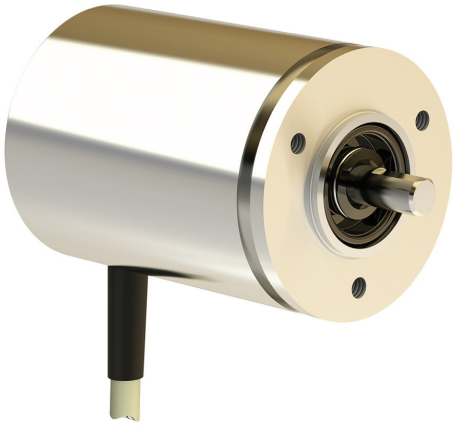
USER MANUAL

CANopen Safety (IEC61508) and CANopen

for Absolute Rotary Encoder TBN/TRN and TBSN/TRSN



SIL2 IEC 61508 FUNCTIONAL SAFETY SENSOR

SIL3 IEC 61508 FUNCTIONAL SAFETY SENSOR

CANopen

CANopen safety easy to use

Specification rotary encoder TBN/TRN and TBSN/TRSN according to CANopen Safety - SIL2, SIL3 acc. IEC 61508 and CANopen Standard

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General

Scope

This specification is valid exclusively for the following absolute encoders: TBN/TRN and TBSN/TRSN with CANopen and CANopen Safety (SIL2/SIL3) interface.

Documentation

The following documents must be observed (depending on device):

- The owner's system-specific operating instructions
- The specification (manual) TXN/TXSN 15469
- Datasheet TBN/TRN 14271 (SIL2)
- Datasheet TBSN/TRSN 16365 (SIL3)
- The connection assignment - TYxxxxx (depending on device, on request: enclosed with every device)
- EDS-File TYxxxxx_xx_xx.eds (on request)
- CRC Calculation Program and additional xml files for special versions (on request)
- EPC_CAN Error description (on request)
- Notes on the wiring & assembly of rotary encoder AN 16169
- Drawings (on request)

Proper use

Absolute encoders by EPC are used to acquire angular positions and provide their measured value in the form of an electrical output signal. As part of a system, they have to be connected to appropriate downstream electronics concerning the use case and must only be used for this purpose.

Commissioning

- The relevant device may only be set up and operated in combination with this and the documentation specified above.
- Protect the device against mechanical damage during installation and operation.
- Device commissioning and operation may only be undertaken by a trained technician.
- Do not operate the device outside of the limit values specified in the datasheet.
- Check all electrical connections before commissioning the system.
-

Note

Provided that the system integrator complies with the obligation to carry out a comprehensive risk analysis, particularly with regard to the transmission path, the device can be considered a safety component within the meaning of the Machinery Directive 2006/42/EC.

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1. INTENDED USE

The rotary encoders TB(S)N and TR(S)N are intended for use in CANopen and in CANopen safety-relevant systems.
The version TB(S)N is a single-turn and TR(S)N is a multi-turn absolute encoder.
Thanks to its robust design, the encoder can be used in applications with harsh environmental conditions.

Both encoders (single-turn and multi-turn) are designed for connection to a control system (PLC) which evaluates the measured values transmitted via the CAN bus and, in the event of error messages or the absence of process data, reacts according to the relevance of the error and prevents a hazardous state.

The following applies to devices with a multi-sensor interface of the nomenclature TBN…M1…:

The device can be used to implement safety functions provided that suitable monitoring measures for the transmission path – in particular with regard to non-secure communication via PDO (Process Data Object, not SRDO) – are implemented by a higher-level instance (e.g. a control system).

The following mechanisms must be provided as minimum requirements for these monitoring measures:

- Cross-checking of sensor signals
- Monitoring of cyclical data output
- Heartbeat monitoring
- Node guarding

Note:
The specific requirements must be determined by the respective system integrator based on the risk analysis to be carried out. The above list is therefore only an example and does not claim to be exhaustive.

If these requirements are met, the device can be considered a safety component within the meaning of the Machinery Directive 2006/42/EC.

2. DESIGN

Position sensing is carried out through angle measurement in case of TB(S)N. For TR(S)N position sensing is carried out through a combined angle and revolution measurement. The signals from the encoders are used to sense the position of the shaft and to scan a mechanical transmission for measuring. The revolutions covered are combined to form a summarized position value. The position sensing system is equipped with a separate controller. Position and revolution sensing are designed in a fully redundant form. The position data is transferred to the evaluation module via two channels.

The evaluation module evaluates the position data supplied by the position registration system. The measured values are filtered, the two redundant channels are compared and the measurement signals are linearized. If the measured values are recognized as safe, the module makes the position data available to the downstream processes.

The absolute encoder module accepts the position data provided by the evaluation module, undertakes calibration depending on the set parameters and transfers the data to the CANopen interface. Depending on the setting, the CANopen interface can transfer both secure data via CANopen Safety (internal name: S4 for SIL2 / S41 for SIL3) and secure data via a normal, insecure CANopen interface to the application.

3. DOCUMENTS

EPC datasheet	TBN/TRN 14271 for SIL2 devices TBSN/TRSN 16365 for SIL3 devices
Manual (Specification)	TXN/TXSN 15469 (this document)
SIL2 TÜV Certificate Registration No.	XX XXX XX XXXXXX (EPC: TXNXXXXX)
SIL3 TÜV Certificate Registration No.	XX XXX XX XXXXXX (EPC: TXSNXXXXX)

4. DERIVED VALUES

4.1 Velocity signal

The encoder provides a velocity signal. It is transmitted safely via SRDO2 and also as a non-safe transmission via PDO (for TBSN/TRSN SIL3 encoders only as per PDO transmission). The relationship between the value v and the value rotations per minute u is:

$$u\left[\mathrm{rev}\,/\,\mathrm{min}\right] = \frac{v[\mathrm{digits}]\times 60000\times S_D}{B[\mathrm{digits}\,/\,\mathrm{rev}]\times T[\mathrm{ms}]\times S_M}$$

It means for safe speed (output at SRDO2):
u = Shaft speed in revolutions per minute
v = Digits read out from SRDO2 (Remark: The velocity signal is in the format Signed 16 Bits. At increasing position values you can use v directly. At decreasing position values you have to calculate:

FFFF - v first, before inserting in the formula. Increasing or decreasing position values depend on the setting of safety code sequence - object 6101h, sub 01h). vmax: 15 Bits due to sign of velocity signal.

B = Basic resolution for velocity signal - depending on device
T = Safety speed integration time in milliseconds - see object 6101h, sub 05h
S_D = Safety speed divider - see object 6101h, sub 07h (if existing, else = 1)
S_M = Safety speed multiplier - see object 6101h, sub 06h (if existing, else = 1)
60000 = Compensation factor milliseconds ↔ minutes

4.2 Residual error rate per hour

CANopen Safety is using the BIA C model for SIL2 and SIL3 systems. The residual error rate per hour Λ is calculated as follows:

$\Lambda = 3600 \cdot P \cdot \dot{v} \cdot (m-1) \cdot 100$

It means:

$P = P_{Rest}^{2}$ and $P_{Rest} = 7 \cdot 10^{-9}$
P: Residual error probability
$\dot{v}$: safety-relevant messages per second
m: number of safety-relevant devices (max. 64)

For SIL3 is the SRDO transfer limited to 44 SRDOs per second. This results in a refresh-time of 23 ms with 64 safety-relevant nodes.

5. CANOPEN FUNCTIONALITY

The CANopen interface enables operation via CANopen Standard and secure operation via CANopen Safety. The CANopen profile definition for the encoder is executed once according to CiA 301 application layer and according to EN 50325-5 framework for safety-relevant communication.

The sensor system (position registration) is designed in redundant form. The sensor system's measured values are supplied to the self-monitoring controller on separate interfaces (SPI). This compares the position values of both sensors. If the measured values lie within a specified tolerance, the signals are transferred as validated for downstream evaluation. Otherwise, an error message is generated and the controller assumes a secure state (pre-operational).

5.1 Process data objects PDO's

Please see Objects 1800h and 1801h for user transmit configuration. For dynamic user configurable mapping, please see Objects 1A00h and 1A01h.
The measured position and speed values are output in these objects as shown in standard configuration.

Byte 0								Byte 1								Byte 2							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
LSB								Position															

Byte 3								Byte 4								Byte 5							
24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
							MSB	LSB							Speed								MSB

5.2 Safety-relevant data object SRDO1

The sensor depending on its resolution eg., 14/16 bit supplies 26/28 significant data bits accordingly in unsigned long format. Objects 6120h / 6121h are output.
Please see Object 1301h for user transmit configuration.

Byte 0								Byte 1								Byte 2								Byte 3							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
LSB								Position																MSB				0	0	0	0

Byte 0								Byte 1								Byte 2								Byte 3							
0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
LSB								Position data inverted																MSB				1	1	1	1

5.3 Safety-relevant data object SRDO2

The sensor supplies 16 significant data in signed word format for the speed measurement value. Objects 6124h / 6125h are output on the SRDO2.
Please see Object 1302h for user transmit configuration.

Byte 0								Byte 1							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LSB								Position							MSB

Byte 0								Byte 1							
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LSB								Speed inverted							MSB

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6. CANOPEN PROFILE DEFINITION

6.1 CANopen profile overview

Table 1 of all objects contained in the encoder profile

Index	Data type	Designation	Data length	Memory type	m/o
General communication parameter					
1000h	VAR	device_type	LONG	ro	m
1001h	VAR	error_register	BYTE	ro	m
1003h	ARRAY	pre_defined_error_field	-	ro	o
1005h	VAR	COB-ID_SYNC	LONG	rw	o
1008h	VAR	manufacturer_device_name	STRING	ro	o
1009h	VAR	manufcturer_hardware_version	STRING	ro	o
100Ah	VAR	manufacturer_software_version	STRING	ro	o
1010h	ARRAY	store_parameters	LONG	-	o
1011h	ARRAY	restore_default_parameters	LONG	-	o
1014h	VAR	COB-ID-EMCY	LONG	rw	o
1015h	VAR	inhibit_time_EMCY	LONG	rw	o
1017h	VAR	producer_heartbeat_time	WORD	rw	o
1018h	RECORD	identity object		ro	m
1029h	ARRAY	Error behavior	BYTE	rw	m
SRDO parameter set					
1301h	RECORD	SRDO1 communication parameters		rw	m
1381h	RECORD	SRDO_1_mapping_parameters			
1302h	RECORD	SRDO2 speed parameters		rw	m
1382h	RECORD	SRDO_2_mapping_parameters			
13FEh	VAR	configuration valid	BYTE	rw	m
13FFh	ARRAY	safety configuration checksum		rw	m
PDO parameter set					
1800h	RECORD	PDO1_communication_parameters	-	rw	
1A00h	RECORD	PDO1_mapping_objects		rw**	
1801h	RECORD	PDO2_communication_parameters	-	rw	
1A01h	RECORD	PDO2_mapping_objects		rw**	
General application parameter					
6000h	VAR	operating parameters	WORD	rw*	m
6001h	VAR	measuring units per revolution	LONG	rw*	m
6002h	VAR	total measuring range in measuring units	LONG	rw*	m
6003h	VAR	preset value	LONG	rw*	m
6004h	VAR	position value	LONG	ro	m
6010h	VAR	preset value for multi sensor interface	-	rw	o
6020h	VAR	position for multi sensor interface	-	ro	o
6030h	RECORD	speed_value	-	ro	o
6031h	RECORD	speed parameters	-	rw*	o
6200h	VAR	cyclic timer	WORD	rw	

Definition of Data Length: Byte = 1 byte, Word = 2 bytes, Long = 4 bytes
* At Single-turn (TBN) encoders with CANopen Safety Profile SIL2 (TBN...S4...), or SIL3 encoders TBSN/TRSN: read only / ro
** Only valid for Multi-turn (TRN) CANopen Safety SIL2 (TRN...S4...) encoder, else: read only / ro

Index	Data type	Designation	Data length	Memory type	m/o
Encoder safety objects					
6100h	RECORD	safety_position_configuration_parameters	-	rw	m
6101h	RECORD	safety_speed_configuration_parameters	-	rw	m
6120h	ARRAY	safety_standard_position_value	-	rw	m
6121h	ARRAY	safety_inverted_standard_position_value	BYTE	rw	m
6124h	ARRAY	safety_speed_value	BYTE	rw	o
6125h	ARRAY	safety_inverted_speed_value	BYTE	rw	o
61FEh	VAR	safety_configuration_valid	BYTE	rw	m
61FFh	ARRAY	safety_configuration_signature	BYTE	rw	m
Objects for achieving compatibility					
6200h		cyclic_timer	WORD	rw	
Encoder diagnosis objects					
6500h	VAR	Operating status	WORD	ro	m
6501h	VAR	Single-turn resolution	LONG	ro	m
6502h	VAR	Number of distinguishable revolutions	WORD	ro	m
6503h	VAR	Alarms	WORD	ro	m
6504h	VAR	Supported alarms	WORD	ro	m
6506h	VAR	Supported warnings	WORD	ro	m
6507h	VAR	Profile and software version	LONG	ro	m
6508h	VAR	Operating time	LONG	ro	m
6509h	VAR	Offset value	LONG	ro	m
650Ah	RECORD	Module identification		ro	m
650Bh	VAR	Serial number	LONG	ro	m
650Ch	VAR	Offset for multi sensor interface	-	ro	0
650Dh	VAR	Absolute accuracy	BYTE	ro	m
650Eh	VAR	Device cabability	LONG	ro	m
NMT objects					
1F80h	VAR	NMT start up (if available)	LONG	rw / ro	o
LMT objects					
2000h	VAR	node ID	BYTE	rw	o
2001h	VAR	bit_rate	BYTE	rw	o
Manufacturer specific Objects					
3100h	VAR	safety_gear_configuration	WORD / LONG	rw	o
3102h	VAR	gear_configuration	WORD / LONG	rw	o
31FEh	VAR	safety_gear_data_valid	BYTE	rw	o
31FFh	RECORD	safety_gear_CRC_checksum	WORD	rw	o
3300h	VAR	safety_encoder_parameter	BYTE / LONG	wp	o

rw read/write
ro read only
o optional
m mandatory
wp Factory programming
Definition of Data Length: Byte = 1 byte, Word = 2 bytes, Long = 4 bytes

6.2 Communication and service data objects (SDO)

For every modification of the encoder via SDO communication, the device must be set pre-operational first.

It is crucial to wait for the response message of the encoder before sending another SDO message. Then you can be sure that the SDO message (e.g. parameterization) is executed properly.

Subsequently, the appropriate save procedure (1010) should be executed to ensure that the parameterized objects keep their values after a power OFF/ON cycle or NMT reset.

Please don't reset the device (power OFF/ON or NMT reset) before all values are transmitted and/or saved properly.

Wait for the response of the encoder after saving or wait at least 500 ms.

6.2.1 Object 1000h device_type

The encoder types are defined as follows:

Coding	Device type designation
1	Single-turn absolute rotary encoder
2	Multi-turn absolute rotary encoder
3	Single-turn absolute rotary encoder with electronic turn count
4	Incremental rotary encoder
5	Incremental rotary encoder with electronic counting
6	Incremental linear encoder
7	Incremental linear encoder with electronic counting
8	Absolute linear encoder
9	Absolute linear encoder with cyclic coding
10	Multi-sensor encoder interface

Device_type structure:

	Byte 0	Byte 1	Byte 2	Byte 3
Device type	Device profile number		Encoder type	
TR(S)N	0x96	0x01	0x02	0x00
TB(S)N	0x96	0x01	0x01	0x00

device_type

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1000h	0h	Device_type	Long	ro	0x00020196	-	-

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6.2.2 Object 1001h error_register

Bit	m/o	Designation
0	m	generic error
1	o	current
2	o	voltage
3	o	temperature
4	o	communication error (overrun, error state)
5	o	device profile specific
6	o	Reserved (always 0)
7	o	manufacturer-specific

The error register is the global error register. It sums all errors in bit 0.

Generic, communication and manufacturer-specific errors are supported. In the event of an error, the generic error bit is always set. The error which has occurred can be read off in object 6503 alarms.

error_register

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1001h	0h	error_register	Byte	ro	0, 0x11, 0x81	-	-

6.2.3 Object 1003h pre_defined_error_field

All alarm messages transmitted via emergency messages are stored in this object. Sub-index 00h contains the number of logged errors. Overwriting sub-index 00h with ZERO deletes the stored messages in all sub-indices. This object contains 20 entries at maximum. When this number is exceeded no further error will be stored.

pre-defined error field

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1003h	0h	number_of_errors	Byte	rw	0, ... 20	-	-
	1h	one_stored_error_msg.					
	2h	two_stored_error_msg.					
		...					

Structure_pre_defined_error_field

Byte 0	Byte 1	Byte 2	Byte 3
Alarm code	Custom error code		

See also: CANopen emergency messages structure

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6.2.4 Object 1005h COB-ID-SYNC

Identifier of the sync message transmitted by the master.
Range and plausibility check takes place according to CiA 301 v 4.2.0, Restricted CAN ID's.

COB-ID-SYNC

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1005h	0h	COB-ID-SYNC	Long	rw	1...0x7FF	-	0x80

6.2.5 Object 1008h manufacturer_device_name

The name of the device is stored as a string and is output via SDO segment transfer.
e.g. "Encoder TRN Safety"

manufacturer_device_name

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1008h	0h	manufacturer_ device_name	String	ro	Depends on device	-	-

6.2.6 Object 1009h manufacturer_hardware_version

Hardware version of the device. It is stored as a string e.g. "P-0824"
It is output via SDO segment transfer.

manufacturer_hardware_version

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1009h	0h	manufacturer_ hardware_version	String	ro	Depends on device	-	-

6.2.7 Object 100Ah manufacturer_software_version

Software version of the device. It is stored as a string e.g. "Safety standard"
It is output via SDO segment transfer.

manufacturer_software_version

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
100Ah	0h	manufacturer_ software_version	String	ro	Depends on device	-	-

6.2.8 Object 1010h store_parameters

By inputting "save" (0x65766173 hex resp. 1702257011 decimal) as a password in the relevant sub-index, the writeable objects are saved to the memory.

The object cannot be changed on writing. Reading the object is possible.
1 (saving through command) is returned.

Which parameters are stored is defined by specifying the sub-index.

Sub-index 01h Storage of all parameters except the 0x2000 to 0x2FFF range.
Sub-index 02h Storage of communication parameters 0x1000 to 0x1FFF.
Sub-index 03h Storage of parameters 0x6000 to 0x9FFF defined in the profile.
Sub-index 04h Storage of the manufacturer-specific range 0x2000 to 0x2FFF (common).
Sub-index 05h Storage of the manufacturer-specific range 0x3000 to 0x3FFF

store_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1010h	0h	largest_supported_ sub-index	-	ro	5	-	-
	1h	save_all_parameters (except node ID and baudrate)	Long	rd/(rw)	"save" =0x65766173	*	1
	2h	save_communication_ parameters	Long		"save"	*	1
	3h	save_application_ parameters	Long		"save"	*	1
	4h	save_LMT_parameters (only node ID, baudrate)	Long		"save"	*	1
	5h	Save_manufacturer_ parameters	Long		"save"	*	1

* Parameters are backed-up in the memory on inputting the correct password (save = 0x65 0x76 0x61 0x73).
→ Wait for response of the encoder after saving before resetting the device

6.2.9 Object 1011h restore_default_parameters

On inputting "load" (0x64616F6C hex resp. 1684107116 decimal) as the password in the relevant sub-index, the default parameters are loaded into the objects of the number group selected with the sub-index in the RAM. Reading the object is possible.

The device has to be set ""pre-operational" at first.
1 (device restores parameters) is returned.

Which parameters are loaded is defined by specifying the sub-index.

Sub-index 01h Loading of all parameters except the 0x2000 to 0x2FFF range.
Sub-index 02h Loading of communication parameters 0x1000 to 0x1FFF.
Sub-index 03h Loading of parameters 0x6000 to 0x9FFF defined in the profile.
Sub-index 04h Loading of the manufacturer-specific range 0x2000 to 0x2FFF.
Sub-index 05h Loading of the manufacturer-specific range 0x3000 to 0x3FFF.

restore_default_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1011h	0h	largest_supported_ sub-index	-	ro	5	-	-
	1h	load_all_default_ parameters (except node ID and baudrate)	Long	rd/(rw)	"load" =0x64616F6C	*	1
	2h	load_communication_ parameters	Long		"load"	*	1
	3h	load_application_ parameters	Long		"load"	*	1
	4h**	load_LMT_parameters (only node ID, baudrate)	Long		"load"	*	1
	5h	load_manufacturer_ parameters	Long		"load"	*	1

* On inputting the correct password (load = 0x6C 0x6F 0x61 0x64), the default parameters are loaded from the ROM. In case for a complete load default (COB IDs included): sub-index 01h and 04h have to be executed.

** When loading the default values: For all default node IDs which exceed 32 decimal (33 ….) the related COB ID 1 and COB ID 2 have to be entered manually in objects 1301h, sub 05h/sub 06h and 1302h, sub 05h/sub 06h. Otherwise the SRDOs are disabled (e.g. 0x8000 0141/0x8000 0142). For all node IDs up to 32 decimal the COB IDs are adopted by the encoder automatically. (See as well objects: 1301h, 1302h and 2000h)

6.2.10 Object 1014h COB-ID-EMCY

Identifier for the emergency message which the encoder transmits on occurrence of an alarm.
After "Load default", the identifier is COB-ID-EMCY + node ID.
If the user changes the COB ID, the node address is no longer added.
Range and plausibility check takes place according to CiA 301 v 4.2.0, Restricted CAN ID's.

COB-ID-EMCY

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1014h	0h	COB-ID-EMCY	Long	rw	-	*	0x80+node ID

* Default state evaluation, then addition of the node address.

6.2.11 Object 1015h inhibit_time_EMCY

Blocking time to limit the bus load in the event of EMCY messages in quick succession. The resolution is 100 µs per digit. The resolution of the inhibit time is internally reduced to 1 ms steps. It is rounded to the next ms value → Only the following values will be executed: 0 and multiples of 1 ms (e.g. 1 for 1 ms, 10 for 1 ms, 30 for 3 ms, 31 for 4 ms, 1000 for 100 ms etc.).

inhibit_time_EMCY

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1015h	0h	inhibit_time_EMCY	Word	rw	0...0xFFFF	-	1000

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6.2.12 Object 1017h producer_heartbeat_time

If a value greater than zero is entered here, the heartbeat message is transmitted on the identifier GUARD COB ID + node ID in the producer_heartbeat_time interval in ms. (GUARD COB-ID = 0x700)

producer_heartbeat_time

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1017h	0h	producer_heartbeat_ time	Word	rw	0...0xFFFF	-	0

The format of the heartbeat message:

Bit No.	7	6	5	4	3	2	1	0
Content	0	Subscriber status						

Subscriber status:

0 (0x0): BOOT-UP
4 (0x4): STOPPED
5 (0x5): OPERATIONAL
127 (0x7F): PRE-OPERATIONAL

6.2.13 Object 1018h identity_object

This object contains data assigned to the individual encoder. The object is the address for the Layer Setting Service (LSS).

The following data must be entered:

1. Manufacturer ID 0x0000 0590
2. Product code EPC-internal
3. Revision number EPC software revision number
4. Serial number x xxx xxx

The serial number can be written via LSS in factory programming state.

An example for parameterization via LSS for the node ID can be obtained at the end of this document: Node ID Parameterization via LSS Service.

identity_object

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1018h	0h	largest_supported_ sub-index	-	ro	4	-	-
	1h	vendor ID	Long	ro	0x0000 0590	-	-
	2h	product_code	Long	ro	0x0000 xxxx*	-	-
	3h	revision_number	Long	ro	0x0001 0001	-	-
	4h**	serial_number	Long	ro(rw)	0	**	-

* depends on device

** Written in factory programming state (wp)

6.2.14 Object 1029h error behavior_object

This object defines the behavior in the event of an error. The sub-indices are assigned to the error types as follows:

Sub-index	Error type	Bit in error register 1001	Bit in alarm object 6503
1h	Communication error	4	-
2h	CRC error	7	5
	Supply out of range	7	6
	Sensor error	7	7
4h	Redundancy error	7	3

The following settings in object 1029h are possible for the behavior in the event of an error:

Value	Description
0x00	Switch from OPERATIONAL to PRE-OPERATIONAL
0x01	No NMT status switch
0x02	Switch to STOP state
0x03	Reserve
::::::::	
0x7F	Reserve
0x80	Manufacturer-specific
::::::::	
0xFF	Manufacturer-specific

error_behavior

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1029h	0h	largest_supported_ sub-index	-	ro	3	-	-
	1h	communication_error	Byte	rw	0, 1, 2	-	0x00
	2h	internal_device_error	Byte	ro	0	-	-
*	4h	redundancy_error	Byte	rw	0, 1, 2	-	0x01

* Valid for full redundant encoder systems

6.3 CANopen Safety process data Objects (SRDO)

The process data are output via two Safety Relevant Data Objects (SRDOs).

Attention:
The SRDO is only active when the object configuration_valid (object 13FEh) is set (written with the value 0xA5).
The configuration_valid object is stored in the EEPROM. The flag is deleted if one of the Safety Relevant Data Objects is changed.

COB ID structure

MSB										LSB
EN	x	x	x	x	x	x	x	0	COB ID high	COB ID low

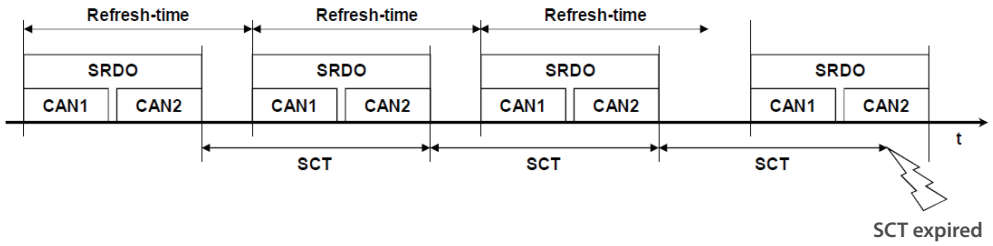
The MSB represents the enable bit.

Bit 31 = 0 (EN) SRDO enabled
Bit 31 = 1 (EN) SRDO disabled (=0x80000"FF+2xID" resp. 0x80000"100+2xID")

The plausibility of the other bits is not checked.
Only transmission type 254 is supported (Cyclic output with the defined refresh time, see object 1301h/1302h).

6.3.1 Timing requirements - SCT

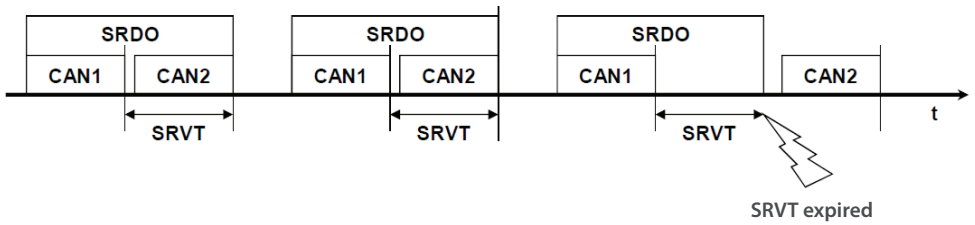
The SRDO is transmitted as defined above and the reception is monitored by the safety controller. The cyclic transmission rate is defined by the refresh-time and monitored with the safety cycle-time (SCT) by the safety controller. If the SCT is elapsed before the corresponding SRDO is received the safety controller shall switch into the safe state. The SCT time used by the safety controller has to be chosen slightly higher than the refresh time to account for sync problems and SW runtime. Further the bit rate effects the SCT time as well and has to be taken into account. Other plausibility checks are not performed. The designer of the overall system is responsible for correctly setting the parameters.



Source CiA 304 / EN 50325-5 / July 2010 page 26

6.3.2 Timing requirements - SRVT

The SRDO consists of two CAN frames that are transmitted subsequently and the reception is monitored by the safety controller. The reception is monitored with the SR validation time (SRVT). If the SRVT is elapsed before the second CAN data frame (inverted dataframe) is received the safety controller shall switch into the safe state. The SRVT must be selected in such a way that an interruption of the SRDO on the CAN bus does not lead to an error at the safety controller. SRVT time has to be smaller than SCT time. Further the bit rate effects the SRVT time as well and has to be taken into account. The designer of the overall system is responsible for correctly setting the parameters.



Source CiA 304 / EN 50325-5 / July 2010 page 27

6.3.3 Object 1301h SRDO1_communication_parameters

The object under this index is only writeable in PRE-OPERATIONAL state.
Modifications will cause 13FEh = '0' (must be set '0xA5' after modification). New CRC Checksum 13FFh/01h must be calculated and transmitted to the encoder.

The configuration_valid byte is reset after each write access.

SRDO_communication_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1301h	0h	largest_supported_ sub-index	-	ro	6	-	-
	1h	information_direction	Byte	ro	1	-	-
	2h	refresh_time (SCT)	Word	rw	1..65,535 [ms]	-	25
	3h	validation_time (SRVT)	Byte	ro	20 [ms]	-	-
	4h	transmission_type	Byte	ro	254	-	-
	5h**	COB-ID_1	Long	rw	257..384 0x8000... SRDO deactivated	*	0xFF + (2x node ID)
	6h**	COB-ID_2	Long	rw	257..384 0x8000... SRDO deactivated	*	0x100 + (2x node ID)

* Default state evaluation, then addition of the node address. After overwriting, addition is no longer executed. The configuration_valid byte 13FEh is reset. No plausibility check is undertaken for the COB IDs.

** For all node IDs which exceed 32 decimal (33 ….) the related COB ID 1 and COB ID 2 have to be entered manually in objects 1301h, sub 05h/sub 06h and 1302h, sub 05h/sub 06h. Otherwise the SRDOs are disabled (e.g. 0x8000 0141 /0x8000 0142). For all node IDs up to 32 decimal the COB IDs are adopted by the encoder automatically. This has to be considered as well when the default value of the node ID exceeds 32 decimal and the default values are loaded by 1011h, sub 04h. (See as well objects 1302h, 1011h and 2000h).

Only transmission type 254 is supported (Cyclic output with the defined refresh time, see object 1301h, sub 02h). To shut off the SRDO, both COB IDs must be disabled. If only one of the two COB IDs is disabled, setting the configuration_valid flag is not possible.

6.3.4 Object 1302h SRDO2_speed_parameters

The object under this index is only writeable in PRE-OPERATIONAL state. Modifications will cause 13FEh = '0' (must be set '0xA5' after modification). New CRC Checksum 13FFh/02h must be calculated and transmitted.

The configuration_valid byte is reset after each write access.

SRDO_speed_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1302h	0h	largest_supported_ sub-index	-	ro	6	-	-
	1h	information_direction	Byte	ro	1	-	-
	2h	refresh_time (SCT)	Word	rw	1..65,535	-	25 [ms]
	3h	validation_time (SRVT)	Byte	ro	20 [ms]	-	-
	4h	transmission_type	Byte	ro	254	-	-
	5h**	COB-ID_1	Long	rw	257..384 0x8000... SRDO deactivated	*	0x13F + (2x node ID)
	6h**	COB-ID_2	Long	rw	257..384 0x8000... SRDO deactivated	*	0x140 + (2x node ID)

* Default state evaluation, then addition of the node address. After overwriting, addition is no longer executed. The configuration_valid byte is reset. No plausibility check is undertaken for the COB IDs.

** For all node IDs which exceed 32 decimal (33 ….) the related COB ID 1 and COB ID 2 have to be entered manually in objects 1301h, sub 05h/sub 06h and 1302h, sub 05h/sub 06h. Otherwise the SRDOs are disabled (e.g. 0x8000 0181/0x8000 0182. For all node IDs up to 32 decimal the COB IDs are adopted by the encoder automatically. This has to be considered as well when the default value of the node ID exceeds 32 decimal and the default values are loaded by 1011h, sub 04h. (See as well objects 1301h, 1011h and 2000h).

Only transmission type 254 is supported (Cyclic output with the defined refresh time, see 1302h, sub 02h).

To shut off the SRDO, both COB IDs must be disabled. If only one of the two COB IDs is disabled, setting the configuration_valid flag is not possible.

6.4 CAN open process data objects (PDO)

6.4.1 Object 1800h Transmit PDO 1

Range and plausibility check takes place according to CiA 301 v 4.2.0, Restricted CAN ID's. The inhibit time has a resolution of 100 µs. The resolution of the inhibit time is internally reduced to 1 ms steps. It is rounded to the next ms value → Only the following values will be executed: 0 and multiples of 1 ms (e.g. 1 for 1 ms, 10 for 1 ms, 30 for 3 ms, 31 for 4 ms, 1000 for 100 ms etc.).

The event timer has a resolution of 1 ms.

Transmit_PDO_1

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1800h	0h	largest_supported_ sub-index	-	ro	5	-	-
	1h	COB ID	Long	rw	-	*	0x180+ID
	2h	transmission type	Byte	rw	0...240**, 252, 253, 254	-	253
	3h	inhibit time	Word	rw	0..65,535 [100 µs]	-	0
	4h	reserved	-	-	-	-	-
	5h	event_timer	Word	rw	0..65,535 [ms]	-	0

* On reading (upload), the node address is added to the selected identifier.
** 0 ≤ n ≤ 240: Every nth sync-message the PDO 1 is transmitted.

252:
event timer = 0: Value is picked-up with sync and transmitted with remote frame
event timer > 0: cyclic transmission via event timer

253:
event timer = 0: Value is picked-up and transmitted with remote frame
event timer > 0: cyclic transmission via event timer

254:
event timer = 0: Value is picked-up and transmitted with every change of value
event timer > 0: Value is picked-up and transmitted with every change of value and updated every event timer ms

Disable PDO1 with 0x80000180+ID as COB ID

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6.4.2 Object 1801h Transmit PDO 2

Range and plausibility check takes place according to CiA 301 v 4.2.0, Restricted CAN ID's.
The inhibit time has a resolution of 100 µs. The resolution of the inhibit time is internally reduced to 1 ms steps. It is rounded to the next ms value → Only the following values will be executed: 0 and multiples of 1 ms (e.g. 1 for 1 ms, 10 for 1 ms, 30 for 3 ms, 31 for 4 ms, 1000 for 100 ms etc.).

The event timer has a resolution of 1 ms.

Transmit_PDO_2

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1801h	0h	largest_supported_ sub-index	-	ro	2		-
	1h	COB ID	Long	rw	-	*	0x280+ID
	2h	transmission type	Byte	rw	0...240**, 252***, 253***, 254***	-	1
	3h***	inhibit time	Word	rw	0..65,535 [100 µs]	-	0
	4h***	reserved	-	-	-	-	-
	5h***	event_timer	Word	rw	0..65,535 [ms]	-	0

* On reading (upload), the node address is added to the selected identifier.
** 0 ≤ n ≤ 240: Every nth sync-message the PDO2 is transmitted.
*** valid for Multi-turn Encoder TR(S)N (SIL2/3) with CANopen safety (TRN...S4/S41...) and Single-turn TBSN (SIL3) with CANopen safety (TBSN...S41..) only, for other encoders: please contact EPC for this functionality

252:
event timer = 0: Value is picked-up with sync and transmitted with remote frame
event timer > 0: cyclic transmission via event timer

253:
event timer = 0: Value is picked-up and transmitted with remote frame
event timer > 0: cyclic transmission via event timer

254:
event timer = 0: Value is picked-up and transmitted with every change of value
event timer > 0: Value is picked-up and transmitted with every change of value and updated every event timer ms

Disable PDO2 with 0x80000280+ID as COB ID

6.5 Mapping objects

6.5.1 Object 1381h SRDO1_mapping_parameters

The parameter contains the following coding for each "mapping" object:

Byte 0	Byte 1	Byte 2	Byte 3
Index		Sub-index	Length

The length is specified as the number of bits in hex coded form.

SRDO_1_mapping_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1381h	0h	largest_supported_ sub-index	-	ro	8	-	-
	1h	first_SRDO_ mapping_object	Long	ro	0x6120 0108	-	-
	2h	second_SRDO_ mapping_object	Long	ro	0x6121 0108	-	-
	3h	third_SRDO_ mapping_object	Long	ro	0x6120 0208	-	-
	4h	fourth_SRDO_ mapping_object	Long	ro	0x6121 0208	-	-
	5h	fifth_SRDO_ mapping_object	Long	ro	0x6120 0308	-	-
	6h	sixth_SRDO_ mapping_object	Long	ro	0x6121 0308	-	-
	7h	seventh_SRDO_ mapping_object	Long	ro	0x6120 0408	-	-
	8h	eighth_SRDO_ mapping_object	Long	ro	0x6121 0408	-	-

6.5.2 Object 1382h SRDO2_mapping_parameters

The parameter contains the following coding for each "mapping" object:

Byte 0	Byte 1	Byte 2	Byte 3
Index		Sub-index	Length

The length is specified as the number of bits in hex coded form.

SRDO_2_mapping_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1382h	0h	largest_supported_ sub-index	-	ro	4	-	-
	1h	first_SRDO_ mapping_object	Long	ro	0x6124 0108	-	-
	2h	second_SRDO_ mapping_object	Long	ro	0x6125 0108	-	-
	3h	third_SRDO_ mapping_object	Long	ro	0x6124 0208	-	-
	4h	fourth_SRDO_ mapping_object	Long	ro	0x6125 0208	-	-

6.5.3 Object 1A00h transmit_PDO_1_mapping

The parameter contains the following coding for each "mapping" object:

Byte 0	Byte 1	Byte 2	Byte 3
Index		Sub-index	Length

The length is specified as the number of bits in hex coded form.

mappable objects are:

0x6004 sub 0x00 length 0x04
0x600C sub 0x00 length 0x04
0x6030 sub 0x01 length 0x02
0x6120 sub 0x01 length 0x01
0x6120 sub 0x02 length 0x01
0x6120 sub 0x03 length 0x01
0x6120 sub 0x04 length 0x01
0x6124 sub 0x01 length 0x01
0x6124 sub 0x02 length 0x01

Else the SDO transfer is aborted with abort code 0x 0604 0041 - Object cannot be mapped to the PDO.
If the PDO length is exceeded abort code 0x 0604 0042 is provided by SDO transfer - The number and length of the objects to be mapped exceed PDO length.

transmit_PDO_1_mapping

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1A00h	0h	largest_supported_ sub-index	-	rw*	0x00 (mapping disabled) to 0x08 (sub index 0x01...0x08 valid)	-**	0x02
	1h	PDO1_mapping_object1	Long	rw*	0x6004 0020 (see above for mappable objects)	-	0x6004 0020
	2h	PDO1_mapping_object2	Long	rw*	0x6030 0110 (see above for mappable objects)	-	0x6030 0110

* Only valid for Multi-turn (TRN) CANopen Safety SIL2 (TRN...S4...),
else e.g.: TBSN/TRSN, TBN...C3/S4 or TRN...C3... these objects are: read only / ro
** upon changing this parameter the value defines which subs become valid for mapping

Note:

The following procedure shall be used for re-mapping, which may take place during the NMT state pre-operational and during the NMT state operational:

1. Destroy TPDO by setting 1800h/01h to 0x 8000 0180 + Node ID as COB ID
2. Disable mapping by setting sub-index 0x00 to 0x00
3. Modify mapping by changing the values of the corresponding sub-indices
4. Enable mapping by setting sub-index 0x00 to the number mapped objects
5. Create TPDO by setting 1800h/01h to 0x180+Node ID as COB ID

6.5.4 Object 1A01h transmit_PDO_2_mapping

The parameter contains the following coding for each "mapping" object:

Byte 0	Byte 1	Byte 2	Byte 3
Index		Sub-index	Length

The length is specified as the number of bits in hex coded form.

mappable objects are:

0x6004 sub 0x00 length 0x04
0x600C sub 0x00 length 0x04
0x6030 sub 0x01 length 0x02
0x6120 sub 0x01 length 0x01
0x6120 sub 0x02 length 0x01
0x6120 sub 0x03 length 0x01
0x6120 sub 0x04 length 0x01
0x6124 sub 0x01 length 0x01
0x6124 sub 0x02 length 0x01

Else the SDO transfer is aborted with abort code 0x 0604 0041 - Object cannot be mapped to the PDO.
If the PDO length is exceeded abort code 0x 0604 0042 is provided by SDO transfer - The number and length of the objects to be mapped exceed PDO length.

transmit_PDO_2_mapping

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1A01h	0h	largest_supported_ sub-index	-	rw*	0x00 (mapping disabled) to 0x08 (sub index 0x01...0x08 valid)	-**	0x02
	1h	PDO2_mapping_object1	Long	rw*	0x6004 0020 (see above for mappable objects)	-	0x6004 0020
	2h	PDO2_mapping_object2	Long	rw*	0x6030 0110 (see above for mappable objects)	-	0x6030 0110

* Only valid for Multi-turn (TRN) CANopen Safety SIL2 (TRN...S4...),
else e.g.: TBSN/TRSN, TBN...C3/S4 or TRN...C3... these objects are read only ro
** upon changing this parameter the values defines, which subs become valid for mapping

Note:

The following procedure shall be used for re-mapping, which may take place during the NMT state pre-operational and during the NMT state operational:

1. Destroy TPDO by setting 1801h/01h to 0x 8000 0280 + Node ID as COB ID
2. Disable mapping by setting sub-index 0x00 to 0x00
3. Modify mapping by changing the values of the corresponding sub-indices
4. Enable mapping by setting sub-index 0x00 to the number mapped objects
5. Create TPDO by setting 1801h/01h to 0x280 + Node ID as COB ID

6.6 Safety CAN objects

6.6.1 Object 13FEh configuration_valid

This parameter is reset (= 0) each time a "safety relevant parameter" is accessed. Entering 0xA5 switches the configuration to valid. In the case of an invalid value (not 0 or 0xA5) in the configuration_valid flag or incorrect setting of the Safety parameters, write access is rejected and the SRDOs are not transmitted in OPERATIONAL mode.

Attention:

The flag is automatically reset by writing to the safety position data in area 61xxh.
The flag can only be activated if the data valid flag of the safety position parameter safety_configuration_valid, object 61FEh , is activated.

The parameter is stored in the EEPROM.

configuration_valid

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
13FEh	0h	configuration_valid	Byte	rw	0 / 0xA5	-	0x0

6.6.2 Object 13FFh safety_configuration_checksum

This parameter contains the checksum calculated across the safety CAN parameters in objects 1301h and 1302h according to the table below. The checksum is written by the master. The checksum is checked on setting the configuration_valid flag. If no correspondence with the checksum stored in this object is ascertained, setting the flag is blocked (configuration_valid remains ZERO). To calculate the CRC checksum you can use the special EPC program.

Link to the program: https://www.encoder.com/hubfs/products/safety/files/CRC-Calculator.zip

Description file: CRC 14076. Please ask our technicians for xml files for special versions of encoders or look at www.encoder.com.

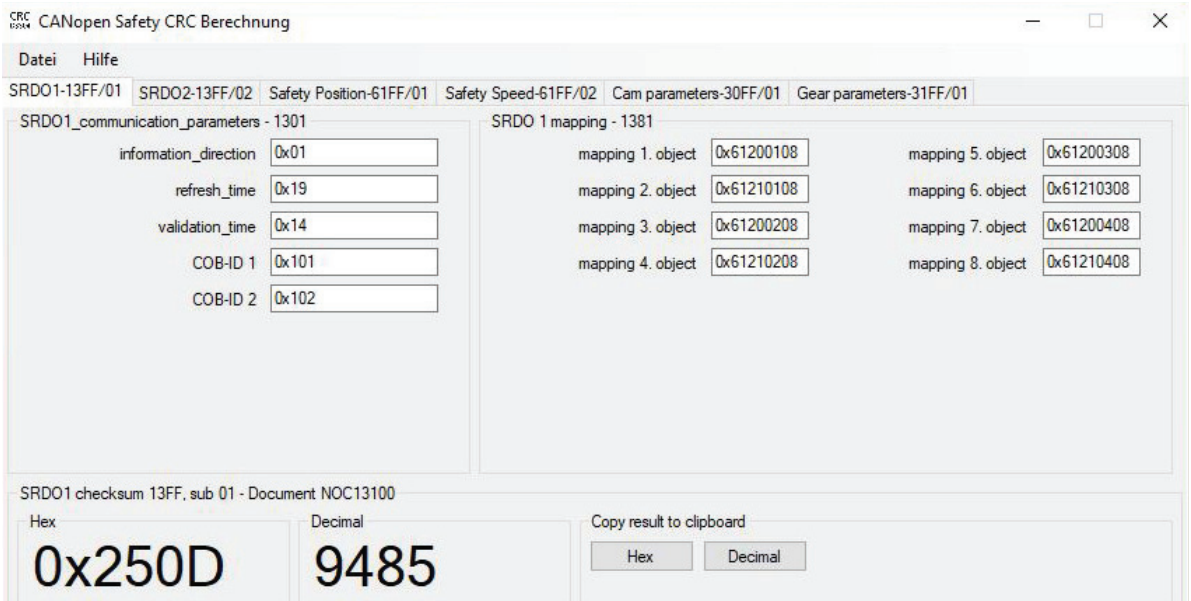
Attention: The parameter can only be written if the data valid flag of the safety position parameter safety_configuration_valid, object 61FEh, is activated. See example for parameterization at the end of this document.

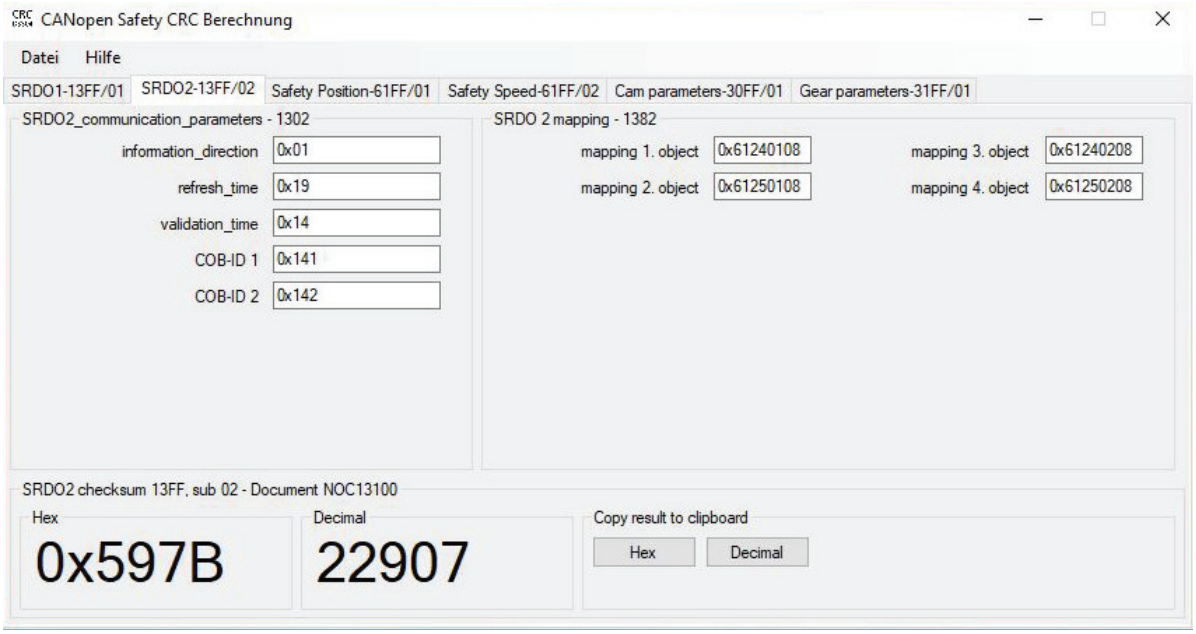
safety_configuration_checksum

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
13FFh	0h	largest_supported_ sub-index	Byte	ro	2	-	2
	1h	SRDO1_checksum (for changes in object 1301)	Word	rw	0 ... 0xFFFF	-	0x250D
	2h	SRDO2_checksum (for changes in object 1302)	Word	rw	0 ... 0xFFFF	-	0x597B

6.6.3 EPC Program for calculation of the checksum

Generator polynomial: $2^{16} + 2^{12} + 2^5 + 1 = 0x11021$
Initial value: 0x0000
Final XOR: no





6.7 NMT objects

6.7.1 Object 1F80h NMT Start up

This object is mandatory if the CANopen device is start up capable. The Object shall configure the startup behavior of a CANopen device. Internal state transitions do not change the value of this object. An attempt to change a bit of a functionality that is not supported by the CANopen device will be responded with an abort message (abort code: 0800 0000h or 0609 0030h).

At the time only available at the following device: TBN80-EA4096RC3K1V2N152.

Value	Description
0x02	NMT slave that shall execute the NMT service 'start remote node' with node-ID set to 0
0x08	NMT slave that shall enter the NMT state 'Operational' after the NMT state 'Initialisation' autonomously (self starting)

NMT start up

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
1F80h	0h	NMT start up	Long	rw	0x02, 0x08	-	-

Bit assignment

31	30	·	·	·	·	9	8	7	6	5	4	3	2	1	0
MSB	reserved 00 00 00 h							configuration							LSB

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6.8 LMT objects

6.8.1 Object 2000h node ID

The node address of the encoder.
The parameter only becomes effective after saving with object 1010h, sub 04h and a power on/NMT reset.
Remark: It is not possible to save this parameter with object 1010h, sub 01h (save all parameters).

The parameter is not reset to the default value with load_default 1011h, sub 01h but with 1011h, sub 04h.

For all node IDs which exceed 32 decimal (33 ….) the related COB ID 1 and COB ID 2 have to be entered manually in objects 1301h, sub 05h/sub 06h and 1302h, sub 05h/sub 06h. Otherwise the SRDOs are disabled (i.e. 0x8000 0122 /0x8000 0123, chap. 9.6). For all node IDs up to 32 decimal the COB IDs are adopted by the encoder automatically. This has to be considered as well when the default value of the node ID exceeds 32 decimal and the default values are loaded by 1011h, sub 04h. (See as well objects 1301h, 1302h and 1011h).

node ID

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
2000h	0h	node ID	Byte	rw	1 ...127 (0x01 ...0x7F) 255 (0xFF)*	-	0x01

* Encoder is in spare part mode and can only be reached by LSS.

6.8.2 Object 2001h bit_rate

Baud rate of the CAN bus.
This object can also be changed using the Layer Setting Service.

The bit rate index is set according to the following table:

Index	Baud rate [kBaud/s]
0h	1000
1h	800
2h	500
3h	250
4h	125
5h	100
6h	50
7h	20

The parameter only becomes effective after saving with object 1010h, sub 04h and a power on reset.
Remark: It is not possible to save this parameter with object 1010h, sub 01h (save all parameters).

The parameter is not reset to the default value with load_default 1011h, sub 01h but with 1011h, sub 04h.

bit_rate

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
2001h	0h	bit_rate	Byte	rw	0 ...7	-	3 (250 kBaud)

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6.9 Objects according to profile definition

6.9.1 Object 6000h operating_parameters

Operating mode byte for the sensor.

Note: The code direction for SRDO (safety communication) has to be set in object 6100h sub 01h.

The state table:

Bit	m/o	Designation	0	1
0	m	Code direction	CW	CCW
1	o	Set firmly to zero		
2	o	scaling_function_control	Inactive	Active
3-11	o	Set firmly to zero		
12	o	slewing ring function	Inactive	Active

operating_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6000h	0h	operating_parameters	Word	rw*	0x0, 0x01, 0x04, 0x05 0x1004, 0x1005	Sen	0x04

* At Single-turn (TBN) encoders with CANopen Safety Profile SIL2 (TBN...S4...), or SIL3 encoders TBSN/TRSN: read only ro

It is mirrored from the safety Object 6100h

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6.9.2 Object 6001h measuring_units_per_revolution

Number of steps per revolution.

measuring_units_per_revolution

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6001h	0h	measuring_units_per_ revolution	Long	rw*	depending on model and perfomance e.g.: 4096	-	-

* At Single-turn (TBN) encoders with CANopen Safety Profile SIL2 (TBN...S4...), or SIL3 encoders TBSN/TRSN: read only ro

6.9.3 Object 6002h total_measuring_range_in_measuring_units

Total measuring range in measuring units.

This value is only relevant for TRN Multi-turn devices. For any TBN devices it is automatically set according to object 6001h.

For TRN...S4... (SIL2) or TBSN/TRSN...S41... (SIL3) safe measuring range for SRDO output please refer to object 3300h.

total_measuring_range_in_measuring_units

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6002h	0h	total_measuring_range_ in_measuring_units	Long	rw*	depending on model and performance e.g.: 16777216	-	-

* At Single-turn (TBN) encoders with CANopen Safety Profile SIL2 (TBN...S4...), or SIL3 encoders TBSN/TRSN: read only ro

6.9.4 Object 6003h preset_value

Presets the current PDO position output to the value specified in object 6003h.

Note: The preset value for SRDO (safety communication) has to be set in object 6100h sub 02h safety_preset_value.

The preset value for multi sensor interface devices has to be set in object 6010.

preset_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6003h	0h	preset_value	Long	rw*	0…(obj. 6002h)-1	-	-

* At Single-turn (TBN) encoders with CANopen Safety Profile SIL2 (TBN...S4...), or SIL3 encoders TBSN/TRSN: read only ro

It is mirrored from the safety object 6100h sub 02h

6.9.5 Object 6004h position_value

Position value. This value is the measured value.
The parameter is provided as a position value by the sensor. This object is updated cyclically.

The following is only valid for single-turn (TBN...S4...) CAN open Safety (SIL2):
The parameter is taken over from the safety area and contains the secure measured value.

Note: For devices with multi sensor interface refer to object 6020h.

position_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6004h	0h	position_value	Long	ro	0..(obj 6002) -1	-	-

Note: Object 600Ch contains the position raw data with a resolution depending on device. 600Ch can be used for calculating the speed signal with max. resolution (see object 6101h).

6.9.6 Object 600Ch raw_position_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
600Ch	0h	raw_position_value	Long	ro	0...0xFFFF	-	-

6.9.7 Object 6010h preset for mullti sensor interface

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6010h	0h	largest_supported_sub_index	Byte	ro	2	-	-
	1h	preset_value_channel_1	Long	rw*	0…(obj. 6002h)-1	-	-
	2h	preset_value_channel_2	Long	rw*	0…(obj. 6002h)-1	-	-

6.9.8 Object 6020h position for mullti sensor interface

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6020h	0h	largest_supported_sub_index	Byte	ro	2	-	-
	1h	position_value_channel_1	Long	ro	0…(obj. 6002h)-1	-	-
	2h	osition_value_channel_2	Long	ro	0…(obj. 6002h)-1	-	-

6.9.9 Object 6030h speed_value

Speed value. The unit is digits per object 6031h sub-index 02h in ms with a resolution depending on speed_source_selector, speed_multiplier and speed_divider. The format is 16bit signed. This object is updated cyclically.

speed_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6030h	0h	largest_supported_ sub_index	Byte	ro	1	-	-
	1h	speed_value_channel1	Word	ro	0...0xFFFF	-	-

6.9.10 Object 6031h speed_parameter

speed_parameter

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6031h	0h	largest_supported_sub_index	Byte	ro	4	-	-
	1h	speed_source_selector**	Byte	rw*	1, 2	-	2
	2h	speed_ integration _time	Word	rw*	1 to 1000 [ms]	-	100
	3h	speed_multiplier	Word	rw*	1 to 65535	-	1
	4h	speed_divider	Word	rw*	1 to 65535	-	10

* At Single-turn (TBN) encoders with CANopen Safety Profile SIL2 (TBN...S4...), or SIL3 encoders TBSN/TRSN: read only ro

They are mirrored from the safety Object 6101h

** 1 = scaled position from object 6004h. 2 = Raw data of position from object 600Ch, no scaling factor enabled. The related resolution of setting 1 or 2 for the speed signal depends on the device.

6.9.11 Object 650Ch Offset for multi sensor interface

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
650Ch	0h	largest_supported_sub_index	Byte	ro	2	-	-
	1h	offset_value_channel_1	Long	ro	0…(obj. 6002h)-1	-	-
	2h	offset_value_channel_2	Long	ro	0…(obj. 6002h)-1	-	-

6.10 Safety Objects according to profile definition

6.10.1 Object 6100h safety_position_configuration_parameters

The object defines the behavior of the position registration system in the safety area.
Modifications will cause 61FE = '0' (must be set '0xA5' after modification). New CRC Checksum 61FF/01 must be calculated and transmitted to the encoder.

The parameter can only be changed in PRE-OPERATIONAL state.

safety_position_configuration_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6031h	0h	largest_supported_sub_index	Byte	ro	3	-	-
	1h	safety_code_sequence	Word	rw	0, 1 (0=cw, 1=ccw)	-	0
	2h	safety_preset_value	Long	rw	0... (obj.3300h/02h)-1 0...(obj. 6002h)-1**		0
	3h	Safety_HR*_preset_value		ro	0x7FFFFFFFFF FFFFFF		

* High resolution

** for TBN...S4... (with CANopen safety Profile SIL2) encoder

Note for encoders TBN/TRN-S4 bearing the product codes 0x6000, 0x6001 and 0x6002 (see Object 1018h sub 02h):

If objects 6100h, sub 01h, sub 02h and sub 03h are modified, objects 6101h, sub 01h, sub 02h and sub 03h are modified automatically and vice versa.
Therfore upon modifying values in object 6100h, checksums 61FFh sub 01h and 61FFh sub 02h have to be modified with the appropriate values.
For all other products with product codes not mentioned above Objects 6100h and 6101h are completly independent from each other.

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6.10.2 Object 6101h safety_speed_configuration_parameters

The object defines the behavior of speed measurement in the safety area.

Modifications will cause 61FEh = '0' (must be set '0xA5' after modification). New CRC Checksum 61FFh/02h must be calculated and transmitted to the encoder.
The parameter can only be changed in PRE-OPERATIONAL state.

If 6100h, sub 01h, sub 02h and sub 03h is modified, 6101h, sub 01h, sub 02h and sub 03h is modified automatically and vice versa.

safety_speed_configuration_parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6101h	0h	largest_supported_sub_index	Byte	ro	7	-	-
	1h	safety_code_sequence	Word	rw	0, 1 (0=cw, 1=ccw)	-	0
	2h	safety_preset_value	Long	rw	0...(obj.3300/02)-1 0...(obj. 6002)-1**	-	0
	3h	safety_preset_HR_value	Long64	ro	0x7FFFFFFFFF FFFFFF	-	-
	4h	safety_speed_source *	Byte	rw/ro	1, 2	-	2
	5h	safety_speed_ integration_time	Word	rw	1…1000 [ms]	-	100
	6h	safety_speed_multiplier	Word	rw	1 … 65535	-	1
	7h	safety_speed_divider	Word	rw	1 … 65535	-	10

* 1 = scaled position from object 6004h for TBN...S4... (SIL2)
1 = scaled position from object 6120h for TRN...S4... (SIL2) or TBSN/TRSN...S41... (SIL3) encoders
2 = Raw data of position from object 600Ch, no scaling factor enabled.
The related resolution of setting 1 or 2 for the speed signal depends on the device

** for TBN...S4... (with CANopen safety Profile SIL2) encoder

Note for encoders TBN/TRN-S4 bearing the product codes 0x6000, 0x6001 and 0x6002 (see Object 1018h sub 02h):

If objects 6100h, sub 01h, sub 02h and sub 03h are modified, objects 6101h, sub 01h, sub 02h and sub 03h are modified automatically and vice versa.

Therfore upon modifying values in object 6101h, checksums 61FFh sub 01h and 61FFh sub 02h have to be modified with the appropriate values.

For all other products with product codes not mentioned above Objects 6100h and 6101h are completly independent from each other.

6.10.3 Object 6120h safety_standard_position_value

The object contains the current position. This object is used in the mapping structure for data output within the SRDO. In the event of access to individual objects, it must be noted that the consistency of the measured value is not ensured.

safety_standard_position_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6120h	0h	largest_supported_sub_index	Byte	ro	7	-	-
	1h	safety_position_value_byte1	Byte	ro	0...0xFF	-	-
	2h	safety_position_value_byte2	Byte	ro	0...0xFF	-	-
	3h	safety_position_value_byte3	Byte	ro	0...0xFF	-	-
	4h	safety_position_value_byte4	Byte	ro	0...0xFF	-	-

6.10.4 Object 6121h safety_inverted_position_value

The object contains the current bit-inverted position. This object is used in the mapping structure for data output within the SRDO. In the event of access to individual objects, it must be noted that the consistency of the measured value is not ensured.

safety_inverted_standard_position_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6121h	0h	largest_supported_sub_index	Byte	ro	4	-	-
	1h	safety_inverted_position_value_byte1	Byte	ro	0...0xFF	-	-
	2h	safety_inverted_position_value_byte2	Byte	ro	0...0xFF	-	-
	3h	safety_inverted_position_value_byte3	Byte	ro	0...0xFF	-	-
	4h	safety_inverted_position_value_byte4	Byte	ro	0...0xFF	-	-

6.10.5 Object 6124h safety_speed_value

The object contains the actual calculated speed value. This object is used in the mapping structure for data output within the SRDO. In the event of access to individual objects, it must be noted that the consistency of the measured value is not ensured.

safety_speed_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6124h	0h	largest_supported_sub_index	Byte	ro	2	-	-
	1h	safety_speed_value_byte1	Byte	ro	0...0xFF	-	-
	2h	safety_speed_value_byte2	Byte	ro	0...0xFF	-	-

6.10.6 Object 6125h safety_inverted_speed_value

The object contains the current bit-inverted measured speed value. This object is used in the mapping structure for data output within the SRDO. In the event of access to individual objects, it must be noted that the consistency of the measured value is not ensured.

safety_inverted_speed_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6125h	0h	largest_supported_sub_index	Byte	ro	2	-	-
	1h	safety_inverted_speed_value_byte1	Byte	ro	0...0xFF	-	-
	2h	safety_inverted_speed_value_byte2	Byte	ro	0...0xFF	-	-

6.10.7 Object 61FEh safety_configuration_valid

The object is the confirmation flag stating that the configuration is valid. On setting the flag, the consistency of the CRC checksum and the set parameters is checked.

This parameter can only be changed in PRE-OPERATIONAL state.

When the CRC checksum is not correct (i.e. in case of changes of parameters without changing the CRC checksum or a wrong checksum is transmitted to the encoder) 61FEh can not be set to 0xA5. An error message comes: (e.g., 0x80 0xFE 0x61 0x00 0x22 0x00 0x00 0x08).

Attention:

safety_configuration_valid

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
61FEh	0h	safety_configuration_valid	Byte	rw	0/0xA5	-	0xA5

6.10.8 Object 61FFh safety_configuration_signature

The object contains the calculated across the safety encoder parameters in objects 6100h and 6101h. The checksum must be rewritten in the event of changes by the user. The checksum is checked on setting the safety_configuration_valid to 0xA5. If no correspondence with the checksum stored in this object is ascertained, setting the flag is blocked (safety_configuration_valid remains ZERO). To calculate the CRC checksum you can use the special EPC program.

Link to the program: https://www.encoder.com/hubfs/products/safety/files/CRC-Calculator.zip

Description file: CRC 14076. Please ask our technicians for xml files for special versions of encoders or look at www.encoder.com.

The parameter can only be changed in PRE-OPERATIONAL state.
safety_configuration_signature

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
61FFh	0h	largest_supported_sub_index	Byte	ro	2	-	2
	1h	SRDO1_signature (for changes in object 6100)	Word	rw	0 ..0xFFFF	-	0x....*
	2h	SRDO2_signature (for changes in object 6101)	Word	rw	0 ..0xFFFF	-	0x....*

* Depends on default values in objects 6100h and 6101h. Pay attention to the different values which have to be tagged in the EPC program for the CRC checksums for sub 01h and sub 02h.

6.11 Objects for achieving compatability

6.11.1 Object 6200h Cyclic Timer

In the case of values > 0, the object position value 6004h is transmitted cyclically with the value of the cyclic timer in ms on PDO 1. This object is logically set equal to event_timer of PDO1 (Object 1800h sub 05h).

Cyclic Timer

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6200h	0h	cyclic_timer	Word	rw	0...0xFFFF	-	0

6.12 Diagnosis objects

6.12.1 Object 6500h operating_status

Current sensor status. This is a representation of object 6000h.
The parameter is provided by the sensor.

operating_status

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6500h	0h	operating_status	Word	ro	Object 6000h*	-	-

* 0x00=CW and inactive, 0x01=CCW and inactive, 0x04=CW and active (standard), 0x05= CCW and active, for slewing ring applications: 0x1004 (CW), 0x1005 (CCW) (bit 12 activated, see Object 6000h for further details)

6.12.2 Object 6501h singleturn_resolution

Maximum Single-turn resolution

single-turn_resolution

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6501h	0h	single-turn_resolution	Long	ro	max. 65536	-	-

6.12.3 Object 6502h number_of_distinguishable_revolutions

Maximum number of distinguishable revolutions.

number_of_distinguishable_revolutions

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6502h	0h	number_of_distinguishable_ revolutions	Word	ro	4096	-	-

6.12.4 Object 6503h alarms

Internally, there is only one error byte. If an alarm occurs, an emergency message is transmitted. During SDO upload, the error byte is loaded into the object's MSB.

The following errors are evaluated:

Bit	Error type
0	Not used
1	Not used
2	Not used
3	Device error
4	Not used
5	CRC parameter error
6	Supply out of range
7	Sensor error

Extended error coding is available for certain errors in this byte in the emergency message and in object 1003h pre_defined_error_field.

CRC error: The alignment parameters and the CAN interface parameters are monitored by CRC. In the case of an error in one of the areas, this flag is set.

Sensor error: Position sensor error or the measured values of the sensors read-in in redundant form lie too far apart. Or the position controller discovers a scanning error.

Device error: In case of full redundant systems each systems controls the other system. If one system recognizes that the other system doesn't work anymore this error will be generated and transmitted via CAN. A hardware error (look at fatal errors) is not transmitted via CAN.

Alarms

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6503h	0h	alarms	Word	ro	-	See above	-

6.12.5 Object 6504h supported_alarms

Supported alarm messages.

This is a representation of the error displays possible in the case of index 6503h.

supported_alarms

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6504h	0h	supported_alarms	Word	ro	0xE8	-	-

6.12.6 Object 6506h supported_warnings

Supported warning messages.
No warnings are supported. Object 6505h can therefore be omitted.

supported_warnings

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6506h	0h	supported_warnings	Word	ro	0	-	-

6.12.7 Object 6507h profile_and_software_version

The profile and software version of the encoder.

profile_and_software_version

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6507h	0h	profile_and_software_version	Long	ro	0x400100102	-	-

6.12.8 Object 6508h operating_time

Not supported.

operating_time

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6508h	0h	profile_and_software_version	Long	ro	0xFFFF FFFF	-	-

6.12.9 Object 6509h offset_value

Output offset. In our encoders, this is the zero point used for internal calculations.
The parameter is evaluated by the sensor (only used internally).

offset_value

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
6509h	0h	offset_value	Long	ro	0..(obj 6002h) -1	SEN	-

6.12.10 Object 650Ah module_identification

The manufacturer offset is used as the zero point parameter for synchronising the two nodes' position data. This parameter is written via the factory programming during system alignment.

module_identification

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
650Ah	0h	largest_supported_sub-index	-	ro	1	-	-
	1h	manufacturer_offset_value	Long	ro	0..(obj 6001h) -1	-	*

* Written in factory programming state.

6.12.11 Object 650Bh serial_number

The serial number is written with the factory programming.

serial_number

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
650Bh	0h	serial_number	Long	wp	0....	*	-

* Written in factory programming state.

6.12.12 Object 650Dh absolute_accuracy

Displays the accuracy of the measuring value.

absolute_accuracy

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
650Dh	0h	absolute_accuracy	Byte	ro	.....	SEN	10 *

* Depending on device

6.12.13 Object 650Eh device_capability

Defines the operating capability of the encoder. The entry is carried out according to the following table:

Name	Bit	Value	Definition
ec: Encoder class	2:0	0b000 (b=binary)	Reserved
		0b001	Class 1
		0b010	Class 2
		0b011	Class 3
		0b100 to 0b111	Reserved
rsl: Resolution	3	0	Low
		1	High
r: Reserved	4	Reserved (always 0)	
saf: Safety	5	0	Safety not supported
		1	Safety supported
st: Safety type	7:6	0b00	CANopen Safety
		0b01 to 0b11	Reserved
r: Reserved	11:8	Reserved (always 0)	
msc 1: Manufacturer-specific capability 1: slewing ring functionality	12	0	slewing ring functionality not supported
		1	slewing ring functionality supported see Objects 3100 (safety) and 3102 (non safety) for programming of slewing ring functionality.
msc 2 to 4: Manufacturer-specific capability 1 to 4	15:13	0	Manufacturer-specific capability 2 to 4 disabled
		1	Manufacturer-specific capability 2 to 4 enabled

Bit assignment parameter definition

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
msc4	msc3	msc2	msc1	r				st		saf	r	rsl	ec		

device_capability

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
650Eh	0h	device_capability	Long	ROM	0x23 safety / 0x1023 (with safety slewing ring functionality)		-
					0x03 standard / 0x1003 (with slewing ring functionality)		

Class 3 encoder with CANopen Safety.

7. MANUFACTURER SPECIFIC OBJECTS

7.1 Object 3100h safety_gear_configuration

This Object is for setting the safety gear parameters for safety SRDO transmission.

Only valid for TRN S4 version with slewing ring function (Version "S" in order code number between ST and MT resolution). If you have a device not marked with S4 on the order designation, please refer to Object 1302h. Output of slewing ring position modifications will cause 31FE = "0" (must be set "A5" after modification). New CRC Checksum 31FF/01 must be calculated and transmitted to TRN.

Note: Maximum gear ratio i =1024 [decimal], Minimum gear ratio i =1, i = slew_gear / measure_gear
Bigger or smaller values are not allowed. A plausibilty check ensures that the valid flag 31FE cannot be set. Error code 0800 0022 - data not stored to device is transmitted via SDO transfer if the plausibility check fails.

Adjustment of gear parameters

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
3100h	0h	largest_supported_sub_index	-	ro	0x03	-	-
	1h	safety_slew_gear [teeth]	Long	rw	0x0 ... 0x FFFF FFFF		0x0
	2h	safety_measure_gear [teeth]	Long	rw	0x0 ... 0x FFFF FFFF		0x0
	3h	safety_measuring_range	Long	rw	0x0 ... 0x FFFF FFFF and ≤ [3300h/01h] x i (i= slew_gear / measure_gear)		0x0

safety_slew_gear Number of teeth on driving gear (slewing)
safety_measure_gear Number of teeth on encoder gear
safety_measuring_range Number of steps output for 1 turn of the slewing ring

Example for 3100h sub 03h:

Condition: Object 3300h sub 01h = 0x4000 (16384[decimal])

If i = 0x03 (3[decimal]) (for example 30 / 10) the maximum of the measuring range is 0xC000 (49,152[decimal]).
If i = 0x01 (1[decimal]) → measuring range is ≤ 0x4000 (16384[decimal]).

Depending on ratio i, 3100h sub 03h has to be matched. This is reasonable for providing every single step of resolution.

The gear parameters in object 3100h can be set easily after disabling of 31FEh and transmission of the related checksum via 31FFh and then setting 31FEh to 0xA5.

In order to completely deactivate the slewing ring function and achieve an encoder behavior exactly as a normal binary encoder, all parameters of 3100h (sub 01h, sub 02h and sub 03h) have to be set to zero.

Checksum 31FFh has to be set accordingly and valid flag 31FEh has to be set 0xA5.
After modifying the gear parameters it has to be ensured that a "safe all" command via object 1010h sub 01h is executed.
Otherwise after switching the supply power off and back on, an error is reported (The encoder is in a safe state, no position signal via SRDO):
0xFF 0xFF 0x81 0x00 0x20 0x01 0x02 0x02
The last saved parameter set is loaded. The parameter set that was not saved and the recorded position is lost.
The error must be eliminated by setting the configuration valid flag 31FEh to 0x0 and setting it to 0xA5 again and a subsequent reset.

After modifying any safety_gear_configuration parameter, the output position is undefined within the code range of the output resolution (object 3100h/03h). By setting a preset value (object 6100h/02h) a defined initial position is set. This parameter is verified by the checksum of the profile specific parameters.

7.1.1 Object 31FEh safety_gear_data_valid

This parameter is reset (= 0x0) each time a "safety relevant parameter" in object 3100h is accessed. Entering 0xA5 switches the configuration to valid. In the case of an invalid value (not 0 or 0xA5) in the safety_gear_data_valid or incorrect setting of the checksum, write access is rejected and the SRDOs are not transmitted in OPERATIONAL mode.

Attention:
The flag is automatically reset by writing to the safety position data in safety_gear_configuration object 3100h.

safety_gear_data_valid

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
31FEh	0h	safety_gear_data_valid	Byte	rw	0 / 0xA5		0xA5

7.1.2 Object 31FFh safety_gear_CRC_checksum

This parameter contains the checksum across the safety CAN parameters in objects 3100h according to the table below. The checksum is written by the master. The checksum is checked on setting the safety_gear_data_valid. If no correspondence with the checksum stored in this object is ascertained, setting the flag is blocked (safety_gear_data_valid remains ZERO). To calculate the CRC checksum you can use the special EPC program.

Link to the program: https://www.encoder.com/hubfs/products/safety/files/CRC-Calculator.zip

Description file: CRC 14076. Please ask our technicians for xml files for special versions of encoders or look at www.encoder.com.

Attention: The parameter can only be written if the valid flag of the safety position parameter safety_configuration_valid, object 61FEh, is activated. See example for parameterization at the end of this document.

safety_gear_CRC_checksum

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
31FFh	0h	largest_supported_sub-index	Byte	ro	0x1		0x1
	1h	safety_gear_configuration_checksum	Word	rw	0 ... 0xFFFF		0x76E9*

* Depends on values in Object 3100h. (76E9 is for 3100, sub 1 to 3: all values = 0, slewing ring function is not activated)

After resetting the gear parameters, the output position is undefined within the code range of the output resolution (object 3100h/03h). By setting a preset value (object 6100h/02h) a defined initial position is set.

7.1.3 Safety Notes to slewing ring functionality for safety_gear_configuration

The encoder can, in the range of 4096 turns, determine an absolute position of the shaft. The working range of the slewing ring function is split in two areas, positive and negative, relative to its zero position.

Without losing the correct position value of the slewing ring, the allowed number of encoder shaft-turns r_{safety} in a situation when the encoder is not supplied with power can be calculated according to the following formula:

r_{safety}	allowed safety encoder revolutions in each direction without power supply to the encoder
i	gear ratio (i= slew gear / measure gear)
s_{multi}	Multi-turn encoder steps $S_{\text{multi}} = \frac{\text{Object } 3300/02}{\text{Object } 3300/01}$ (S_{multi}=4096 for most applications)

$$r_{\text{safety}} = \frac{S_{\text{multi}}}{2} - i$$

r_{safety} is rounded down to "full revolutions"

Safety Note:
It has to be ensured in the application, that the shaft is never turned x revolutions, where x > r_{safety} in a state where the encoder is not connected to supply power.
If in a non power state the encoder shaft is turned for x revolutions, where x > r_{safety} the output position is not valid, this is not detected by the encoder upon reconnecting it to supply power.

The smallest possible value for r_{safety} = 1024 encoder shaft turns in the case of i (gear ratio) = 1024. Bigger values for the gear ratio are not possible since the plausibility check of the gear ratio rejects the parameterization and valid flag 31FE cannot be set.

This means the safety area will always be in the range of 2047 ≥ r_{safety} ≥ 1024 revolutions of the encoder shaft depending on the gear ratio.

Example 1:
s_{multi} = 4096 [decimal]
i. = 3 [decimal]
r_{safety} = 2045 [encoder shaft revolutions]

Example 2:
s_{multi} = 4096 [decimal]
i. = 3.2 [decimal]
r_{safety} = 2044 [encoder shaft revolutions]

7.2 Object 3102h gear_configuration

This Object is for setting the gear parameters for non safety PDO transmission.

Only valid for TRN version with slewing ring function (Version "S" in order code number between ST and MT resolution).

Note: Maximum gear ratio i =1024 [decimal], Minimum gear ratio i =1, i = slew_gear / measure_gear
Bigger values are not allowed. A plausibilty check ensures that bit 12 in object 6000h cannot be set to "1". Error code 0x0800 0022 - data not stored to device is transmitted via SDO transfer if the plausibility check fails.

Setting of the Preset value is possible via object 6003h.

Adjustment of gear parameters.

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
3102h	0h	largest_supported_sub_index	-	ro	0x03	-	-
	1h	slew_gear [teeth]	Long	rw	0x0 ... 0x FFFF FFFF		0x0
	2h	measure_gear [teeth]	Long	rw	0x0 ... 0x FFFF FFFF		0x0
	3h	measuring_range	Long	rw	0x0 ... 0x FFFF FFFF and ≤ [6001h] x i (i= slew_gear / measure_gear)		0x0

slew_gear — Number of teeth on driving gear (slewing)
measure_gear — Number of teeth on encoder gear
measuring_range — Number of steps output for 1 turn of the slewing ring

Example for 3102h sub 03h:

Condition: Object 6001h = 0x4000 (16384[decimal])

If i = 3 (for example 30 / 10) the maximum of the measuring range is 49,152 (0xC000) (Object 6001h x i).
If i = 1 → measuring range is ≤ 16,384 (0x4000). Depending on ratio i, 3102h sub 03h has to be matched. This is normal for providing every single step of resolution.

Note: Before setting values in Object 3102h it is mandatory to set the following:

Object	Value [hex]	Value [decimal]
6000h	0x04 (for CW) or 0x05 (for CCW)	4 (for CW) or 5 (for CCW)
6001h	0x4000	16,384
6002h	0x400,0000	67,108,864

To activate / deactivate the standard slewing ring function please refer to Object 6000h bit 12 (slewing ring function).

If a gear parameter is changed before the Data Valid flag is reset, the Data Valid is automatically deleted (set "0"). The attempt to set the flag fails without an error message. The flag can only be set after deleting the deleted flag.

After that, the error message appears at startup:
0xFF 0xFF 0x81 0x00 0x20 0x00 0x02 0x02
The error message can only be deleted by a reset, so the changed values have to be saved in order to activate the new setting.

After modifying any gear parameter, the output position is undefined within the code range of the output resolution (object 3102h sub 03h). By setting a preset value (object 6003h) a defined initial position is set.

Mandatory steps in order to set Object 3102h gear_configuration

1. Set Objects 6000h, 6001h and 6002h as described above
2. Set Object 3102h sub 01h, 02h and 03h as desired
3. Set Object 6000h to 0x1004 for CW or 0x1005 for CCW (Activate slewing ring functionality)
4. Set Object 1010h sub 01h to 0x65766173 in order to save_all_parameters

If step 4 was not fulfilled the encoder upon reset will give out the error code: 0xFF 0xFF 0x81 0x00 0x20 0x00 0x02 0x02.
To solve this issue it is mandatory to do a load default (Object 1011h sub 01h) and a reset. After that the recommended steps shall be followed to parameterize the slewing gear functionality.

7.2.1 Safety notes to slewing ring function of standard slewing ring position

The encoder can in the range of 4096 turns determine an absolute position of the shaft. The working range of the slewing ring function is split in two areas, positive and negative relative to its zero position.

The allowed number of encoder shaft-turns r_{safety} in a situation when the encoder is not supplied with power can be calculated according to the following formula:

r_{safety}	allowed safety encoder revolutions in each direction without power supply to the encoder
i	gear ratio (i= slew gear / measure gear)
s_{multi}	Multi-turn encoder steps $S_{\text{multi}} = \frac{\text{Object } 6002}{\text{Object } 6001}$ (S_{multi}=4096 for most applications)

$$r_{\text{safety}} = \frac{S_{\text{multi}}}{2} - i$$

r_{safety} is rounded down to "full revolutions"

Safety Note:
It has to be ensured in the application, that the shaft is never turned x revolutions, where x > r_{safety} in a state where the encoder is not connected to supply power.
If in a non power state the encoder shaft is turned for x revolutions, where x > r_{safety} the output position is not valid, this is not detected by the encoder upon reconnecting it to supply power.

The smallest possible value for r_{safety} = 1024 encoder shaft turns in the case of i (gear ratio) = 1024. Bigger values for the gear ratio are not possible since the plausibility check of the gear ratio rejects the parameterization and operating byte 12 in Object 6000h cannot be set.
This means the safety area will always be in the range of 2047 ≥ r_{safety} ≥ 1024 revolutions of the encoder shaft depending on the gear ratio.

Example 1:
s_{multi} = 4096 [decimal]
i. = 3 [decimal]
r_{safety} = 2045 [encoder shaft revolutions]

Example 2:
s_{multi} = 4096 [decimal]
i. = 3.2 [decimal]
r_{safety} = 2044 [encoder shaft revolutions]

7.3 Object 3300h safety_encoder_parameter extension of Safety Parameters for 610Xh

Note: Only valid for Multi-turn Encoder (TRN) with CANopen Safety SIL2 (TRN...S4...) and TBSN/TRSN with CANopen Safety SIL3 (TBSN/TRSN...S41...).

This parameter contains an extension for safety parameters not defined in the scope of standard encoder Objects.
These parameters define the capability of a safety encoder with respect to model and performance for safety tasks, which are otherwise not communicated through CANopen safety protocol.
These parameters cannot be changed and are set at the factory (wp).

safety_encoder_parameter

Index	Sub	Description	Length COM	Memory Type	Range/value	Action	Default
3300h	0h	largest_supported_sub_index	Byte	ro	0x03		0x03
	1h	safety_measuring_units_per_revolution	Long	wp	depending on model and perfomance e.g.: 4096		
	2h	safety_ total_measuring_ range_in_measuring_units	Long	wp	depending on model and performance e.g.: 16777216		
	3h	safety_factory_offset	Long	wp	0...(Obj. 3300h/02h)-1		

* Written in factory programming state.

8. OBJECT LISTING

Name	Index	Sub	Len	Value decimal	Value hex	Remark
device_type	1000h		4	131478	0x00020196	
error_register	1001h		1	0	0x00	
PredefinedErrorField	1003h					
NumberofErrors		0h	1	0	0xX	
StandardErrorField_1 to StandardErrorField_20		1h to 14h	4			
COB-ID_SYNC	1005h		4	128	0x00000080	
manufacturer_device_name	1008h		18	-	-	Encoder TRN/TBN/TBSN/ TRSN Safety
manufacturer_hardware_version	1009h		13	-	-	P-0xxx
manufacturer_software_version	100Ah		15	-	-	Safety Standard
store_parameters	1010h					
largest_supported_sub-index		0h	1	5	0x05	
save_all_parameters		1h	4	1	0x00000001	
SaveCommunicationParameters		2h	4	1	0x00000001	
SaveApplicationParameters		3h	4	1	0x00000001	
SaveLMTDefinedParameters		4h	4	1	0x00000001	
SaveManufacturerDefinedParameters		5h	4	1	0x00000001	
restore_default_parameters	1011h					
largest_supported_sub-index		0h	1	5	0x05	
restore_all_default_parameters		1h	4	1	0x00000001	
RestoreCommunicationDefaultParameters		2h	4	1	0x00000001	
RestoreApplicationDefaultParameters		3h	4	1	0x00000001	
RestoreLMTDefinedDefaultParameters		4h	4	1	0x00000001	
RestoreManufacturerDefinedDefaultParameters		5h	4	1	0x00000001	
COB-ID_EMCY	1014h		4	141	0x0000008D	
EMCY_inhibit_time	1015h		2	1000	0x03E8	
producer_heartbeat_time	1017h		2	0	0x0	
identity_object	1018h					
largest_supported_sub-index		0h	1	4	0x04	
vendor-ID		1h	4	269	0x0000010D	
product_code		2h	4	25376	0x0000xxxx	
revision_number		3h	4	65537	0x00020002	
serial_number		4h	4	x	0xxxxxxxxx	

Definition of Data Length (Len): 1 byte = Byte, 2 bytes = Word, 4 bytes = Long

Name	Index	Sub	Len	Value decimal	Value hex	Remark
error_behavior	1029h					
NrofErrorClasses		0h	1	3	0x03	
CommunicationError		1h	1	0	0x00	
InternalDeviceError		2h	1	0	0x00	
		3h	1	1	0x00	
RedundancyError (only for full redundant encoders)		4h	1	1	0x01	
SRDO1_communication_parameter	1301h					
largest_supported_sub-index		0h	1	6	0x06	
information_direction		1h	1	1	0x01	
SRDO_refresh_time		2h	2	25	0x0019	
validation_time		3h	1	20	0x14	
transmission_type		4h	1	254	0xFE	
SRDO_compar_COB_ID_1		5h	4	281	0x00000119	0: active 8: inactive
SRDO_compar_COB_ID_2		6h	4	282	0x0000011A	0: active 8: inactive
SRDO2_communication_parameter	1302h					
largest_supported_sub-index		0h	1	6	0x06	
information_direction		1h	1	1	0x01	
SRDO_refresh_time		2h	2	25	0x0019	
validation_time		3h	1	20	0x14	
transmission_type		4h	1	254	0xFE	
SRDO_compar_COB_ID_1		5h	4	345	0x00000159	0: active 8: inactive
SRDO_compar_COB_ID_2		6h	4	346	0x0000015A	0: active 8: inactive
SRDO1_mapping_parameter	1381h					
largest_supported_sub-index		0h	1	8	0x08	
first_SRDO_mapping_object		1h	4	1629487368	0x61200108	
second_SRDO_mapping_object		2h	4	1629552904	0x61210108	
third_SRDO_mapping_object		3h	4	1629487624	0x61200208	
fourth_SRDO_mapping_object		4h	4	1629553160	0x61210208	
fifth_SRDO_mapping_object		5h	4	1629487880	0x61200308	
sixth_SRDO_mapping_object		6h	4	1629553416	0x61210308	
seventh_SRDO_mapping_object		7h	4	1629488136	0x61200408	
eighth_SRDO_mapping_object		8h	4	1629553672	0x61210408	
SRDO2_mapping_parameter	1382h					
largest_supported_sub-index		0h	1	4	0x04	
first_SRDO_mapping_object		1h	4	1629749512	0x61240108	
second_SRDO_mapping_object		2h	4	1629815048	0x61250108	
third_SRDO_mapping_object		3h	4	1629749768	0x61240208	
fourth_SRDO_mapping_object		4h	4	1629815304	0x61250208	
Configuration_valid	13FEh		1	0	0x00	

Name	Index	Sub	Len	Value decimal	Value hex	Remark
safety_configuration_signature	13FFh					
Safety_signature_Number_of_entries		0h	1	4	0x04	
SRDO1_signature		1h	2	..... *	0x.... *	
SRDO2_signature		2h	2	..... *	0x.... *	
first_transmit_PDO_parameter	1800h					
largest_supported_sub-index		0h	1	5	0x05	
COB-ID_used_by_PDO		1h	4	385	0x8000018D	0: active 8: inactive
transmission_type		2h	1	253	0xFD	
inhibit_time		3h	2	0	0x0	
reserved		-	-	-	-	
event_timer		5h	2	0	0x0	
second_transmit_PDO_parameter	1801h					
largest_supported_sub-index		0h	1	5	0x05	
COB-ID_used_by_PDO		1h	4	641	0x8000028D	0: active 8: inactive
transmission_type		2h	1	1	0x01	
inhibit_time		3h	2	0	0x0	
reserved		-	-	-	-	
event_timer		5h	2	0	0x0	
first_transmit_PDO_mapping	1A00h					
largest_supported_sub-index		0h	1	2	0x02	0x0: mapping disabled
PDO_mapping_for_the_first_object		1h	4	1610874912	0x60040020	
PDOMappingEntry_2		2h	4	1613758736	0x60300110	
second_transmit_PDO_mapping	1A01h					
largest_supported_sub-index		0h	1	2	0x02	0x0: mapping disabled
PDO_mapping_for_the_first_object		1h	4	1610874912	0x60040020	
PDOMappingEntry_2		2h	4	1613758736	0x60300110	
operating_parameters	6000h		2	4	0x04	
measuring_units_per_revolution	6001h		4	16384*	0x00004000*	
total_measuring_range_in_measuring_units	6002h		4	67108864*	0x400 0000*	
preset_value	6003h		4	0	0x0	
position_value	6004h		4	x	0xX	
raw_position_value	600Ch		4	x	0xX	
preset for multi sensor interface	6010h					
largest_supported_sub-index		0h	1	2	0x02	
preset_channel_1		1h	4	0	0x0	
preset_channel_2		2h	4	0	0x0	

Name	Index	Sub	Len	Value decimal	Value hex	Remark
position for multi sensor interface	6020h					
largest_supported_sub-index		0h	1	2	0x02	
position_channel_1		1h	4	x	0xX	
position_channel_2		2h	4	x	0xX	
Speed value	6030h					
NrOfObjects		0h	1	1	0x1	
Speed value channel 1		1h	2	x	0xX	
speed_parameter	6031h					
NrOfObjects		0h	1	4	0x04	
speed_source_selector		1h	1	2	0x02	
speed_integration_time		2h	2	100	0x0064	
speed_multiplier		3h	2	1	0x0001	
speed_divider		4h	2	10	0x000A	
safety_position_configuration_parameters	6100h					
NrOfObjects		0h	1	3	0x03	
safety_code_sequence		1h	2	0	0x0	
safety_preset_value		2h	4	0	0x0	
safety_preset_value_high_resolution		3h	8		0x7FFFFFFFFFFFFF	
safety_speed_configuration_parameters	6101h					
NrOfObjects		0h	1	7	0x07	
safety_code_sequence		1h	2	0	0x0	
safety_preset_value		2h	4	0	0x0	
safety_preset_value_high_resolution		3h	8	0	0x7FFFFFFFFFFFFF	
safety_speed_source_selector		4h	1	2	0x02	
safety_speed_integration_time		5h	2	100	0x0064	
safety_speed_multiplier		6h	2	1	0x0001	
safety_speed_divider		7h	2	10	0x000A	
safety_position_value	6120h					
NrOfObjects		0h	1	4	0x04	
safety_position_value_byte1		1h	1	x	0xX	
safety_position_value_byte2		2h	1	x	0xX	
safety_position_value_byte3		3h	1	x	0xX	
safety_position_value_byte4		4h	1	x	0xX	
safety_inverted_position_value	6121h					
NrOfObjects		0h	1	4	0x04	
safety_inverted_position_value_byte1		1h	1	x	0xX	
safety_inverted_position_value_byte2		2h	1	x	0xX	
safety_inverted_position_value_byte3		3h	1	x	0xX	
safety_inverted_position_value_byte4		4h	1	x	0xX	

* Depends on factory default settings.

Name	Index	Sub	Len	Value decimal	Value hex	Remark
safety_speed_value	6124h					
NrOfObjects		0h	1	2	0x02	
safety_speed_value_byte1		1h	1	x	0xX	
safety_speed_value_byte2		2h	1	x	0xX	
safety_inverted_speed_value	6125h					
NrOfObjects		0h	1	2	0x02	
safety_inverted_speed_value_byte1		1h	1	x	0xX	
safety_inverted_speed_value_byte2		2h	1	x	0xX	
safety_application_configuration_valid	61FEh		1	165	0xA5	
safety_application_configuration_signature	61FFh					
NrOfObjects		0h	1	2	0x02	
SRDO1_signature		1h	2	..... *	0x.... *	
SRDO2_signature		2h	2	..... *	0x.... *	
cyclic_timer	6200h		2	0	0x0	
operating_status	6500h		2			
singleturn_resolution	6501h		4	4096	0x1000	
number_of_distinguishable_revolutions	6502h		2	4096	0x1000	
alarms	6503h		2	0	0x0	
supported_alarms	6504h		2	63488	0xF800	
supported_warnings	6506h		2	0	0x0	
profile_and_software_version	6507h		4	xxxxxxx	0xXXXXXXX	
operating_time	6508h		4	-1	0xFFFFFFFF	
offset_value	6509h		4	0	0x0	
module_identification	650Ah					
largest_supported_sub-index		0h	1	1	0x01	
manufacturer_offset_value		1h	4	0	0x0	
serial_number	650Bh		4	x	0xX	
offset for multi sensor interface	650Ch					
largest_supported_sub-index		0h	1	2	0x02	
offset_channel_1		1h	4	x	0xX	
offset_channel_2		2h	4	x	0xX	
absolute_accuracy	650Dh		1	10	0xA	
Device_capability	650Eh		4	35	0x23	
NMT start up	1F80h		4	2	0x02	TBN-N152
node-ID	2000h		1	13	0x0D	
bit_rate	2001h		1	2	0x03	
safety_gear_configuration	3100h					
largest supported sub index		0h	1	3	0x03	
safety_slew_gear		1h	4	0 *	0x0 *	
safety_measure_gear		2h	4	0 *	0x0 *	
safety_measuring_range		3h	4	0 *	0x0 *	

* Depends on factory default settings.

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Name	Index	Sub	Len	Value decimal	Value hex	Remark
gear_configuration	3102h					
largest supported sub index		0h	1	3	0x03	
slew_gear		1h	4	0 *	0x0 *	
measure_gear		2h	4	0 *	0x0 *	
measuring_range		3h	4	0 *	0x0 *	
safety_gear_configuration_valid	31FEh		1	165	0xA5	
safety_gear_configuration_signature	31FFh					
largest supported sub index		0h	1	1	0x01	
safety_gear_configuration_checksum		1h	2	30441*	0x76E9*	
safety_encoder_parameter	3300h					
largest_supported_sub_index		0h	1	3	0x03	
safety_measuring_units_per_revolution		1h	2	16384*	0x00004000*	
safety_total_measuring_range_in_measuring_units		2h	2	67108864*	0x400 0000*	
safety_factory_offset		3h	2	..... *	0x..... *	

Definition of Data Length (Len): 1 byte = Byte, 2 bytes = Word, 4 bytes = Long
* Depends on factory default settings.

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9. EXAMPLE PARAMETERIZATION OF ENCODER TBN/TRN AND TBSN/TRSN WITH CANOPEN SAFETY

9.1 Parameter setting Object 2000h safety_node ID: 0x1 -> 0x11 (= 17decimal), SW Version "R" binary

Step	Description	ID	DLC	Byte								Comment
				1	2	3	4	5	6	7	8	
				cs	Index		Sub-Index	Value				
1	Set preoperational	0	2	80	01							
2	Deactivating 13FE/00h: configuration_valid	601	8	2f	fe	13	00	00	00	00	00	13FE/00h: 00
		581	8	60	fe	13	00	00	00	00	00	
3	Set 2000h/00h node ID: 0x11	601	8	2f	00	20	00	11	00	00	00	2000h/00h: 0x11
		581	8	60	00	20	00	00	00	00	00	
4	Save_LMT_parameters 1010h/04h	601	8	23	10	10	04	73	61	76	65	1010h/04h: 0x65766173 (save)
		581	8	60	10	10	04	00	00	00	00	
5	Set 1301h/05h: COB-ID1	601	8	23	01	13	05	21	01	00	00	1301h/05h: 121 COB_ID_1 = FF + 2 * Node ID
		581	8	60	01	13	05	00	00	00	00	
6	Set 1301h/06h: COB-ID2	601	8	23	01	13	06	22	01	00	00	1301h/06h: 122 COB_ID_2 = 100 + 2 * Node ID
		581	8	60	01	13	06	00	00	00	00	
7	Set 1302h/05h: COB-ID1	601	8	23	02	13	05	61	01	00	00	1302h/05h: 161 COB_ID_1 = 13F + 2 * Node ID
		581	8	60	02	13	05	00	00	00	00	
8	Set 1302h/06h: COB-ID2	601	8	23	02	13	06	62	01	00	00	1302h/06h: 162 COB_ID_2 = 140 + 2 * Node ID
		581	8	60	02	13	06	00	00	00	00	
9	Calculate CRC checksum (EPC program)											
10	Set 13FFh/01h: safety_ configuration_checksum SRDO1	601	8	2b	ff	13	01	40	DC	00	00	13FFh/01h: 0xDC40 COB-ID1: 0x121 COB-ID2: 0x122
		581	8	60	ff	13	01	00	00	00	00	
11	Set 13FF/02h: safety_ configuration_checksum SRDO2	601	8	2b	ff	13	02	CC	81	00	00	13FF/02h: 0x81CC COB-ID1: 0x161 COB-ID2: 0x162
		581	8	60	ff	13	02	00	00	00	00	
12	Activating 13FEh/00h: configuration_valid	601	8	2f	fe	13	00	a5	00	00	00	13FEh/00h: 0xa5
		581	8	60	fe	13	00	00	00	00	00	
13	Save _all_parameters 1010h/01h	601	8	23	10	10	01	73	61	76	65	1010h/01h: 0x65766173 (save) See object 1010 for detailed information concerning sub-indices!
		581	8	60	10	10	01	00	00	00	00	
14	Power off/Power on											
15	Set operational	0	2	11								
16	Position	121	4	12	23	01	00					
17	Position inverted	122	4	ED	DC	FE	FF					
18	Velocity	161	2	23	01							
19	Velocity inverted	162	2	DC	FE							

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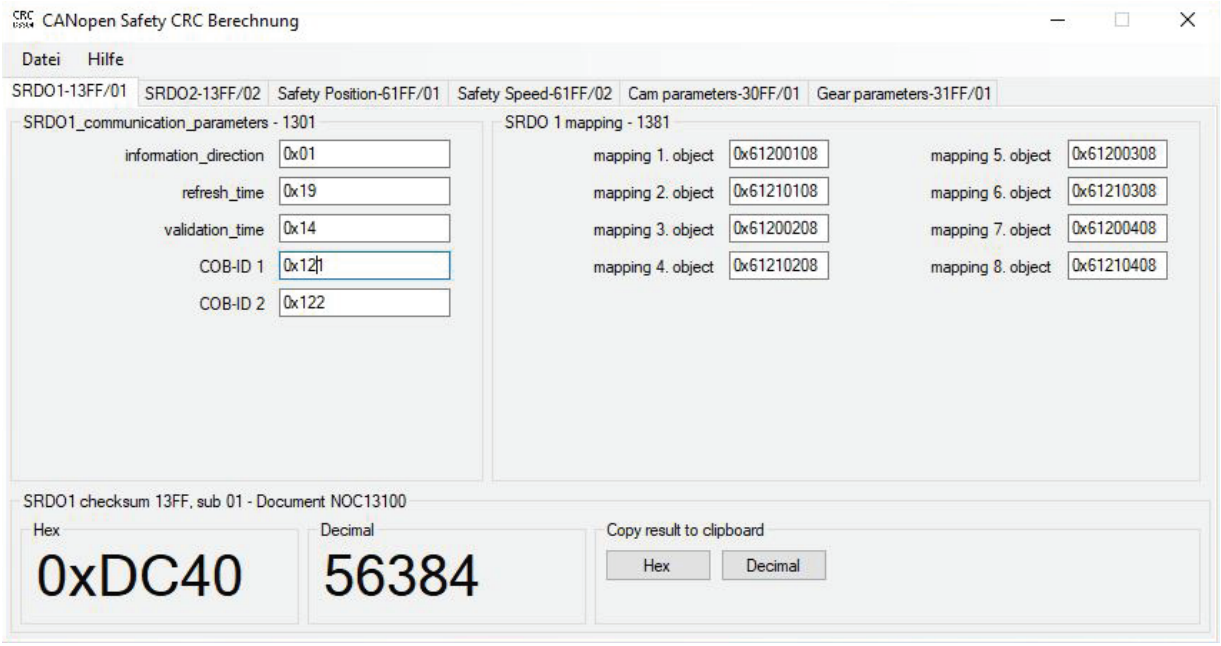
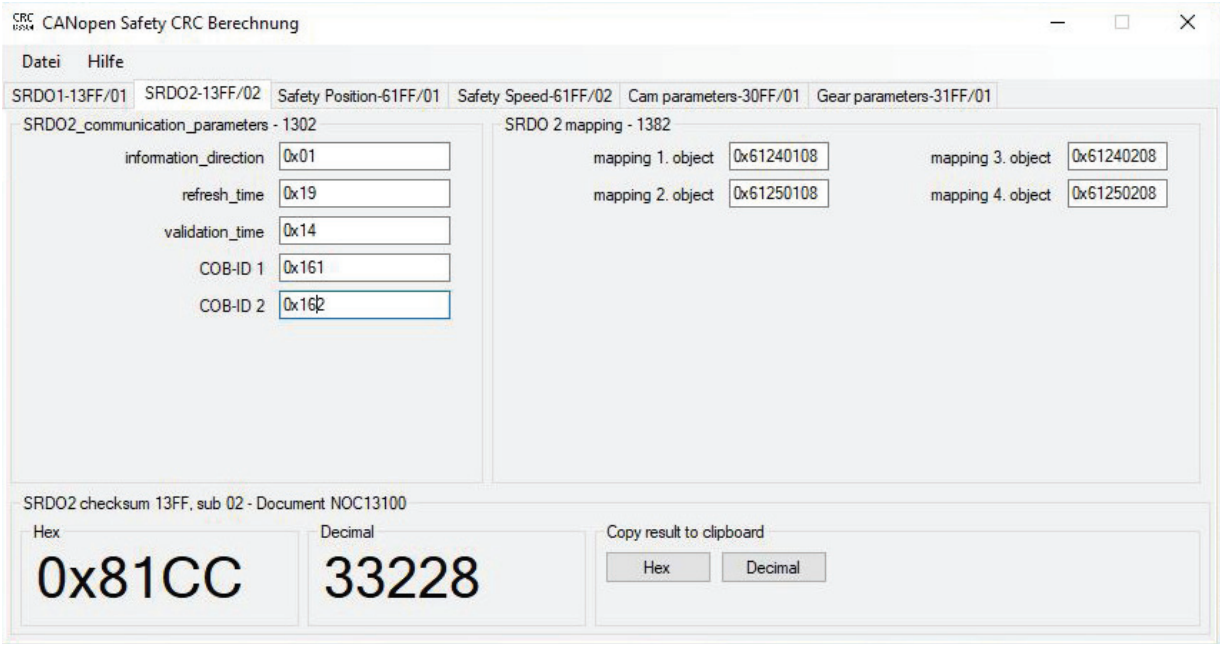
9.2 Screenshots: CRC checksum calculation program

Checksum for 13FFh, sub 01h and 02h for Node-ID:.0x11





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9.3 Node ID Parameterization via LSS Service

In the case of LSS, either all CANopen subscribers are addressed via a global command or an individual subscriber is addressed via its LSS address, which is comprised of the manufacturer name, the product name, the revision number and the serial number.

In the following example, the sensor is addressed via its LSS address (i.e. is switched from LSS-Operation-Mode to LSS-Configuration-Mode), node address 2 is programmed and saved. LSS-Operation-Mode is subsequently reset.

The sensor then reboots and logs on (without voltage off/on) with its boot-up protocol. It is now ready to operate with its new address.

In order ro do this, a switch first has to be made to stop status and the heartbeat timer has to be deactivated, i.e. heartbeat time= 0 (default status).

Attention: During LSS-programming the Heartbeat-Time (Index 1017h) has to be zero (default status).
After programming with LSS service, new checksums have to be calculated accordingly, as mentioned in 11.1 and 11.2 .

Action	ID	Rx/Tx	DLC	Databytes								Comment
				00	01	02	03	04	05	06	07	
Stop Node	0	Tx	2	02	00							Stop node for all nodes
LSS-Switch Mode Selective	7E5	Tx	8	40	0D	01	00	00	00	00	00	1. Transmission of the manufacturer name (010D; Object 1018h sub 01h)
LSS-Switch Mode Selective	7E5	Tx	8	41	02	63	00	00	00	00	00	2. Transmission of the product number (in this case: 6302; Object: 1018h sub 02h)
LSS-Switch Mode Selective	7E5	Tx	8	42	01	00	01	00	00	00	00	3. Transmission of the revision number (in this case: 10001; Object 1018h sub 03h)
LSS-Switch Mode Selective	7E5	Tx	8	43	66	BE	02	00	00	00	00	4. Transmission of the serial number (in this case: 179814 [decimal]; Object 1018h sub 04h)
	7E4	Rx	8	44	00	00	00	00	00	00	00	Success message from the sensor, which is now in LSS Configuration-Mode
LSS-Configure Modul ID	7E5	Tx	8	11	02	00	00	00	00	00	00	Node address 2 programming
	7E4	Rx	8	11	00	00	00	00	00	00	00	Success message from the sensor
LSS-Store Configuration	7E5	Tx	8	17	00	00	00	00	00	00	00	Zero-voltage-protected saving
	7E4	Rx	8	17	00	00	00	00	00	00	00	Success message from the sensor
LSS-Switch Mode Global: Operation Mode	7E5	Tx	8	04	00	00	00	00	00	00	00	Sensor is reset to LSS-Operation-Mode
	702	Rx	1	00								Boot-up node with new node address

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9.4 Example parameterization of safety slewing ring function

Step	Description	ID	DLC	Byte								Comment
				1	2	3	4	5	6	7	8	
				cs	Index		Sub-Index	Value				
1	Set preoperational	0	2	80	01							
2	Set 3100h/01h: safety_slew_gear	601	8	23	00	31	01	83	00	00	00	3100h/01h: 0x83 Note: valid flag 31FE is automatically deactivated (set 0) by writing to this object
		581	8	60	00	31	01	00	00	00	00	
3	Set 3100h/02h: safety_measure_gear	601	8	23	00	31	02	0b	00	00	00	3100h/02h: 0xb
		581	8	60	00	31	02	00	00	00	00	
4	Set 3100h/03h: safety_measuring_range	601	8	23	00	31	03	a0	8c	00	00	3100h/03h: 0x8ca0
		581	8	60	00	31	03	00	00	00	00	
5	Calculate CRC checksum (EPC program)											
6	Write checksum 31FFh: safety_gear_ configuration_checksum	601	8	2b	ff	31	01	c2	0c	00	00	31FFh: 0x0cc2
		581	8	60	ff	31	01	00	00	00	00	
7	Activating 31FEh/00h: safety_gear_data_valid	601	8	2f	fe	31	00	a5	00	00	00	31FEh/00h: 0xa5
		581	8	60	fe	31	00	00	00	00	00	
8	Activating 61FEh/00h: safety_application_ configuration_valid	601	8	2f	fe	61	00	a5	00	00	00	1302h/06h: 162 COB_ID_2 = 140 + 2 * Node ID
		581	8	60	fe	61	00	00	00	00	00	
9	Activating 13FEh/00h: configuration_valid	601	8	2f	fe	13	00	a5	00	00	00	
		581	8	60	fe	13	00	00	00	00	00	
10	Save _all_parameters 1010h/01h	601	8	23	10	10	01	73	61	76	65	1010h/01h: 0x65766173 (save) See object 1010 for detailed information concerning sub-indices!
		581	8	60	10	10	01	00	00	00	00	
11	Set operational	0	2	11								

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10. ERROR BEHAVIOR OF THE ENCODER

10.1 General hints to the error behavior

All errors that occur are displayed and stored in a hierarchical structure. In the error register (object 1001h and 1003h) the error type of the whole system is coded. In object 6503h the error type is coded. The error code gives a detailed error description depending on the error type. The data output of the CANopen Safety system is no longer able to work if a sensor error occurs.

Through the error_behavior object 1029h the CAN interface can be set up to be operated independently from the status of the sensor.

10.1.1 Fatal errors

Errors which place the functional capability of the controller in doubt, ROM or RAM CRC errors, oscillator drift and watchdog triggering - are not answered with a CAN message. Immediately after detecting the error the controller assumes a secure state (endless loop without actions). This error must be detected and processed by the control system (e.g. hardware device error).

10.1.2 CANopen emergency messages

If the encoder has discovered an error, an emergency message is transmitted unless the node is set to STOP state. The error code is additionally entered in the error register and in object 6503h. The behavior in the event of an error is defined in object 1029h error behavior. In the event of an error, the sensor switches to the NMT state PRE-OPERATIONAL. If an error disappears (CAN channel error), an EMC message is transmitted again with a deleted error bit. The time interval between emergency messages is determined by object 1015h Inhibit Time EMCY. The absolute encoder's error states remain set until reset or power on occurs.

The structure of the emergency messages can be seen at CANopen emergency messages structure.

11. CANOPEN EMERGENCY MESSAGES STRUCTURE

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
EMC (emergency) error code		Error register	Object 6503h (Alarms)		Specific error code		

EMC (emergency) error codes (Byte 0-1)	
0xFFFF	Customer-specific error; error in the sensor system
0x8120	Passive state error
0x8140	Return from bus off state
0x8110	Overrun error, not all messages can be transmitted by the sensor

Error register (Byte 2): Object 1001h		
Bit	M/O	Designation
0	M	generic error
1	O	current
2	O	voltage
3	O	temperature
4	O	communication error (overrun, error state)
5	O	device profile specific
6	O	Reserved (always 0)
7	O	manufacturer-specific error

Object 6503h (Alarms), (Byte 3-4):	
Bit	Error type
0 - 2	Not used
3	Device error
4	Not used
5	CRC parameter error
6	Supply out of range
7	Sensor error

Specific error code (Byte 5-7):
Error code may vary. Examples of typical error messages shown below.

11.1 CANopen emergency messages

Emergency messages (sent on ID 80 + node-ID)							
B0	B1	B2	B3	B4	B5	B6	B7
FF	FF	81	00	80	01	02	42
error in the sensor system		generic error, manufacturer-specific error		sensor error		sensor error	error parameter
FF	FF	81	00	20	00	00	00
				CRC parameter error			
FF	FF	81	00	40	00	00	01
				supply voltage out of range			supply voltage too high
FF	FF	81	00	40	00	00	02
				supply voltage out of range			supply voltage too low or short voltage dips
FF	FF	81	00	80	03	03	00
				sensor error	overall	speed overflow	
FF	FF	81	00	80	03	04	00
						synchronisation fault	
20	81	11	00	00	00	00	00
passive error state		generic error, communication error					
40	81	11	00	00	00	00	00
return from bus off state							
Expiry of the inhibit time is followed by the message “correct operation”							
00	00	00	00	00	00	00	00
Expiry of the inhibit time is followed by the message "correct operation"							

The data are output on the bus in Intel format (little endian).

A distinction is made between two types of error:

1. Errors in the sensor system (error code 0xFFFF)
   All errors which render proper sensor operation impossible.
2. Communication errors (error code 0x81xx)
   Errors due to the bus system; these are not usually caused by the sensor but indicate a malfunction in the bus system.

All sensor errors are critical errors.

The user of the overall system must assess the errors in the bus system and define the reaction to them.

12. APPENDIX

12.1 Appendix

12.2 Command specifier for SDO Messages

Command specifier describes the type of SDO Message (see examples for SDOs, CiA 301 Work Draft - CANopen application layer and communication profile)

Command specifier in hex	Type	Data length	Function
22	SDO (rx)	max. 4 bytes (Long)	Transmit parameter to encoder Initiate download request
23	SDO (rx)	4 bytes (Long)	Transmit parameter to encoder Initiate download request
27	SDO (rx)	3 bytes	Transmit parameter to encoder Initiate download request
2B	SDO (rx)	3 bytes	Transmit parameter to encoder Initiate download request
2F	SDO (rx)	2 bytes (Word)	Transmit parameter to encoder Initiate download request
60	SDO (rx)	1 byte (Byte)	Confirmation of take-over to master Initiate download response
40	SDO (rx)		Request parameter from encoder Initiate upload request
43	SDO (rx) Initiate upload response	4 bytes (Long)	Parameter to master Initiate upload response (Unsigned 32)
47	SDO (rx) Initiate upload response	3 bytes	Parameter to master Initiate upload response (Unsigned 24)
4B	SDO (rx) Initiate upload response	2 bytes (Word)	Parameter to master Initiate upload response (Unsigned 16)
4F	SDO (rx) Initiate upload response	1 byte (Byte)	Parameter to master Initiate upload response (Unsigned 8)
80	SDO (rx)		Encoder reports error code to master Abort domain transfer

12.3 Configuration valid of the safety node (SRDO Parameter set)

Switch the safety node 1 in the state configuration valid

ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Function
		cs	SDO		Sub-Index	Data				
701	1	7F								Node 1 in preoperational mode
601	8	2F	FE	13	00	A5	00	00	00	configuration valid
581	8	60	FE	13	00	00	00	00	00	answer sensor

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12.4 NMT State transitions

ID	DLC	Byte 0	Byte 1	Byte 2 - 7	Function
		Command Specifier	Node ID		
0	2	01	01	00	change to NMT state operational (node-Id = 1)
0	2	02	01	00	change to prepared (stop)
0	2	80	01	00	change to NMT state pre-operational
0	2	81	01	00	reset node
0	2	82	01	00	reset communication

12.5 NMT States

ID	DLC	Byte 0	Function
700 + Node-Id	1	0	Boot up
700 + Node-Id	1	04	Stop
700 + Node-Id	1	05	operational mode
700 + Node-Id	1	7F	pre-operational

12.6 CANopen features of the encoder

- NMT Master: no
- NMT-Slave: yes
- Maximum Boot up: no
- Minimum Boot up: yes
- COB ID Distribution: Default, SDO
- Node ID Distribution: via Index 2000 or LSS (CiA 305)
- No. of PDOs: 2 Tx/Rx
- PDO-Modes: sync, async, cyclic, acyclic, safety specific regarding standard
- Variable PDO-Mapping: yes
- Emergency Message: yes
- Heartbeat: yes
- No. of SRDOs: 2 (Position and Velocity - normal and inverted)
- Device Profile: CiA DS 406 Version 4.1.0 (CANopen and CANopen Safety - SIL2/SIL3)

12.7 Contact addresses

Do you have any questions about this product?
EPC Technical Support will be happy to help you.

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13. CHANGE LOG

Revision	Date	Reason for change
TXN/TXSN 15469 HE	02.12.2025	creation