7 bytes for the data.

3.8 Device profile

The CANopen device profiles describe the "what" of the communication. In the profiles the meaning of the transmitted data is defined unequivocally and independent of the manufacturer. Thus the basic functions of any device class, e.g. for encoder: ***CiA DS406***, can be uniformly addressed. On the basis of these standardized profiles, CANopen devices can be accessed via the bus in exactly the same manner. Thus devices which have the same device profile are largely interchangeable with each other.

You can obtain further information on CANopen from the ***CAN in Automation*** User and Manufacturer Association (CiA) at the following address:

CAN in Automation e. V.
Kontumazgarten 3
DE - 90429 Nuremberg, Germany

Tel. +49-911-928819-0
Fax: +49-911-928819-79

Website: www.can-cia.org
Email: headquarters@can-cia.org

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4 CANopen Safety / Cyclic data exchange specifications

The information provided here serves solely for guidance, assignment and procedure and does not on any account replace the information contained in standard EN 50325-5.

More detailed information on the topic "Safety Related Communication Profile and Protocols" or general information on the topic "Safety Related Communication" can be taken directly from the standard.

In 2010 the CANopen Safety protocol (CiA 304) was published as European standard EN 50325-5. CANopen Safety is designed to allow safety-related communication based on CAN according to EN 61508 and EN ISO 13849-1. Safety-related devices up to "SIL3/SIL CL3" (SIL Level) and "PLe/Cat.4" (Performance Level) can be supported.

The protocol allows both safety-related and NON-safety-related devices to be operated in a CANopen network. The safety functions are implemented via special communication objects, `SRDOs` (safety related data objects).

Similar to standard PDOs, cyclic data are exchanged in `OPERATIONAL` state via SRDOs. However, the interval between two SRDOs is determined by a monitoring time. As with PDOs, the configuration of SRDOs is performed via SDOs. However, it is recommended that safety-related SRDO mapping is performed with tool support, using an appropriate configuration tool. If the control system does not provide such a configuration tool, the `TR CAN Device TOOL` configuration tool provided by TR Electronic can be used, see chap. 6.2 on page 48.

The measuring system supports communication objects 1301h (SRDO1), 1302h (SRDO2) and 1303h (SRDO3). These can be used either for sending or receiving cyclic data, depending on configuration. Transmission of the safety-related position, speed, preset value and status, as well as safe execution of the preset function, is provided for.
The configuration is performed via the freely settable mapping of the mapping objects 1381h (SRDO1), 1382h (SRDO2) and 1383h (SRDO3).

4.1 Transmission of safety-related process data (SRDO)

An SRDO always consists of two CAN telegrams. The following must be observed for transmission:

- The COB-IDs of the two CAN telegrams in the communication objects 1301h-1303h are different in at least two bit positions. The COB-ID of the CAN telegram with the normal data is always odd. The COB-ID of the CAN telegram with the inverted data is always the next even value.
- The data of the two CAN telegrams in the mapping objects 1381h-1383h are redundant. However, the data of the second CAN telegram must be transmitted with bitwise inversion.
- The order of the two CAN telegrams of an SRDO must be observed. First of all the normal data are transmitted, then the inverted data.
- SRDOs are sent cyclically. The time between two SRDOs is determined by the `Refresh time` / `Safeguard Cycle Time (SCT)` parameter in the communication objects 1301h-1303h subindex 2, also see following Figure 7.
- The interval between the two CAN telegrams of an SRDO must not exceed the `Safety Related Object Validation Time` (SRVT). The validation time is preset in the communication objects 1301h-1303h subindex 3, also see following Figure 8.

The receiver must check the validity of the SRDO. For this purpose, the time and logical sequence of the CAN telegrams of an SRDO must be compared with the settings of the communication parameters of the SRDO connection. A verification of the user data must then take place. Detected errors must lead to a change to safe state of the assigned safety function. The safe state must be defined by the user, depending on the application.

The characteristics of the SRDOs (COB-ID, SCT, SRVT, Mapping) are stored in the object dictionary and must be checked for validity via a CRC (16-bit cyclic redundant check). The CRC calculations (signatures) are stored via object 13FFh.

According to EN 50325-5, maximum 64 SRDO producers (devices) are possible.

Refresh Time / SCT (1301h-1303h, Subindex 2)

The Refresh Time / SCT defines the interval between two transmissions of an SRDO, i.e. the interval between the first CAN messages of an SRDO.

For Transmit SRDOs this parameter means the time (Refresh Time) between two SRDO transmissions.

For Receive SRDOs it is the maximum time (SCT) that is permitted between two transmissions of the SRDO, for the SRDO to be recognized as valid.

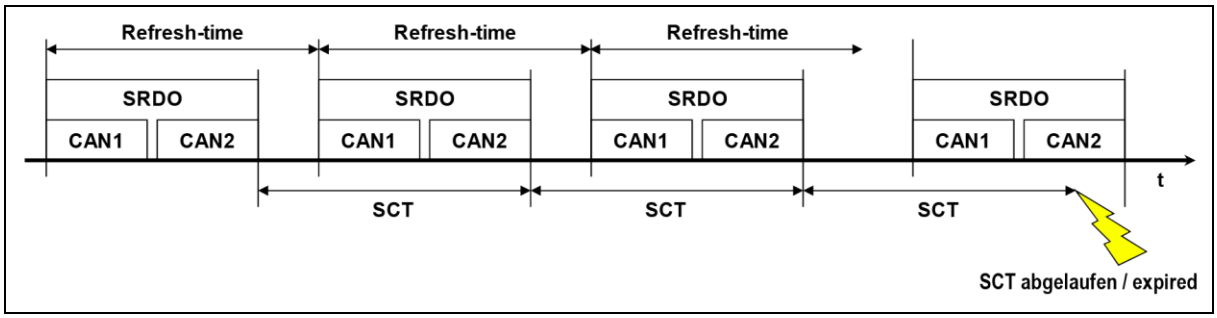


Figure 7: **Refresh time / SCT**

SRVT (1301h-1303h, Subindex 3)

The SRVT defines the maximum interval between the two CAN messages of a Receive SRDO, i.e. the time between the message with the normal data and the message with the bitwise inverted data. Transmit SRDOs are sent directly after one another.

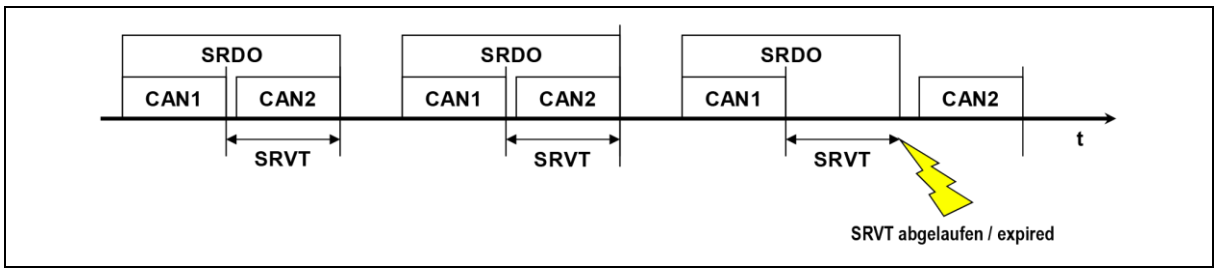


Figure 8: **SRVT**

4.2 Set system configuration as valid

`Object 13FEh: Configuration valid` is used to indicate whether the system configuration of the measuring system is valid or not:

- A5h: System configuration is valid
- 00h: System configuration is invalid

Any write access, even with the same data content, to a safety-relevant communication object (1301h-1303h), incorrect CRC signatures or if `Object 3010h: Active mode` is in state 00h = `OFF, no mapping is active` or 03h = `ERROR`, will automatically result in an invalid system configuration. The measuring system is then in safe state according to chap. "Safe State Definition" on page 141.

Only if the system configuration is set as valid can cyclic PDO or SRDO data be transmitted in `OPERATIONAL` NMT state.

Preconditions / Procedure

1. The prevailing mode for TR / CiA DS406 mode must have been correctly configured, see chap. "Mode Switchover TR / CiA DS406 Encoder Profile" on page 59.

   When the configuration is done, the CRC signature can be calculated for each configured SRDO and written to the corresponding subindexes in `Object 13FFh: Safety configuration signature`.

2. The safety-related application-specific parameters belonging to the prevailing mode must be set to valid, or must match the entered CRC signatures for the set parameter data record:

   If you are in TR mode, the parameters under `Object 2410h: TR safety configuration parameter` must be adapted according to the application-specific requirements, the CRC signature required for the prevailing setting must be calculated and entered in `Object 24FFh: TR safety configuration signature`. The configuration must then be set to valid via `Object 24FEh: TR safety configuration valid` with the value = A5h.

   If you are in CiA DS406 mode, the parameters under `Object 6100h: Safety position configuration parameters` and `Object 6101h: Safety speed configuration parameters` must be adapted according to the application-specific requirements, the CRC signature required for the prevailing setting must be calculated and entered in `Object 61FFh: Safety application configuration signature`. The configuration must then be set to valid via `Object 61FEh: Safety application configuration valid` with the value = A5h.

3. When the **mapping configuration and application-specific parameter configuration** is concluded, the **system configuration** can be set to valid overall via `Object 13FEh: Configuration valid` with the value = A5h.

   When the value is written via an `SDO-WRITE-REQUEST`, comprehensive checks take place. However, only mapping settings that have also been switched to active are included in the check. Mapping settings not switched to active are ignored and therefore do not result in an invalid system configuration. If no errors are detected during the checks, after approx. 800 ms the measuring system answers with a corresponding `SDO-WRITE-RESPONSE` (0x60). If errors are detected, the measuring system answers with a corresponding `ABORT CODE` (0x80 + 4 byte error code).

A status inquiry about the current mapping configuration can be made via `Object 3010h: Active mode`.

5 Installation / Preparation for Commissioning

5.1 Basic rules

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

- All nodes of the safety-related communication must be certified according to IEC 61010 or have a corresponding declaration of conformity.
- All safety devices must also have a certificate from a "Notified Body" (e.g. TÜV, BIA, HSE, INRS, UL, etc.).
- The 24V power supplies used must meet the requirements according to IEC 60364-4-41 SELV/PELV and conform to NEC Class 2 in UL applications.
- The shielding effect of cables must also be guaranteed after installation (bending radii/tensile strength!) and after connector changes. In cases of doubt, use more flexible cables with a higher current carrying capacity.
- For connecting the measuring system only use M12 connectors, which guarantee good contact between the cable shield and connector housing. The cable shield must be connected to the connector housing over a large area.
- Compensating currents due to potential differences across the shield to the measuring system must be avoided.
- A shielded and stranded data cable must be used to ensure high electromagnetic interference stability of the system. The shielding should be connected with low resistance to protective ground using large shield clips at both ends. The shielding should be grounded in the switch cabinet on one side, 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.
- Recommendation, if no special CAN hybrid cable is used: Power and signal cables must be laid separately. During installation the national safety and installation directives for data and energy cables must be observed.
- Observe the manufacturer's instructions for the installation of converters and for shielding power cables between frequency converter and motor.
- Ensure adequate dimensioning of the energy supply.
- Recommendation: Before starting serial operation, the CANopen network must be checked for sufficient bandwidth reserves (bus load determination).

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

To ensure safe and fault-free operation,

- *ISO 11898,*
- *DIN EN IEC 61918*
  (Industrial communication networks, common part)
- *the recommendations of CiA DR 303-1*
  (CANopen cabling and connector pin assignment)
- *and the documents referenced therein must be observed!*

In particular, the applicable EMC directive and the shielding and grounding directives must be observed!

5.2 Cable specification

The CANopen system is wired in bus topology with terminating resistors (120 Ohm) at the beginning and at the end. Spur lines should be avoided if possible. The cable is to be implemented as shielded twisted pair cable and should have a wave impedance of 120 ohms and a resistance of 70 mΩ/m for a max. bus length of 40 m. The data transmission is carried out via differential signals CAN-H and CAN-L and is galvanically isolated from the supply ground (0V). Optionally, a 24 volt supply voltage can also be carried.

A maximum of **127 nodes** can be connected in a CANopen network. The measuring system supports the Node-ID range from 1–127. The transmission speed can be adjusted to a limited extent by DIP switches and to the full extent via LSS protocol or SDO and supports the following baud rates:

- 10 kbit/s
- 20 kbit/s
- 50 kbit/s
- 100 kbit/s
- **1)** 125 kbit/s
- **1)** 250 kbit/s
- **1)** 500 kbit/s
- 800 kbit/s
- **1)** 1 Mbit/s

1) adjustable via DIP switches in addition to LSS/SDO

The length of a CANopen network is dependent on the transmission speed and is shown below:

Cable cross section	10 kbit/s	20 kbit/s	50 kbit/s	100 kbit/s	125 kbit/s	250 kbit/s	500 kbit/s	800 kbit/s	1 Mbit/s
0.25 mm^2 – 0.34 mm^2	5000 m	2500 m	1000 m	ca. 600 m	500 m	250 m	100 m	50 m	25 m

5.3 Connection information

The pin assignment is dependent on the device type and is therefore noted on the type plate of each measuring system as a pin assignment number: TR-ECE-TI-DGB-0387

Download: www.tr-electronic.de/f/TR-ECE-TI-DGB-0387

⚠ WARNING

NOTICE

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

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

5.3.1 Supply voltage

NOTICE

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

- The power supply used must meet the requirements of
  - SELV/PELV (IEC 60364-4-41:2005)
  - NEC Class 2 (design),
    also see chapter "UL / CSA approval" in the Safety Manual

Cable specification: min. 0.34 mm^2 (0.5 mm^2 recommended). Generally the cable cross-section must be matched to the cable length. The use of a shielded cable is recommended for applications in particularly sensitive EMC environments.

Prefabricated hybrid cables offered and recommended by TR Electronic:
www.tr-electronic.en/f/TR-E-TI-DGB-0216

5.3.2 Optional additional interfaces (Incremental, SSI)

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

5.4 Bus termination

If the measuring system is the last node in the CAN segment, the bus must be terminated by an external terminating resistor of 120 ohms. For this purpose TR Electronic offers an appropriate terminator plug (M12x1, 5-pole, A-coded), which can be plugged directly into the CAN_OUT flange socket: Art. no. 62-000-1366

5.5 Setting the Node-ID and baud rate

The Node-ID and baud rate can be set via

- hardware switches, see plug assignment TR-ECE-TI-DGB-0387
- LSS services, see chap. "Layer Setting Services (LSS) and protocols" from page 28
- or SDOs, see chap. "Object 3000h: Node ID" on page 110 and chap. "Object 3001h: Baud rate" on page 110

.

The valid Node-ID address range can be set via two HEX rotary switches 16^0 and 16^1 according to the plug assignment TR-ECE-TI-DGB-0387 from 1 to 127 (01h…7Fh). Two DIP switches 2^0 and 2^1 are provided for setting the baud rate. The four baud rates 125/250/500 and 1000 kbit/s can thus be set, according to the plug assignment.
Both hardware switches are only read at the moment of switch-on, therefore changes during operation are not accepted.

The HEX rotary switch setting 00h has the effect that when the measuring system is restarted, it takes the settings for the Node-ID and baud rate from the internal EEProm memory. The default settings are Node ID = 1 and baud rate = 250 kbit/s. If the settings are made via LSS services or SDOs, the (default) settings in the EEProm memory are overwritten with these values.

Settings of the two HEX rotary switches in the range from 80h to FFh have the effect that the measuring system is put directly into LSS Waiting Mode (ERR LED = Flickering) and responds to LSS requests. The Node-ID is set to FFh, the baud rate corresponds to the set DIP switch value.

In delivery state, the switch settings are active, the Node-ID has the address 1 and the baud rate is set to 250 kbit/s.

Settings via LSS or SDOs can always be made, regardless of the switch settings. The values set via LSS or SDOs are active immediately and overwrite the value set via the hardware switches. However, after a restart the value set via the hardware switches will be active again, if the HEX rotary switches are set to ≠ 0.

1. *If the Node-ID is set via LSS or SDO and the HEX addressing switches simultaneously have the value 0x00,*

or

2. *if, when the supply voltage is switched on, it is found that the switch position has changed in comparison to operation,*

the COB IDs are immediately reset to their default values and the system configuration is set via Object 13FEh to 00h = invalid:

- Process Data Objects (PDOs),
see subindex 1 chap. 7.1.1 on page *49*

- Safety Related Process Data Objects (SRDOs),
see subindex 5 and 6 chap. 7.2.1 from page *54*

- EMCY Messages,
see chap. 9.12 on page 67

- Validity of the system configuration,
see Object 13FEh: Configuration valid Chap. 9.23 on page 72

5.6 Incremental interface / SIN/COS interface (optional)

In addition to the CANopen interface, the measuring system can be equipped with an additional incremental interface for output of the absolute position.

Adjustable parameters, see chapter 0 from page 106.

Alternatively, this can also be designed as a SIN/COS interface. This interface is not parameterizable.

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

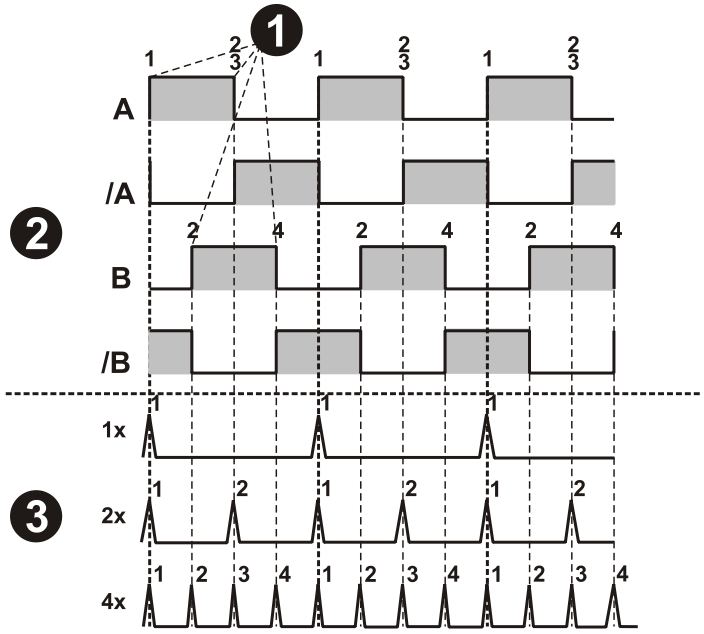
- ➢ The interface is generally used as position feedback for motor control applications.

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

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

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

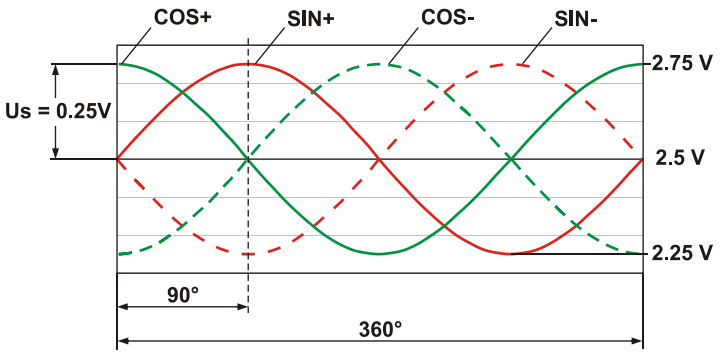
5.6.1 Signal characteristics



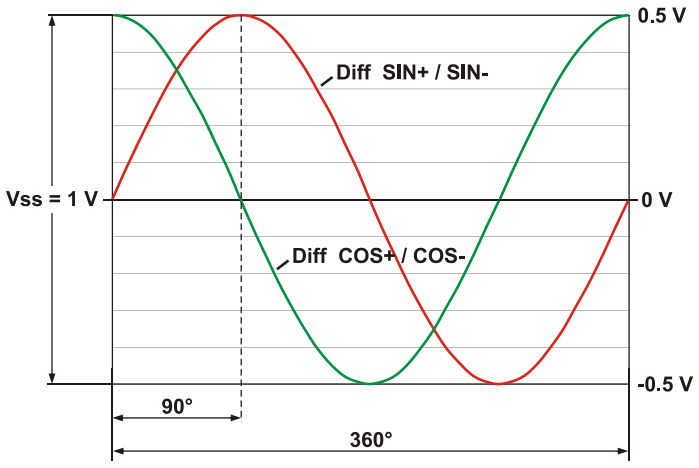
1: Edge evaluation
2: Measuring system with 1024 pulses/rev.
3: Counter evaluation

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

Figure 9: **Counter evaluation, Incremental interface**



Measurement of signals against 0 V



Differential measurement

Figure 10: Level definition, SIN/COS interface

5.6.2 HTL / TTL levels (optional)

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

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

The following diagrams show the different dependencies in relation to three different supply voltages, separated into TTL version and HTL version.

TR's own hybrid cable (art. no.: 64-200-021) was used for the measurements.

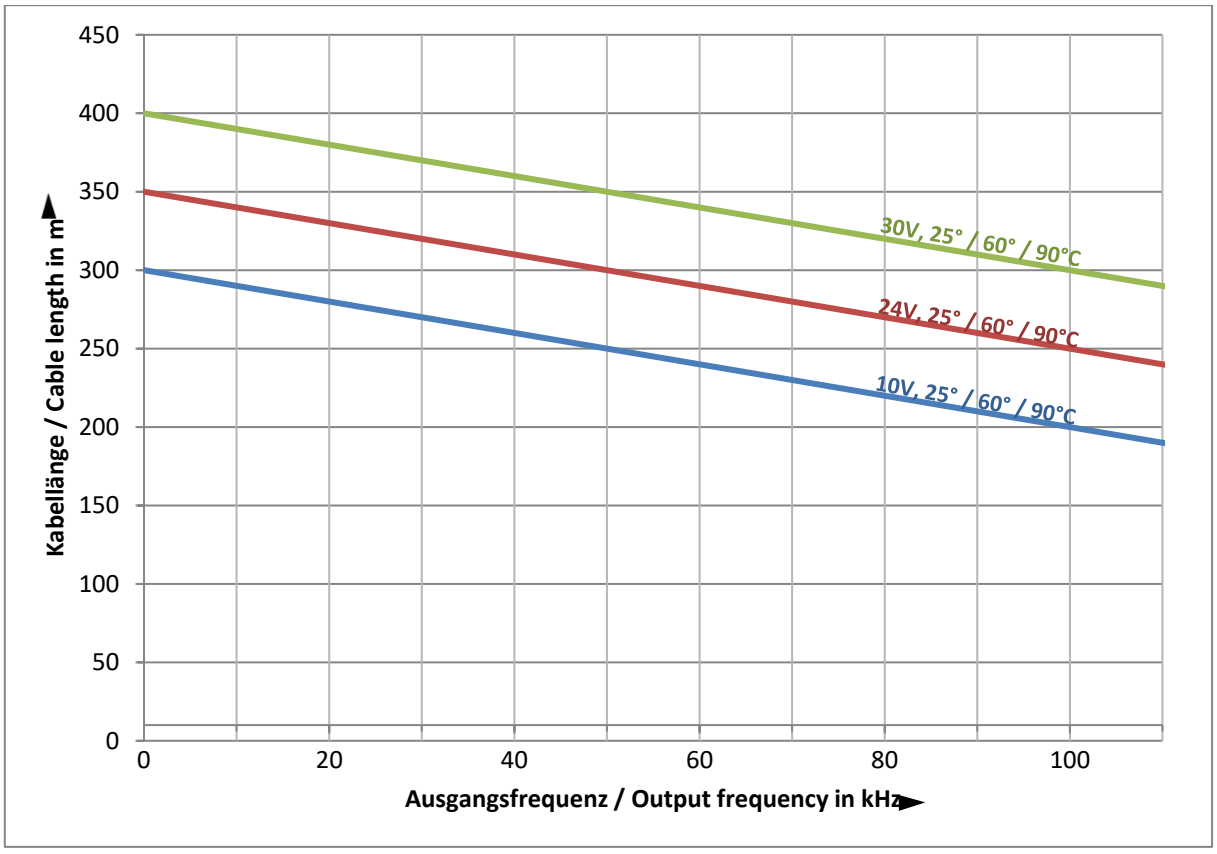


Figure 11: Cable lengths / limit frequencies, TTL version

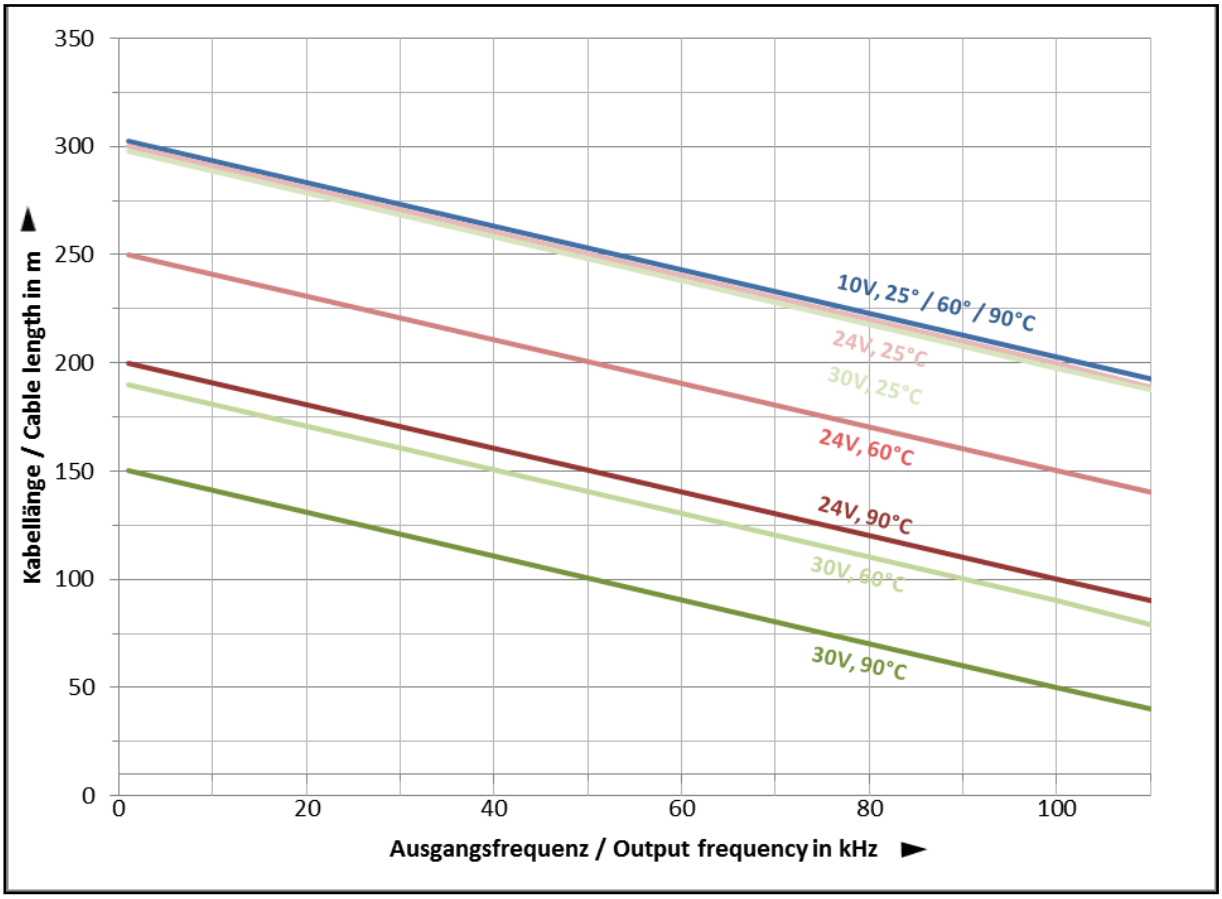


Figure 12: Cable lengths / limit frequencies, HTL version

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

Faultless operation of the incremental interface must therefore be checked with the application-dependent parameters before production mode.

5.7 SSI interface (optional)

Instead of the incremental interface, the measuring system can optionally be equipped with a synchronous-serial absolute SSI interface, in addition to the CANopen interface.

Adjustable parameters, see chapter 0 from page 106.

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

- The interface is generally used for monitoring purposes for the transfer of absolute value data to a second non-safety-related control.

5.7.1 Signal characteristics

Data+ and Clock+ are on High in idle state. This corresponds to the time before point **(1)** in the diagram shown below.

With the first change of the clock signal from High to Low **(1)** the device-internal retriggerable monoflop is set with monoflop time t_M.
The time t_M defines the lowest transmission frequency ($T = t_M / 2$). The upper limit frequency results from the total of all signal transit times and is additionally limited by the integrated filter circuits.

With each additional falling clock edge, the active state of the monoflop is extended by time t_M, and this is the case for point **(4)**.
When the monoflop **(1)** is set, the bit-parallel data present at the internal parallel-serial converter are stored in an input latch of the shift register by an internally generated signal. This ensures that the data do not change during transmission of a position value.

With the first change of the clock signal from Low to High **(2)** the most significant bit (MSB) of the device information is placed at the serial data output. With each additional rising edge, the next lower bit is pushed to the data output.
At the end of the clock sequence the data lines are kept at 0V (Low) for the duration of the mono-time t_M **(4)** . This also gives the minimum pause time t_p, which must be kept between two consecutive clock sequences and is $2 * t_M$.

The data from the evaluation electronics are read in with the first rising clock edge. Due to a number of factors, a delay time t_V >100 ns results, without cables. As a result, the measuring system pushes the data to the output delayed by the time t_V. Therefore, a “Pause-1” is read at time **(2)**. This must be rejected or can be used in conjunction with a “0” after the LSB data bit for line break monitoring. The MSB data bit is only read at time **(3)**. For this reason, the number of clock pulses must always be one higher (n+1) than the number of data bits to be transmitted.

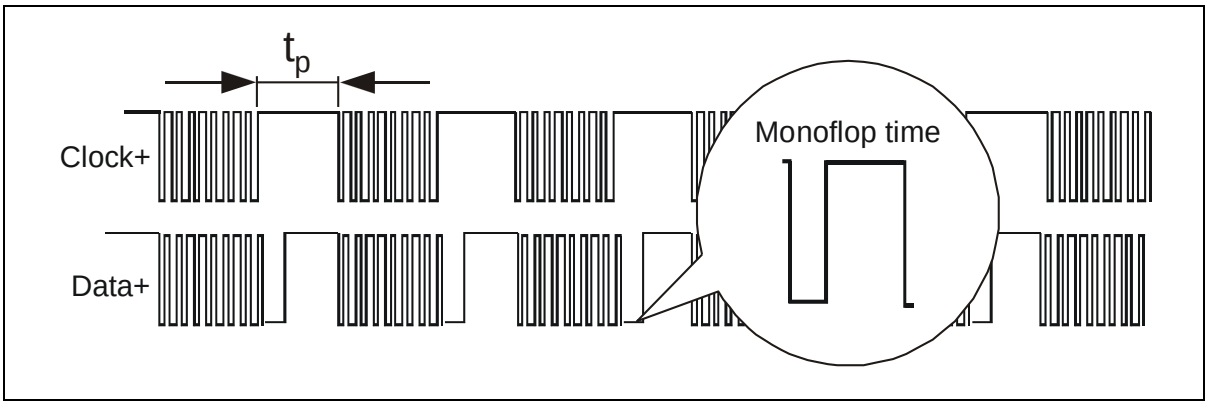


Figure 13: Typical SSI transmission sequences

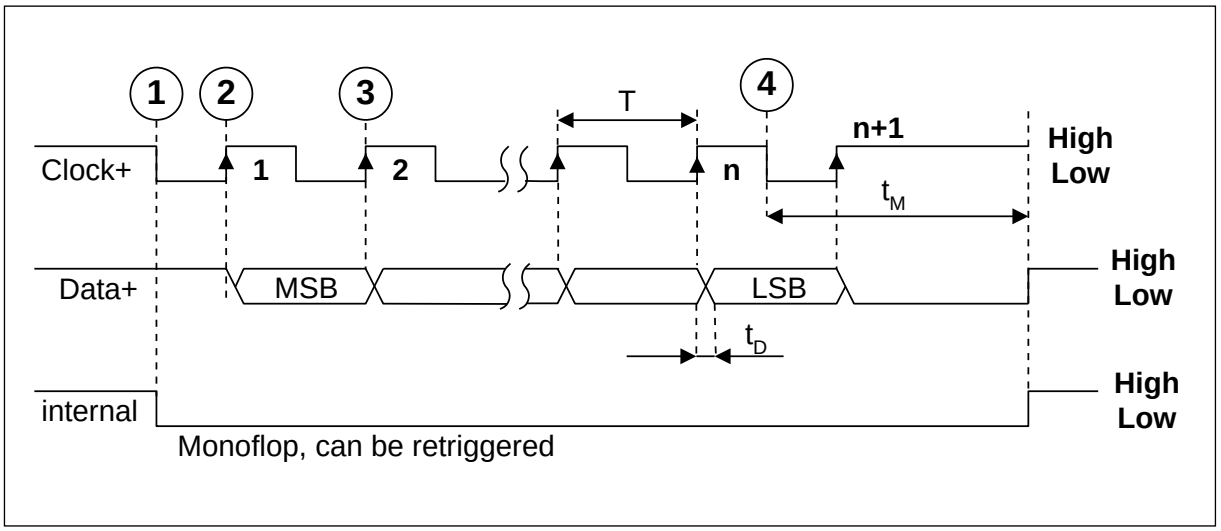


Figure 14: SSI transmission format

5.7.2 Cable lengths

The maximum cable length depends on the SSI clock frequency and the cable composition.

TR's own hybrid cable (art. no.: 64-200-021) was used for the measurements.

SSI clock frequency [kHz]	2000	1000	500	250	125	125	125
Cable length [m]	ca.12.5	ca. 25	ca. 50	ca. 100	ca. 150	ca. 200	ca. 250

Table 8: **SSI clock frequency / cable lengths**

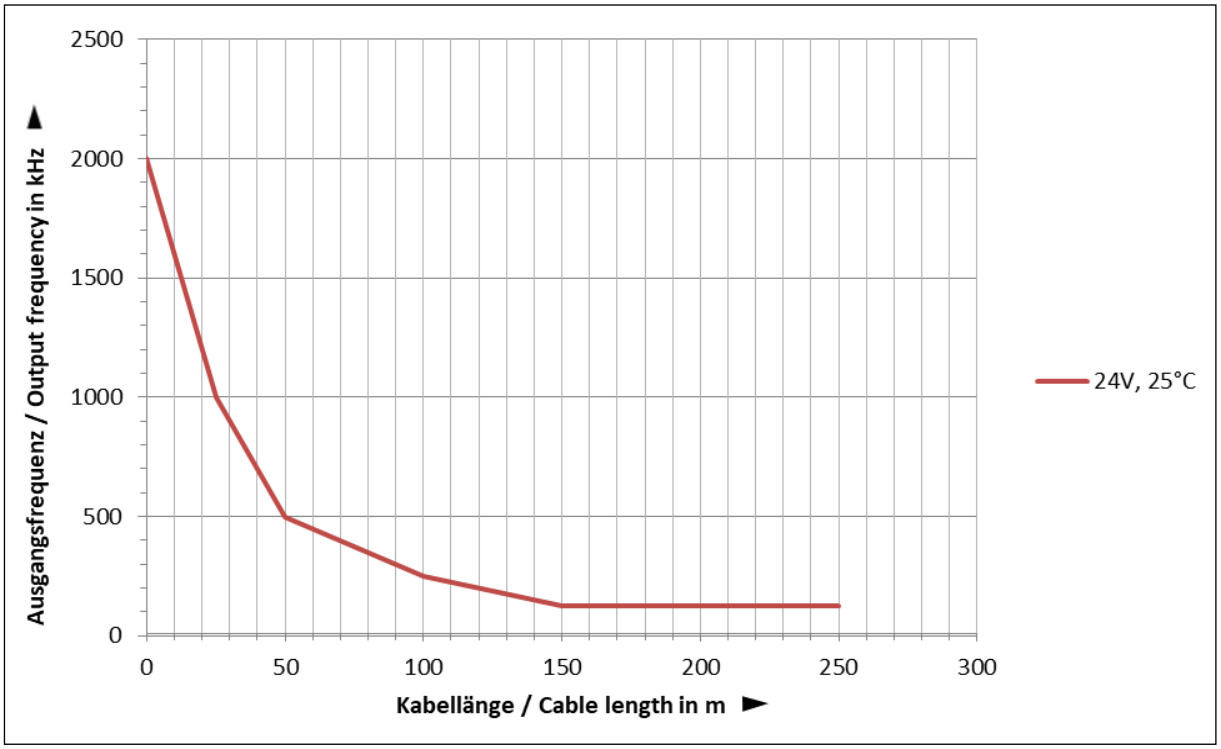


Figure 15: SSI clock frequency / cable lengths

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

Faultless operation of the SSI interface must therefore be checked with the application-dependent parameters before production mode.

5.8 Switching on the supply voltage

Once the connection and hardware switch settings have been made, the supply voltage can be switched on.

After switching on the supply voltage and the end of initialization, the measuring system goes into pre-operational state (PRE-OPERATIONAL). In the default setting, this state is confirmed by the boot-up message "**COB-ID 0x700+Node ID"**. If the measuring system detects an internal error, an Emergency message (8 bytes) is transmitted with an error code, see page 148.

In PRE-OPERATIONAL state only a parametrization via Service Data Objects (SDOs) is initially possible. However, it is possible to configure PDOs or SRDOs using SDOs. If the measuring system has entered OPERATIONAL state, a transmission of PDOs or SRDOs is also possible.

5.8.1 Important default settings for initial boot-up

- Switch settings active: NODE ID = 1, Baud rate = 250 kbit/s
- The system configuration in Object 13FEh: Configuration valid has been set to the value 00h = invalid and, in order to transmit cyclic process data in OPERATIONAL state, must be set to the value A5h = valid. The measuring system is preconfigured in such a way that no further measures are required and the measuring system can be put directly into OPERATIONAL state with the Start Remote Node command.

  If the measuring system is to set the system configuration to valid automatically after switching on the supply voltage, the value A5h in Object 13FE can also be stored permanently with Object 1010h: Store parameters. If no errors are detected during the checks at the next start-up, the measuring system can be put directly into OPERATIONAL state with the Start Remote Node command, otherwise the prevailing system configuration is automatically set to invalid = 00h via Object 13FEh.
- After the Start Remote Node command the measuring system is then in OPERATIONAL state in CiA DS406 mode and the objects for the encoder profile 6xxxh are switched to active.
- The mapping for the NON-safety-related process data (PDOs) in communication parameters 1800h to 1803h is deactivated via the respective VALID-bit in subindex 1, so that **no process data are transmitted**.
- The mapping for the safety-related process data (SRDOs) is set as follows:

Communication parameter	1301h = SRDO1	1302h = SRDO2	1303h = SRDO3
Active	yes	no	no
Direction	Transmit (Tx)	Transmit (Tx)	-
Refresh time/SCT	25 ms	25 ms	-
SRVT	20 ms	20 ms	-
COB-ID1	101h	121h	-
COB-ID2 (inverse data)	102h	122h	-
Mapping object	6120h (4 byte position)	6124h (2 byte speed)	-
Mapping object (inverse data)	6121h	6125h	-

- Setting for fail-safe state = Passive Safe State according to chap. 13.1 on page 141

6 Commissioning

6.1 CAN - interface

The CAN bus interface is defined by the international standard ISO/DIS 11898 and specifies the two lowest layers of the CAN reference model.
The CAN bus interface is galvanically isolated from the measuring system electronics and is fed via an internal DC/DC converter. An external supply voltage is not required for the bus driver.
The CANopen communication profile CiA DS 301 is based on the CAN Application Layer (CAL) and describes how the services are used by devices. The CANopen profile allows the definition of device profiles for a decentralized I/O.
The measuring system with CANopen protocol supports the device profile for encoders (CiA DS 406, Version 4.1.0). **The measuring systems also support the extended scope of functions in Class C3.**
The communication functionality and objects, which are used in the encoder profile, are described in an EDS file (Electronic Data Sheet). If a CANopen configuration tool is used (e.g. CANSETTER), the user can read out the objects (SDOs) of the measuring system and program the functionality.
The transmission rate and Node-ID (device address) are selected via DIP switches, LSS services, or via SDO service.

6.1.1 EDS file

The EDS file (electronic datasheet) contains all information on the measuring system-specific parameters and the operating modes of the measuring system. The EDS file is integrated by the CANopen network configuration tool, in order to enable correct configuration and commissioning of the measuring system.

Download: www.tr-electronic.en/f/TR-ECE-ID-MUL-0075

6.1.2 Bus status display

The measuring system is equipped with two status LEDs:

- **RUN LED** (green), for displaying NMT operating states
- **ERR LED** (red), for displaying error states

Position, assignment and flashing frequency of the LEDs can be found in the device-specific plug assignment:

Download: www.tr-electronic.de/f/TR-ECE-TI-DGB-0387

For appropriate measures in case of error, see chap. "Optical displays", page 142.

6.2 TR CAN Device Tool – Commissioning tool

The TR CAN Device TOOL is a manufacturer-specific parametrization and display tool, which implements the requirements for an external configuration tool according to EN 50325-5 (CANopen Safety). The TR CAN Device TOOL is a standalone Windows application, which establishes a connection to the CANopen Safety measuring system via a CAN interface adapter.

It is recommended to carry out the safety-related mapping configuration and programming of the safety-related application-specific parameters using the configuration options provided by the control system.

If no such options are provided by the control system, the TR CAN Device TOOL can be used as an alternative configuration tool.

The following functions can be simply carried out:

- Calculation of all CRC signatures for the SRDO configuration and application-specific parameters in objects 13FFh, 24FFh and 61FFh
- Downloading of the safety configuration
- Uploading of the safety configuration for verification
- Locking of the safety configuration
- Updating of the device firmware
- Display of the device diagnosis and the operating data

If the safety configuration is "locked" by the TR CAN Device TOOL, it is no longer possible to access the safety-related data via SDO services, in order to protect the safety configuration. If a write access is attempted, the measuring system responds with the abort code: 0x0800 0021h.

Activation is via Object 1011h: Restore default parameters *on page 66.* *The safety configuration is unlocked again via subindex 1 and the "load" signature.*

Download:

- Program: http://www.tr-electronic.de/f/zip/TR-ECE-SW-MUL-0052
- Description: http://www.tr-electronic.de/f/TR-ECE-TI-DGB-0398

7 Communication profile

7.1 NOT safety-oriented

Generally there are two types of Process Data Objects (PDO):

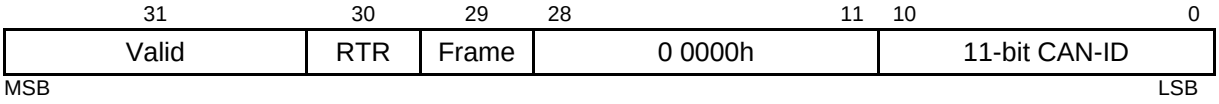
1. Transmit PDOs (TPDO), for transmitting data
2. Receive PDOs (RPDO), for receiving data

Only Transmit PDOs are supported by the measuring system, for transmitting the actual value or speed value.
The TPDOs are defined by TPDO communication parameters 1800h-1803h and TPDO mapping parameters 1A00h-1A03h. While the TPDO communication parameters describe the communication possibilities, the TPDO mapping parameters contain information about the content of the TPDO.

7.1.1 Structure of the communication parameters, 1800h-1803h

Subindex 0 contains the number of valid object entries.

Subindex 1 contains the COB-ID for the TPDO:



Bit(s)	Description
Valid	0: PDO exists / is valid 1: PDO does not exist / is not valid
RTR	0: Remote frame allowed for this PDO 1: No remote frame allowed for this PDO
Frame	0: 11-bit CAN-ID valid, normal CAN frame 1: 29-bit CAN-ID valid, extended CAN frame (not supported)
11-bit CAN-ID	11-bit CAN-ID of normal CAN frame

Object	Default values
1800h	Valid: 1 = PDO does not exist / is not valid RTR: 0 = Remote frame allowed for this PDO Frame: 0 = 11-bit CAN-ID CAN-ID: 180h + Node-ID
1801h	Valid: 1 = PDO does not exist / is not valid RTR: 0 = Remote frame allowed for this PDO Frame: 0 = 11-bit CAN-ID CAN-ID: 280h + Node-ID
1802h	Valid: 1 = PDO does not exist / is not valid RTR: 0 = Remote frame allowed for this PDO Frame: 0 = 11-bit CAN-ID CAN-ID: 380h + Node-ID
1803h	Valid: 1 = PDO does not exist / is not valid RTR: 0 = Remote frame allowed for this PDO Frame: 0 = 11-bit CAN-ID CAN-ID: 480h + Node-ID

Subindex 2 defines the transmission type for the TPDO:

Value	Description
00h	Actual value is transmitted synchronously (acyclically)
01h	Actual value is transmitted synchronously by a remote frame or SYNC telegram
02h	Actual value is transmitted synchronously by a remote frame or cyclically after every 2nd SYNC telegram
03h	Actual value is transmitted synchronously by a remote frame or cyclically after every 3nd SYNC telegram
…	…
F0h	Actual value is transmitted synchronously by a remote frame or cyclically after every 240nd SYNC telegram
FCh	Actual value can only be transmitted by a remote frame (synchronously)
FDh	Actual value can only be transmitted by a remote frame (event-controlled)
FEh	Actual value is transmitted asynchronously with the timer value from objects 1800h-1803h (subindex 5)
FFh	Actual value is transmitted event-controlled

Object	Default values
1800h	FEh: Actual value is transmitted asynchronously
1801h	01h: Actual value is transmitted synchronously
1802h	FEh: Actual value is transmitted asynchronously
1803h	FEh: Actual value is transmitted asynchronously

Subindex 3 contains the inhibit time for the TPDO. The time defines the minimum time between two consecutive PDO transmissions, if transmission type FEh has been set. The value is defined as a multiple of 100 µs. The default value 0 deactivates the inhibit time.
The value may not be changed while the PDO exists (bit 31 of subindex 1 = 0).

Subindex 4 is not supported.

Subindex 5 contains the event timer. The time defines the maximum time between two consecutive PDO transmissions, if transmission type FEh has been set. The value is defined as a multiple of 1 ms. The default value 0 deactivates the event timer.
The event timer, subindex 5 of communication parameter 1800h, is permanently linked to `Object 6200h: Cyclic timer`. This means that any change in the event timer also has an effect on the cyclic timer and vice versa.
Communication parameters 1801h-1803h exclusively use their own timer, access via subindex 5.

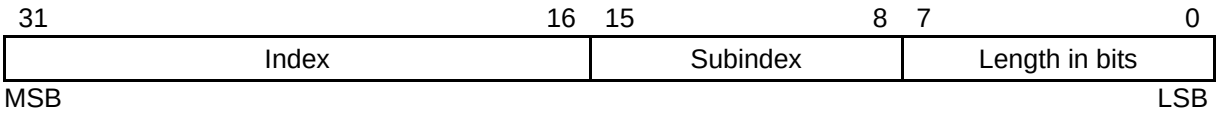
Subindex 6 contains the SYNC start value. The default value SYNC start value = 0 means that the SYNC message counter is not processed for this PDO. SYNC start value 1 to 240 indicates that the SYNC message counter is processed for this PDO. If the SYNC message counter is not activated, see `Object 1019h: Synchronous counter overflow value`, subindex 6 is ignored. The SYNC message whose counter value is equal to the SYNC start value, is considered the first SYNC message received. The value may not be changed as long as the PDO exists (bit 31 of subindex 1 = 0).

7.1.2 Structure of the mapping parameters, 1A00h-1A03h

Subindex 0 contains the number of valid object entries. The value 0 deactivates the mapping.

The following subindexes contain the information for the mapped application objects.

The object describes the content of the PDO by its index, subindex and the length in bits:



Object	Default values, subindex 0
1A00h	1: A mapped application object is active (6004h, position value)
1A01h	1: A mapped application object is active (6004h, position value)
1A02h	0: Mapping deactivated
1A03h	0: Mapping deactivated

7.1.2.1 Changing the mapping setting

Any attempt to change the value of an object entry to an unsupported value is answered with the SDO abort service. The cause of an unsupported value could be the mapping (index and subindex) of a non-existent application object, incorrect length for the mapped application object or an incorrect length for the PDO itself.
For re-mapping, which is supported during `PRE-OPERATIONAL` and `OPERATIONAL` NMT state, follow the procedure below:

- Deactivate the TPDO by setting the "Valid" bit to 1 in subindex 1 of the corresponding communication parameter 1800h-1803h.
- Deactivate the mapping function by setting subindex 0 to 0 in the corresponding mapping parameters 1A00h-1A03h.
- Change the mapping in the corresponding mapping parameters 1A00h-1A03h (from subindex 1).
- Activate the mapping function by setting subindex 0 to the number of mapped objects in the corresponding mapping parameters 1A00h-1A03h.
- Generate the TPDO by setting the "Valid" bit to 0 in subindex 1 of the corresponding communication parameter 1800h-1803h. The desired COB-ID and the "Valid" bit must be set with a write process!
- Save the mapping configuration via "Object 1010h: Store parameters".
- As the NON-safety-related mapping configuration is part of the system configuration, the whole configuration must also be declared as valid according to chap. "4.2" on page 34.

Objects intended for NON-safety-related mapping:

TR mode
- Object 2041h: TR TPDO values, see from page 86
  - Subindex 1: Sensor status
  - Subindex 2: Position
  - Subindex 3: Velocity 32 Bit
  - Subindex 4: Velocity 16 Bit
- Object 2211h: TR alarms, see page 129
- Object 2212h: TR warnings, see page 130

CiA DS406 mode
- Object 6004h: Position value, see page 116
- Object 600Ch: Position raw value, see page 116
- Object 6030h: Speed value, see page 117
- Object 6400h: Area state register, see page 120
- Object 6503h: Alarm, see page 132
- Object 6505h: Warnings, see page 134

7.1.3 Transmission types - position output

7.1.3.1 First Transmit Process Data Object

This TPDO transmits the measuring system actual value asynchronously in the default setting. The timer value is stored in subindex 5 or index 6200h. The default setting of the timer is 0, i.e. the timer is switched off.

Object	Subindex	Comment	Default value	Attr.
1800h	0	Largest subindex supported	6	ro
	1	COB-ID used by TPDO 1	180h + Node-ID	rw
	2	Transmission type	254	rw
	3	Inhibit time	0	rw
	4	-	-	-
	5	Event timer	0	rw
	6	SYNC start value	0	rw
1A00h	0	Largest subindex supported	1 (max. 4)	rw
	1	1st mapped object	6004 0020h	rw
	2	2nd mapped object	0000 0000h	rw
	3	3rd mapped object	0000 0000h	rw
	4	4th mapped object	0000 0000h	rw

7.1.3.2 Second Transmit Process Data Object

This TPDO transmits the measuring system actual value synchronously (once on request) in the default setting. Request by remote frame (default COB-ID: 280h+Node-ID) or SYNC telegram (default COB-ID: 080h).

Object	Subindex	Comment	Default value	Attr.
1801h	0	Largest subindex supported	6	ro
	1	COB-ID used by TPDO 2	280h + Node-ID	rw
	2	Transmission type	1	rw
	3	Inhibit time	0	rw
	4	-	-	-
	5	Event Timer	0	rw
	6	SYNC start value	0	rw
1A01h	0	Largest subindex supported	1 (max. 4)	rw
	1	1. mapped object	6004 0020h	rw
	2	2. mapped object	0000 0000h	rw
	3	3. mapped object	0000 0000h	rw
	4	4. mapped object	0000 0000h	rw

7.2 Safety-oriented

Generally there are two types of Safety Related Process Data Objects (SRDO):

1. Transmit SRDOs, for transmitting data
2. Receive SRDOs, for receiving data

The information direction (transmit/receive) is defined in the communication parameters (1301h-1303h) in subindex 1.

The measuring system supports Transmit SRDOs for position, speed and status output and Receive SRDOs for the preset control and preset value.
The SRDOs are defined by communication parameters 1301h-1303h and mapping parameters 1381h-1383h. While the SRDO communication parameters describe the communication possibilities, the SRDO mapping parameters contain information about the content of the SRDO.

7.2.1 Structure of the communication parameters, 1301h-1303h

Subindex 0 contains the number of valid object entries.

Subindex 1 specifies whether the SRDO is declared as a Transmit SRDO, a Receive SRDO or as invalid. If the entry is declared as invalid, the mapping is switched off and no cyclic data can be transmitted.

Value	Description
00h	Not valid, mapping is switched off
01h	Valid, SRDO is set as Transmit SRDO (Tx, Producer)
02h	Valid, SRDO is set as Receive SRDO (Rx, Consumer)

Object	Default values
1301h	01h: Transmit SRDO
1302h	00h: Mapping switched off
1303h	00h: Mapping switched off

Subindex 2 defines the SRDO `Refresh Time` in the transmit direction and the `Safeguard Cycle Time` (SCT) in the receive direction. The time can be set from 0 to 65535 ms. Depending on the system, you can expect the set time on the CAN bus to actually deviate by ± 1 ms.

Object	Default values
1301h	25 ms
1302h	25 ms
1303h	50 ms

Subindex 3 defines the SRDO `Safety Related Validation Time` (SRVT) and therefore specifies the validation time for the two CAN telegrams on the receive side. The time can be set from 1 to 255 ms. Regardless of the information direction (send/receive), this time must always be less than the set `Safeguard Cycle Time` under subindex 2.

Object	Default values
1301h	20 ms
1302h	20 ms
1303h	20 ms

Subindex 4 defines the SRDO transmission type and is invariably set to `FEh` for all communication objects. Thus SRDOs in the transmit direction are transmitted with the `Refresh Time` (cycle time) set under subindex 2 and in the receive direction the monitoring time window is preset for SRDO receipt with the `Safeguard Cycle Time` set under sub-index 2.

Subindex 5 specifies the COB-ID which is used by the SRDO for normal safety-related data (1st CAN data frame, COB-ID1) and must be an odd number in the range from 101h to 17Fh. The value for COD-ID1 can only be written if the mapping has been declared as invalid by subindex 1 with the value = 00h.

Object	Default values
1301h	FFh + (2 * Node-ID)
1302h	11Fh + (2 * Node-ID)
1303h	13Fh + (2 * Node-ID)

Subindex 6 specifies the COB-ID which is used by the SRDO for bitwise inverted data (2nd CAN data frame, COB-ID2) and must be the even number following the COB-ID specified in subindex 5. The COB-ID must be in the range from 102h to 180h. The value for COD-ID2 can only be written, if the mapping has been declared as invalid by subindex 1 with the value = 00h.

Object	Default values
1301h	100h + (2 * Node-ID)
1302h	120h + (2 * Node-ID)
1303h	140h + (2 * Node-ID)

Notes on assigning COB-IDs in subindex 5 and 6

The measuring system requires two Transmit SRDOs (Tx) for position and speed output and one Receive SRDO (Rx) for setting the preset value and triggering the preset function. Max. three SRDOs are thus required in total. The following procedure is recommended, in order to ensure overlap-free assignment of the COB-IDs for Node-IDs 1 to 16:

*FFh + (2 * Node-ID) for SRDO1 Tx*
*100h + (2 * Node-ID) for SRDO1 Tx, bitwise inverted transmission*

*11Fh + (2 * Node-ID) for SRDO2 Tx*
*120h + (2 * Node-ID) for SRDO2 Tx, bitwise inverted transmission*

*13Fh + (2 * Node-ID) for SRDO3 Rx*
*140h + (2 * Node-ID) for SRDO3 Tx, bitwise inverted transmission*

From Node-ID 17 the calculation value for the Node-ID = [1](Node-ID % 16)

[1] "%" means modulo, division with remainder

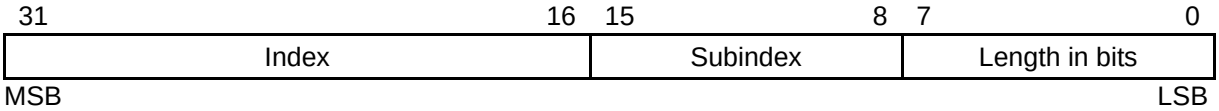
In this case a unique COB-ID must be ensured!

7.2.2 Structure of the mapping parameters, 1381h-1383h

Subindex 0 contains the number of valid object entries. The value 0 deactivates the mapping.

The following subindexes contain the information for the mapped application objects. As the bitwise inverted data must also be transmitted during safety-related data transmission, twice the number of application objects must be provided, as would normally be necessary for the pure user data.

The object describes the content of the SRDO by its index, subindex and the length in bits:



Object	Default values, subindex 0
1381h	8: eight mapped application objects active
1382h	4: four mapped application objects active
1383h	0: Mapping deactivated

SRDO1 default settings with set Node-ID = 1:
Transmission of the safety-related position from object 6120h

Object	Subindex	Comment	Default value	Attr.
1301h	0	Largest subindex supported	6	ro
	1	Information direction	1, Tx SRDO	rw
	2	Refresh time / SCT	25 ms	rw
	3	SRVT	20 ms	rw
	4	Transmission type	FEh	ro
	5	COB-ID 1 for normal transmission	101h	rw
	6	COB-ID 2 for bitwise inverted transmission	102h	rw
1381h	0	Largest subindex supported	8 (max. 8)	rw
	1	1. SR ADO, normal (position, byte 1 of 4)	61200108h	rw
	2	1. SR ADO, bitwise inverted	61210108h	rw
	3	2. SR ADO, normal (position, byte 2 of 4)	61200208h	rw
	4	2. SR ADO, bitwise inverted	61210208h	rw
	5	3. SR ADO, normal (position, byte 3 of 4)	61200308h	rw
	6	3. SR ADO, bitwise inverted	61210308h	rw
	7	4. SR ADO, normal (position, byte 4 of 4)	61200408h	rw
	8	4. SR ADO, bitwise inverted	61210408h	rw

SRDO 2 default settings with set Node-ID = 1:
Transmission of the safety-related speed from object 6124h, if the mapping has been enabled via subindex 1 = 1.

Object	Subindex	Comment	Default value	Attr.
1302h	0	Largest subindex supported	6	ro
	1	Information direction	0, deactivated	rw
	2	Refresh time / SCT	25 ms	rw
	3	SRVT	20 ms	rw
	4	Transmission type	FEh	ro
	5	COB-ID 1 for normal transmission	121h	rw
	6	COB-ID 2 for bitwise inverted transmission	122h	rw
1382h	0	Largest subindex supported	4 (max. 8)	rw
	1	1. SR ADO, normal (speed, byte 1 of 2)	61240108h	rw
	2	1. SR ADO, bitwise inverted	61250108h	rw
	3	2. SR ADO, normal (speed, byte 2 of 2)	61240208h	rw
	4	2. SR ADO, bitwise inverted	61250208h	rw

7.2.2.1 Changing the mapping setting

It is recommended that safety-related mapping is performed with tool support, using an appropriate configuration tool. If the control system does not provide such a configuration tool, the `TR CAN Device TOOL` provided by TR Electronic can be used, see chap. 6.2 on page 48. This tool allows you to easily set the mapping, carry out safety-related parametrization, calculate the individual CRC signatures and perform verification.

Any attempt to change the value of an object entry to an unsupported value is answered with the SDO abort service. The cause of an unsupported value could be the mapping (index and subindex) of a non-existent application object, an incorrect length for the mapped application object or an incorrect length for the PDO itself.
For re-mapping, which is only supported during `PRE-OPERATIONAL` NMT state, follow the procedure below:

Generally, if the content of a safety-related communication parameter changes, the system configuration is set via `Object 13FEh: Configuration valid` to the **value 00h = invalid**, even if the resulting CRC signature would be correct.

- Delete the mapping by setting the value 00h in subindex 1 `Information direction` of the corresponding communication parameter 1301h-1303h.
- Deactivate the mapping function by setting subindex 0 to 0 in the corresponding mapping parameters 1381h-1383h.
- Change the mapping in the corresponding mapping parameters 1381h-1383h from subindex 1.
- Activate the mapping function by setting subindex 0 to the number of mapped objects in the corresponding mapping parameters 1381h-1383h.
- Generate the mapping by setting the desired value in subindex 1 `Information direction` of the corresponding communication parameter 1301h-1303h.
  Value 01h = Transmit SRDO, value 02h = Receive SRDO.
- Save mapping configuration via `Object 1010h: Store parameters`.
- Set system configuration to valid according to chap. 4.2 on page 34.

Objects intended for safety-related mapping:

TR mode

- Object 2420h: TR safety status / 2421h, see from page 98
- Object 2422h: TR safety position / 2423h, see from page 100
- Object 2424h: TR safety velocity 32Bit / 2425h, see from page 100
- Object 2426h: TR safety velocity 16Bit / 2427h, see from page 101
- Object 2430h: TR safety control / 2431h, see from page 99
- Object 2432h: TR safety preset value / 2433h, see from page 101

CiA DS406 mode

- Object 6120h: Safety normal resolution position value / 6121h, see page 125
- Object 6124h: Safety speed value / 6125h, see from page 126

8 Mode Switchover TR / CiA DS406 Encoder Profile

The prevailing mode is determined by the mapping settings. Either just TR-related or just CiA DS406-related mapping objects may be included in the **active mapping**. This applies for both safety-related and NON-safety-related mapping objects. If the NON-safety-related channel is not required, the mapping can be deactivated via communication parameters 1800h-1803h, subindex 1, VALID bit 31 = 1.

The safety-related mapping is generally carried out for both modes via communication parameters 1301h to 1303h and mapping parameters 1381h to 1383h. The NON-safety-related mapping is generally carried out for both modes via communication parameters 1800h to 1803h and mapping parameters 1A00h to 1A03h.

The safety-related mapping can either be carried out with tool support or manually according to specification, as described under chap. "Changing the mapping setting" on page 58.

The NON-safety-related mapping can only be carried out manually, according to specification, as described under chap. "Changing the mapping setting" on page 52.

Once the mapping settings are completed, the system configuration must be declared as valid according to chap. 4.2 on page 34.

Valid mapping objects for TR mode

Safety-related

- Object 2420h: TR safety status / 2421h, see from page 98
- Object 2422h: TR safety position / 2423h, see from page 100
- Object 2424h: TR safety velocity 32Bit / 2425h, see from page 100
- Object 2426h: TR safety velocity 16Bit / 2427h, see from page 101
- Object 2430h: TR safety control / 2431h, see from page 99
- Object 2432h: TR safety preset value / 2433h, see from page 101

NON-safety-related

- Object 2041h: TR TPDO values, see from page 86
- Object 2211h: TR alarms, see page 129
- Object 2212h: TR warnings, see page 130

Valid mapping objects for CiA DS406 mode

Safety-oriented

- Object 6120h: Safety normal resolution position value / 6121h, see page 125
- Object 6124h: Safety speed value / 6125h, see from page 126

NOT safety-oriented

- Object 6004h: Position value, see page 116
- Object 600Ch: Position raw value, see page 116
- Object 6030h: Speed value, see page 117
- Object 6400h: Area state register, see page 120
- Object 6503h: Alarm, see page 132
- Object 6505h: Warnings, see page 134

9 Communication-specific standard objects (CiA DS-301)

Index (h)	Object	Name	Type	Attr.	Page
1000	VAR	Device type	Unsigned32	ro	61
1001	VAR	Error register	Unsigned8	ro	61
1003	ARRAY	Pre-defined error field	Unsigned32	rw	62
1005	VAR	COB-ID SYNC	Unsigned32	rw	62
[1)] 1008	VAR	Manufacturer device name	VisibleString	const	63
[1)] 1009	VAR	Manufacturer hardware version	VisibleString	const	63
[1)] 100A	VAR	Manufacturer software version	VisibleString	const	63
100C	VAR	Guard time	Unsigned16	rw	63
100D	VAR	Life time factor	Unsigned8	rw	64
1010	ARRAY	Store parameters	Unsigned32	rw	64
1011	ARRAY	Restore default parameters	Unsigned32	rw	66
1014	VAR	COB-ID emergency message	Unsigned32	rw	67
1015	VAR	Inhibit time EMCY	Unsigned16	rw	67
1016	ARRAY	Consumer heartbeat time	Unsigned32	rw	68
1017	VAR	Producer heartbeat time	Unsigned16	rw	68
1018	RECORD	Identity object	Identity (23h)	ro	69
1019	VAR	Synchronous counter overflow value	Unsigned8	rw	69
1020	ARRAY	Verify configuration	Unsigned32	rw	70
[1)] 1021	VAR	Store EDS	Domain	ro	70
1022	VAR	Store format	Unsigned8	ro	70
1029	ARRAY	Error behavior	Unsigned8	rw	71
1300	VAR	Global failsafe command parameter	Unsigned8	rw	71
13FE	VAR	Configuration valid	Unsigned8	rw	72
13FF	ARRAY	Safety configuration signature	Unsigned16	rw	73
1F80	VAR	NMT startup	Unsigned32	rw	72

Table 9: Communication-specific standard objects

Write parameters must be permanently stored after modification via `Object 1010h: Store parameters`!

[1)] segmented reading

9.1 Object 1000h: Device type

The object with index 1000h describes the `device type` and its functionality. It comprises a 16 bit field, which describes the device profile used (device profile no. 406 = 196h) and a second 16 bit field, which provides information on the device type.

Unsigned32, read only

31 30 29 27 26 24 23 16 15 0				
Res.	SRDO	PDO	Encoder type	Device profile number
Additional information				196h (CiA DS406)

MSB LSB

Encoder type: 02h = Absolute Multi-Turn Encoder
PDO: 000b = Standard PDO mapping
SRDO: 110b = Standard SRDO mapping
Res.: Reserve

9.2 Object 1001h: Error register

The object `error register` displays the error status of the measuring system in bit code. Several errors can also be displayed simultaneously by a set bit. The more detailed error cause can be found in bits 0 – 15 in object 0x1003. At the time of occurrence, an error is indicated by an EMCY message. If a manufacturer-specific error occurs, the manufacturer-specific error field (bytes 3 to 7) must also be evaluated in the EMCY message, see chap. "Emergency message (8 bytes)" on page 148.

Unsigned8

Bit	Meaning
0	General error
1	0
2	Supply voltage
3	Temperature
4	Communication error (overflow, error status)
5	0
6	0
7	Manufacturer-specific

9.3 Object 1003h: Pre-defined error field

The `Pre-defined error field` object stores the last occurring measuring system error and displays the error via the emergency object. Each new error is stored in subindex 1, older errors are moved to the next highest subindex. Subindex 0 contains the number of errors that have occurred. Object 1003 is part of the Emergency message (8 bytes), see chap. 14.3 on page 148.

Index	Subindex	Comment	Type	Attr.
1003h	0	Number of errors	Unsigned8	ro
	1 to 4	Standard error field	Unsigned32	rw

Subindex 0: The entry in subindex 0 contains the number of errors that have occurred and registers them in subindex 1 to 4.

Subindex 1-4: The error field consists of a 16-bit error code and a 16-bit additional error message: Error no. and module no.

Unsigned32

Standard error field			
Byte 0	byte 1	Byte 2	Byte 3
Error code		Error no.	Module no.

9.4 Object 1005h: COB-ID SYNC

The object `COB-ID SYNC message` defines the COB-ID of the synchronization object (SYNC). It also defines whether the device processes the SYNC message, or if the device generates the SYNC. However, the measuring system only supports processing of SYNC messages and uses the 11-bit identifier.

Unsigned32

MSB LSB

31	30	29	28-11	10-0
X	0	0	0	00 1000 0000

Bit 31 No meaning
Bit 30 = 0, device does not generate a SYNC message
Bit 29 = 0, 11 Bit ID (CAN 2.0A)
Bit 28 –11 = 0
Bit 10 – 0 = 11 Bit SYNC-COB-IDENTIFIER, default value = 080h

Object	Function code	COB-ID
SYNC	0001	80h

9.5 Object 1008h: Manufacturer device name

Contains the `manufacturer device name` (visible string),
Transmission via "Segment Protocol".

9.6 Object 1009h: Manufacturer hardware version

Contains the `manufacturer hardware version` (visible string),
Transmission via "Segment Protocol".

9.7 Object 100Ah: Manufacturer software version

Contains the `manufacturer firmware no.` (visible string),
Transmission via "Segment Protocol".

9.8 Object 100Ch: Guard time

The objects of indexes 100Ch Guard Time and 100Dh Life Time Factor contain the `monitoring time` in milliseconds and the `time duration factor`. The `time duration factor` multiplied by the `monitoring time` gives the time duration for the Node Guarding protocol.
Default value = 0.

Unsigned16

Guard time	
Byte 0	byte 1
2^7 to 2^0	2^{15} to 2^8

9.9 Object 100Dh: Life Time Factor

The `time duration factor` multiplied by the `monitoring time` gives the time duration for the Node Guarding protocol. Default value = 0.

Unsigned8

Life time factor
Byte 0
2^7 to 2^0

9.10 Object 1010h: Store parameters

This object supports `Store parameters` in the non-volatile memory (EEPROM).

Index	Subindex	Comment	Type	Attr.
1010h	0	Largest subindex supported	Unsigned8	ro
	1	Store all parameters	Unsigned32	rw
	2	Store communication parameters (Objects: 1000h…1FFFh)	Unsigned32	rw
	3	Store device-specific parameters (Objects: 6000h…9FFFh)	Unsigned32	rw
	4	Store manufacturer-specific parameters (Objects: 2000h…5FFFh)	Unsigned32	rw

Subindex 0: The entry in subindex 0 contains the largest supported subindex. Value = 4.

Subindex 1…4: Contains the store command

Upon read access to subindex 1 the device provides information about its storage capability.

Bit 0 = 1, the device only stores parameters on command. This means that if parameters have been changed by the user and the "Store parameters" command has not been executed, the parameters will have the old values again when the operating voltage is next switched on.

Unsigned32

MSB LSB

Bits	31-2	1	0
Value	= 0	0	1

In order to avoid storage of parameters by mistake, storage is only executed when a specific signature is written to the relevant subindex. This signature is "save".

Unsigned32

MSB LSB

e	v	a	s
65h	76h	61h	73h

Upon receipt of the correct signature, the device stores the parameters. If storage failed, the device responds with abort transmission: Error code 0606 0000 h.

If a wrong signature was written, the device rejects storage and responds with abort transmission: Error code 0800 0020 h.

9.11 Object 1011h: Restore default parameters

This object supports `restoring of the parameter default values`.

Index	Subindex	Comment	Type	Attr.
1011h	0	Largest subindex supported	Unsigned8	ro
	1	Restore all parameters	Unsigned32	rw
	2	Restore communication parameters (objects: 1000h…1FFFh)	Unsigned32	rw
	3	Restore device-specific parameters (objects: 6000h…9FFFh)	Unsigned32	rw
	4	Restore manufacturer-specific parameters (objects: 2000h…5FFFh)	Unsigned32	rw

Subindex 0: The entry in subindex 0 contains the largest supported subindex. Value = 4.

Subindex 1…4: Contains the restore command

Upon read access to subindex 1, the device provides information about its options for restoring default values.

Bit 0 = 1 means that the device supports restoring of default values.

Unsigned32

MSB LSB

Bits	31-1	0
Value	= 0	1

In order to avoid restoring of parameter values by mistake, restoring is only executed when a specific signature is written to the relevant subindex. This signature is "load".

Unsigned32

MSB LSB

d	a	o	l
64h	61h	6Fh	6Ch

Upon receipt of the correct signature, the corresponding default values are restored. If restoring failed, the device responds with abort transmission: Error code 0606 0000 h.

If a wrong signature was written, the device rejects restoring and responds with abort transmission: Error code 0800 0020 h.

9.12 Object 1014h: COB-ID emergency message

This object displays the configured COB-ID for the EMCY message write service. Default value = 80h + Node-ID.

EMCY Identifier, rw:

31	30	29	28 ... 11	10 ... 0
Valid	0	Frame	0 0000h	11-bit CAN-ID
MSB				LSB

Bit(s)	Description
Valid	0: EMCY exists / is valid 1: EMCY does not exist / is not valid
30	reserved, always 0
Frame	0: 11-bit CAN-ID valid, normal CAN frame 1: 29-bit CAN-ID valid, extended CAN frame (not supported)
11-bit CAN-ID	11-bit CAN-ID of normal CAN frame

Bits 0-29 must not be changed while the object exists and is valid (bit 31 = 0). If a new value is to be written, bit 31 must be set to 1 together with the new value. The Node-ID must also be taken into account in the entry.

9.13 Object 1015h: Inhibit time EMCY

This object defines the inhibit time for emergency messages. The value is specified in the unit 100 µs. The input value 10, for example, corresponds to the inhibit time 1000 µs. The default value is 0 and deactivates the inhibit time.

Unsigned16

Inhibit time EMCY	
Byte 0	byte 1
2^7 to 2^0	2^{15} to 2^8

9.14 Object 1016h: Consumer heartbeat time

The Consumer heartbeat time object defines the expected Producer heartbeat cycle time. Monitoring of the Heartbeat producer starts on receipt of the first heartbeat. The Consumer heartbeat cycle time should be greater than the corresponding Producer heartbeat cycle time. If the heartbeat is not received within the Consumer heartbeat cycle time, Emergency 8130h is output. The Producer/Consumer timer values are then set to 0.

Index	Subindex	Comment	Type	Attribute
1016h	0	Largest supported subindex	Unsigned8	ro
	1	Consumer Heartbeat Time	Unsigned32	rw
	2	Consumer Heartbeat Time	Unsigned32	rw

Consumer Heartbeat Time:

31 24	23 16	15 0
reserved, 00h	Node ID, Default = 0	Heartbeat time [ms], Default = 0
MSB		LSB

The heartbeat time must be set as a multiple of 1 ms. The entry for the Node-ID corresponds to the Node-ID of the node to be monitored. For the value to be valid, the Node-ID must be between 1 and 127 and the Heartbeat time must be unequal to 0.

9.15 Object 1017h: Producer heartbeat time

The object defines the Producer heartbeat cycle time and is set as a multiple of 1 ms. The value 0 deactivates the Producer heartbeat cycle time.

Immediately after configuration of the cycle time (value > 0), cyclic transmission of the heartbeat message is started.

If the cycle time has been configured, heartbeat messages are transmitted after switching on the device and changing to PRE-OPERATIONAL state. In this case the boot-up message is considered the first heartbeat message.

Unsigned16

Producer heartbeat time	
Byte 0	byte 1
2^7 to 2^0	2^{15} to 2^8

It is not permitted to use both error control mechanisms "Guarding Protocol" and "Heartbeat Protocol" at one node at the same time. If the Producer Heartbeat Cycle time is unequal to 0, the Heartbeat Protocol is therefore used.

9.16 Object 1018h: Identity object

This object contains general information about the device.

Index	Subindex	Comment	Type	Attribute
1018h	0	Largest subindex supported	Unsigned8	ro
	1	Vendor-ID	Unsigned32	ro
	2	Product Code	Unsigned32	ro
	3	Revision-No.	Unsigned32	ro
	4	Serial-No.	Unsigned32	ro

Subindex0: The entry in subindex 0 contains the largest supported subindex:
Value 4.

Subindex1: Upon read access, the device provides the manufacturer's Vendor-ID:
0x0000025C

Subindex2: Upon read access, the device provides information about the product code:
device-specific

Subindex3: Upon read access, the device provides information about the revision no.:
current revision no.

Subindex4: Upon read access, the device provides information about the serial no.:
current serial no.

9.17 Object 1019h: Synchronous counter overflow value

This object defines whether the `SYNC message` for the SYNC consumer should be transmitted with a data length of 0 or 1 byte.
The measuring system monitors whether the value is the right length. Otherwise, the value is used when object 180xh subindex 6 `SYNC start value` is active, to output or start the value only for the corresponding SYNC value.

Value	Meaning
0	The SYNC message should be transmitted as a CAN message with data length "0".
1	reserved
2-240	The SYNC message should be transmitted as a CAN message with data length "1".
241-255	reserved

Default value = 0

9.18 Object 1020h: Verify configuration

This object specifies the date and time of the downloaded configuration. A network configuration tool or a CANopen manager can use this object to check the configuration after a CANopen device reset and to determine whether a reconfiguration is necessary.
The configuration tool saves the time and date in this object and saves the same values in the device configuration file (DCF). The measuring system configuration can be saved by writing the "save" signature to index 1010h subindex 01h via the configuration tool.
After a `RESET` the measuring system restores the last configuration and the signature, automatically or on request. If another command changes the values of the boot-up configuration, the measuring system resets the object `Verify Configuration` to 0. The Configuration Manager compares the signature and configuration with the value from the DCF and decides whether or not a reconfiguration is necessary.

Use of this object speeds up the boot-up process considerably. If it is used, the system integrator assumes that a user has changed a configuration value and then activates the command `Store configuration 1010h` without changing the value from 1020h. The system integrator thus guarantees completely consistent use of this function.

Index	Subindex	Comment	Default	Type	Attr.
1020h	0	Largest subindex supported	2	Unsigned8	ro
	1	Configuration date	00h	Unsigned32	rw
	2	Configuration time	00h	Unsigned32	rw

9.19 Object 1021h: Store EDS

Via the object `Store EDS`, the EDS file can be read out in segmented mode as an ASCII code.

9.20 Object 1022h: Store format

The object `EDS store format` displays the storage format of the EDS file output via object 0x1021.
Default: 00h (/ISO10646/, not compressed)

9.21 Object 1029h: Error behavior

The object `Error behavior` controls the behavior, if a network or device error occurs.

Index	Subindex	Comment	Default	Type	Attr.
1029h	0	Largest subindex supported	2	Unsigned8	ro
	1	Behavior in case of communication errors (81xx, 82xx), see Table 12 on page 149	00h	Unsigned8	rw
	2	Behavior in case of device errors (≠ 81xx, 82xx), see Table 12 on page 149	00h	Unsigned8	rw

Value	Meaning
00h	Put NMT into `PRE-OPERATIONAL` mode (only if the device is in `OPERATIONAL` mode)
01h	No change in NMT status
02h	Put NMT into `STOPPED` mode (only if the device is in `OPERATIONAL` mode)

9.22 Object 1300h: Global failsafe command parameter (GFC)

The GFC can be used to also put other safety-related CANopen safety devices into failsafe state. This improves the reaction time of the entire system in the event of an error. The GFC itself is NON-safety-related and is transmitted event-controlled. It consists of a high-priority CAN telegram with COB-ID 0x001. The GFC contains no data and can therefore be sent from (GFC provider) and received by (GFC consumer) all devices.

The behavior of the GFC bits is controlled via `Object 3011h: GFC setting`.

If the measuring system enters failsafe state, no SRDO corresponding to the error is transmitted! Instead, the measuring system enters `Active Safe State` or `Passive Safe State` depending on the setting, see chap. "Safe State Definition" on page 141.

Value	Meaning
0	GFC was not triggered, or was cleared. With the value 0, only a GFC triggered by the consumer can be cleared or acknowledged. A GFC triggered by the provider is cleared according to chap. "Safe State Definition" on page 141.
1	GFC is active and was triggered either actively (provider) or passively (consumer). The GFC bit is exclusively activated by the firmware and cannot be set via an SDO write service.

Default value = 0

9.23 Object 13FEh: Configuration valid

This object indicates whether the **current system configuration** of the measuring system is valid. Any write access to at least one of the safety-related communication objects (1301h-1303h), wrong CRC signatures in objects 13FFh, 24FF, 61FFh, non-compliant mode settings according to chap. 8 on page 59, or if the measuring system is in error state (object 3010h = 00h or 03h), will automatically result in an invalid system configuration.
The measuring system is then in safe state according to chap. "Safe State Definition" on page 141.

Once the entire configuration of the measuring system is complete, the safety-related configuration tool must transmit the value A5h to this object. This indicates that the configuration has been done.
If all parameters are correct and the self-tests performed do not show any errors, the measuring system is transferred from safe state into normal operating state and can be put into `OPERATIONAL` NMT state.
If errors have been detected, the measuring system responds with a corresponding `ABORT-CODE` (0x80 + 4-byte error code) and rejects the SDO request to validate the system configuration.

An exact procedure must be observed for activating the system configuration, see chap. "Set system configuration as valid*" on page 34.*

When the system configuration has been set to valid = A5h , the value should be read back again for verification. The `OPERATIONAL` operating state should only be adopted, if the read-back value is also = A5h.

Attribute	Meaning
Access	ro, if NMT state = OPERATIONAL
	rw, if NMT state = PRE-OPERATIONAL
Range of values	A5h: System configuration is valid
	00h: System configuration is invalid
Default value	00h

9.24 Object 13FFh: Safety configuration signature

This object is used to verify the **SRDO Mapping Configuration (CiA DS406 or TR)**. A safety configuration signature is applied to each SRDO. It is recommended that safety-related mapping is performed with tool support, using an appropriate configuration tool. If the control system does not provide such a configuration tool, the `TR CAN Device TOOL` provided by TR Electronic can be used, see chap. 6.2 on page 48.
The configuration tool downloads the configuration data of the SRDOs to the measuring system, calculates the CRC signatures based on the configuration data of the SRDOs and then transmits the calculated CRC signatures to the measuring system. The measuring system also calculates the CRCs based on the configuration data of the SRDOs and then compares the downloaded CRC signatures with the calculated CRC signatures. If the downloaded CRC signatures match the calculated CRC signatures, the configuration is valid.

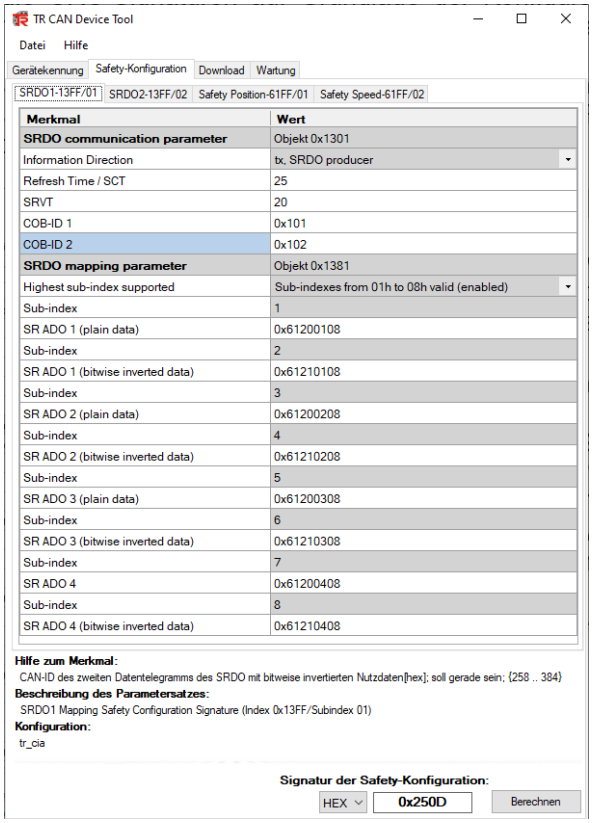


Figure 16: **CRC calculation for SRDO configuration**

Figure 16 shows an example of all relevant SRDO1 communication parameters (object 1301h) or mapping parameters (object 1381h), which are included in the CRC calculation, and the obtained result: `0x250D`.

The signature example refers to the prevailing safety-related SRDO1 mapping default setting for the CiA DS406 encoder profile Node-ID = 1 and is entered in object 13FFh under subindex 1.
The signatures of SRDOs two and three are entered by the `TR CAN Device Tool` in the following subindexes 2 and 3 upon downloading.

Safety configuration signature

Index	Subindex	Comment	Default value	Type	Attr.
13FFh	0	Largest subindex supported	3	Unsigned16	rw
	1	SRDO1 signature	250Dh	Unsigned16	rw
	2	SRDO2 signature	AD5Fh	Unsigned16	rw
	3	SRDO3 signature	B6CFh	Unsigned16	rw

Attribute	Meaning
Access Subindex 1 to 3	ro, if NMT state = OPERATIONAL
	rw, if NMT state = PRE-OPERATIONAL

9.25 Object 1F80h: NMT startup

Object `NMT Autostart` configures the start-up behavior of the measuring system and defines whether the measuring system should be automatically transferred to `OPERATIONAL` state after initialization:

- Configuration byte = 04h: Default setting
  Transfer to `OPERATIONAL` state only via NMT master

OR

- Configuration byte = 08h:
  Automatic transfer to `OPERATIONAL` state

Bit assignment:

31 … 24	23 … 16	15 … 8	7 … 0
Reserved 0000 00h			Configuration

MSB LSB

Breakdown of the configuration byte

7	6	5	4	3	2	1	0
X	X	X	X	Start Node	NMT Master Start	X	X

MSB LSB

If an attempt is made to change a bit that is not present, the measuring system responds with a corresponding abort code. This is also the case if bits 2 and 3 are set simultaneously in the configuration byte (0Ch).

10 Parametrization

Index (h)	Object	Name	Data length	Attr.	Page
TR Parameter					
2040	REC	TR configuration parameter	-	rw	77
2041	REC	TR TPDO values	-	ro	86
2220	VAR	TR safe state simulation	Unsigned8	rw	89
2221	VAR	Blinking mode	Unsigned8	rw	77
2222	REC	LED status	-	rw	77
2410	REC	TR safety configuration parameter	-	rw	89
2420	VAR	TR safety status	Unsigned16	ro	98
2421	VAR	TR safety inverted status	Unsigned16	ro	98
2422	VAR	TR safety position	Unsigned32	ro	100
2423	VAR	TR safety inverted position	Unsigned32	ro	100
2424	VAR	TR safety velocity 32Bit	Integer32	ro	100
2425	VAR	TR safety inverted velocity 32Bit	Integer32	ro	100
2426	VAR	TR safety velocity 16Bit	Integer16	ro	101
2427	VAR	TR safety inverted velocity 16Bit	Integer16	ro	101
2430	VAR	TR safety control	Unsigned16	rw	99
2431	VAR	TR safety inverted control	Unsigned16	rw	99
2432	VAR	TR safety preset value	Unsigned32	rw	101
2433	VAR	TR safety inverted preset value	Unsigned32	rw	101
24FE	VAR	TR safety configuration valid	Unsigned8	rw	102
24FF	ARRAY	TR safety configuration signature	Unsigned16	rw	103
2500	REC	TR SSI parameter	-	rw	106
2520	REC	TR Incremental parameter	-	rw	109
27xx	VAR	Factory-27xx (reserve)	DOMAIN	rw	-
3000	VAR	Node ID	Unsigned8	rw	104
3001	VAR	Baud rate	Unsigned8	rw	110
3010	VAR	Active mode	Unsigned8	ro	111
3011	VAR	GFC setting	Unsigned8	rw	112

Write parameters must be permanently stored after modification via `Object 1010h: Store parameters`!

…

…

Index (h)	Object	Name	Data length	Attr.	Page
CiA DS406 Parameter					
6000	VAR	Operating parameters	Unsigned16	rw	113
6001	VAR	Measuring units per revolution	Unsigned32	rw	114
6002	VAR	Total measuring range in measuring units	Unsigned32	rw	114
6003	VAR	Preset value	Unsigned32	rw	115
6004	VAR	Position value	Unsigned32	ro	116
600C	VAT	Position raw value	Unsigned32	ro	116
6030	ARRAY	Speed value	Integer16	ro	117
6031	REC	Speed parameter	-	rw	117
6100	REC	Safety position configuration parameters	-	rw	121
6101	REC	Safety speed configuration parameters	-	rw	123
6120	ARRAY	Safety normal resolution position value	Unsigned8	ro	125
6121	ARRAY	Safety inverted normal resolution position value	Unsigned8	ro	125
6124	ARRAY	Safety speed value	Unsigned8	ro	126
6125	ARRAY	Safety inverted speed value	Unsigned8	ro	126
61FE	VAR	Safety application configuration valid	Unsigned8	rw	127
61FF	ARRAY	Safety application configuration signature	Unsigned16	rw	127
6200	VAR	Cyclic timer	Unsigned16	rw	121
6400	ARRAY	Area state register	Unsigned8	ro	120
6401	ARRAY	Work area low limit	Integer32	rw	120
6402	ARRAY	Work area high limit	Integer32	rw	120
Measuring System Diagnosis					
2200	VAR	TR diagnostic V2 (internal purposes)	DOMAIN	rw	-
2201	VAR	TR clear diagnostic (internal purposes)	Unsigned8	ro	-
2211	VAR	TR alarms	Unsigned16	ro	129
2212	VAR	TR warnings	Unsigned16	ro	130
6500	VAR	Operating status	Unsigned16	ro	129
6501	VAR	Single-turn resolution	Unsigned32	ro	131
6502	VAR	Number of distinguishable revolutions	Unsigned16	ro	131
6503	VAR	Alarms	Unsigned16	ro	132
6504	VAR	Supported alarms	Unsigned16	ro	133
6505	VAR	Warnings	Unsigned16	ro	134
6506	VAR	Supported warnings	Unsigned16	ro	135
6507	VAR	Profile and software version	Unsigned32	ro	136
6508	VAR	Operating time	Unsigned32	ro	136
6509	VAR	Offset value	Integer32	ro	137
650A	ARRAY	Module identification	Integer32	ro	137
650B	VAR	Serial number	Unsigned32	ro	137
650D	VAR	Absolute accuracy	Unsigned8	ro	138
650E	VAR	Device capability	Unsigned16	ro	138

Table 10: Encoder profile range

Write parameters must be permanently stored after modification via `Object 1010h: Store parameters`!

10.1 TR mode, non-safety-related

10.1.1 Object 2221h: Blinking mode

With this object, the corresponding measuring system can be identified purely optically via the `ERR-LED` and `RUN LED`. By writing a "1", both LEDs are put into `Alternate slow blinking` mode for 5 seconds.
The bit is automatically reset after 5 s and can then be set again.

UNSIGNED8

Lower limit	0
Upper limit	1
Default	**0**

10.1.2 Object 2222h: LED status

The object contains the current states of the RUN and ERR LEDs. Via subindex 1, the two LEDs can generally be switched off (0x00) or on (0x01).

Index	Subindex	Comment	Default	Type	Attr.
2222h	0	Max. subindex	3	Unsigned8	ro
	1	Settings	1: LEDs switched on	Unsigned8	rw
	2	RUN LED	-	Unsigned8	ro
	3	ERR LED	-	Unsigned8	ro

LED condition	Condition code, subindex 2 resp. 3
ON	0xFF
OFF	0x00
Flickering	0x01
Blinking	0x10
Single flash	0x21
Double flash	0x22
Inverse Single flash	0x31, red LED
Inverse Single flash	0x32, green LED
Alternate Blinking	0x12
Alternate Slow Blinking	0x11

For appropriate measures in the event of a fault, see section "Optical displays", page 142.

10.1.3 Object 2040h: TR configuration parameter

This object contains all non-safety-related, TR-related configuration parameters.

Index	Sub	Comment	Default [unit]	Type	Attr.	Page
2040h	0	Max. subindex	12	Unsigned8	ro	-
	1	Rotational direction	1 [rising]	Unsigned8	rw	78
	2	Measuring range	536870912 [Steps]	Unsigned32	rw	79
	3	Revolutions numerator	65536 [rev. numerator]	Unsigned32	rw	79
	4	Revolutions denominator	1 [rev. denominator]	Unsigned32	rw	79
	5	Velocity format	1 [rev./min]	Unsigned8	rw	82
	6	Velocity factor	1 [factor]	Unsigned16	rw	82
	7	Velocity integration time	100 [ms]	Unsigned16	rw	83
	8	Velocity filter intensity	0 [filter intensity]	Unsigned8	rw	83
	9	Velocity filter type	0 [static]	Unsigned8	rw	84
	10	Substitute position	0 [substitute position OFF]	Unsigned8	rw	84
	11	Coupled channel	0 [coupled channel OFF]	Unsigned8	rw	84
	12	Preset value	0 [preset value]	Unsigned32	rw	85

10.1.3.1 Subindex 1: Rotational direction

⚠ WARNING

Danger of death, serious physical injury and/or damage to property due to a jump of the absolute value following a change in the rotational direction function!

NOTICE

- The internal calculation algorithm produces different absolute positions for the counting direction settings `decreasing` or `rising`. After a change of rotational direction, the correct function must therefore be ensured by means of a protected test run. It may be necessary to adapt the output position using the preset function.

UNSIGNED8

Lower limit	0
Upper limit	1
Default	**1**

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

10.1.3.2 Subindex 2, 3, 4: Scaling parameters

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!

⚠ WARNING

⚠ CAUTION

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

- 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 output position must be verified with the desired mechanical position before starting the application.

Via the scaling parameters

- Subindex 2 - Measuring range
- Subindex 3 - Revolutions numerator
- Subindex 4 - Revolutions denominator

the physical resolution of the measuring system can be changed. The measuring system supports the gear function for round axes.

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

The position value output is calculated with a zero point correction, the counting direction set and the gearbox parameter entered.

Subindex 2: **MEASURING RANGE**

Defines the ***total number of steps*** of the measuring system, before the measuring system starts at zero again.

UNSIGNED32

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

The actual upper limit value to be entered for the `measuring length` 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 type plate.

Subindex 3: **REVOLUTIONS NUMBERATOR /** Subindex 4: **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 (as is e.g. 3.4), but they may have an infinite number of digits after the decimal point (e.g. 3.43535355358774...) the number of revolutions is entered as a fraction.

UNSIGNED32

Numerator lower limit	1
Numerator upper limit	256000
Numerator default	65536

UNSIGNED32

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

Formula for gearbox calculation:

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

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, for example, 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 length` 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 `denominator revolutions` can be programmed as a fixed value of "1" for linear axes. The parameter `numerator revolutions` 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
  Revolutions denominator = 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

Assumed:

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

Derived:

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

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

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

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 off)*

10.1.3.3 Subindex 5: Velocity format

Subindex 5 indicates the resolution at which the speed is calculated and output.

The speed is output signed, as a 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)

UNSIGNED8

Value	Assignment	Description	Default
0	rev/sec * factor	Output in [rev./second], multiplied by the factor set under the *Velocity factor* parameter, see Subindex 6.	
1	rev/min * factor	Output in [rev./minute], multiplied by the factor set under the *Velocity factor* parameter, see Subindex 6.	X
2	rev/hour * factor	Output in [rev./hour], multiplied by the factor set under the *Velocity factor* parameter, see Subindex 6.	
3	steps/integration time	Integration time in [ms]	

10.1.3.4 Subindex 6: Velocity factor

Subindex 6 indicates the factor value for the parameter `Subindex 5: Velocity format`.

UNSIGNED16

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

10.1.3.5 Subindex 7: Velocity integration time

Subindex 7 indicates the integration time in [ms] for the parameter `Subindex 5: Velocity format`, see page 82.

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

UNSIGNED16

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

Find:
- Output value in steps/integration time

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

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

Steps/integration time = 32768 steps / 50 ms

10.1.3.6 Subindex 8: Velocity filter intensity

The output speed can be averaged using the `Velocity filter intensity` parameter. The averaging strength can be preset. You can also select whether the filtering is dynamically switched off in acceleration phases, see `Velocity filter type` parameter described below. This means that the speed signal can quickly follow the actual course in the event of changes and is stable in the stationary range.

UNSIGNED8

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

0: no filtering

1: weak filtering, high limit frequency

. . .

10: strong filtering, low limit frequency

10.1.3.7 Subindex 9: Velocity filter type

Also see the parameter `Subindex 8: Velocity filter intensity` on page 83.

UNSIGNED8

Value	Assignment	Description	Default
0	static	The low-pass filter characteristic influences the speed actual value output, independently 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 acceleration in the speed signal. The low-pass filter is reactivated, as soon as the measuring system detects a uniform movement.	

10.1.3.8 Subindex 10: Substitute position

UNSIGNED8

Value	Assignment	Description	Default
0	off	Function switched off	X
1	on	Output of the substitute position, if the position channel is in error state, also see parameter `Subindex 1: Sensor status` on page 86.	

10.1.3.9 Subindex 11: Coupled channel

UNSIGNED8

Value	Assignment	Description	Default
0	off	Function switched off	X
1	on	The `Coupled channel = on` allows you to define whether the NON-safety-related process data channel (PDO) will be linked to the safety-related channel (SRDO). In this case the settings for the position (object 2410h, subindexes 1 to 4) and speed (object 2410h, subindexes 5 to 9) are used by the safety-related process data channel and the prevailing settings in the NON-safety-related process data channel for the position (object 2040h, subindexes 1 to 4) and speed (object 2040h, subindexes 5 to 9) are ignored. The preset function can only be executed in the safety-related process data channel (object 2432h), and the NON-safety-related preset function via object 2040h, subindex 12 is locked.	

10.1.3.10 Subindex 12: Preset value

⚠ WARNING

NOTICE

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

- The preset 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!

The preset function is used to set the measuring system value to any position value within the range of 0 to measuring range in steps — 1. The output position value in `Object 2041h: TR TPDO values`, `Subindex 2: Position` is set to the `Preset value` parameter, when written to this subindex.

If the measuring system is not in TR mode during execution of the preset function, the measuring system responds with abort code 0601 0000h and rejects the preset execution.

If an invalid preset value is entered, the measuring system responds with abort code: 0600 0030h.

UNSIGNED32

Lower limit	0
Upper limit	536870911
Default	**0**

Preset value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.1.4 Object 2041h: TR TPDO values

This object contains all non-safety-related cyclic output data such as status, position and speed and can be included in the TPDO process data mapping.

Index	Subindex	Comment	Default	PDO mapping	Type	Attr.	Page
2041h	0	Max. subindex	4	no	Unsigned8	ro	-
	1	Sensor status	0	yes	Unsigned8	ro	86
	2	Position	0	yes	Unsigned32	ro	87
	3	Velocity 32 Bit	0	yes	Integer32	ro	87
	4	Velocity 16 Bit	0	yes	Integer16	ro	88

10.1.4.1 Subindex 1: Sensor status

The current non-safety-related measuring system status is output via subindex 1 `Sensor status`.

UNSIGNED8, read only

Lower limit	0
Upper limit	255
Default	**0**
PDO mapping	yes

Bit	Function
0	Speed overflow 32 bit 0: no speed overflow 1: Speed overflow present
1	Output of original position 0: Position incorrect, channel in error state 1: Output of original position
2	Output of substitute position 0: no output of substitute position 1: Output of substitute position The substitute position (`Substitute position` = `on`) must be set accordingly, see chap. 10.1.3.8, page 84.
3	not used
4	Speed overflow 16 bit 0: no speed overflow 1: Speed overflow present
5-7	not used

If bits 1 and 2 are set to 0, no more valid values are output. In `OPERATIONAL` state this indicates that a re-parametrization is currently taking place via SDO services. This is also the case if the preset function has been triggered via object 2040h. When bit 1 has been reset to 1, the re-parametrization is complete.

10.1.4.2 Subindex 2: Position

The current scaled non-safety-related measuring system position is output via subindex 2 `Position`.

UNSIGNED32, READ only

Lower limit	0
Upper limit	4294967295
Default	**0**
PDO mapping	yes

Position value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.1.4.3 Subindex 3: Velocity 32 Bit

The current scaled non-safety-related measuring system speed is output as a 32-bit value via subindex 3 `Velocity 32 Bit`. For setting options see Object 2040h: TR configuration parameter on page .78.

If the measured speed exceeds the display range of 2147483648…+2147483647, this results in an overflow, which is indicated via subindex 1 `Sensor status` bit 0. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in the `Sensor status` is also deleted.
The speed is output in `rev./min` in the default setting.

INTEGER32, read only

Lower limit	-2147483648
Upper limit	2147483647
Default	**0**
PDO mapping	yes

Speed value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.1.4.4 Subindex 4: Velocity 16 Bit

The current scaled non-safety-related measuring system speed is output as a 16-bit value via subindex 4 `Velocity 16 Bit`. For setting options see Object 2040h: TR configuration parameter on page 78.

If the measured speed exceeds the display range of 32768…+32767, this results in an overflow, which is indicated via subindex 1 `Sensor status` bit 4. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in the `Sensor status` is also deleted.
The speed is output in `rev./min` in the default setting.

INTEGER16, read only

Lower limit	-32768
Upper limit	32767
Default	**0**
PDO mapping	yes

Speed value	
Byte 0	byte 1
2^7 to 2^0	2^{15} to 2^8

10.2 TR mode, safety-related

10.2.1 Object 2220h: TR safe state simulation

In the set-up phase or for test purposes, the measuring system can be put into failsafe state by writing the value 2Ch. The measuring system then behaves exactly the same as if a safety-related error had occurred. Depending on the prevailing settings, the measuring system is either put into `Passive Safe State` or `Active Safe State`, see chap. 13 on page 141.

The measuring system can only be switched back to operating mode on receiving the value 00h; other values will result in an error. As for an actually occurring error, a corresponding error acknowledgment must then be given in accordance with chap. 13.

UNSIGNED8

Lower limit	0
Upper limit	255
Default	**0**

10.2.2 Object 2410h: TR safety configuration parameter

This object contains all safety-related, TR-related configuration parameters.

In order to verify the safety-related configuration parameters, a safety signature is applied to each parameter,
see `Object 24FFh: TR safety configuration signature` on page 103.

Index	Subindex	Comment	Default [unit]	Type	Attr.	Page
2410h	0	Max. subindex	12	Unsigned8	ro	-
	1	Rotational direction	1 [rising]	Unsigned8	rw	90
	2	Measuring range	536870912 [Steps]	Unsigned32	rw	90
	3	Revolutions numerator	65536 [rev. numerator]	Unsigned32	rw	90
	4	Revolutions denominator	1 [rev. denominator]	Unsigned32	rw	90
	5	Velocity format	1 [rev./min]	Unsigned8	rw	94
	6	Velocity factor	1 [factor]	Unsigned16	rw	94
	7	Velocity integration time	100 [ms]	Unsigned16	rw	95
	8	Velocity filter intensity	0 [filter intensity]	Unsigned8	rw	95
	9	Velocity filter type	0 [static]	Unsigned8	rw	96
	10	Window increments	1000 [increments]	Unsigned16	rw	96
	11	Error behavior	0 [error behavior]	Unsigned8	rw	96
	12	Preset value	0 [preset value]	Unsigned32	rw	97

10.2.2.1 Subindex 1: Rotational direction

⚠ WARNING

NOTICE

Danger of death, serious physical injury and/or damage to property due to a jump of the absolute value following a change in the rotational direction function!

- The internal calculation algorithm produces different absolute positions for the counting direction settings `decreasing` or `rising`. After a change of rotational direction, the correct function must therefore be ensured by means of a protected test run. It may be necessary to adapt the output position using the preset function.

UNSIGNED8

Lower limit	0
Upper limit	1
Default	**1**

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

10.2.2.2 Subindex 2, 3, 4: Scaling parameters

⚠ 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 settings of the scaling parameters specified below deviate from the default settings, the zero point of the multiturn measuring system may be lost if more than the permissible number of revolutions are executed in 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 output position must be verified with the desired mechanical position before starting the application.
  If the permissible number of revolutions have been exceeded, this is indicated when the system restarts via object 2420h `TR safety status`, bit 7 `Scaling Error` = 1. After positive verification the `Scaling Error` bit can be deleted by executing the preset adjustment function, see chapter 10.2.11 on page 104.

Via the scaling parameters

- Subindex 2 - Measuring range
- Subindex 3 - Revolutions numerator
- Subindex 4 - Revolutions denominator

the physical resolution of the measuring system can be changed. The measuring system supports the gear function for round axes.

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

The position value output is calculated with a zero point correction, the counting direction set and the gearbox parameter entered.

Subindex 2: **MEASURING RANGE**

Defines the ***total number of steps*** of the measuring system, before the measuring system starts at zero again.

UNSIGNED32

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

The actual upper limit value to be entered for the `measuring length` 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 type plate.

Subindex 3: **REVOLUTIONS NUMBERATOR /** Subindex 4: **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 (as is e.g. 3.4), but they may have an infinite number of digits after the decimal point (e.g. 3.43535355358774...) the number of revolutions is entered as a fraction.

UNSIGNED32

Numerator lower limit	1
Numerator upper limit	256000
Numerator default	65536

UNSIGNED32

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, for example, 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 length` 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 `denominator revolutions` can be programmed as a fixed value of "1" for linear axes. The parameter `numerator revolutions` 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
  Revolutions denominator = 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

Assumed:

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

Derived:

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

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

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

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 off)*

10.2.2.3 Subindex 5: Velocity format

Subindex 5 indicates the resolution at which the speed is calculated and output.

The speed is output signed, as a 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)

UNSIGNED8

Value	Assignment	Description	Default
0	rev/sec * factor	Output in [rev./second], multiplied by the factor set under the *Velocity factor* parameter, see Subindex 6.	
1	rev/min * factor	Output in [rev./minute], multiplied by the factor set under the *Velocity factor* parameter, see Subindex 6.	X
2	rev/hour * factor	Output in [rev./hour], multiplied by the factor set under the *Velocity factor* parameter, see Subindex 6.	
3	steps/integration time	Output in [steps/ms]	

10.2.2.4 Subindex 6: Velocity factor

Subindex 6 indicates the factor value for the parameter `Subindex 5: Velocity format`.

UNSIGNED16

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

10.2.2.5 Subindex 7: Velocity integration time

Subindex 7 indicates the integration time in [ms] for the parameter `Subindex 5: Velocity format`, see page 94.

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

UNSIGNED16

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

Find:
- Output value in steps/integration time

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

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

Steps/integration time = 32768 steps / 50 ms

10.2.2.6 Subindex 8: Velocity filter intensity

The output speed can be averaged using the `Velocity filter intensity` parameter. The averaging strength can be preset. You can also select whether the filtering is dynamically switched off in acceleration phases, see `Velocity filter type` parameter described below. This means that the speed signal can quickly follow the actual course in the event of changes and is stable in the stationary range.

UNSIGNED8

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

0: no filtering

1: weak filtering, high limit frequency

. . .

10: strong filtering, low limit frequency

10.2.2.7 Subindex 9: Velocity filter type

Also see the parameter `Subindex 8: Velocity filter intensity` on page 95.

UNSIGNED8

Value	Assignment	Description	Default
0	static	The low-pass filter characteristic influences the speed actual value output, independently 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 acceleration in the speed signal. The low-pass filter is reactivated, as soon as the measuring system detects a uniform movement.	

10.2.2.8 Subindex 10: Window Increments

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

UNSIGNED16

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

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

For the position deviation in increments, the unscaled resolution of 13 bit = 8192 steps/revolution is always used as the basis.

10.2.2.9 Subindex 11: Error behavior

The parameter defines how the measuring system behaves when a safety-related error has occurred.

Value 0: When a safety-related error occurs, the measuring system is put into `Passive Safe State`.

Value 1: When a safety-related error occurs, the measuring system is put into `Active Safe State`.

General definition of the safe state, see chap. 13 on page 141.

UNSIGNED8

Lower limit	0
Upper limit	1
Default	**0**

10.2.2.10 Subindex 12: Preset value

⚠ WARNING

NOTICE

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

- The preset 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!

The preset function is used to set the safety-related measuring system value `PRE-OPERATIONAL` state to any position value within the range of 0 to measuring range in steps — 1. The following procedure must be followed in order to set the safety-related position value in `Object 2422h: TR safety position` to the `Preset value` parameter:

1. NMT state = `PRE-OPERATIONAL`
2. The measuring system must be in TR mode.
3. Carry out the desired parametrization of the safety-related parameters in `Object 2410h: TR safety configuration parameter`.
4. Transmit the desired preset value to this subindex via an SDO write service. Even if the desired preset value should already be included, an SDO write service is necessary to initiate the function.
5. Calculate the CRC via the parameters contained in `Object 2410h: TR safety configuration parameter` and transmit them to the `Object 24FFh: TR safety configuration signature`.
6. Read back all safety-related parameters and the CRC signatures and compare with the written parameters.
7. In `Object 24FEh: TR safety configuration valid` set the parameter configuration to valid with value A5h.

If all parameters are correct and the self-tests performed do not show any errors, the preset function is executed and the specified preset value is set as the new position value.
If a safety-related error is present, the preset function is not executed and the parameter configuration in `Object 24FEh: TR safety configuration valid` is marked as invalid with the value = 00h.
If an invalid preset value (outside the measuring range) is entered the measuring system responds with a corresponding abort code, however the parameter configuration in object 24FEh remains valid (A5h).

UNSIGNED32

Lower limit	0
Upper limit	536870911
Default	**0**

Preset value, safety-related			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.2.3 Object 2420h: TR safety status

The safety-related measuring system status is output via the object `TR safety status` and is intended for the SRDO mapping.

Object 2421h contains the bitwise inverted data of object 2420h.

⚠ WARNING

NOTICE

Danger of death, serious physical injuries and/or damage to property due to uncontrolled start-up of the drive system, in the event of non-evaluation of `Safe State` bit!

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

UNSIGNED16, read only, SRDO mapping

Bit	Description
0	`Velocity 32 Bit Error` Bit = 1, if the speed value in object 2424h is outside the range from –2147483648…+2147483647. The bit is automatically reset when the speed returns to the permissible range.
1	`Velocity 16 Bit Error` Bit = 1, if the speed value in object 2426h is outside the range from –32768…+32767. The bit is automatically reset when the speed returns to the permissible range.
2	`Preset OK` Bit = 1, if a preset request was successfully executed.
3	`Preset Error` Bit = 1, if a preset request could not be executed due to an error. The bit can be reset again via the preset control bits `Preset Request` and `Preset Preparation` in object 2430h.
4	`Safe State` Bit = 0, - in the initialization phase, or if the initialization could not be successfully completed - if a preset request is initiated via the control bit `Preset Preparation` - if the measuring system is in safe state Bit = 1, - if the initialization was successfully completed - if the preset control bits `Preset Request` and `Preset Preparation` have been reset
5	`Preset Active` Bit = 1, if the preset execution is triggered via the control bit `Preset_Request`. When the preset has been executed, the bit is automatically reset.
6	reserved
7	Scaling Error Bit = 1, if the measuring system was moved in de-energized state. As it is not possible to check whether a zero transition was generated during this process, the output position must be verified with the desired mechanical position before starting the application. After positive verification the bit can be deleted by executing the preset adjustment function, see chap. 10.2.11 on page 104.

Continued on next page

Continued: TR safety status

8	Error Acknowledge Request Bit = 1, if a previously adopted safe state can be left again. To do this, an error acknowledgment by the user via output bit 2^6 `Error Acknowledge` in object 2430h is required.
9	reserved
10	`Device Fault` Bit = 1, if at least one active device error is present and the measuring system is in failsafe state. Troubleshooting, see chap. `Optical displays` -> `ERR-LED` -> Flashing mode `Inverse Single Flash` on page 143. After eliminating the error, acknowledgment of the error is required according to chap. "Safe State Definition" on page 141.
11…15	reserved

10.2.4 Object 2430h: TR safety control

Via the `TR safety control` object different measuring system-related control functions can be executed, intended for SRDO mapping.

When setting the bits, it must be ensured that the bitwise inverted data of object 2430h are written to object 2431h!

UNSIGNED16, SRDO mapping

Bit	Description
0	`Preset Preparation` This bit serves to prepare the preset adjustment function. Only if this bit is set can the actual preset be executed via the control bit `Preset_Request`. A precise sequence must be observed in order to execute the function, see chapter 10.2.11 on page 104.
1	`Preset Request` This bit serves to control the preset adjustment function. When this function is executed, the position in object 2422h is set to the position value stored in `Object 2432h: TR safety preset value`. A precise sequence must be observed in order to execute the function, see chapter 10.2.11 on page 104.
2…5	reserved
6	`Error Acknowledge` This bit serves for error acknowledgment by the user and occurs at input bit 2^8 `Error Acknowledge Request` =1 in object 2420h.
7…15	reserved

10.2.5 Object 2422h: TR safety position

Via the `TR safety position` the current scaled absolute safety-related actual position of the measuring system is output unsigned as a 32-bit binary value.

The object is intended for SRDO mapping.

Object 2423h contains the bitwise inverted data of object 2422h.

UNSIGNED32, read only, SRDO mapping

Lower limit	0
Upper limit	536870911
Default	**0**

Position value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.2.6 Object 2424h: TR safety velocity 32Bit

Via the object `TR safety velocity 32Bit` the current scaled safety-related speed of the measuring system is output as a signed 32-bit two's complement value. Default setting: `rpm`, see parameter `Subindex 5: Velocity format` on page 94.
The object is intended for SRDO mapping.

If the measured speed exceeds the display range of 2147483648…+2147483647, this results in an overflow, which is indicated via `Object 2420h: TR safety status` bit 0. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in `Object 2420h: TR safety status` bit 0 is also deleted again.

Object 2425h contains the bitwise inverted data of object 2424h.

INTEGER32, read only, SRDO mapping

Lower limit	-2147483648
Upper limit	2147483647
Default	**0**

Speed value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.2.7 Object 2426h: TR safety velocity 16Bit

Via the object `TR safety velocity 16Bit` the current scaled safety-related speed of the measuring system is output as a signed 16-bit two's complement value. Default setting: `rpm`, see parameter `Subindex 5: Velocity format` on page 94.
The object is intended for SRDO mapping.

If the measured speed exceeds the display range of -32768…+32767, this results in an overflow, which is indicated via `Object 2420h: TR safety status` bit 1. At the time of the overflow the speed stops at the respective +/- maximum value, until the speed is once again in the display range. In this case the message in `Object 2420h: TR safety status` bit 1 is also deleted again.

Object 2427h contains the bitwise inverted data of object 2426h.

INTEGER16, read only, SRDO mapping

Lower limit	-32768
Upper limit	32767
Default	**0**

Speed value	
Byte 0	byte 1
2^7 to 2^0	2^{15} to 2^8

10.2.8 Object 2432h: TR safety preset value

Via the object `TR safety preset value` the zero point of the measuring system can be adapted to the mechanical zero point. The desired safety-related preset value must be in the range from 0 to (measuring range in steps – 1), otherwise the preset adjustment function is not executed and in `Object 2420h: TR safety status` bit 3 `Preset Error` = 1 is set.
The preset value is set as the new position value in `Object 2422h: TR safety position`, if the preset adjustment value is executed, see chap. 10.2.11 on page 104.

The object is intended for SRDO mapping.

When setting the bits, it must be ensured that the bitwise inverted data of object 2432h are written to object 2433h!

UNSIGNED32, SRDO mapping

Lower limit	0
Upper limit	536870911
Default	**0**

Preset value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.2.9 Object 24FEh: TR safety configuration valid

This object indicates whether the currently set safety-related measuring system-related TR mode parameter data from `Object 2410h: TR safety configuration parameter` are valid. A write access to one of these parameters automatically sets the object to invalid = 00h.

The object must be set to valid = A5h, once the safety application has been configured and the signature of the safety application configuration has been validated via `Object 24FFh: TR safety configuration signature`.

UNSIGNED8

Attribute	Meaning
Access	ro, if NMT state = OPERATIONAL
	rw, if NMT state = PRE-OPERATIONAL
Range of values	A5h: Configuration is valid
	≠ A5h: Configuration is invalid
Default value	00h

10.2.10 Object 24FFh: TR safety configuration signature

This object is used to verify the safety-related measuring system-related TR mode parameter data. A safety signature is applied to each parameter. TR Electronic provides a corresponding configuration tool called the `TR CAN Device Tool` for this purpose, see chap. 6.2 on page 48. The configuration tool downloads the set parameter data to the measuring system, calculates the CRC signature and then transmits the calculated CRC signature to the measuring system in subindex 1. The measuring system also calculates the CRC based on the set parameter data and then compares the downloaded CRC signature with the calculated CRC signature. If both match, the parameter data are valid.

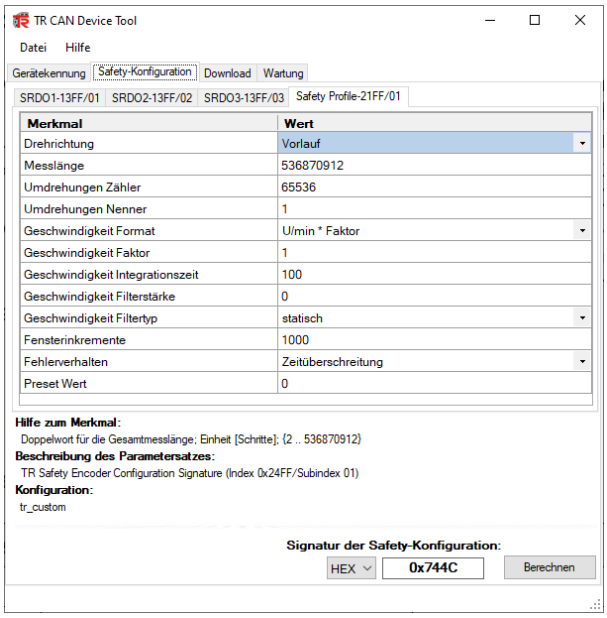


Figure 17: CRC calculation parameter data set

Figure 17 shows all relevant parameters, which are included in the CRC calculation, and the obtained result: `0x744C`

The signature example refers to the prevailing safety-related parameter default setting for the TR profile and is entered by the `TR CAN Device Tool` in object 24FFh under subindex 1 during downloading.

TR safety configuration signature

Index	Subindex	Comment	Default value	Type	Attr.
24FFh	0	Largest subindex supported	1	Unsigned16	ro
	1	TR safety signature	744Ch	Unsigned16	rw

Attribute	Meaning
Access Subindex 1	ro, if NMT state = OPERATIONAL
	rw, if NMT state = PRE-OPERATIONAL

10.2.11 Preset adjustment function

⚠ WARNING

NOTICE

Danger of death, serious physical injury and/or damage to property due to uncontrolled start-up of the drive system during execution of the preset adjustment function!

- The relevant drive systems must be locked to prevent automatic start-up
- It is advisable to protect the preset triggering via the safety control by means of additional protective measures, such as e.g. key-operated switch, password etc.
- The procedure specified below must be observed; in particular, the status bits must be evaluated by the safety control, in order to check successful or incorrect execution
- The new position must be checked after execution of the preset function

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

The measuring system must be in TR mode and at least the following objects must have been included in the mapping:
Position 2422h+2423h, status word 2420h+2421h, preset value 2432h+2433h and control word 2430h+2431h. At least one Transmit SDRO is required for transmitting the position and status word, and at least one Receive SRDO is required for writing the preset value and operating the control word. The measuring system must be in NMT state = `OPERATIONAL` and have a valid system configuration according to chap. 4.2 on page 34. Only the "normal" data objects are specified in the following procedure. It must be ensured that the bitwise inverted data are managed synonymously with the normal data.

10.2.11.1 Procedure

- Write object 2432h `Preset value` in the safety control output data with the desired preset value.
- Set the `Preset Preparation` and `Preset Request` control bits in object 2430h to 0.
- Set the `Preset Preparation` control bit in object 2430h to 1. As a result the `Safe State` status bit in object 2420h is set to 0, and the safety control must then switch the system to a safe state. The output position value in object 2422h is no longer safe!
- With a rising edge of the `Preset_Request` control bit in object 2430h, the preset value is accepted. Receipt of the preset value is acknowledged by setting (=1) the `Preset Active` status bit in object 2420h. When the preset has been executed, the `Preset Active` status bit is reset to 0.
- After receipt of the preset value, the measuring system checks that all prerequisites for execution of the preset adjustment function are fulfilled. If so, the preset value is written as the new position value. In case of error, the execution is rejected and an error message is output by setting the `Preset Error` status bit in object 2420h.
- After successful execution of the preset adjustment function, the measuring system sets the `Preset OK` status bit object 2420h to 1 to indicate to the safety control that the preset execution is complete.
- Reset the `Preset Request` control bit in object 2430h to 0.
- Reset the `Preset Preparation` control bit in object 2430h to 0. As a result the `Safe State` status bit in object 2420h is reset to 1.
- Finally, the safety control must check that the new position object 2422h corresponds to the new set position.

10.2.11.2 Timing diagram

Blue area: Output signals safety control -> measuring system
Orange area: Input signals measuring system -> safety control

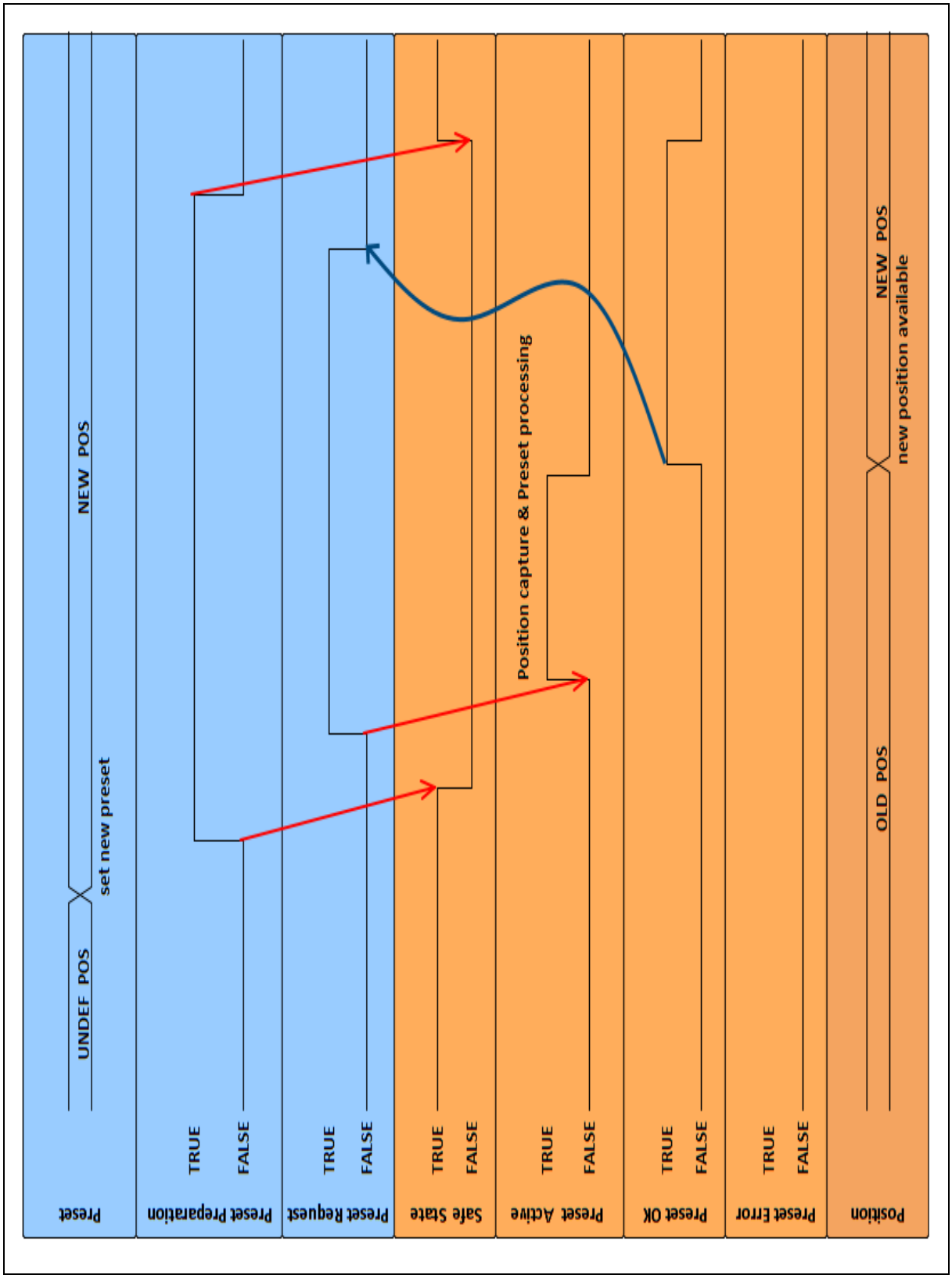


Figure 18: Preset timing diagram

10.3 OPTION: Second interface

10.3.1 Object 2500h: TR SSI parameter

The measuring system can optionally be equipped with a synchronous-serial absolute SSI interface, in addition to the CANopen 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

Index	Subindex	Comment	Default	Type	Attr.
2500h	0	Largest subindex supported	7	Unsigned8	ro
	1	Source	0: channel 1	Unsigned8	rw
	2	Coding	0: binary code	Unsigned8	rw
	3	Data bits	29: 29 data bits	Unsigned8	rw
	4	Mono time	1: 20 µs	Unsigned8	rw
	5	Status bits	0: no status bits	Unsigned8	rw
	6	Sign of Life bits	0: no sign of life bits	Unsigned8	rw
	7	Checksum	0: no checksum	Unsigned8	rw

10.3.1.1 Subindex 1: Source

UNSIGNED8

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

10.3.1.2 Subindex 2: Coding

UNSIGNED8

Value	Description	Default
0	SSI output is binary-coded	X
1	SSI output is gray-coded	

10.3.1.3 Subindex 3: Data bits

The `Data bits` subindex defines the number of reserved bits for the measuring system position, and the number of required SSI clock pulses to the LSB of the data is also specified. Special bits such as status bits, sign-of-life bits or checksum bits are not included and are output in this order after the data bits.

UNSIGNED8

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

10.3.1.4 Subindex 4: Mono time

UNSIGNED8

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

10.3.1.5 Subindex 5: Status bits

UNSIGNED8

Value	Description	Default
0	No status bits output	X
1	One-bit status output 0: No errors 1: Error in master system or test system; depending on the source	
2	Two-bit status output MSB bit = 0: No errors MSB bit = 1: Error in master system LSB bit = 0: No errors LSB bit = 1: Error in test system	

10.3.1.6 Subindex 6: Sign of Life bits

The *Sign of Life bits* subindex defines the number of reserved bits for the sign-of-life output.

The sign-of-life counter is incremented depending on the scanning processes and inserted into the SSI telegram. Monitoring of this incrementation by the control ensures that the newly transferred position value originates from a current scanning process.

UNSIGNED8

Value	Description	Default
0	No sign-of-life bits output	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	

10.3.1.7 Subindex 7: Checksum

The type of checksum is set in SSI data transmission format via the Checksum subindex.

The checksum is generally calculated over all useful data (position, status and sign-of-life) in the SSI telegram and is always inserted in the SSI telegram in the last position (LSB).

An incorrect checksum does not indicate a measuring system error, but a communication problem. The cause may be an EMC fault, for example. However, communication problems in SSI interfaces can also be caused by excessively long cables or excessively high SSI scanning frequencies.

UNSIGNED8

Value	Description	Default
0	No checksum output	X
1	Even parity: The parity represents the checksum of the bits in the SSI data word. If the SSI data word contains an odd number of ones, the bit is = "1" and changes the checksum to even parity.	
2	Odd parity: The parity represents the checksum of the bits in the SSI data word. If the SSI data word contains an even number of ones, the bit is = "1" and changes the checksum to odd parity.	
3	8-bit CRC checksum: Polynomial: $X^8 + X^5 + X^4 + 1$ (Maxim/Dallas) Start value 0xFF Min. Hamming distance: 4	

10.3.2 Object 2520h: TR Incremental parameter

The measuring system can optionally be equipped with an incremental interface, in addition to the CANopen interface.

Index	Subindex	Comment	Default	Type	Attr.
2520h	0	Largest subindex supported	1	Unsigned8	ro
	1	Pulses per revolution	0: 1024 pulses	Unsigned8	rw

10.3.2.1 Subindex 1: Pulses per revolution

The `Pulses per revolution` subindex defines the number of pulses per revolution.

UNSIGNED8

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

10.4 Object 3000h: Node ID

In addition to setting options via hardware switches and LSS services, this object also offers a further option for setting the Node-ID of the measuring system. The measuring system supports the Node-ID range from 1–127.

If the Node-ID is set via this object and the HEX addressing switches simultaneously indicate the value 0x00, the COB-IDs are immediately reset to their default values and the system configuration is set via object 13FEh to 00h = invalid:

- ***Process Data Objects (PDOs),***
  see subindex 1 chap. 7.1.1 on page 49
- ***Safety Related Process Data Objects (SRDOs),***
  see subindex 5 and 6 chap. 7.2.1 from page 54
- ***EMCY Messages,***
  see chap. 9.12 on page 67
- ***Validity of the system configuration,***
  see `Object 13FEh: Configuration valid` *chap. 9.23 on page 72*

UNSIGNED8

Lower limit	1
Upper limit	127
Default	**1**

10.5 Object 3001h: Baud rate

In addition to setting options via hardware switches and LSS services, this object also offers a further option for setting the baud rate of the measuring system.

UNSIGNED8

Value	Description	Default
0	1 Mbit/s	
1	800 kbit/s	
2	500 kbit/s	
3	250 kbit/s	X
4	125 kbit/s	
5	100 kbit/s	
6	50 kbit/s	
7	20 kbit/s	
8	10 kbit/s	

10.6 Object 3010h: Active mode

The current mode setting status is output via this object.

UNSIGNED8, read only

Value	Description	Default
0	OFF, no mapping active. No mapping has been activated via communication objects 1301h-1303h (safety-related) or 1800h-1803h (non-safety-related), using the corresponding "VALID bits" in subindex 1. In this state it is not possible to activate the prevailing system configuration via `Object 13FEh: Configuration valid`. If the measuring system is in `PRE-OPERATIONAL` NMT state, then the ERR-LED is in `BLINKING MODE` and indicates a general configuration error. If an attempt is made to switch to `OPERATIONAL` NMT state, then an emergency message is sent and the ERR LED indicates safe state of the measuring system via `INVERSE SINGLE FLASH MODE`.	
1	TR mode active All OK, only the manufacturer-specific objects 2xxx are activated via the mapping settings.	
2	CiA DS406 encoder profile active All OK, only the profile-specific objects 6xxx are activated via the mapping settings.	X
3	ERROR No mapping could be activated: - An attempt was made to activate manufacturer-specific and profile-specific objects via the mapping settings. Only either manufacturer-specific or profile-specific objects may be activated via the mapping settings. - The NON-safety-related mapping was changed in `OPERATIONAL` NMT state so that the mode settings are no longer correct, and a corresponding emergency message has been sent. In this state it is not possible to reactivate the prevailing system configuration via `Object 13FEh: Configuration valid`. If the measuring system is in `PRE-OPERATIONAL` NMT state, then the ERR-LED is in `BLINKING MODE` and indicates a general configuration error. If an attempt is made to switch to `OPERATIONAL` NMT state, then an emergency message is sent and the ERR LED indicates safe state of the measuring system via `INVERSE SINGLE FLASH MODE`.	

10.7 Object 3011h: GFC setting

Via this object you can set whether the measuring system operates as GFC provider or/and as GFC consumer, or whether the GFC function is switched off completely. In the default setting the measuring system operates as GFC provider.

UNSIGNED8

Bit	Function	Description
0	GFC provider	0: GFC provider function switched off In case of error, according to "Safe State Definition" on page 141, the GFC bit in `Object 1300h: Global failsafe command parameter (GFC)` is not set. 1: GFC provider active In case of error, according to "Safe State Definition" on page 141, the GFC bit in `Object 1300h: Global failsafe command parameter (GFC)` is set.
1	GFC consumer	0: GFC consumer function switched off Upon receipt of a CAN telegram with COB-ID 0x001, the GFC bit in `Object 1300h: Global failsafe command parameter (GFC)` is not set. The measuring system is not put into safe state according to "Safe State Definition" on page 141. 1: GFC consumer active Upon receipt of a CAN telegram with COB-ID 0x001, the GFC bit in `Object 1300h: Global failsafe command parameter (GFC)` is set. The measuring system is put into safe state according to "Safe State Definition" on page 141.

10.8 CiA DS406 mode, non-safety-related

10.8.1 Object 6000h: Operating parameters

The object with index 6000h contains all relevant measuring system operating parameters.

Index	**0x6000**
Description	Operating parameter
Data type	UNSIGNED16
Object code	VARIABLE
Access	rw
PDO Mapping	no
Default	**0**

Bit	**Function**	**Bit = 0**	**Bit = 1**
0	Counting direction	Position rising	Position falling
1	Diagnostic control	switch off	switch on
2	Scaling function	switch off	switch on
3 – 15	reserved		

Bit 0, Counting direction:
The counting direction defines whether rising or falling position values are output, when the measuring system shaft is turned clockwise or counter-clockwise (when looking at the shaft).

Bit 1, Diagnostic control:
When the diagnostic control is switched on, detected errors are indicated by the alarm bit in object 6503h. The commissioning diagnostics allows you to check the scanning components responsible for position detection at a standstill.

Bit 2, Scaling function:
When the scaling function is switched on, the output position in object 6004h is scaled according to the scaling parameters in objects 6001h and 6002h. The output position value is also calculated with the set counting direction and the preset value from object 6003h.

When the scaling function is switched off, the measuring system is set to the default values:

- Steps per revolution = 8192
- Number of revolutions = 65536
- Measuring range in steps = 536870912

These values cannot be changed, but the set counting direction and preset value are taken into account during position output.

10.8.2 Scaling parameters

If the scaling parameters are activated via `Object 6000h: Operating parameters`, the physical resolution of the measuring system can be changed. The position value output is binary decoded and is calculated with a zero point correction and the counting direction set.
The measuring system does not support decimal numbers in this configuration. Therefore the `Total number of steps` in object 6002h must be a whole multiple of the `Steps per revolution` in object 6001h.
The `Number of revolutions` parameter indirectly programmed through the entries in objects 6001h and 6002h must be in the range of 1 to 256000 revolutions.

If the entry for `Steps per revolution` does not result in a whole multiple or if the revolution range of 1…256000 is not observed, the `Total number of steps` is adapted to the next lower value, and the entered `Number of steps per revolution` is adopted.
If the entry for `Total number of steps` does not result in a whole multiple or if the revolution range of 1…256000 is not observed, the programming is not accepted and an error message is output.
For the purposes of verification, it is therefore advisable to read back and check the `Total number of steps` parameter in object 6002h.

10.8.2.1 Object 6001h: Measuring units per revolution

The `Measuring units per revolution` object defines the number of steps per revolution.

Index	**0x6001**
Description	Measuring steps per revolution
Data type	UNSIGNED32
Object code	VARIABLE
Access	rw
PDO Mapping	no
Lower limit	2 steps/revolution
Upper limit	8192
Default	**8192**

Measuring steps per revolution			
Byte 0	byte 1	Byte 2	Byte 3
2^{7} to 2^{0}	2^{15} to 2^{8}	2^{23} to 2^{16}	2^{31} to 2^{24}

10.8.2.2 Object 6002h: Total measuring range in measuring units

This object defines the ***total number of steps*** of the measuring system, before the measuring system starts at zero again.

Index	**0x6002**
Description	Total measuring range in steps
Data type	UNSIGNED32
Object code	VARIABLE
Access	rw
PDO Mapping	no
Lower limit	4 steps
Upper limit	536870912
Default	**536870912**

Total measuring range in steps			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

The total measuring range in steps can be calculated according to the following formula. As the value "0" is already counted as a step, the end value = measuring range in steps - 1.

*Total measuring range in steps = measuring steps per revolution * number of revolutions*

For the purposes of calculation, the parameters ***Measuring steps/revolution*** and ***Number of revolutions*** can be taken from the measuring system type plate.

10.8.3 Object 6003h: Preset value

⚠ WARNING

NOTICE

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

- The preset 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!

The preset function is used to set the measuring system value to any position value within the range of 0 to measuring range in steps — 1. The output position value is set to the `Preset value` parameter if writing to this object.

If an invalid preset value is entered, the measuring system responds with the abort code: 0600 0030h.

Index	**0x6003**
Description	Preset value
Data type	UNSIGNED32
Object code	VARIABLE
Access	rw
PDO Mapping	no

Preset value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.8.4 Object 6004h: Position value

The current non-safety-related scaled position value is output via object 6004h, intended for the PDO mapping.

Index	0x6004
Description	Position value (scaled)
Data type	UNSIGNED32
Object code	VARIABLE
Access	ro
PDO Mapping	yes

Position value (scaled)			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.8.5 Object 600Ch: Position raw value

The current non-safety-related and unscaled position value is output via object 600Ch. This object is intended for PDO mapping.

The position value is output with the following conditions

- Scaling function and preset function do not affect the position output
- The current counting direction setting is taken into account
- Steps per revolution = 8192
- Number of revolutions = 65536
- Measuring range in steps = 536870912

Index	0x600C
Description	Position value (unscaled)
Data type	UNSIGNED32
Object code	VARIABLE
Access	ro
PDO Mapping	yes

Position value (unscaled)			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.8.6 Object 6030h: Speed value

In subindex 1 `Speed value channel 1`, object 6030h displays the speed of the measuring system with the resolution defined in `Object 6031h: Speed parameter`(default: Steps / (s*factor).

The speed is output signed, as a two's complement:

- Counting direction setting = ascending
  - Output positive, with clockwise rotation (facing flange-mounting)
- Counting direction setting = descending
  - Output negative, with clockwise rotation (facing flange-mounting)

Index	**0x6030**
Description	Speed
Data type	INTEGER16
Object code	ARRAY
Access	ro
PDO Mapping	yes

Speed value	
Byte 0	byte 1
2^7 to 2^0	2^{15} to 2^8

If the speed value range (-32768…+32767) is exceeded or not reached, the limit values (0x7FFF or 0x8000) are output.

10.8.7 Object 6031h: Speed parameter

This object contains all necessary parameters that are required for the speed calculation:

Subindex 1 contains the basic position value and scaling. In the default setting, `Object 6004h: Position value` is used for this purpose.

Subindex 2 contains the speed integration time and is specified as a multiple of 1 ms. The default setting is 100 ms.

Subindex 3 specifies the multiplier value and subindex 4 the divider value.
An appropriate scaling factor can thus be generated with the product of multiplier and divider. In the default setting, both parameters are set to 1.

The speed [steps/integration time] is calculated internally in the default setting as follows:

$$V_{6030h}\ [\text{Steps/s}] = \frac{X_{6004h}\ \text{new} - X_{6004h}\ \text{old}\ [\text{Steps}]}{T_{6031\ 02h} * 10^{-3}\ [\text{ms}]} * \frac{C1_{6031\ 03h}}{C2_{6031\ 04h}}$$

V_{6030h}: Calculated speed value [Steps/s] in `Object 6030h: Speed value`
$X_{6004h\ new}$: Position value [Steps] new from `Object 6004h: Position value`
$X_{6004h\ old}$: Position value [Steps] old from `Object 6004h: Position value`
$T_{6031\ 02h}$: Integration time [ms] from `Object 6031h: Speed parameter, subindex 2`
$C1_{6031\ 03h}$: Multiplier value from `Object 6031h: Speed parameter, subindex 3`
$C2_{6031\ 04h}$: Divider value from `Object 6031h: Speed parameter, subindex 4`

Index	Subindex	Comment	Default	PDO mapping	Type	Attr.	Page
6031h	0	Max. subindex	4	no	Unsigned8	ro	-
	1	Speed source selector	1	no	Unsigned8	rw	118
	2	Speed integration time	100 ms	no	Unsigned16	rw	118
	3	Multiplier value	1	no	Unsigned16	rw	118
	4	Divider value	1	no	Unsigned16	rw	119

10.8.7.1 Subindex 1: Speed source selector

The basic position for the speed calculation is selected via subindex 1 `Speed source selector`. `Object 6004h: Position value` contains the scaled position and `Object 600Ch: Position raw value` the unscaled position.

UNSIGNED8

Value	Description	Default
1	Position from `Object 6004h: Position value` is used	X
2	Position from `Object 600Ch: Position raw value` is used	

10.8.7.2 Subindex 2: Speed integration time

The basic integration time for the speed calculation is preselected via subindex 2 `Speed integration time`.

UNSIGNED16

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

10.8.7.3 Subindex 3: Multiplier value

The multiplier value required for the speed scaling is defined via subindex 3 `Multiplier value`.

UNSIGNED16

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

10.8.7.4 Subindex 4: Divider value

The divider value required for the speed scaling is defined via subindex 4 `Divider value`.

UNSIGNED16

Lower limit	1
Upper limit	10000
Default	**1**

10.8.8 Object 6200h: Cyclic timer

This object defines the transmission cycle in [ms] for the communication parameter `TPDO1 Object 1800h`. An asynchronous transmission of the position value is set by programming the cyclic timer to > 0. Values between 1 ms and 65535 ms can be set. Default value = 0.

e.g.: 1 ms = 1 h
256 ms = 100 h

If the measuring system is started with the `NODE-START` command and the value of the cyclic timer is > 0, the first Transmit Process Data Object 1800h transmits the measuring system position in the default settings.

Index	**0x6200**
Description	Cyclic timer
Data type	UNSIGNED16
Object code	VARIABLE
Access	rw
PDO Mapping	no

The event timer, subindex 5 of communication parameter 1800h, is permanently linked to the cyclic timer. This means that any change in the event timer also has an effect on the cyclic timer and vice versa.
Communication parameters 1801h…1803h exclusively use their own timer, access via subindex 5.

10.8.9 Object 6400h: Area state register

A work area can be defined within the measuring range together with objects `Object 6401h: Work area low limit` and `Object 6402h: Work area high limit`.
`Object 6400h: Area state register` subindex 1 `Work area state channel 1` contains the current area state of the measuring system position. Using this function saves on external position switches, for example.

Index	0x6400
Description	Area state register
Data type	UNSIGNED8
Object code	ARRAY
Access	ro
PDO Mapping	yes

Bit	Function
0	0 = position between min/max value from `Object 650Ah` 1 = min/max position from `Object 650Ah` was reached or exceeded
1	1 = above the work area
2	1 = below the work area
3 – 7	reserved

10.8.10 Object 6401h: Work area low limit

`Object 6401h: Work area low limit` defines the lower limit of the work area. The value must be within the measuring range and lower than/equal to the limit value from `Object 6402h: Work area high limit`.

Index	0x6401
Description	Work area lower limit value
Data type	INTEGER32
Object code	ARRAY
Access	rw
PDO Mapping	no
Lower limit	0
Upper limit	536 870 911 = (0x1FFF FFFF)
Default	**0**

10.8.11 Object 6402h: Work area high limit

`Object 6402h: Work area high limit` defines the upper limit of the work area. The value must be within the measuring range and higher than/equal to the limit value from `Object 6401h: Work area low limit`.

Index	0x6402
Description	Work area upper limit value
Data type	INTEGER32
Object code	ARRAY
Access	rw
PDO Mapping	no
Lower limit	0
Upper limit	536 870 911 = (0x1FFF FFFF)
Default	**536 870 911**

10.9 CiA DS406 mode, safety-related

10.9.1 Object 6100h: Safety position configuration parameters

This object contains the configuration parameters necessary for the safety-related position in `Object 6120h: Safety normal resolution position value: Counting direction switching` and `preset value`.

In order to verify the safety-related configuration parameters, a safety signature is applied to each parameter,
see `Object 61FFh: Safety application configuration signature` on page 127.

Index	Subindex	Comment	Default	PDO mapping	Type	Attr.	Page
6100h	0	Max. subindex	2	no	Unsigned8	ro	-
	1	CANopen Safety code sequence	0 [rising]	no	Unsigned16	rw	121
	2	Safety preset value for encoder with normal resolution	0	no	Unsigned32	rw	122

10.9.1.1 Subindex 1: CANopen Safety code sequence

⚠ WARNING

Danger of death, serious physical injury and/or damage to property due to a jump of the absolute value following a change in the rotational direction function!

NOTICE

- The internal calculation algorithm produces different absolute positions for the counting direction settings `decreasing` or `rising`. After a change of rotational direction, the correct function must therefore be ensured by means of a protected test run. It may be necessary to adapt the output position using the preset function.

UNSIGNED16

Lower limit	0
Upper limit	1
Default	**0**

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

10.9.1.2 Subindex 2: Safety preset value for encoder with normal resolution

⚠ WARNING

NOTICE

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

- The preset 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!

The preset function is used to set the safety-related measuring system value `PRE-OPERATIONAL` state to any position value within the range of 0 to measuring range in steps — 1. The following procedure must be followed in order to set the safety-related position value in `Object 6120h: Safety normal resolution position value` to the `Safety preset value` parameter:

1. NMT state = `PRE-OPERATIONAL`
2. The measuring system must be in CiA DS406 mode.
3. Carry out the desired parametrization of the safety-related parameters in `Subindex 1: CANopen Safety code sequence` and in `Object 6101h: Safety speed configuration parameters`.
4. Transmit the desired preset value to this subindex via an SDO write service. Even if the desired preset value should already be included, an SDO write service is necessary to initiate the function.
5. Calculate the CRC using the parameters contained in objects 6100h and 6101h and transfer it to `Object 61FFh: Safety application configuration signature`.
6. Read back all safety-related parameters and the CRC signatures and compare with the written parameters.
7. In `Object 61FEh: Safety application configuration valid` set the parameter configuration to valid with value A5h.

If all parameters are correct and the self-tests performed do not show any errors, the preset function is executed and the specified preset value is set as the new position value.
If a safety-related error is present, the preset function is not executed and the parameter configuration in `Object 61FEh: Safety application configuration valid` is marked as invalid with the value = 00h.
If an invalid preset value (outside the measuring range) is entered the measuring system responds with a corresponding abort code, however the parameter configuration in object 61FEh remains valid (A5h).

UNSIGNED32

Lower limit	0
Upper limit	536870911
Default	**0**

Preset value, safety-related			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.9.2 Object 6101h: Safety speed configuration parameters

This object contains the configuration parameters necessary for the safety-related speed in Object 6124h: Safety speed value.

The parameters in subindex 1 CANopen Safety code sequence and subindex 2 Safety preset value for encoder with normal resolution are identical to the parameters in Object 6100h: Safety position configuration parameters. The reason for this is that both objects can be operated independently of each other.
Recommendation: If both objects are operated simultaneously, the parameters for Counting direction and Preset value should be controlled via object 6100h.

In order to verify the safety-related configuration parameters, a safety signature is applied to each parameter,
see Object 61FFh: Safety application configuration signature on page 127.

The safety-related speed calculation results from the following parameters:

Subindex 4 contains the basic position value and scaling. In the default setting, Object 6004h: Position value is used for this purpose.

Subindex 5 contains the speed integration time and is specified as a multiple of 1 ms. The default setting is 100 ms.

Subindex 6 specifies the multiplier value and subindex 7 the divider value.
An appropriate scaling factor can thus be generated with the product of multiplier and divider. In the default setting, both parameters are set to 1.

The speed [steps/integration time] is calculated internally in the default setting as follows:

$$V_{6124h}\ [\text{Steps/s}] = \frac{X_{6004h}\ \text{new} - X_{6004h}\ \text{old}\ [\text{Steps}]}{T_{6101\ 05h} * 10^{-3}\ [\text{ms}]} * \frac{C1_{6101\ 06h}}{C2_{6101\ 07h}}$$

V_{6124h}: Calculated speed value [Steps/s] in Object 6124h: Safety speed value
$X_{6004h\ new}$: Position value [Steps] new from Object 6004h: Position value
$X_{6004h\ old}$: Position value [Steps] old from Object 6004h: Position value
$T_{6101\ 05h}$: Integration time [ms] from Object 6101h: Safety speed configuration parameters, subindex 5
$C1_{6101\ 06h}$: Multiplier value from Object 6101h: Safety speed configuration parameters, subindex 6
$C2_{6101\ 07h}$: Divider value from Object 6101h: Safety speed configuration parameters, subindex 7

Index	Subindex	Comment	Default	PDO mapping	Type	Attr.	Page
6101h	0	Max. subindex	7	no	Unsigned8	ro	-
	1	CANopen Safety code sequence	0 [rising]	no	Unsigned16	rw	121
	2	Safety preset value for encoder with normal resolution	0	no	Unsigned32	rw	122
	3	not used	0	no	Unsigned8	ro	-
	4	Safety speed source selector	1	no	Unsigned8	rw	124
	5	Safety speed integration time	100 ms	no	Unsigned16	rw	124
	6	Multiplier value	1	no	Unsigned16	rw	125
	7	Divider value	1	no	Unsigned16	rw	125

10.9.2.1 Subindex 1: CANopen Safety code sequence

See subindex 1 from `Object 6100h: Safety position configuration parameters` on page 121.

10.9.2.2 Subindex 2: Safety preset value for encoder with normal resolution

See subindex 2 from `Object 6100h: Safety position configuration parameters` on page 122.

10.9.2.3 Subindex 4: Safety speed source selector

The basic position for the safety-related speed calculation is selected in subindex 4 `Safety speed source selector`.
`Object 6004h: Position value` contains the scaled position and `Object 600Ch: Position raw value` the unscaled position.

UNSIGNED8

Value	Description	Default
1	Position from `Object 6004h: Position value` is used	X
2	Position from `Object 600Ch: Position raw value` is used	

10.9.2.4 Subindex 5: Safety speed integration time

The basic integration time for the safety-related speed calculation is preselected in subindex 5 `Speed integration time`.

UNSIGNED16

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

10.9.2.5 Subindex 6: Multiplier value

The multiplier value required for the safety-related speed scaling is defined in subindex 6 `Multiplier value`.

UNSIGNED16

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

10.9.2.6 Subindex 7: Divider value

The divider value required for the safety-related speed scaling is defined in subindex 7 `Divider value`.

UNSIGNED16

Lower limit	1
Upper limit	10000
Default	**1**

10.9.3 Object 6120h: Safety normal resolution position value

This object contains the 32-bit position value of the CANopen normal resolution divided into four bytes. The position value is transmitted via the safety-related CANopen communication mechanisms.

Scaling of the position value is not possible. The following unchangeable resolution data apply:

- Steps per revolution = 8192
- Number of revolutions = 65536
- Measuring range in steps = 536870912

However, the set counting direction and preset value are taken into account during position output.

The object is intended for SRDO mapping.

Object 6121h contains the bitwise inverted data of object 6120h.

Index	**0x6120**
Description	Position value, safety-related
Data type	UNSIGNED8
Object code	ARRAY

Subindex	Comment	Default	SRDO mapping	PDO mapping	Type	Attr.
0	Max. subindex	4	no	no	Unsigned8	ro
1	Position, byte 0	-	Tx	no	Unsigned8	ro
2	Position, byte 1	-	Tx	no	Unsigned8	ro
3	Position, byte 2	-	Tx	no	Unsigned8	ro
4	Position, byte 3	-	Tx	no	Unsigned8	ro

Lower limit	0
Upper limit	536870911
Default	**0**

Position value			
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^{23} to 2^{16}	2^{31} to 2^{24}

10.9.4 Object 6124h: Safety speed value

This object contains the signed 16-bit speed value divided into two bytes. The speed value is transmitted via the safety-related CANopen communication mechanisms. Output occurs in accordance with the scaling parameters in Object 6101h: Safety speed configuration parameters on page 123. Default setting: Step/s, integration time = 100 ms

The object is intended for SRDO mapping.

Object 6125h contains the bitwise inverted data of object 6124h.

Index	**0x6124**
Description	Speed value, safety-related
Data type	UNSIGNED8
Object code	ARRAY

Subindex	Comment	Default	SRDO-mapping	PDO mapping	Type	Attr.
0	Max. subindex	2	no	no	Unsigned8	ro
1	Speed, byte 0	-	Tx	no	Integer8	ro
2	Speed, byte 1	-	Tx	no	Integer8	ro

Lower limit	-32768
Upper limit	32767
Default	**0**

Speed value	
Byte 0	byte 1
2^7 to 2^0	2^{15} to 2^8

10.9.5 Object 61FEh: Safety application configuration valid

This object indicates whether the currently set safety-related measuring system-related CiA DS406 mode parameter data in `Object 6100h: Safety position configuration parameters` or `Object 6101h: Safety speed configuration parameters` are valid. A write access to one of these parameters automatically sets the object to invalid = 00h.

The object must be set to valid = A5h, once the safety application has been configured and the signature of the safety application configuration has been validated via `Object 61FFh: Safety application configuration signature` .

UNSIGNED8

Attribute	Meaning
Access	ro, if NMT state = OPERATIONAL
	rw, if NMT state = PRE-OPERATIONAL
Range of values	A5h: Configuration is valid
	≠ A5h: Configuration is invalid
Default value	00h

10.9.6 Object 61FFh: Safety application configuration signature

This object is used to verify the safety-related measuring system-related CiA DS406- mode parameter data. A safety signature is applied to each parameter. TR Electronic provides a corresponding configuration tool called the `TR CAN Device Tool` for this purpose, see chap. 6.2 on page 48. The configuration tool downloads the set parameter data for the position or speed to the measuring system, calculates the CRC signature and then transmits the calculated CRC signature to the measuring system. The CRC signature for the position is written to subindex 1 and the CRC signature for the speed is written to subindex 2. The measuring system also calculates the CRC based on the set parameter data and then compares the downloaded CRC signature with the calculated CRC signature. If both match, the parameter data are valid. This process is performed separately for the position and for the speed.

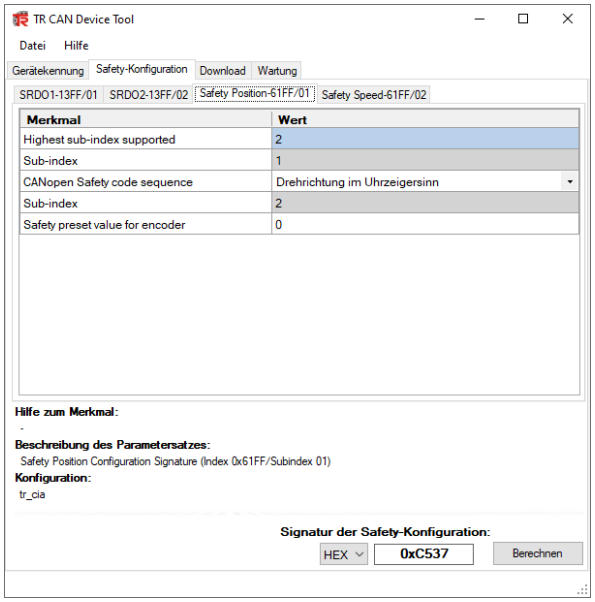


Figure 19: **CRC calculation parameter data set - position**

Figure 19 shows all relevant position-related parameters, which are included in the CRC calculation, and the obtained result: `0xC537`

The signature example refers to the prevailing safety-related parameter default setting for the CiA DS406- encoder profile and is entered by the `TR CAN Device Tool` in object 61FFh under subindex 1 during downloading.

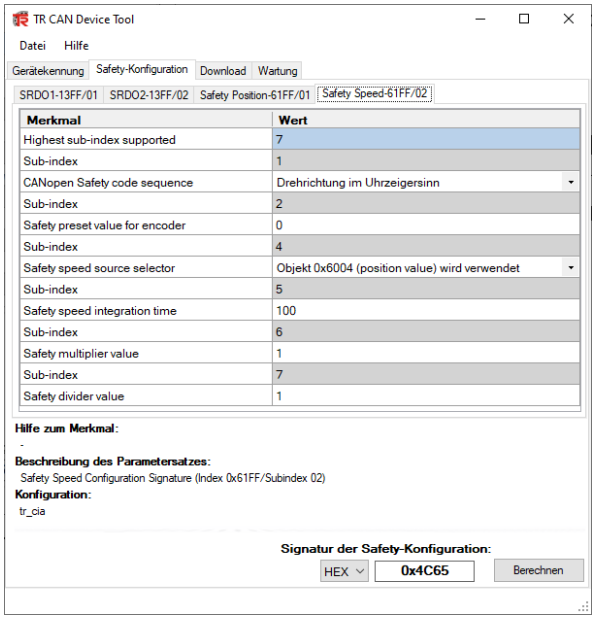


Figure 20: **CRC calculation parameter data set - speed**

Figure 20 shows all relevant speed-related parameters, which are included in the CRC calculation, and the obtained result: `0x4C65`

The signature example refers to the prevailing safety-related parameter default setting for the CiA DS406- encoder profile and is entered by the `TR CAN Device Tool` in object 61FFh under subindex 2 during downloading.

Safety application configuration signature

Index	Subindex	Comment	Default value	Type	Attr.
61FFh	0	Largest subindex supported	2	Unsigned16	ro
	1	Safety position configuration signature	C537h	Unsigned16	rw
	2	Safety speed configuration signature	4C65h	Unsigned16	rw

Attribute	Meaning
Access Subindex 1	ro, if NMT state = OPERATIONAL
	rw, if NMT state = PRE-OPERATIONAL

10.10 Measuring System Diagnosis

10.10.1 Object 2211h: TR alarms

In addition to the "emergency message" object 2211h contains further alarm messages, which can also be displayed in the process data via the PDO mapping. An alarm is set if a fault in the measuring system could lead to an incorrect position value. If an alarm occurs, the relevant bit is set to logic "High", until the alarm is cleared and the measuring system is ready to output a correct position value.

Index	**0x2211**
Description	TR alarms
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	yes

Bit	**Function**
0	Scaling error
1	reserved
2	reserved
3	reserved
4	reserved
5	reserved
6	reserved
7	reserved
8	reserved
9	reserved
10	reserved
11	reserved
12	reserved
13	reserved
14	reserved
15	reserved

Scaling error

The bit is set to 1 if the internal hardware diagnostics has detected a movement of the shaft in deactivated state, which is outside the valid monitored range. Monitored range: SIL2 = 3200 revolutions, SIL3 = 320 revolutions

10.10.2 Object 2212h: TR warnings

Object 2212h contains information about warnings and indicates that certain operating parameters of the measuring system have been exceeded. Unlike alarms, warnings do not contain notifications of incorrect position values.

Index	0x2212
Description	TR warnings
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	yes

Bit	Function
0	Light source
1	Undervoltage, internal
2	Overvoltage, internal
3	Undervoltage 24 V
4	Overvoltage 24 V
5	Permissible speed
6	Temperature
7 – 14	reserved
15	General warning

Light source

The bit is set to 1, if the regulation of the optical scanning light source is outside the normal range.

Undervoltage, internal / Overvoltage, internal

The bit is set to 1, if the measuring system has detected an undervoltage or overvoltage in the internal supply network.

Undervoltage 24 V / Overvoltage 24 V

The bit is set to 1, if the supply network is below or above the tolerance limit.

Permissible speed

The bit is set to 1, if the mechanically permissible speed of 6600 rpm has been exceeded.

Temperature

The bit is set to 1, if the internal temperature of 105 °C has been exceeded.

General warning

The bit is set to 1, if an unspecified warning has been detected.

If problems persist after a system restart, please contact Product Support.
All warnings are deleted automatically, as soon as the operating parameters are back in the normal range.

10.10.3 Object 6500h: Operating status

This object provides the operating status of the measuring system functions configured in `Object 6000h: Operating parameters`.

Index	0x6500
Description	Operating status
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	no

Bit	Function	Bit = 0	Bit = 1
0	Counting direction	Position rising	Position falling
1	Diagnostic control	switched off	switched on
2	Scaling function	switched off	switched on
3 – 15	reserved		

10.10.4 Object 6501h: Single-turn resolution

This object contains the maximum number of measuring steps per revolution, which can be output by the measuring system.

Index	0x6501
Description	Single-turn resolution
Data type	UNSIGNED32
Object code	VARIABLE
Access	ro
PDO Mapping	no
Default	8192 steps per revolution

10.10.5 Object 6502h: Number of distinguishable revolutions

This object contains the maximum number of revolutions, which the measuring system can output.

Index	0x6502
Description	Number of revolutions
Data type	UNSIGNED32
Object code	VARIABLE
Access	ro
PDO Mapping	no
Default	65536 revolutions

10.10.6 Object 6503h: Alarms

In addition to the "emergency message" object 6503h contains further alarm messages, which can also be displayed in the process data via the PDO mapping. If an alarm occurs, the relevant bit is set to logic "High", until the alarm is cleared and the measuring system is ready to output a correct position value.

Index	**0x6503**
Description	Alarms
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	yes

Bit	**Function**
0	Position error (NON-safety-related)
1	Start-up diagnostic error
2	reserved
3	reserved
4	reserved
5	reserved
6	reserved
7	reserved
8	reserved
9	reserved
10	reserved
11	reserved
12	manufacturer-specific functions
13	manufacturer-specific functions
14	manufacturer-specific functions
15	manufacturer-specific functions

Position error (NON-safety-related)

The bit is set to 1, if the measuring system detects a system fault.

Start-up diagnostic error

The bit is set to 1, if an error has been detected in the scanning components responsible for position detection at a standstill.

10.10.7 Object 6504h: Supported alarms

Object 6504h contains information about the alarms supported by the measuring system.

Index	**0x6504**
Description	Alarms supported
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	no

Bit	**Function**	**Bit = 1** (supported)
0	Position error (NON-safety-related)	Yes
1	Start-up diagnostic error	Yes
2	reserved	No
3	reserved	No
4	reserved	No
5	reserved	No
6	reserved	No
7	reserved	No
8	reserved	No
9	reserved	No
10	reserved	No
11	reserved	No
12	manufacturer-specific functions	No
13	manufacturer-specific functions	No
14	manufacturer-specific functions	No
15	manufacturer-specific functions	No

10.10.8 Object 6505h: Warnings

Object 6505h contains information about the warnings that have occurred in the system.
This object can also be transmitted in the process data via the PDO mapping.

Index	0x6505
Description	Warnings
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	yes

Bit	Function
0	reserved
1	Light control reserve
2 – 5	reserved
6	Speed range (NON-safety-related)
7 – 11	reserved
12	Undervoltage
13	Overvoltage
14	General warning
15	reserved

Light control reserve

The bit is set to 1, if the regulation of the optical scanning light source is outside the normal range.

Speed range (NON-safety-related)

The bit is set to 1, if the measured speed either falls below or exceeds the display range. See `Object 6030h: Speed value`, page 117.

Undervoltage / Overvoltage

The bit is set to 1, if the measuring system has detected an undervoltage or an overvoltage in the internal supply network.

General warning

The bit is set to 1, if an unspecified warning has been detected.

If problems persist after a system restart, please contact Product Support.

All warnings are deleted automatically, as soon as the operating parameters are back in the normal range.

10.10.9 Object 6506h: Supported warnings

Object 6506h contains information about the warnings supported by the measuring system.

Index	**0x6506**
Description	Warnings supported
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	no

Bit	**Function**	**Bit = 1** (supported)
0	Frequency	No
1	Light control reserve	Yes
2	CPU watchdog status	No
3	Operating time limitation	No
4	Battery charge	No
5	Reference point	No
6	Speed range (NON-safety-related)	Yes
7	Acceleration range	No
8	Jerk range	No
9 – 11	reserved	–
12	Undervoltage	Yes
13	Overvoltage	Yes
14	General warning	Yes
15	reserved	–

10.10.10 Object 6507h: Profile and software version

This object contains the implemented profile version of the measuring system in the first 16 bits. It is combined with a revision number and an index.

Index	0x6507
Description	Profile and software version
Data type	UNSIGNED32
Object code	VARIABLE
Access	ro
PDO Mapping	no

e.g.: Profile version: 3.02
Binary code: 0000 0011 0000 0010
Hexadecimal: 03 02

The second 16 bits contain the software version index from object 100Ah.

e.g.: Software version index: 1.06
Binary code: 0000 0001 0000 0110
Hexadecimal: 01 06

The software version without the version index is contained in object 100Ah, see page 63.

Profile version		Software version index	
Byte 0	byte 1	Byte 2	Byte 3
2^7 to 2^0	2^{15} to 2^8	2^7 to 2^0	2^{15} to 2^8

10.10.11 Object 6508h: Operating time

This object stores the operating time in the non-volatile memory as long as the measuring system is supplied with power.

The operating time is recorded in 0.1 hour per digit.

Index	0x6508
Description	Operating time
Data type	UNSIGNED32
Object code	VARIABLE
Access	ro
PDO Mapping	no

10.10.12 Object 6509h: Offset value

This object contains the offset value, which is calculated by the preset function. The offset value is stored and can be read by the measuring system.

Index	0x6509
Description	Offset value
Data type	INTEGER32
Object code	VARIABLE
Access	ro
PDO Mapping	no

10.10.13 Object 650Ah: Module identification

This object contains the manufacturer-specific offset value, as well as the manufacturer-specific minimum and maximum position value. The offset value is stored in subindex 1. This value provides information about the zero point offset in number of steps compared to the physical zero point of the code disk. The minimum/maximum position value is stored in subindexes 2 and 3.

Index	0x650A
Description	Manufacturer offset value
Data type	INTEGER32
Object code	ARRAY
Access	ro
PDO Mapping	no

Subindex	Comment	Default value	Type	Attr.
0	Largest subindex supported	3	INTEGER32	ro
1	Manufacturer offset value	0	INTEGER32	ro
2	Manufacturer min position value	0 steps	INTEGER32	ro
3	Manufacturer max position value	536870911 steps	INTEGER32	ro

10.10.14 Object 650Bh: Serial number

This object contains the current serial no. of the device and corresponds to identity object 1018h, subindex 4.

Index	0x650B
Description	Serial Number
Data type	UNSIGNED32
Object code	VARIABLE
Access	ro
PDO Mapping	no

10.10.15 Object 650Dh: Absolute accuracy

This object contains the absolute accuracy of the sensor element. The value specifies the effective number of bits with an accuracy of ±1 bit.

Index	0x650D
Description	Absolute accuracy
Data type	UNSIGNED8
Object code	VARIABLE
Access	ro
PDO Mapping	no
Default	13 bits (8192 steps/rev.)

10.10.16 Object 650Eh: Device capability

This object provides additional information about `Object 1000h: Device type`, i.e. device classes, measuring system resolution type and CANopen Safety functionalities.

Index	0x650E
Description	Device capability
Data type	UNSIGNED16
Object code	VARIABLE
Access	ro
PDO Mapping	no
Default	23h

Breakdown of the default value: 0010 0011b (23h)

Encoder class: Class 3 functionality; according to CiA DS406 Encoder Profile
Resolution: Normal, max. 32 bit
Safety: supports safety-related functionalities
Safety type: CANopen Safety

11 Resetting the Device Parameters

⚠ WARNING

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

NOTICE

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

Resetting of the device parameters is carried out using two HEX rotary switches SW1 and SW2. The position and assignment of the HEX rotary switches can be found in the accompanying pin assignment.

Procedure:

1. Loosen closing screw
2. Switches SW1 / SW2 ≠ 0
3. Switches SW1 / SW2 ≠ 0
4. Wait 3 s, LED1 for 2 s in `Flickering` mode
5. Switch SW1 = 5 / SW2 = 2, corresponds to 0x52 = 'R' (RESET)
6. Wait 3 s, LED1 / LED2 are in `Alternate Blinking` mode
7. Switches SW1 / SW2 ≠ 0
8. The memories for parameters, Node-ID, baud rate, Config-Verified and Config-Locked are deleted
9. After completion of the delete procedure, LED1 goes into `Flickering` mode
10. Set switches SW1 / SW2 to the desired address value
11. Restart the measuring system via POWER OFF/ON
12. The procedure is complete, the closing screw can be screwed in again

12 Output of substitute values in case of error

When the measuring system is in safe state, e.g. after a critical error, static substitute values are output instead of the cyclic SRDO data, depending on the prevailing settings. The position is set to 0xFF FF FF FF, while the remaining data are set to "0".

Static substitute values are output instead of the cyclic SRDO data in the following cases:

- On start-up of the safety-related system
- Current system configuration is invalid. Object 0x13FE `Configuration valid` contains the value ≠ 0xA5.
- In case of errors in the safety-related communication between control and measuring system via the CANopen Safety protocol according to EN 50325-5
- If the value set in object 0x2410 `TR safety configuration parameter` for `Window increments` has been exceeded
- if the permissible ambient temperature range specified under the corresponding article number falls far below or is exceeded
- Technical hardware faults in the measuring system

13 Safe State Definition

In safe state the measuring system, as a CANopen Safety node, must switch to failsafe state. Generally this state is indicated with a high-priority CAN telegram, the `Global Fail Safe Command (GFC)`. This message has COB-ID 0x001 and has no parameters. Settings for the `GFC bit` in `Object 1300h: Global failsafe command parameter (GFC)` can be made via `Object 3011h: GFC setting`, see page 112.

There are two safe states in TR mode:

1. **Passive Safe State** (TR mode / CiA DS406 mode)
Passive Safe State is set when the value = 0 is set in `Object 2410h: TR safety configuration parameter` under `Subindex 11: Error behavior`.

2. **Active Safe State** (TR mode)
Active Safe State is set when the value = 1 is set in `Object 2410h: TR safety configuration parameter` under `Subindex 11: Error behavior`. In addition, the `Object 1029h: Error behavior` for subindex 1 and 2 must be set to the value = 1 --> `no change`.

13.1 Passive Safe State

In Passive Safe State the measuring system no longer participates in the CANopen Safety communication and no longer outputs any cyclic SRDO data. After expiry of the `Safeguard Cycle Time (SCT)`, the CANopen Safety master detects corresponding safety-relevant errors. The process is in accordance with the CANopen Safety protocol according to EN 50325-5. In CiA DS406 mode only the Passive Safe State is therefore adopted in case of error, regardless of the setting in object 2410h.

Error acknowledgment:
In order to leave failsafe state again after elimination of an error, the measuring system must be transferred to `PRE-OPERATIONAL` state. Cyclic SRDO communication can then be resumed in `OPERATIONAL` state.

13.2 Active Safe State

In Active Safe State the measuring system still maintains cyclic communication via SRDO. In the user data of the SRDO the safe state is indicated via the `Safe-State-Bit` 2^4 in object `TR safety status` 0x2420 = "0". If user data are available, e.g. only one measuring channel, these are still output. The aim of this process is to allow the user, for example in manual mode, to move to a parking position and put the system into a safe state.

Error acknowledgment:
After elimination of the error, the measuring system sets the `Error Acknowledge Request` Bit 2^6 in object `TR safety status` 0x2420 and displays any necessary acknowledgment. In order to leave failsafe state again, the `Error Acknowledge` Bit 2^6 in object `TR safety control` 0x2430 must therefore be set to "1".

If the current system configuration is set to invalid ≠ A5h via `Object 13FEh: Configuration valid`, instead of cyclic SRDO data no more data are output.

14 Error causes and solutions

14.1 Optical displays

Position, assignment and flashing frequency of the LEDs can be found in the device-specific plug assignment, see chap. "Bus status display" on page 47.

ERR LED, red:

LED status	Cause	Solution
ON	CAN driver in "BUS OFF" state, due to too many transmission errors.	- Check bus cable. - Check bus termination - Check plug connections. - Check for unique Node-IDs - Set baud rate must match the master baud rate.
OFF	No errors, or measuring system switched off.	–
Flickering	LSS `Waiting Mode` active	No errors, measuring system can be put into LSS `Configuration Mode` for parametrization, or directly perform the services supported in LSS `Waiting Mode`. If the Node-ID was reset, the NMT service `Reset Communication` must be executed for activation in this mode.
Blinking	When attempting to declare the system configuration or parameter configuration as valid via objects 13FEh, 24FEh or 61FEh, a general configuration error was detected during the check. `Object 3010h: Active mode` contains the value 0 = mapping switched off or 3 = incorrect mapping settings.	- For error analysis read out `Object 3010h: Active mode` and adapt mapping settings. - Set system configuration to valid according to chap. 4.2 on page 34. - Check interdependent parameters in their overall constellation for plausibility, e.g. scaling parameters (measuring length, rev. numerator/denominator). - If the measuring system is in safe state, see measures under `Inverse single flash`.
Single flash	At least one error counter of the CAN controller has reached or exceeded the warning level (too many error frames)	- Check for unique Node-IDs - Set baud rate must match the master baud rate. - Check the physical structure of the bus system.
Double flash	Guard event occurred. (NMT slave or NMT master)	- General bus utilization ≤ 85 %! - Try to increase the baud rate. - Increase cycle time for the node guarding protocol via objects 100Ch and 100Dh.
	Heartbeat event occurred. (Heartbeat Consumer)	- General bus utilization ≤ 85 %! - Try to increase the baud rate. - Adapt cycle time for the heartbeat protocol via objects 1016h and 1017h.

Continued on next page

Continued: ERR LED

LED status	Cause	Solution
Inverse Single Flash	**Measuring system is in safe state due to the following reasons:**	- For error analysis read out `Object 3010h: Active mode` and evaluate emergency messages. `Object 2420h: TR safety status` offers another diagnostic option and can also be read in passive safe state via SDO services. - In order to restart the measuring system after a safety-relevant error, the error must generally be eliminated first of all and then an error acknowledgment carried out according to chap. 13 on page 141. If the error cannot be acknowledged, the supply voltage must first be switched off and then on again.
	- Current system configuration is invalid. `Object 13FEh: Configuration valid` contains the value 00h.	- Set system configuration to valid according to chap. 4.2 on page 34.
	- Error in the safety-related communication between control and measuring system.	- Try to localize the error with the aid of diagnostic mechanisms (control-dependent). - Check that the set timeout times are suitable for the automation task. - Check whether the connection between safety control and measuring system is faulty.
	- Set value for the `Window increments` parameter in `Object 2410h: TR safety configuration parameter` was exceeded.	- Check that the set value for the `Window increments` parameter is suitable for the automation task, see chapter 10.2.2.8 on page 96.
	- Permissible ambient temperature range was far exceeded or fallen below.	- Suitable measures must be taken to ensure that the permissible ambient temperature range can be observed at all times.
	- Hardware error occurred.	- Supply voltage OFF/ON. If the error persists after this measure, the measuring system must be replaced.
Alternate Blinking	- No errors, software download or reset to factory settings active.	–
Alternate Slow Blinking	- No errors, device search function active.	–

RUN LED, green:

LED status	Cause	Solution
ON	- Measuring system is in OPERATIONAL NMT state.	Normal operating state
OFF	- Measuring system switched off.	–
Flickering	- LSS Configuration Mode active.	No errors, measuring system can be put into LSS Waiting Mode or directly perform the services supported in LSS Configuration Mode. For permanent storage of the adapted parameters, the LSS Store Configuration Protocol must be transferred to the measuring system. To activate the Node-ID, the NMT service RESET COMMUNICATION must be executed in LSS Waiting state. To activate the baud rate, the LSS Activate Bit Timing Parameters Protocol must be transferred to the measuring system in LSS Configuration state.
Blinking	- Measuring system is in PRE-OPERATIONAL NMT state.	If no errors are present, the measuring system can be put into OPERATIONAL NMT state.
Single flash	- Measuring system is in STOPPED NMT state.	If no errors are present, the measuring system can be put directly into OPERATIONAL MNT state.
Inverse single flash	- Error acknowledgment requested.	Carry out error acknowledgment according to chap. 13 on page 141.
Alternate Blinking	- No errors, software download or reset to factory settings active.	–
Alternate Slow Blinking	- No errors, device search function active.	–

"Object 1029h: Error behavior " allows you to control whether the measuring system should be transferred from OPERATIONAL to PRE-OPERATIONAL or STOPPED mode, see page 71. In this case the emergency message sent must be evaluated, see chap. 14.3 from page 148.

14.2 SDO error codes

In case of an error (SDO Response CCD = 0x80) the data range contains a 4-byte error code. The measuring system supports the following error codes:

Error code	Meaning	Solution
0x0503 0000	Toggle bit has not changed.	A telegram was not correctly transmitted during segmented transfer of an SDO. - Repeat process
0x0504 0000	SDO protocol time exceeded	The time of 5 s between telegrams was exceeded during segmented SDO download/upload. - Repeat process
0x0504 0001	Invalid or unknown command code (CCD)	For a list of valid CCDs see Table 3 on page 21.
0x0504 0004	CRC error. An attempt was made to declare the system configuration or parameter configuration as valid via objects 13FEh, 24FEh or 61FEh. Incorrectly entered CRC signatures were detected during testing.	Check the CRC signatures entered in objects 13FFh, 24FFh or 61FFh, correct them and try again to declare the system configuration or parameter configuration as valid.
0x0601 0000	- No supported access to the object. An attempt was made to access a mapping object via an SDO write service. - An attempt was made to delete the GFC via object 1300h, although provider errors are still pending. - An attempt was made to cancel the preset function via object 2040h or 6003h, although the prevailing mode setting does not match the selected preset function. - An attempt was made to activate the life guard protocol with the heartbeat protocol already activated. - An attempt was made to write subindexes 3 and 6 with PDOs set to valid (objects 1800h-1803h, subindex 1, bit 31 = 0). Or an attempt was made to write the subindexes of objects 1A00h-1A03h. - With the mapping function activated (objects 1A00h-1A03h, subindex 0 ≠ 0), an attempt was made to write the following subindexes.	- Mapping objects such as e.g. `Object 2432h: TR safety preset value`, may only be accessed via SDO read service. - Only delete GFC via object 1300h, once no provider errors are pending. - Only execute preset function via object 2040h in TR mode. Only execute preset function via object 6003h in CiA DS406 mode. - When the monitoring protocol is activated, ensure that either only the heartbeat protocol or the life guard protocol is used. - Observe access regulations for the communication parameters and mapping parameters according to chapter "Communication profile" on page 49.
0x0601 0001	Read access to an object that can only be written.	Incorrect command code (CCD), only write commands (0x2x) are permitted, see Table 3 on page 21.
0x0601 0002	Write access to an object that can only be read.	Incorrect command code (CCD), only read commands (0x4x) are permitted, see Table 3 on page 21.
0x0602 0000	Object not present in object dictionary.	Valid objects, see Table 9 and Table 10 on page 60 and 76.
0x0604 0041	Object cannot be mapped	Supported mapping objects, see chap. 8 from page 59.
0x0604 0042	Number and length of mapped objects exceeds the permissible PDO length	Check - Mapping objects ≤ 8 byte data length per TPDO - Number of mapping objects ≤ 2 per TPDO

Continued on next page

Continued: SDO error codes

Error code	Meaning	Solution
0x0604 0043	General parameter incompatibility	- Incorrect EMCY COB-ID in object 1014h? - Incorrect heartbeat consumer COB-ID (object 1016h)? permissible range = 1…127 - Incorrect PDO-COB-ID (object 1800h-1803h)? - Incorrect SRDO-COB-ID (object 1301h-1303h)? - Is the `Safeguard Cycle Time` (SCT) greater than the `Safety Related Validation Time` (SRVT)? see objects 1301h-1303h. - Depending on the set mode: Check TR mode parameter data from object 2410h or CiA DS406 mode parameter data from object 6100h or 6101h and set the respective configuration to valid via object 24FEh or 61FEh, so that the system configuration can be set to valid via `Object 13FEh: Configuration valid`.
0x0606 0000	Access failed due to a hardware error	Store/restore parameters again (objects 1010h, 1011h).
0x0607 0010	Data type or length of service parameters incorrect.	The command code used (CCD) does not match the data length of the transmitted object. Compare command codes on page 21 with the objects, see Table 9 and Table 10 on page 60 and 76.
0x0607 0012	Data type or length of service parameters too great.	The command code used (CCD) is longer than the transmitted object. Compare command codes on page 21 with the objects, see Table 9 and Table 10 on page 60 and 76.
0x0607 0013	Data type or length of service parameters too small.	The command code used (CCD) is shorter than the transmitted object. Compare command codes on page 21 with the objects, see Table 9 and Table 10 on page 60 and 76.
0x0609 0011	Subindex not present.	Check which subindexes the corresponding object supports.
0x0609 0030	Invalid parameter value (download only)	Check permissible value range for the corresponding object.
0x0609 0031	Sent parameter value too large	Observe valid range of object.
0x0609 0032	Sent parameter value too small	Observe valid range of object.
0x060A 0023	- Resource not available - An error occurred during internal update of parameters	- Measuring system does not support a second interface, so that the associated parameters cannot be read or written. - Execute last process repeatedly - Check parameters for plausibility - Load default values and execute repeatedly - Perform restart of the measuring system

Continued on next page

Continued: SDO error codes

Error code	Meaning	Solution
0x0800 0000	General error has occurred: - NON-safety-related preset function via objects 2040h or 6003h could not be executed. - Node-ID in object 3000h could not be set. - GFC consumer in object 3011h could not be activated. - Preset or parameter update could not be performed when setting the configuration to valid via `Object 13FEh: Configuration valid`. - Too many heartbeat consumers were configured (object 1016h).	- Execute last process repeatedly - Check parameters for plausibility - Load default values and execute repeatedly - Perform restart of the measuring system
0x0800 0020	Data cannot be transmitted or stored	Incorrect signature written when storing / restoring parameters, see objects 1010h/1011h, page 64/66.
0x0800 0021	- Data cannot be sent or stored due to local activation. - The safety-related parameters may be locked by the `TR CAN Device Tool` and cannot be changed.	- Incorrect mode activation, see chap. 8 on page 59. - The safety-related parameters are activated via Object 1011h: Restore default parameters on page 66. The safety configuration is locked again via subindex 1 and the "load" signature.
0x0800 0022	Data cannot be transmitted or stored due to the device status: - Parameter initialization failed. - NON-safety-related preset function is still in use and is currently running. - An attempt was made to access an SRDO mapping object (2430h-2433h) via an SDO write service. - An attempt was made to write safety-related parameters, although the measuring system is not in `OPERATIONAL` state. - When attempting to set the parameter configuration to valid via object 24FEh or object 61FEh it was found that internal checks are currently still taking place and the request could not be processed. - An attempt was made to set the parameter configuration to valid via object 24FEh or 61FEh, although the prevailing mode setting does not match the selected activation function.	- Incorrect procedure during mapping configuration, see chap. "Changing the mapping setting" on page 52. - Repeatedly perform executed action at a later time. - Writable SRDO mapping objects (2430h-2433h) can only be transmitted or written according to EN 50325-5. - Safety-related parameters can only be written in `OPERATIONAL` state. - Only execute activation function via object 24FEh in TR mode. Only execute activation function via object 61FEh in CiA DS406 mode. - Restart measuring system if necessary.
0x0800 0024	No data available	Indication that no more errors are present, upon read access to object 1003h subindex 01, see page 62.

Table 11: SDO error codes

14.3 Emergency message (8 bytes)

Emergency messages are triggered if an internal fault occurs and are sent with the highest priority from the relevant application device to the other devices.

Emergency message								
Byte	0	1	2	3	4	5	6	7
	Emergency error code		Error register	Manufacturer-specific error field				
Contents	Object 1003h, Byte 0-1		Object 1001h	Module no.	Error no.	Error class, Byte 0-1		Sensor no.
				Object 1003 Byte 3	Object 1003 Byte 2	see from page 150		0: All 1-4: Sensor 1 to 4

Standard COB-Identifier = 080h + Node-ID

If the measuring system detects an internal error, an emergency message is sent with the error code of object 1003h (Predefined error field) and the error register (object 1001h).
If a manufacturer-specific error is present, then a manufacturer-specific error code is additionally sent via the "Manufacturer-specific error field" (bytes 3 to 7), see from page 150.

If the error is no longer present, the measuring system sends an emergency message with the error code "0" (reset error / no error) and error register "0".

14.3.1 Object 1003h: Predefined error field, bytes 0 – 1

Only the most recent error is displayed by the emergency object. An emergency message with the error code "0x0000" is sent for each EMCY message that is deleted. The result can be found in object 0x1003. If no more errors are present, the error register also does not display any more errors.

The error list in object 0x1003 can be deleted by different methods:

1. Writing the value "0" to subindex 0 in object 0x1003
2. Restarting the measuring system

Error code	Meaning	Solution
0x0000	Error reset / no error	-
0x1000	General error has occurred	- Group error display: At least one error has occurred. Read out error register 1001h for further error analysis. If a manufacturer-specific error is present, also evaluate bytes 3 to 7 in the emergency message or bytes 2 to 3 in object 1003h.
0x3100 + sensor no. (0 to 4)	Supply voltage outside tolerance	- For further error analysis also evaluate bytes 3 to 7 in the emergency message or bytes 2 to 3 in object 1003h.
0x4200 + sensor no. (0 to 4)	Temperature outside tolerance	
0x6001	Safety-related error – fieldbus interface, own processor	
0x6002	Safety-related error – fieldbus interface, remote processor	
0x6100 + sensor no. (0 to 4)	General internal software error has occurred	
0x8110	CAN overflow (lost objects)	- General bus utilization ≤ 85%. - Try to increase the baud rate.
0x8120	CAN error (Passive Mode)	- Check for unique Node-IDs. - Set baud rate must match the master baud rate. - Check the physical structure of the bus system.
0x8130	Node Guarding error	- General bus utilization ≤ 85 %! - Try to increase the baud rate. - Increase cycle time for the node guarding protocol via objects 100Ch and 100Dh.
	Heartbeat error	- General bus utilization ≤ 85 %! - Try to increase the baud rate. - Adapt cycle time for the heartbeat protocol via objects 1016h and 1017h.
0x8140	Restoring, BUS-OFF state	- Check for unique Node-IDs. - Set baud rate must match the master baud rate. - Check the physical structure of the bus system.
0x8210	PDO or SRDO is not processed due to a length error.	- Transmission data for PDO/SRDO checked and adjusted by the control.
0x8240	Unexpected SYNC data length (SYNC consumers expect a different SYNC format: with or without SYNC numerator)	- Check whether or not a 1-byte numerator value is expected within a SYNC message. The setting is made via `Object 1019h: Synchronous counter overflow value`.

Table 12: Emergency error codes

81xx, 82xx: Communication error
≠ 81xx, 82xx: Device error

14.3.2 Object 1001h: Error register, byte 2

The error register displays the error status of the measuring system in bit code. Several errors can also be displayed simultaneously by a set bit. The error code of the most recent error is stored in object 0x1003, subindex 1, the number of errors in subindex 0. At the time of occurrence, an error is indicated by an EMCY message. The error list is only deleted by writing the value "0" to object 1003h subindex 0, or after restarting the measuring system.

Bit	Meaning
0	General error
1	0
2	Supply voltage
3	Temperature
4	Communication error (overflow, error status)
5	0
6	0
7	Manufacturer-specific

14.3.3 Manufacturer-specific error field, bytes 3 – 7

Bytes 3 and 4 in the emergency message for the `Module no.` and `Error no.` stand for internal system codes and can be sent to TR Electronic for error analysis when they occur.

Byte 7 in the emergency message for the `Sensor no.` is broken down as follows:
0x00: All sensors defective
0x01: Sensor 1 = master channel, NON-safety-related is defective
0x02: Sensor 2 = slave channel, NON-safety-related is defective
0x03: Sensor 3 = safety-related channel is defective
0x04: Sensor 4 = additional interface is defective

Bytes 5 and 6 in the emergency message for the `Error class` are specified below:

Error class	Meaning	Solution
0x0000	**No error** Normal state	- **INFO**: Applies if all remaining bytes in the `Manufacturer-specific error field` (bytes 3-4, 7), and the `Error register` object 1001h (byte 2) and the `Predefined error field` object 1003h (bytes 0-1) are set to 0.
0x0002	**Undervoltage 24 V** The supply voltage is below the tolerance limit.	- The supply voltage range specified for the article no. must be observed.
0x0003	**Overvoltage 24 V** The supply voltage is above the tolerance limit.	- The supply voltage range specified for the article no. must be observed.

Continued on next page

Continued: Manufacturer-specific error field

Error class	Meaning	Solution
0x0005	**Overtemperature** The output stage is overloaded and gets too hot.	- The ambient temperature range specified for the article no. must be observed.
0x2000	**Processor unit – CPU** Error in the processor-internal hardware diagnostics.	- Perform system restart
0x2001	**Processor unit – cross-communication** Error in the cross-communication between the two scanning channels/partner channel.	- An error acknowledgment must be performed according to chap. 13 on page 141. - If problems persist after a system restart, please contact Product Support.
0x2002	**Processor unit – sensor communication** Error in the data transmission between sensor and CAN interface.	- An error acknowledgment must be performed according to chap. 13 on page 141. - If problems persist after a system restart, please contact Product Support.
0x2003	**Process – cross data comparison** The device is in failsafe state.	- Check that the set value for the `Window increments` parameter is suitable for the automation task. See chap. "Subindex 10: Window Increments" on page 96. - If problems persist after a system restart, please contact Product Support.
0x2004	**ST-scanning - channel 1** The device is in failsafe state.	- If problems persist after a system restart, please contact Product Support.
0x2005	**MT-scanning - channel 1** The device is in failsafe state.	- If problems persist after a system restart, please contact Product Support.
0x2006	**ST-scanning - channel 2** The device is in failsafe state.	- If problems persist after a system restart, please contact Product Support.
0x2007	**MT-scanning - channel 2** The device is in failsafe state.	- If problems persist after a system restart, please contact Product Support.
0x2009	**Hardware – service life** The end of the service life interval has been reached.	- The device must be subjected to a proof test by the manufacturer.
0x200A	**Process - preset adjustment** The preset adjustment is defective.	- The safety-related adjustment process must be repeated.
0x200B	**Process – configuration** Error initializing application configuration data from the configuration memory.	- Contact Product Support.
0x200C	**Processor unit – memory** The internal hardware diagnostics has found an error in the internal memory areas.	- A system restart is required. - If problems persist after a system restart, please contact Product Support.
0x200D	**Process – parameter check** The device parametrization is incorrect.	- Check all parameters in the device configuration -> transmit correct parameters.

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Continued: Manufacturer-specific error field

Error class	Meaning	Solution
0x200E	**Processor unit – program sequence** The device is in failsafe state.	- Perform system restart.
0x200F	**MT scanning – gear** The device is in failsafe state.	- If problems persist after a system restart, please contact Product Support.
0x2013	**Process – scaling** The internal hardware diagnostics has detected a movement of the shaft in deactivated state, which is outside the valid monitoring range. Monitoring range (SIL2 = 3200 revolutions, SIL3 = 320 revolutions).	- Check that current process data are correct. In order to clear the alarm, a preset adjustment must be carried out.
0x2015	**Processor unit – reset** Error in the processor-internal hardware diagnostics.	- Perform system restart.
0x2016	**Processor unit – partner channel** The device is in failsafe state.	- The partner channel replaces the current process data value of the measuring channel.
0x2017	**Error in the RLB module** (ReflexLightBarrier)	- Perform system restart.
0x2018	**Process - FSCP communication** The device is in failsafe state.	- Perform system restart.
0x2019	**Speed** Mechanically permissible speed of 6600 rpm was exceeded	- To prevent mechanical damage to the measuring system, the current speed must be reduced to ≤ 6000 rpm.
0x201A	**Temperature** Internally permissible warning temperature of 105 °C was exceeded	- To prevent thermal damage to the measuring system, the current ambient temperature must be reduced to ≤ 85 rpm.
0x4001	**CAN - interface** Safety-related error (Own processor)	- Perform system restart.
0x4002	**CAN - interface** Safety-related error (Remote processor)	- Perform system restart.
0x4003	**CAN - interface** Error in the processor-internal fieldbus hardware diagnostics.	- Perform system restart.

14.4 Alarm messages

14.4.1 CiA DS406 mode

In addition to the emergency message, further alarm messages are output via object 6503h. The corresponding error bit is deleted when the error is no longer present.

Error	Cause	Solution
Bit 0 = 1, Position error	Failure of scanning elements in the measuring system	Switch off the supply voltage if necessary, and then on again. If the error occurs repeatedly despite these measures, the measuring system must be replaced.
Bit 1 = 1, Start-up diagnostic error	Errors have been detected in the scanning components responsible for position detection **at a standstill**.	

Table 13: Alarm messages – CiA DS406 mode

14.4.2 TR mode

In addition to the emergency message, further alarm messages are output via object 2211h.

Error	Cause	Solution
Bit 0 = 1, Scaling error	The internal hardware diagnostics has detected a movement of the shaft in deactivated state, which is outside the valid monitoring range. Monitoring range (SIL2 = 3200 revolutions, SIL3 = 320 revolutions).	- Check that current process data are correct. In order to clear the alarm, a preset adjustment must be carried out.

Table 14: **Alarm messages – TR mode**

14.5 Warning messages

14.5.1 CiA DS406 mode

Device-related warning messages are output via object 6505h in CiA DS406 mode:

Error	Cause	Solution
Bit 1 = 1, Light control reserve	Optical scanning outside the normal range	- If problems persist after a system restart, please contact Product Support.
Bit 6 = 1, Speed range (NON-safety-related)	Current speed has either fallen below or exceeded the display range.	- Reduce speed - Adjust speed resolution accordingly via `Object 6031h: Speed parameter`.
Bit 12 = 1, Undervoltage	Measuring system has detected an undervoltage in the internal supply network.	- If problems persist, please contact Product Support.
Bit 13 = 1, Overvoltage	Measuring system has detected an overvoltage in the internal supply network.	- If problems persist, please contact Product Support.
Bit 14 = 1, General warning	Unspecified warning detected.	- If problems persist after a system restart, please contact Product Support.

Table 15: **Warning messages – CiA DS406 mode**

14.5.2 TR mode

Device-related warning messages are output via object 2212h in TR mode:

Error	Cause	Solution
Bit 0 = 1, Light source	Optical scanning outside the normal range.	- If problems persist after a system restart, please contact Product Support.
Bit 1 = 1, Undervoltage, internal	Measuring system has detected an undervoltage in the internal supply network.	- If problems persist, please contact Product Support.
Bit 2 = 1, Overvoltage, internal	Measuring system has detected an overvoltage in the internal supply network.	- If problems persist, please contact Product Support.
Bit 3 = 1, Undervoltage 24 V	Supply voltage is below the tolerance limit.	- The supply voltage range specified for the article no. must be observed.
Bit 4 = 1, Overvoltage 24 V	Supply voltage is above the tolerance limit.	- The supply voltage range specified for the article no. must be observed.
Bit 5 = 1, Permissible speed	Mechanically permissible speed of 6600 rpm was exceeded.	- To prevent mechanical damage to the measuring system, the current speed must be reduced to ≤ 6000 rpm.
Bit 6 = 1, Temperature	Internally permissible warning temperature of 105 °C was exceeded.	- To prevent thermal damage to the measuring system, the current ambient temperature must be reduced to ≤ 85 rpm.
Bit 15 = 1, General warning	Unspecified warning detected.	- If problems persist after a system restart, please contact Product Support.

Table 16: **Warning messages – TR mode**

15 Checklist, Part 2 of 2

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

Checklist Part 1 of 2, see under http://www.tr-electronic.de/f/TR-ECE-BA-GB-0142

Documentation basis	Date	edited	checked

Sub-item	to note	can be found under	yes
Present user manual has been read and understood	–	Document no.: TR-ECE-BA-GB-0171	☐
Check that the measuring system can be used for the present automation task on the basis of the specified safety requirements	• Safety functions of the fail-safe processing unit • Compliance with all technical data	• Chapter Safety functions of the fail-safe processing unit, page 15 • Product data sheets www.tr-electronic.com/s/S025893	☐
Supply voltage	• The power supply used must satisfy the specified requirements	• Chapter Supply voltage, Page 37	☐
Correct CANopen installation	• Observance of the international standards valid for CANopen / CANopen Safety or the directives specified by the CiA User Organization	• Chapter Installation / Preparation for Commissioning, from page 35 • Chapter Commissioning, page 47	☐
After commissioning and parameter changes - System test - Validation (Axis settings)	• During commissioning and after each parameter change - all affected safety functions must be checked - in the case of several (similar) axes it must be ensured that the settings have also been made to the desired axis	• Chapter Setting the Node-ID and baud rate, page 38 • Chapter 10.9 Relating to parametrization CiA DS406 profile, from page 121 • Chapter 10.9.1.2 Preset adjustment function CiA DS406 profile, page 122 • Chapter 10.2 Relating to parametrization TR profile, from page 89 • Chapter 10.2.11 Preset adjustment function TR profile, page 104	☐

Continued on next page

Continued: Checklist, Part 2 of 2

Sub-item	to note	can be found under	yes
Preset adjustment function	● It must be ensured that the preset adjustment function cannot be inadvertently triggered ● After execution of the preset adjustment function the new position must be checked before restarting	● Chapter 10.9.1.2 Preset adjustment function CiA DS406 profile, page 122 ● Chapter 10.2.11 Preset adjustment function TR profile, page 104	☐
Device replacement	● It must be ensured that the new device corresponds to the replaced device ● All affected safety functions must be checked	● Safety Manual (Checklist Part 1 of 2) ● Chapter 10.9 Relating to parametrization CiA DS406 profile, from page 121 ● Chapter 10.2 Relating to parametrization TR profile, from page 89	☐

16 Appendix

16.1 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

16.2 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