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ABSOLUTE ROTARY ENCODER SIL CL 2

WITH CANOPEN INTERFACE

USER MANUAL

CANopen Safety

Main Features

- Compact and heavy-duty industrial design
- Interface: CANopen / CANopen safety
- Housing: 25 mm ∅, 58 mm ∅
- Solid shaft: 6 mm ∅,10 mm ∅, flattened 21 mm with two M5 thread
- Resolution max. 4096 steps per revolution (12 Bit)
- Single-Turn
- Redundant 2 axis Hall – IC for position measurement

Software Features Non Safety

- Emergency Messages
- Heartbeat
- LSS for baud rate and node setting
- SDO for baud rate and node setting

Software Features Safety

- Direction of rotation (complement)
- Resolution per Revolution
- Total Resolution
- Preset value
- Position via SRDO-CP according to EN 50325-5 with specific protocol modification

Mechanical Structure

- Aluminium flange
- Zinc-Nickel-plated steel housing
- Stainless steel shaft
- Optional: Stainless steel flange
- Precision ball bearings with sealing or cover rings

Electrical Features

- Polarity inversion protection
- Over-voltage-peak protection
- CANopen and CANopen Safety interface with specific protocol modification

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General Security Advise

Important Information

Read these instructions carefully, and look at the equipment to become familiar with the device before trying to install, operate, or maintain it. The following special messages may appear throughout this documentation or on the equipment to warn of potential hazards or to call attention to information that clarifies or simplifies a procedure.

The addition of this symbol to a Danger or Warning safety label indicates that an electrical hazard exists, which will result in personal injury if the instructions are not followed.

This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all

safety messages that follow this symbol to avoid possible injury or death.

Red marked areas or sentences indicate very important safety relevant requirements to be taken into account!

Please Note

Electrical equipment should be serviced only by qualified trained personnel. No responsibility is assumed by FRABA AG for any consequences arising out of the use of this material. This document is not intended as an instruction manual for untrained persons.

About this Manual

Background

This user manual describes how to install and configure a IXARC SIL CL 2 Absolute Rotary Encoder with CANopen interface. This English version of document is the original version and was part of a type approval performed by TÜV Rheinland.

The “Original Instructions” is a set of documents containing data sheet, user manual, leaflet and declaration of EC conformity delivered on a CD with the product. The information can be also downloaded from the website or get in contact with the manufacturer FRABA AG or authorized distributors.

Relate Note

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User Annotation

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1. Introduction

This manual explains how to install and configure the IXARC absolute rotary encoder SIL CL 2 with CANopen interface applicable for military and industrial applications with CANopen or CANopen Safety-CP protocol. The products are compliant with standard DS406 (encoder device profile), DS301 (CANopen communication profile) and according to EN50325-5 (CANopen Safety protocol) with some modifications. Safety and non safety CANopen communication can be used in the same time with this device.

1.1. Safety Definitions

In the following chapters Safety related definitions are described.

1.1.1. Intended Usage

The sensor shall be able to measure the physical angle of its shaft and converts this into a digital position value transmitted via the CAN bus to other field devices. This device function can be used for example in positioning tasks or length measurements. General applications could be: like cranes, construction machines, lifts, packing machines etc.

For safety-related applications this encoders shall be used in combination with a safety-related master (PLC). This PLC shall compare the position values of both channels to each other and on deviations greater than 1 % per 360° = 3.6° the PLC shall transit the machine into inherent safe state. A maximum system speed (shaft rotation) of 166 RPM (revolution per minute) shall not be exceeded to fulfill 3.6° deviation for safe position value between both channels.

1.1.2. Safety Level

Safety Integrity Level (SIL) Standard EN 62061	Safety Integrity Level (SIL) Claim Limit 2
Performance Level (PL) Standard EN ISO 13849-1	d
Safety Category (Cat.) Standard EN ISO 13849-1	3
Logical Architecture	Redundant design
Physical Architecture	Redundant design
Certified by	TÜV Rheinland

1.1.3. Safety Function

Measurement of the position angle with a resolution of 4096 steps per revolution (12 bits) for each channel with an overall measurement step deviation of ±1.8° per channel.
The deviation between both channels shall never exceed 1% per 360° = 3.6°.

1.1.4. Safety State

Within the safety state the encoder stopped the communication of SRDO-CP data.

1.1.5. Failure Reaction Function

The transmission of SRDO-CP shall be stopped and the encoder enters the inherently safe state.

1.1.6. Reaction Time

The failure reaction time is defined to mimimal 10 ms. It is possible to transmit the safety position value much faster, but it is not guaranteed that the

transmitted position value in between is proven. Furthermore a transmission time below 10 ms can lead to a high bus load for the encoder and messages could be lost in some cases.

The parameter Safety Cycle (refresh time / SCT) of the SRDO-CP communication channel has no influence on the communication behavior of the encoder, because of the protocol modification with regard to the SYNC transmission mode. But the setting is still relevant for the calculation of the SRDO-CP checksum. This time SCT can be defined in the set of communication parameter of the SRDO-CP object (1301 hex). Further details in this manual in chapter 5.5. Object Description with "Object 1301h: 1st Transmit SRDO-CP Communication Parameter".

1.1.7. Safety Cycle Time

The safety cycle time of the sensor is 10 ms. On the safety-related master (PLC) side this safety cycle time shall be considered.

1.1.8. Interfaces

The sensor has one CAN interface and supports the protocol CANopen (according to DS-301) and CANopen Safety (acc. To EN50325-5) with protocol modifications. Both protocols can be used at the same time in the device.

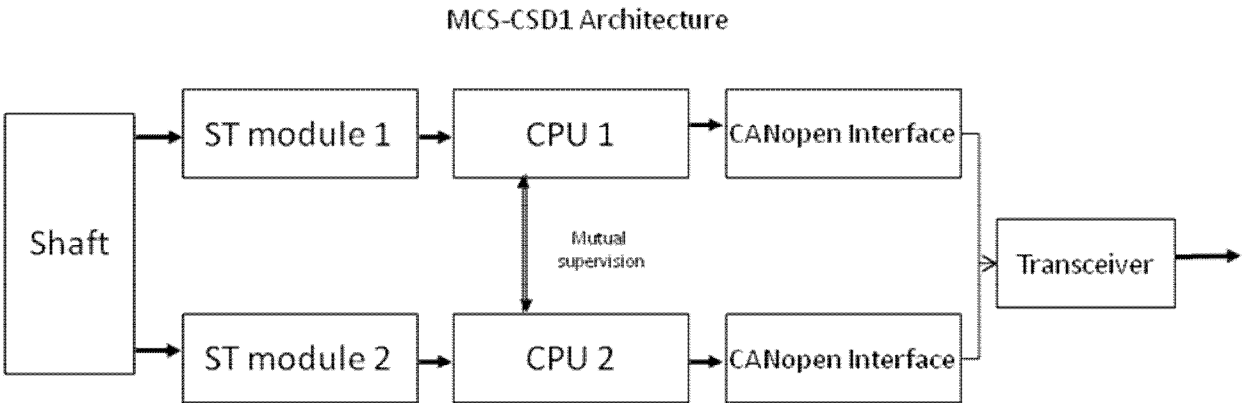
1.1.9. Maintenance

For the device is no maintenance necessary!

1.1.10. Intended Time of Usage

In general the maximum intended time of usage is 20 years and for the bearings the load is separately specified in a table mechanical lifetime with L10 (90% reliability) in the corresponding data sheet, which can be downloaded free of charge from the website or ask your local distributor.

1.2. Function Principle



For safety-related applications this encoders shall be used in combination with a safety-related master (PLC). This PLC shall compare the position values of both channels to each other and on deviations greater than 1 % of the measuring range the PLC shall transit the machine into inherent safe state.

The encoder is built up by the following parts:

- Shaft is containing a magnet for position measurement. High mechanical load is achieved with double ball bearings.
- ST (Single-Turn) module to measure the resolution per revolution by a redundant Hall sensor element.
- CPU module is needed for signal conditioning and CANopen, CANopen Safety stack handling.
- CANopen interface: Fieldbus controller for CAN network
- Transceiver is transmitting and receiving messages from CANopen Interface 1 and 2.

As shown in the block diagram above the encoder is built up redundant. A microcontroller (CPU) reads in the position value from a HALL sensor and transmits via a full CAN controller and one transceiver the information to the CANopen safety network. So only one CAN interface to the outer CAN network is needed. Regarding communication protocol standards CANopen and CANopen Safety with protocol modification is supported whereby both can be used at the same time. The two redundant path are called master and slave. Both CAN nodes have their own object dictionary for parametrization, parameter memory and node addresses.

1.3. Detailed Measurement Principle

The measuring system in the single-turn module consists of a magnet, a HALL sensor and precision ball bearings. Rotation of the magnet will be measured by the HALL sensor as variation of magnetic field strength. Signal condition by the microcontroller is conducted and an absolute

position value transmitted via the field bus interface to other devices on the network.

1.3.1. Single-Turn

Single turn encoders specify the absolute position for one turn of the shaft i.e. for 360°. After one turn the measuring range is completed and starts again from the beginning.

Typical Applications:
• Packing Machines
• Mobile Machines
• Wind Mills
• Medical Equipment

There are several types of encoder versions. Please refer to the datasheets to find out which is the best version for your application.

1.4. General CANopen Information

The CANopen system is used in industrial applications. It is a multiple access system, which means that all devices can access the bus. In simple terms, each user checks whether the bus is free, and if it is the user can send messages. If two users try to access the bus at the same time, the user with the higher priority level (lowest ID number) has permission to send its message.
Users with the lowest priority level must cancel their data transfer and wait before re-trying to send their message. Data communication is carried out via messages. These messages consist of 1 COB-ID followed by a maximum of 8 bytes of data. The COB-ID, which determines the priority of the message, consists of a function code and a node number. The node number corresponds to the network address of the device. It is unique on a bus. The function code varies according to the type of message being sent:

- Management messages (LMT, NMT)
- Messaging and service (SDOs)
- Data exchange (PDOs)
- Layer Setting Services (LSS)
- Predefined messages (synchronization, emergency messages)

The absolute rotary encoder supports the following operating modes:

- SYNC mode: The position value is sent as SRDO-CP message after a synchronization message (SYNC) is received. The position value is sent every n SYNCs (n ≥ 1).

Other functions (offset values, resolution, etc) can be configured. The absolute rotary encoder corresponds to the class 1 encoder profile (DS 406 in which the characteristics of encoder with CANopen interface are defined) with additional parameter for scaling and diagnostics.

1.5. General CANopen Safety Information

It is intended, that the additional safe CANopen communication is not affecting the normal operation and services on a CANopen network. Safe communication is not related to a special class of devices, so no special device profile is required. To ensure compatibility, the usage of identifiers and pre-defined objects shall be coordinated with the CANopen standard and existing device profiles.

The safety-relevant data transfer is performed by means of SRDO-CP. An SRDO-CP shall consist of two CAN data frames with identifiers, which shall be different in at least two bit positions. The process data in both transmissions is redundant, but the data on the 2nd transmission is inverted bitwise. SRDO-CPs shall be transmitted after a synchronization message (SYNC) is n-times received. RTR shall be not possible.

SRDO-CPs shall be only allowed in the NMT state operational. Furthermore an SRDO-CP shall be only valid on PLC / master side, if both CAN frames are received properly (without failure and in time). The redundant transmission is sent after the first transmission to the CAN controller with minimum delay. The order of both SRDO-CP messages (inverted and non-inverted data) is not defined and could vary. Be aware, that the data of both SRDO-CP telegrams can deviate less than 1 % of the measuring range in normal condition mode. If the deviation of both SRDO-CP data is bigger than 1%, then the PLC shall transit the machine into inherent safe state. For this encoder with a measuring range of 360° means 1 % per 360° = 3.6° is the maximum allowed tolerance between SRDO-CP data of COB-ID1 and COB-ID2.

1.6. General Configuration Information

The node number and speed in bauds are determined by software using CANopen objects or LSS for encoder with cable or plug interfaces.

The transmission speed can range from 60kBaud up to 1Mbaud (30m cable length for a maximum speed of 1Mbaud). More detailed information about the CANopen interface configuration can be found in chapter 2 “Installation”.

Various software tools for configuration and parameter-setting are available from different suppliers. It is easy to align and program the rotary encoders using the EDS (electronic data sheet) configuration file provided. For example a tool from company Vector Informatik CANsetter can be used for configuration.

In general the customer shall be responsible for verification and validation of the configuration. Procedure: From the tool written safety parameter shall be read out of the encoder again and compared to the written one to check the correct transmission: Furthermore the encoder checks internal the value range and for safety related parameters the checksum. In a case of failure an SDO abort message is sent.

A checksum shall be calculated for the safety relevant parameters to guarantee data consistency. For the checksum calculation a tool named “CRC-16 Calculator”, from FRABA, can be downloaded free of charge from our website www.posital.eu. The customer shall ensure the right checksum by own calculation!

Further information is available at:

CAN in Automation (CiA) International Users and Manufacturers Group e.V.
Kontumazgarten 3
DE-90429 Nuremberg

(*) Reference: CAN Application Layer for Industrial Applications
CiA Draft Standard 201 … 207, Version 1.1

CAL-based Communication Profile for Industrial Systems

CiA Draft Standard 301

CiA Draft Standard 303 LED-Behavior

CiA Draft Standard 305 Layer Setting Services

CiA Draft Standard 406 Device Profile for Encoders

Note: All datasheets and manuals can be downloaded for free from our website www.posital.eu

We do not assume responsibility for technical inaccuracies or omissions. Specifications are subject to change without notice.

2. Installation

General Instructions to mechanically install and electrically connect the absolute rotary encoder:

Only proper trained staffs aware of local safety regulations are allowed to commission, install and operate, or to work on this product after procedures contained in the documentation.

Do not remove or mount the connector while the encoder is under power!

The absolute rotary encoder must be connected to the main signal ground over the machine chassis or by means of a separate potential compensating line.

Do not stand on the encoder!

Do not adapt the driving shaft additionally!

Avoid mechanical load!

Do not adapt the housing additionally!

Prevent mechanical damage to the encoder by correct installation design measures and / or additional mechanical covering elements.

The absolute encoder is using a magnetic measurement principle. Therefore strong external magnetic fields shall be prevented. Refer to the data sheet in section environmental conditions regarding detailed information about the allowed external magnetic field.

Mounting Instructions Coupling

First the encoder shall be mounted mechanically. After that the coupling shall be fixed on encoder and drive side. By keeping these mounting order mechanical pretensioning and unallowed bearing loads will be prevented.

A screw coupling with 2 set screws has to be used. The shaft encoder has a slotted shaft side. On this slotted shaft side the coupling screw has to grab into the shaft surface. The second set screw shall be also mounted on the shaft and is used as redundant kind of mounting. Usage of thread locking compound is mandatory (recommended Loctite 243 or 2701) to prevent the loosening of the set screw during shock or vibration. Coupling and set screw shall be treated with a cleaner (recommended Loctite 7063) to eliminate oil or fat achieving higher adhesive strength. Detailed information regarding handling of cleaner and glue according to manufacturer definition can be found on the web site www.loctite.com. Especially detailed specification can be found in the product data sheet and safety data sheet.

Mounting Instruction Synchro Flange

For YF1 / PF6 (Synchro) flange the user has to mount the flange with 3 threads on the front side of the flange

For the PPK (Synchro) flange the user has to take care of a posive locking of the flange by using the slot in the flange towards the shaft side. The shaft is mounted by 2 screws with M5 thread.

Screws shall be mounted with a torque of 1 Nm.

2.1 Electrical Connection

Installation hints

Both the cable shielding and the metal housings of encoders and subsequent electronics have a shielding function. The housing must have the same potential and be connected to the main signal ground over the machine chassis or by means of a separate potential compensating line. Potential compensating lines should have a minimum cross section of 6 mm^2.

Do not lay signal cable in the direct vicinity of interference sources (air clearance > 100 mm (4 in.).

A minimum spacing of 200 mm (8 in.) to inductors is usually required, for example in switch-mode power supplies.

Configure the signal lines for minimum length and avoid the use of intermediate terminals. Shielded field bus cable shall be used with specification according to CANopen requirements (refer to DR-303-1)! The shield must be grounded according to EMC rules!

In metal cable ducts, sufficient decoupling of signal lines from interference signal transmitting cable can usually be achieved with a grounded partition

2.1.2 Electrical Connection

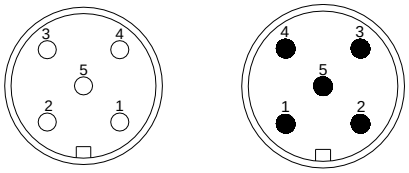
Signal Assignment Connector

Signal	5 pin round connector pin number (male / female)
CAN Ground	1
9-35 V DC supply voltage Battery powered or SELV/PELV supply.	2
0 V supply voltage	3
CAN High	4
CAN Low	5

Tab.1 Signal Assignment Connector

Absolute rotary encoders shall be connected only to subsequent electronics whose power supplies comply with EN 50178 (protective low voltage, PELV or SELV). The standard EN61326-3-2 (Industrial applications with specified electromagnetic environment) is valid!

5 pin M12 connector female/male

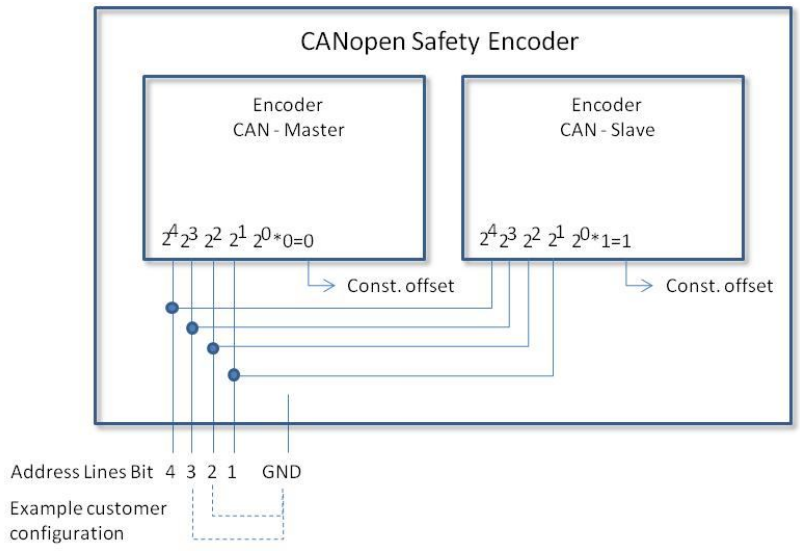


Signal Assignment Cable

Signal	open cable
CAN Ground	Black
9-35 V DC supply voltage Battery powered or SELV/PELV supply	Red
0 V supply voltage	Blue
CAN High	Green
CAN Low	Yellow
Address Line Bit 1	White
Address Line Bit 2	Brown
Address Line Bit 3	Gray
Address Line Bit 4	Violet
Address Line GND	Pink

Absolute rotary encoders shall be connected only to subsequent electronics whose power supplies comply with EN 50178 (protective low voltage, PELV or SELV) The standard EN61326-3-2 (Industrial applications with specified electromagnetic environment) is valid!The signal lines Address Line Bit 1 up to Address Line Bit 4 shall be only connected to Address Line GND and not direct to any other potential!

A diagnostic function is executed on the address lines and a faulty wiring will be detected.



An address line signal connected to ground lead to a logical 0, open address line to logical 1. In this example a resulting offset of $1*2^4+0*2^3+0*2^2+1*2^1$ = 16+2 = 18 decimal is configured.

The constant offset of 1 = 2^0 decimal in the device between master and slave node prevents an identical address for both nodes, because the address lines are used for both of them. In general it is recommended to use short cable length to prevent EMC influences.

After configuration of the address lines the store command with object 1010 hex shall be conducted. With the store command the configuration sequence on the node number is set valid.

If the store command is not conducted and the address line configuration is changed, a mismatch compared to the last stored configuration set is detected. An emergency message will be sent with warning level, if the attempt to change the operating state from pre-operational to operational is conducted. SRDO-CP data will be not sent, because the node number change will modify the COB-ID1 and COB-ID2 of the object 1301h SRDO-CP1 communication parameter. Furthermore the object 13Feh configuration vaild is set to 0 because of an unvalid safety configuration signature in object 13FFh.

The following table is describing the method of addressing in an easy way. The hidden calculated offset is calculated according to the following formula:

Hidden calculated offset = Node number 3000h – address line offset

Sequence Number	**Address lines offset (hardware setup)**	**Hidden calculated offset in encoder**	**Object 3000h node number**	**Resulting Node number**
1	8	10 (=18-8)	18 write access	18
	Store command executed, power off and power on cycle, normal operation			
2	This sequence describes the change of address line setup.			
	16 hardware changed	10	26 read access	26
	Emergency message is sent on state transition from pre-operational to operational state, because the change of the stored configured address lines between actual setup is observed. No SRDO-CP will be sent.			
3	This sequence describes the consequences when a write access to object 3000h is done.			
	16	-6 (=10-16)	10 write access	10
	Store command executed, power off and power on cycle, normal operation			
4	This sequence describes the consequences when address line is changed with store command as validation.			
	8 Hardware changed	-6	2 (=-6+8)	2
	Store command executed, power off and power on cycle, normal operation			

Grey marked parts in the table indicate changes.

2.1.3. Setting Node Number via SDO Objects

If the device has a connector or a cable exit, the node number has to be adjusted via SDO objects or using LSS.
The default node number is 47 decimal for the master node number and for slave node number 48 decimal. This is also valid for the encoder version with cable exit, if all address lines are open. To set node number object 3000h has to be written. For further information regard chapter 5.5 Object Dictionary.

ATTENTION: Take care of the procedures for node number checking in chapter: “Requirement for Validation of Setting”

2.1.4. Setting Baud Rate via SDO Objects

If the device has a connector or a cable exit, the baud rate has to be adjusted via SDO objects or using LSS. The default manufacturer baud rate is set to 250 kBaud. To set baud rate object 3001h has to be written. Allowed value range is 0-7 for the object data. For further information please regard chapter 5.5 Object Dictionary.

Wrong setting of the baud rate in a network will lead to a crash of the communication. Ensure a right configuration before adding the device in an existing network.

2.1.5. Setting Baud Rate; Node number via LSS

The baud rate and node number can be set via the service LSS similar to the specification DS-305 from the organization CiA. Be aware, that in the status stopped the LSS is active and LSS is also active if the node number is set to FFh.

3. Technical Data

For details regarding electrical, mechanical, sensor data, mechanical drawing, environmental condition, please refer to the corresponding datasheet of the used encoder.

These specifications shall be fulfilled in the application! The data sheet is also part of the Original Instructions and available on a CD delivered with the encoder or as file from the website.

The data sheet can be downloaded free of charge from the website http://www.posital.eu or get direct in contact with your local distributor or the manufacturer FRABA AG.

4. Configuration

The purpose of this chapter is to describe the configuration parameters of the Absolute Rotary Encoder with CANopen interface.

4.1 Operating Modes

4.1.1 General

The encoder accesses the CAN network after power up in pre-operational mode:
BootUp Message: 700 hex + Node Number

It is recommended that the parameters can be changed by the user when the encoder is in preoperational mode. Pre-operational mode entails reduced activity on the network, which simplifies the checking of the accuracy of the sent/received SDOs.

It is not possible to send or receive SRDO-CPs in pre-operational mode.

With the boot up message a check shall be done, if the corresponding identifier of the boot up message is based on the configured node number in the sensor. Additional by reading out the identity object a check shall be done, whether the right device belongs to the node number and respectively identifier for SDO communication. This check shall be done for each power up cycle or NMT command for reset node or reset communication by the master (safety control PLC). For detailed information see chapter: “Requirement for Validation of Setting”.

4.1.2 Mode: Preoperational

To set a node to pre-operational mode, the master must send the following message:

Identifier	Byte 0	Byte 1	Description
0 h	80 h	00	NMT-PreOp, all nodes
0 h	80 h	NN	NMT-PreOp, NN

NN: node number

It is possible to set all nodes (Index 0) or a single node (Index NN) to pre-operational mode.

4.1.3 Mode: Start- Operational

To put one or all nodes in the operational state, the master have to send the following message:

Safety related information: Only in the operational mode the safety function is active and SRDO-CPs can be transmitted. For an active SRDO-CP communication the SRDO-CP configuration shall be set valid, otherwise no transmit of SRDO-CP is possible.

Identifier	Byte 0	Byte 1	Description
0 h	01 h	00	NMT-Start, all nodes
0 h	01 h	NN	NMT-Start, NN

NN: node number

It is possible to set all nodes (Index 0) or a single node (Index NN) to operational mode.

4.1.4 Mode: Stopped

To put one or all nodes in the stopped state, the master have to send the following message:

Identifier	Byte 0	Byte 1	Description
0 h	02 h	00	NMT-Stop, all nodes
0 h	02 h	NN	NMT-Stop, NN

NN: node number

It is possible to set all nodes (Index 0) or a single node (Index NN) to stop mode.

4.1.5 Reinitialization of the Encoder

If a node is not operating correctly, it is advisable to carry out a reinitialization:

NN	Command	Index	Description
0 h	82 h	00	Reset Communication
0 h	81 h	NN	Reset Node

NN: node number

It is possible to set all nodes (Index 0) or a single node (Index NN) in reset mode.

After reinitialization, the encoder accesses the bus in pre-operational mode.

By execution of the NMT command Reset Node or Reset Communication the actions shall be done described in chapter 4.1.1. General. Boot-up message evaluation and check of identity object (1018h) via SDO communication. For detailed information see chapter: “Requirement for Validation of Setting”.

4.2 Normal Operating CANopen

Sync Mode	After receiving a sync telegram by the host, the encoder answers with the current process value. If more than one node number (encoder) shall answer after receiving a sync telegram, the answer telegrams of the nodes will be received by the host in order of their node numbers. The programming of an offset-time is not necessary. If a node should not answer after each sync telegram on the CAN network, the parameter sync counter can be programmed to skip a certain number of sync telegrams before answering again.

Tab. 2 CAN Transmission Mode Description

4.2.1 Operating CANopen Safety

In the table below the safety related properties are red colored marked.

SRDO-CPs communication is only allowed in the OPERATIONAL mode and SDO access to safety objects only as read and not as write access. In the state Pre-Operational any SDO access to safety objects is possible.

	INITIALISING	PRE-OPERATIONAL	OPERATIONAL	STOPPED
PDO			Allowed	
SDO		Allowed	Allowed[1]	
SRDO			Allowed	
Synchronization object		Allowed	Allowed	
Time stamp object		Allowed	Allowed	
Emergency object		Allowed	Allowed	
Boot-up object	Allowed			
NMT object		Allowed	Allowed	Allowed

[1] Writing to a safety object in the NMT state operational shall lead to an abort message (abort code: 0800 0022_h). Reading of a safety entry in the NMT state operational is allowed.

4.2.2 Initialization Procedure for CANopen Safety

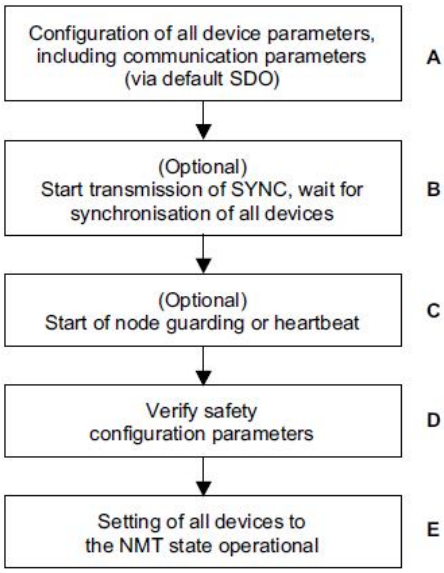


Figure 1: Initialization for safety devices (DS-304)

Step A:

The encoder shall be in the NMT state pre-operational, which is entered automatically after power-on. In this state, the encoder is accessible via default SDO using Can-IDs that are been assigned according to the pre-defined connection set. In this step, the configuration of encoder parameters take place, whereby some of these configuration data are safety-relevant. Additional measures shall be taken, to ensure the safety function in the network.

This is done from a configuration application or tool, e.g. CANsetter from the company Vector.

In the pre-operational state a configuration of SRDO-CPs, SRDO-CP mapping and optionally setting of Cob-IDs may be performed via the default SDO objects. In many cases, a configuration is not necessary as default values are defined for all application and communication parameters.

Step B:

It may be used to ensure that all devices are synchronised by the SYNC object before entering the NMT state operational.

Step C:

The node guarding or heartbeat functionality can be started. Details about functionality please refer to the standard DS-301 CANopen from the organisation CiA (CAN in Automation).

Step D:

The configuration of safety parameters is verified and configuration valid is set. If the configuration of SRDO-CP communication parameter is not set active, no SRDO-CP are transmitted! The customer shall be responsible for the verification and validation of the configuration. From the PLC to the encoder written parameter shall be read out afterwards for verification. Conducted configuration shall be logged for documentation purposes! The configuration valid can only be

set active, if the checksum is correct for the saftey related parameters. With the checksum data consistency is guaranteed.

Step E:

All or specific devices are set into the OPERATIONAL state. For safety devices the SRDO-CP communication starts.

4.3 Storing Parameter

4.3.1 List of Storeable Parameters

Object Index	Object Description
1005h	COB-ID Sync
1017h	Producer Heartbeat Time
1023h	OS command
1029h	Error Behavior
1301h	SRDO-CP1 communication parameter
1381h	SRDO-CP1 mapping parameter
13Feh	Configuration valid
13FFh	Safety configuration checksum
2003h	Hysteresis Control
3000h	Node Number
3001h	Baud Rate
6000h	Operating Parameter
6001h	Measuring Units per Revolution
6002h	Total Measuring Range in Measuring Units
6003h	Preset Value

Tab. 3 List of Storable Parameters

Red colored entries indicate safety related objects.

4.3.2 Storing Procedure

The parameter settings can be stored in a non-volatile E^2PROM. The parameter settings are stored in RAM when being programmed. When all the parameters are set and proved, they can be transferred in the E^2PROM. Only after SDO save parameter command (0x1010) these both sources (RAM, E^2PROM) are identical. If this command is send during NMT operational special verifications have to be done accordingly EN-ISO-13849-1 chapter 4.6.4.

The user has to take care, that the encoder needs internal a storing time of minimum 1000 ms. Before sending NMT commands or any other SDO write command to the device the SDO response of the Store command 1010h shall be received. Otherwise inconsistent data are set in the EEPROM and the encoder will use default settings. This setting to default data could lead to an expected behavior of the device.

Storing

By using the object 1010h from the communication profile related object dictionary you can store the parameters into the non-volatile memory. The encoder needs internally for writing of parameters minimum 1000 ms.

Within this storing time the NMT commands for Start, Reset Node respectively Reset Communication or power cycle and other SDO write commands are not allowed. If this is not considered, the encoder sets automatically default values to guarantee a defined consistent parameter setting. This leads to a customer unexpected behavior! It is recommended to validate the parameters after a storing cycle.

4.4 Restoring Parameters

The default parameters can be restored by using the object 1011h from communication profile related object dictionary. The already in the non-volatile memory programmed parameters are set active after NMT reset node command or power cycle. The restored parameters are equal for every type of CANopen encoder and might not fit with the status after delivery. Please check the restored parameters by reading out all safety related parameters before writing to the non-volatile memory or setting the node into state operational.

Be aware, that for encoder with cable or connector interface the baud rate and node number are restored with their default values. This shall be done by trained persons to prevent a wrong device configuration and unresolved bus conflicts!

If restoring is conducted for several devices of this encoder type at the same time, you have identical node number configuration which is not allowed and leads to bus conflicts, because of identical CAN-IDs! It is strongly recommended to restore parameters for each devices individual and setting the desired node number and baud rate before restoring the next device.

4.5 Udate firmware

After conducted firmware update by usage of the UDS protocol with the update tool, the customer shall verify the identity of the new flashed safety application by reading CAN open object 0x100A “Manufacturer Software Version”. For conducting the update the UDS bootloader tool needs a password which is needed to be requested from the encoder manufacturer separatly to prevent an unauthorized usage. The customer is responsible for the distribution of the password to qualified persons.

5. Programmable Parameters

Objects are based on the CiA 406 DS V3.2: CANopen profile for encoders (www.can-cia.org)

Command	Function	Telegram	Description
22h	Domain Download	Request	Parameter to Encoder
23h, 27h, 2Bh, 2Fh (*)	Domain Download	Request	Parameter to Encoder (Bytes indicated)
60h	Domain Download	Confirmation	Parameter received
40h	Domain Upload	Request	Parameter request
43h, 47h, 4Bh, 4Fh (*)	Domain Upload	Reply	Parameter to Master (Bytes indicated)
80 h	Warning	Reply	Transmission error

Tab. 4 General Command Byte Description

(*)The value of the command byte depends on the data length of the called parameter:

Command	Data length	Data type		Command	Data length	Data type
43h	4 Byte	Unsigned 32		23h	4 Byte	Unsigned 32
47h	3 Byte	Unsigned 24		27h	3 Byte	Unsigned 24
4Bh	2 Byte	Unsigned 16		2Bh	2 Byte	Unsigned 16
4Fh	1 Byte	Unsigned 8		2Fh	1 Byte	Unsigned 8

Tab. 5 Detailed Command Byte Description

Object Dictionary

The data transmission according to CAL is realized exclusively by object oriented data messages. The objects are classified in groups by an index record. Each index entry can be subdivided by sub-indices. The overall layout of the standard object dictionary is shown beside:

Both CAN nodes master and slave have their own object dictionary and memory for storing their parameters.

Index (hex)	Object
0000	not used
0001-001F	Static Data Types
0020-003F	Complex Data Types
0040-005F	Manufacturer Specific Data Types
0060-0FFF	Reserved for further use
1000-1FFF	Communication Profile Area
2000-5FFF	Manufacturer Specific Profile Area
6000-9FFF	Standardized Device Profile Area
A000-FFFF	Reserved for further use

Tab. 6 Overview Object Dictionary

5.1 Programming example: Preset Value

If a CANopen device is connected and configured with the right baudrate and also configured to an unused node number, it will start up into the pre-operational mode and sends a bootup massage to the master.

5.1.1 Set Encoder Preset Value

Master to Encoder with Node Number 1

All values in the following tables are given as hexadecimal values.

Setting Preset Value (Value 1000h)

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	6003h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	22	03	60	00	00	10	00	00

Answer of the Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	6003h			Byte 4	Byte 5	Byte 6	Byte 7
581	8	43	03	60	00	00	00	00	00

Read Preset Value from the Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	6003h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	40	03	60	00	00	00	00	00

Answer of the Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	6003h			Byte 4	Byte 5	Byte 6	Byte 7
581	8	43	03	60	00	00	10	00	00

Save Parameters to EEPROM

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN 1		Download	1010h			Byte 4	Byte 5	Byte 6	Byte 7
601	8	22	10	10	01	73	61	76	65

5.2 Communication Profile DS301 specific objects from 100–– - 1FFFh

In this manual we refer to the communication profile DS301 V4.02

Object	Description	Page EN50325-5	Page DS301 V4.02	Page DS406
1000h	Device type		86	8
1001h	Error register		87	8
1003h	Pre-defined error field		88	
1005h	COB-ID SYNC-message		89	
1008h	Device name		91	
1009h	Manufacturer Hardware version		91	
100Ah	Manufacturer Software version		91	
1010h	Store parameters		92	
1011h	Restore default parameters		94	
1014h	COB-ID Emergency		98	
1015h	Inhibit Time Emergency		99	
1017h	Producer Heartbeat Time		101	
1018h	Identity Object		101	
1023h	OS command		120	
1029h	Error Behavior		133	
1301h	SRDO-CP1 communication parameter	15		
1381h	SRDO-CP1 mapping parameter	19		
13Feh	Configuration valid	25		
13FFh	Safety configuration checksum	23		

Tab. 7 Object Dictionary 1000h-1FFFh

Red colored entries indicate safety related objects

5.3 Manufacturer specific objects 2000h – 5FFFh

Object	Description
2003h	Hysteresis Control
3000h	Node Number
3001h	Baudrate
3100h	Temperature Sensor A, only supported by master node
3110h	Temperature Sensor B, only supported by master node
3200h	Safe State Status

Tab. 8 Object Dictionary 2000-5FFF

Red colored entries indicate safety related objects.

5.4 Application specific objects 6000h – 9FFFh

In this manual we refer to the communication profile DS406 V3.2

Object	Description	Page DS406
6000h	Operating Parameters	17
6001h	Measuring Units per Revolution	18
6002h	Total Measuring Range in Measuring Units	19
6003h	Preset Value	19
6004h	Position Value	20
6500h	Operating Status	28
6501h	Single Turn Resolution	64
6502h	Number of Distinguishable Revolutions	65

Tab. 9 Object Dictionary 6000h-9FFFh

5.5 Object Descriptions

In the following chapter you will find detailed information of the object dictionary related to the encoderdevice. Both CAN nodes master and slave have their own object dictionary and memory for storing their parameter.

Object 1000h: Device Type

The object at index 1000h describes the type of device and its functionality. It is composed of a 16-bit field which describes the device profile that is used and a second 16-bit field which gives additional information about optional functionality of the device. The additional information parameter is device profile specific.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	Unsigned 32	N/A	ro	no

OCD absolute rotary encoder single turn: 10196h
OCD absolute rotary encoder multi turn: 20196h

Object 1001h: Error Register

This object is used by the device to display internal faults. When a fault is detected, the corresponding bit is therefore activated.

The following errors are supported:

Bit	Description	Comments
0	Generic Error	The generic error is signaled at any error situation.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	Unsigned 8	N/A	ro	no

Object 1003h: Pre-Defined Error Field

The object holds the errors that have occurred on the device and have been signaled via the Emergency Object.

- The error code is located in the least significant word
- Additional Information is located in the most significant word
- Subindex 0 contains the number of recorded errors

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of recorded errors	Unsigned 8	0	rw	no
1	Most recent errors	Unsigned 32	-	ro	no
2	Second to last error	Unsigned 32	-	ro	no
…					
10					

Clearing Error Log

The error log can be cleared by writing 0 to subindex 0 of object 1003.

Object 1005h: COB-ID Sync

This object contains the synchronization message identifier.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	Unsigned 32	80000080h	rw	no

Object 1008h: Manufacturer Device Name

This object contains the device name.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	String	-	ro	no

Object 1009h: Manufacturer Hardware Version

This object contains the article name of the circuit board.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	String	-	ro	no

Object 100Ah: Manufacturer Software Version

This object contains the manufacturer software version.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	String	-	ro	no

Object 1010h: Store Parameters

This object is used to store device and CANopen related parameters to non volatile memory.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of sub indices	Unsigned 8	1	ro	no
1	Store all parameters	Unsigned 32	“save”	rw	no

Storing procedure

To save the parameters to non volatile memory the access signature “save” has to be sent to the corresponding subindex of the device.

IMPORTANT: See notes in chapter 4.3.2 Storing Procedure to prevent unexpected device behavior!

	Most significant word		Least significant word	
ASCII	e	v	a	s
Hex value	65h	76h	61h	73h

Object 1011h: Restore Parameters

This object is used to restore device and CANopen related parameters to factory settings.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of sub indices	Unsigned 8	1	ro	no
1	Restore all parameters	Unsigned 32	“load”	rw	no

Storing procedure

To save the parameters to non volatile memory the access signature “load” has to be sent to the corresponding subindex of the device.

	Most significant word		Least significant word	
ASCII	d	a	o	l
Hex value	64h	61h	6Fh	6Ch

Note: The restoration of parameters will only be taken into account after a power up or reset command. Please check all parameters before you store them to the non volatile memory. **See also chapter 4.4. Restoring Parameters to prevent unexpected device behavior!**

Object 1014h: COB-ID Emergency Object

This object contains the EMCY emergency message identifier.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	Unsigned 32	80h + Node ID	rw	no

Object 1017h: Producer Heartbeat Time Object

The object contains the time intervall in milliseconds in which the device has to produce the a heartbeat message.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	-	Unsigned 16	0	rw	yes

Object 1018h: Identity Object

This object contains the device information.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of entries	Unsigned 8	4	ro	no
1	Vendor ID	Unsigned 32	42h	ro	no
2	Product Code	Unsigned 32	5053434Dh	ro	no
3	Revision Number	Unsigned 32	00010001h	ro	no
4	Serial Number	Unsigned 32	See type shield	ro	no

Object 1023h: OS Command Object

This object is used to control the UDS-bootloader for updating the firmware. It is strongly recommended to use the bootloader tool from FRABA AG to ensure the right handling of programming sequences. Get in contact with the company FRABA AG or distributors to get the tool free of charge.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of entries	Unsigned 8	3	ro	no
1	Command	Octet String		rw	no
2	Status	Unsigned 8		ro	no
3	Reply	Octet String		ro	no

Object 1029h: Error Behavior Object

This object defines the device behavior on communication errors.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of entries	Unsigned 8	1	ro	no
1	Communication Error	Unsigned 8	0h	ro	yes

Value	Status
0	pre-operational (only if current state is operational)
1	no state change
2	stopped
3…127	reserved

Object 1301h: 1st Transmit SRDO-CP Communication Parameter

This object contains the communication parameter of the 1st transmit SRDO-CP.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of sub indices	Unsigned 8	6	ro	no
1	Information Direction	Unsigned 8	1	rw (only in Pre-Operational)	yes
2	Refresh Time	Unsigned 16		rw (only in Pre-Operational)	yes

3	Not used				
4	Transmission Type	Unsigned 8	4	Rw (only in Pre-Operational)	yes
5	COB-ID1	Unsigned 32	**For Master Node** 0000 0100$_h$ + ($node-$ID) **For Slave Node** 8000 00FF$_h$ + ($node-$ID)	Rw (only in Pre-Operational)	yes
6	COB-ID2	Unsigned 32	**For Master Node** 8000 0101$_h$ + ($node-$ID) **For Slave Node** 0000 0100$_h$ + ($node-$ID)	Rw (only in Pre-Operational)	yes

Sub-Index 0 Number of sub indices:

This parameter contains the maximum number of entries within the object 1301 hex.

Sub-Index 1 Information Direction:

Value definition:

Value	Decription
0 h	Does not exist / is not valid
1 h	Exists / is valid for transmit (tx)
2h	Not used for this device
3h – ff h	Reserved

A COB-ID1 and / or COB-ID2 shall be only modified, when the information direction is set to value 0h, that means SRDO-CP is not vaild.

For the encoder the information direction tx is only supported with value 1h and not rx for receive. So the value range 2h up tp ff h is not allowed.

Sub-Index 2 Refresh Time:

The reaction time is defined to mimimal 10 ms and cannot be modified.

ATTENTION: This parameter “Refresh Time” is not supported, because the SRDO-CP telegram is not cyclically event-driven transmitted, but SYNC driven. This is a customer protocol modification against the standard EN50325-5. However this parameter has to be taken into account for the CRC calculation!

Sub-Index 4 Transmission Type:

See PDO communication parameters (transmission type) in standard DS-301 (CANopen communication profile).

For SRDO-CP telegramm transmission here the number of needed SYNC telegrams has to be set after that a SRDO-CP data shall be sent by the encoder.

For example if this parameter is set to number 4, the master has to send 4 SYNC telegramms to get SRDO-CP data from the sensor.

Sub-Index 5 COB-ID1:

Specifies the COB-ID for the position value not inverted**. The default value is different to the pre-defined connection set specified in the standard EN50325-5.** Here the COB-ID default value is different for the master node and slave node.

Sub-Index 6 COB-ID2:

Specifies the COB-ID for the position value inverted. **The default value is different to the pre-defined connection set specified in the standard EN50325-5.** Here the COB-ID default value is different for the master node and slave node.

It is not allowed to use the same identifier for COB-ID1 and COB-ID2.

ATTENTION: The data content in the SRDO-CP data with COB-ID1 and COB-ID2 could be not identical and a deviation up to 1% of the measuring range in normal condition mode is allowed. This is a difference compared to the standard EN50325-5. Furthermore the sequence of SRDO-CP data with COB-ID1 and COB-ID2 is not guaranteed.

Example for the COB-ID1 and COB-ID2 for the node number of master 11h and slave 12h:

Object 1301h	**Master Node Number = 11h**	**Slave Node Number = 12h**
COB-ID1, Sub-Index 5h	0000 0100h + ($node-$ID) = 0000 0111h	8000 00FFh + ($node-$ID) = 8000 0111h
COB-ID2, Sub-Index 6h	8000 0101h + ($node-$ID) = 8000 0112h	0000 0100h + ($node-$ID) = 0000 0112

As a consequence of above configuration the COB-ID1 is sent by the master node number 11h and the COB-ID2 by the slave node number 12h. The position data is transmitted non-inverted with COB-ID1 and inverted with COB-ID2. With this configuration the position data is sent from redundant physical nodes as one SRDO-CP data package.

Object 1381h: 1st Transmit SRDO-CP Mapping Parameter

This object contains the mapping parameter of the 1st transmit SRDO-CP.

The default value for sub-index 1 and 2 are identical, because of specific SRDO-CP definition!

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of sub indices	Unsigned 8	2	ro	no
01h	SRDO-CP application data object 1 (plain data)	Unsigned 32	60040010 h	ro	no
02h	SRDO-CP application data object 1 (bitwise inverted data)	Unsigned 32	60040010 h	ro	no

The mapping is fixed and cannot be modified!

Object 13Feh: Configuration Valid

This object shall contain an acknowledgement flag for a valid configuration. After write access to any of the safety-relevant parameter, this object is automatically set to invalid configuration (00h). If the configuration is finished, the user has to write the “valid” value “A5h” to this object. By setting the configuration valid the verification of configuration is documented.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Configuration Valid	Unsigned 8	0h	rw (only in Pre-Operational)	yes

Object 13FFh: Safety configuration Checksum

This object contains the configuration checksum of the 1st transmit SRDO-CP.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Number of sub indices	Unsigned 8	1	ro	no
1	SRDO1 signature Checksum-1	Unsigned 16	0	rw (only in Pre-Operational)	yes

Coding rules see EN50325-5. For easier calculation of the checksum a tool can be downloaded free of charge from the website www.posital.eu. The program, named “CRC-16 Calculator”, calculates the checksum of the safety related communication objects and encoder function safety related objects.

Object 2003h: Hysteresis Control

This control will prevent noise on the signal output, that means variations on the position value during standstill and a monotonous code sequence.

Value	Function
0	Hysteresis not enabled
1	Hysteresis enabled

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Hysteresis Control	Unsigned 8	1h	rw	Yes

Object 3000h: Node Number

This object contains the node number of the device. The POSITAL standard node number for the master is 47 decimal and for slave node number 48 decimal.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Node Number	Unsigned 8	2Fh (master) 30h (slave)	rw	Yes

NOTE: Only the node number range 1-64 decimal is allowed. In the case node number is in range of 65 – 127 decimal the SRDO-CP is disabled by setting the MSB in the COB-ID of object 1301h when the operating mode is changed from pre-operational into operational. As a consequence no SRDO-CP data is transmitted.

If the node number is higher than 127 decimal, the encoder automatically sets the address to 255 decimal which leads to LSS mode after conducting a power cycle or NMT-Reset.

If the node address is modified the right configuration of the node number shall be verified. For detailed information see chapter: "**Requirement for Validation of Setting".**

Prevent double node number setting in a CAN network, because this cannot be resolved and lead to unexpected network behavior. A restore with object 1011h will lead to a setting of default values for the node number and this has to be taken into account in the case more than one devices are restored, because of resulting in double node numbers. Because of that it is strongly recommended to restore and configure afterwards the devices individual in a sequence and not at the same time.

Setting the node number to FFh the LSS mode is activated.

Object 3001h: Baudrate

This object contains the baudrate of the device.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0	Baudrate	Unsigned 8	4h	rw	yes

Six different baud rates are provided. To adjust the baud rate only one byte is used.

Baud rate in kBit/s	Byte
100	02h
125	03h
250	04h
500	05h
800	06h
1000	07h

Object 3100h: Temperature Sensor A

With this object the temperature inside the sensor can be read out. The temperature value is given in degree Celcius. Be aware, that only the master node supports that object.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Temperature Sensor A	Integer 16	-	ro	no

Object 3110h: Temperature Sensor B

With this object the temperature inside the sensor can be read out. The temperature value is given in degree Celcius. Be aware, that only the master node supports that object.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Temperature Sensor B	Integer 16	-	ro	no

Object 3200h: Safe State Status

With this object the safe state status of the device can be read out. It could be used as diagnostic object to determine the internal status of the device.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Safe State Status	Unsigned 8	-	ro	no

Value	Status
Chapter 9.	No safe state
Eh	safe state
Other values are reserved.	

Object 6000h: Operating parameters

This object shall indicate the functions for code sequence, commissioning diagnostic control and scaling function control.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Operating Parameter	Unsigned 16	0h	rw	yes

Code sequence: The code sequence defines, whether increasing or decreasing position values are output, in case the encoder shaft rotates clockwise or counter clockwise as seen from the point of view of the shaft.

Scaling function control: With the scaling function the encoder numerical value is converted in software to change the physical resolution of the encoder. The measuring units per revolution (object 6001h) and total measuring range in measuring units (object 6002h) are the scaling parameters. The scaling function bit is set in the operating parameters. If the scaling function bit is set to zero, the scaling function is disabled.

Bit structure for the operating parameters

Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Use	MS	MS	MS	MS	R	R	R	R	R	R	R	R	MD	SFC	CD	CS

Table Descript i on :

MS: Manufacturer Specific Function (not available)

R: Reserved for future use

MD: Measuring direction (not available)

SFC: Scaling function (0 = disable, 1 = enable)

CD: Commissioning diagnostic control (not availabe)

CS : Code sequence (0 = CW, 1 = CCW)

Object 6001h: Measuring units per revolution

This object shall indicate the number of distinguishable steps per revolution.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Measuring units per revolution	Unsigned 32	see type sign	rw	yes

Object 6002h: Total measuring range in measuring units

This object shall indicate the number of distinguishable steps over the total measuring range. For a single-turn encoder version the object 6001h and 6002h should be set to the same value.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Total measuring steps	Unsigned 32	see type sign	rw	yes

Object 6003h: Preset value

This object indicates the preset value for the output position value

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Preset Value	Unsigned 32	0h	rw	yes

The preset value is set as position value when a value is written in object 6003h.

Object 6004h: Position value

This object contains the process value of the encoder.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Process Value	Unsigned 32	-	romap	no

Object 6500h: Operating status

This object shall provide the operating status of the encoder. It gives information on encoder internal programmed parameters.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter

0h	Operating status	Unsigned 16	-	ro	no

The operating status object corresponds to the value of the object 6000h.

Object 6501h: Single-turn resolution

The object contains the physical measuring steps per revolution of the absolute rotary encoder.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Single Turn Resolution	Unsigned 32	see type sign	ro	no

Object 6502h: Number of distinguishable revolutions

This object contains number of revolutions of the absolute rotary encoder.

Subindex	Description	Data Type	Default Value	Access	Storeable Parameter
0h	Number of Revolutions	Unsigned 16	see type sign	ro	no

6. Diagnosis

6.1.1 Emergency Messages

If the network load and safety state of the sensor allows, an emergency message is sent in the case of an error detection.

Following list gives an overview about available error messages. The error code is byte 7 in the manufacturer specific error field of the emergency object data, see page 61 in specification DS301-V4.02.

Byte	0	1	2	3	4	5	6	7
Content	Emergency Error Code (see Table 21)		Error register (Object 1001H)	Manufacturer specific Error Field				

Emergency Error Code: Is defined as hexadecimal value in below table.
Manufacturer specific Error Field: Byte 3 – 6 id fix predefined with 0x00000000.
Manufacturer specific Error Field: Byte 7 is used as classification.

Overview of classification:

Classification name	**no Error**	**INFO**	**WARNING**	**CRITICAL**	**SEVERE**
Classification No.	0x00	0x05	0x10	0x20	0x30
Device Reaction	No reaction	No reaction	No reaction	No SRDO-CP transmission if already in operational state	No SRDO-CP transmission if already in operational state
Device State	No state change	No state change	No state change	Pre-Operational, Safe state	Pre-Operational, Safe state

Emergency Error code, Byte 0 – 1 (hexadecimal)	**Classification No. (hexadecimal)**	**Meaning**
00xxh	00h	Error Reset or No error
3001h	20h	Input voltage out of range, too low
3002h	05h	Input voltage out of range, too high (> appr. 38V)
3003h	20h	Input voltage out of range, too high (> appr. 42V)

4201h	20h	Hardware error temperature sensor
4202h	20h	Encoder Temperature too low (< -45°C)
4203h	05h	Encoder temperature too high (> appr. 75°C)
4204h	20h	Encoder temperature too high (> appr. 83°C)
5001h	10h	CAN address line signal different value after start up
5002h	20h	Hardware runtime failure
5003h	20h	Hardware startup failure
5004h	20h	Sensor error: too low magnetic field strength
5005h	20h	Sensor error: too high magnetic field strength
5006h	20h	Sensor error: communication or data
5007h	20h	Sensor error: ADC saturation, magnet field or electrical error
5008h	20h	Sensor error: General error
5009h	20h	Master / Slave sensor synchronization exceeded
5011h	20h	CAN address line offset value out of range
5012h	20h	Non-Volatile Data consistency error
6100h	20h	Internal software: generic error
6101h	20h	Internal software: program flow error
6102h	20h	Internal software
6103h	20h	Internal software
6104h	20h	Contact manufacturer, do not use sensor
6105h	20h	Contact manufacturer, do not use sensor
6106h	05h	CANopen SYNC Rx overrun Next sync messages received before SRDO-CP was sent.
6300h	20h	Runtime Data inconsistency
8101h	20h	Error ADC
8102h	20h	Error supply voltage monitoring
8103h	20h	Other node in safe state
8110h	10h	CAN overrun (objects lost)
8120h	10h	CAN in error passive mode
8140h	10h	Recovered from bus off

Be aware, that in error cases several emergency messages could be sent. **The first sent emergency message has the highest relevance** and the further following messages are consecutive fault. For further details or here not listed error codes please contact FRABA AG.

6.2 Troubleshooting

6.2.1 Power on – Encoder doesn't respond

Problem:
The bus is active but the installed encoder transmitted no boot up message.

Possible solution:

- switch of the PLC
- check the wiring regarding loose connection and correct wiring
- power on

6.2.2 Malfunction of the position value during transmission

Problem:
During the transmission of the position value occasional malfunction occurs. The CAN bus can be temporary in the bus off state also.

Possible solution:
Check, if the last bus nodes have switched on the terminal resistor.

6.2.3 Too much ERROR-Frames

Problem:
The bus load is too high in case of too much error frames.

Possible solution:

Check if all bus nodes have the same baud rate. If one node has another baud rate error frames are produced automatically.

7. Configuration Example

Configuration Messages

The following configuration messages give only an example how the encoder could be configured.

In general the user is responsible to take care of a right configuration sequence and needed configuration setup.

All values in the table below are given as hexadecimal value indicated by “h” behind the number.

Setup:

Actual master node number 9h

Actual slave node number 10h

New master node node number 11h

New slave node number 12h

Every 4th SYNC message a SRDO-CP data shall be sent

Remark	**CAN-ID**	**Data byte 0**	**Data byte 1**	**Data byte 2**	**Data byte 3**	**Data byte 4**	**Data byte 5**	**Data byte 6**	**Data byte 7**
Power On									
Boot-Up message of encoder (master and slave node), 700h + node ID	709h 710h	0 0							
Configuration sequence for node number 9h	Start of sequence								
Set new node number for node number 9h: 11h	600h+ 09h	22	00	30	00	11	00	00	00
Response from encoder	580h+ 09h	60	00	30	00	00	00	00	00
Set information direction of object 1301h, sub-index 1h to 0h. For change of COB-ID the SRDO is deactivated.	600h+ 09h	22	01	13	01	00	00	00	00

Remark	CAN-ID	Data byte 0	Data byte 1	Data byte 2	Data byte 3	Data byte 4	Data byte 5	Data byte 6	Data byte 7
Response from encoder	580h+ 09h	60	01	13	01	00	00	00	00
Set refresh time 19 hex of object 1301h, sub-index 2h.	600h+ 09h	22	01	13	02	19	00	00	00
Response from encoder	580h+ 09h	60	01	13	02	00	00	00	00
Set validation time 14 hex of object 1301h, sub-index 3h.	600h+ 09h	22	01	13	03	14	00	00	00
Response from encoder	580h+ 09h	60	01	13	03	00	00	00	00
Set transmission type 4 hex of object 1301h, sub-index 4h.	600h+ 09h	22	01	13	04	04	00	00	00
Response from encoder	580h+ 09h	60	01	13	04	00	00	00	00
Set COB-ID1 with 0000 0111h of object 1301h, sub-index 5h. 0000 0100h + ($node-$ID) = 0000 0111h	600h+ 09h	22	01	13	05	11	01	00	00
Response from encoder	580h+ 09h	60	01	13	05	00	00	00	00
Set COB-ID2 with 8000 0112h of object 1301h, sub-index 6h. 8000 0101h + ($node-$ID) = 8000 0112h	600h+ 09h	22	01	13	06	12	01	00	80
Response from encoder	580h+ 09h	60	01	13	06	00	00	00	00
Set information direction of object 1301h, sub-index 1h	600h+ 10h	22	01	13	01	01	00	00	00

Remark	CAN-ID	Data byte 0	Data byte 1	Data byte 2	Data byte 3	Data byte 4	Data byte 5	Data byte 6	Data byte 7
to 1h. The COB-ID of SRDO is activated.									
Response from encoder	580h+ 09h	60	01	13	01	00	00	00	00
Set configuration valid with A5h in object 13Feh, sub-index 0h	600h+ 09h	22	FE	13	00	A5	00	00	00
Response from encoder	580h+ 09h	60	FE	13	00	00	00	00	00
Store configuration in the node	600h+ 09h	22	10	10	01	73	61	76	65
Response from encoder	580h+ 09h	60	10	10	01	00	00	00	00
Configuration sequence for node number 9h	End of sequence								
Configuration sequence for node number 10h	Start of sequence								
Set new node number for node number 10h: 12h	600h+ 10h	22	00	30	00	12	00	00	00
Response from encoder	580h+ 10h	60	00	30	00	00	00	00	00
Set information direction of object 1301h, sub-index 1h to 0h. For change of COB-ID the SRDO is deactivated.	600h+ 10h	22	01	13	01	00	00	00	00
Response from encoder	580h+ 10h	60	01	13	01	00	00	00	00
Set refresh time 19 hex of object 1301h, sub-index 2h.	600h+ 10h	22	01	13	02	19	00	00	00
Response from encoder	580h+	60	01	13	02	00	00	00	00

Remark	CAN-ID	Data byte 0	Data byte 1	Data byte 2	Data byte 3	Data byte 4	Data byte 5	Data byte 6	Data byte 7
	10h								
Set validation time 14 hex of object 1301h, sub-index 3h.	600h+ 10h	22	01	13	03	14	00	00	00
Response from encoder	580h+ 10h	60	01	13	03	00	00	00	00
Set transmission type 4 hex of object 1301h, sub-index 4h.	600h+ 10h	22	01	13	04	04	00	00	00
Response from encoder	580h+ 10h	60	01	13	04	00	00	00	00
Set COB-ID1 with 8000 0111h of object 1301h, sub-index 5h. 8000 00FFh + ($node-$ID) = 8000 0111h	600h+ 10h	22	01	13	05	11	01	00	80
Response from encoder	580h+ 10h	60	01	13	05	00	00	00	00
Set COB-ID2 with 0000 0112h of object 1301h, sub-index 6h. 0000 0100h + ($node-$ID) = 0000 0112	600h+ 10h	22	01	13	06	12	01	00	00
Response from encoder	580h+ 10h	60	01	13	06	00	00	00	00
Set safety configuration checksum D65Fh in object 13FFh, sub-index 1h	600h+ 10h	22	FF	13	01	5F	D6	00	00
Response from encoder	580h+ 10h	60	FF	13	01	00	00	00	00
Set configuration valid with A5h in object 13Feh, sub-index 0h	600h+ 10h	22	FE	13	00	A5	00	00	00

Remark	**CAN-ID**	**Data byte 0**	**Data byte 1**	**Data byte 2**	**Data byte 3**	**Data byte 4**	**Data byte 5**	**Data byte 6**	**Data byte 7**
Response from encoder	580h+ 10h	60	FE	13	00	00	00	00	00
Store configuration in the node	600h+ 10h	22	10	10	01	73	61	76	65
Response from encoder	580h+ 10h	60	10	10	01	00	00	00	00
Before this command is sent, the last response of the encoder shall be receipt! Reset all Nodes	000h	81	00						
Boot-Up message of encoder (master and slave node), 700h + node ID	711h 712h	0 0							
Set Operational	000h	01	00						
Send cyclic SYNC	80								
Send cyclic SYNC	80								
Send cyclic SYNC	80								
Send cyclic SYNC	80								
SRDO-CP Data Position value Master Node	111	XX Low byte	XX	XX	XX High byte				
SRDO-CP Data Position value Slave Node	112	YY Low byte	YY	YY	YY High byte				
Send cyclic SYNC	80								
Send cyclic SYNC	80								
Send cyclic SYNC	80								
Send cyclic SYNC	80								
SRDO-CP Data Position value Slave Node	112	YY Low byte	YY	YY	YY High byte				

Remark	CAN-ID	Data byte 0	Data byte 1	Data byte 2	Data byte 3	Data byte 4	Data byte 5	Data byte 6	Data byte 7
SRDO-CP Data Position value Master Node	111	XX Low byte	XX	XX	XX High byte				

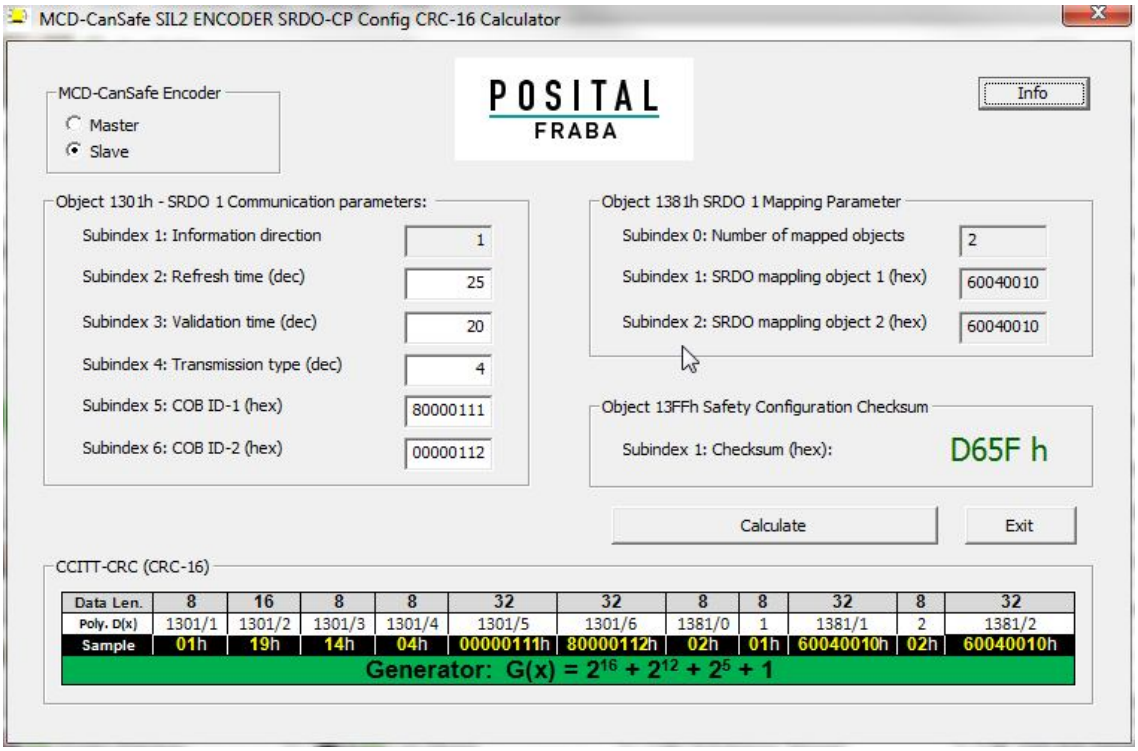
Tab. 10 Example Configuration

And so on the SRDO-CP data will be sent, if the CAN PLC Master will further on sent SYNC messages. Be aware, that the sequence of the responses of the encoder master and slave node SRDO-CP telegrams are not defined. This is shown in above telegram table.

The described sequence above does not contain several other requirements like verification of parameter setting and check of identity entries and so on. With the table is just shown a rough principle of configuration.

8. CRC Tool

With the usage of the CRC tool the user has the possibility to check his calculation of CRC for the SRDO configuration.



First the user has to select the configuration for the master or slave node. Then the parameter fields from object 1301h sub index 2 up to sub index 6 have to be filled out. Within the right part of the window the fixed and calculated checksum are displayed. When pressing the button “calculate” the software will calculate the checksum in a different way than the firmware in the encoder.

At the bottom the content for the polynomial calculation of the checksum is shown as an example.

Be aware, that the identifier for sub-index 5 and 6 has to be entered complete and take care, that one of both COB-ID has to be deactivated for each of the master / slave node.

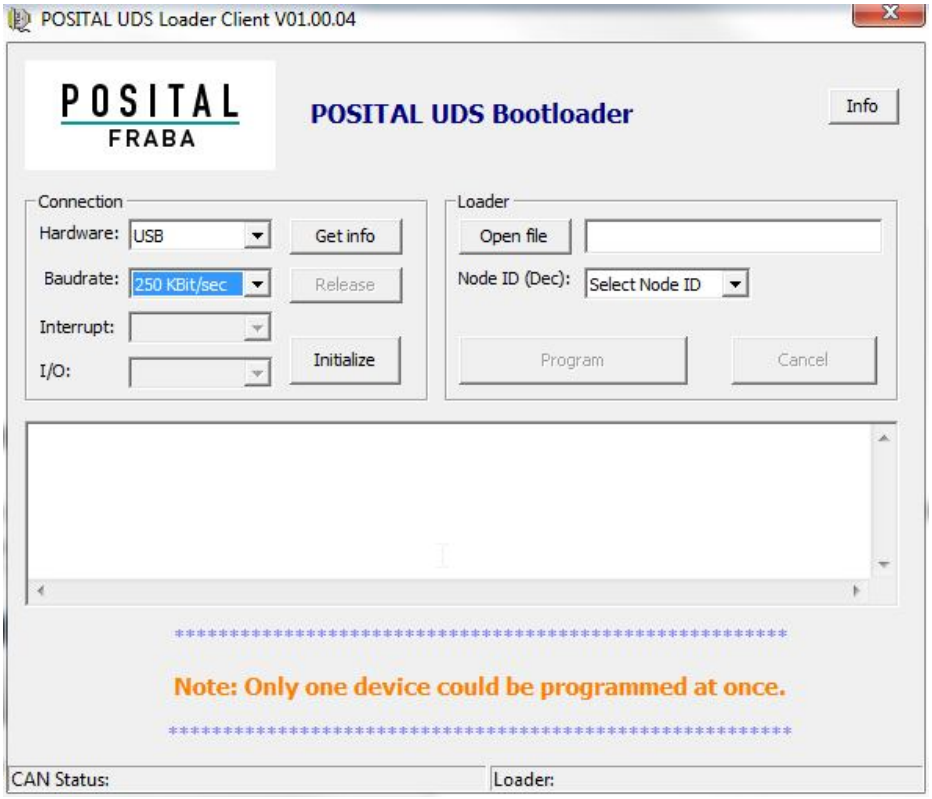
9. UDS update tool

The update of the firmware shall be only conducted, if it is recommended by the manufacturer FRABA AG. Only authorized persons shall conduct the update process and they are responsible for the correct handling.

Before the tool can be started a password is needed which has to be requested from the manufacturer FRABA AG. The user has to take care, that the password is only available for authorized persons.

For conducting the update process a CAN hardware dongle from the company PEAK is needed.

After entering the correct password a new window will open.



The correct type of hardware dongle has to be selected. We recommend the USB type, because this version was tested during the development of this software. Then configure the current valid baudrate and press the initialize button. After that press the open file button to select the right update file. Then the node number for the slave node could be selected for updating and afterwards the master. It is also possible to conduct the update process in another order for master and slave. With the program button the update process is started. If the power supply is interrupted or the CAN transmission, then the update process can be restarted, because the firmware is checking the consistency of the firmware data.

The user has to take care, that the update of the encoder is logged. Data transmission is checked by using a CRC in the UDS data protocol. In the Update tool an additional CRC is generated about the firmware file which is also checked by the firmware in the encoder. With this method data integrity is assured. The user has to validate, if the update has been done with the desired new firmware version. This is realized by reading out the CAN object 100A hex “Manufacturer Software Version”. Check this information with the firmware version specified from the manufacturer regarding identical value and log this process. If an update was not successful in case of for example a power loss in between, the encoder will not boot-up and is only available with UDS protocol. A standard CANopen communication would be in this case not possible. If a update shall be conducted this shall be requested at the manufacturer FRABA AG.

Appendix A: Glossary

A

Address	Number, assigned to each node, irrespective of whether it is a master or slave. The encoder address (non-volatile) is configured in the base with rotary switches or SDO objects.
APV	Absolute Position Value.

B

Baud rate	Transmission speed formulated in number of bits per second. Bus node Device that can send and/or receive or amplify data by means of the bus.
Byte	8-bit unit of data = 1 byte.

C

CAL	CAN application layer.
CAN	Controller Area Network or CAN multiplexing network.
CANopen	Application layer of an industrial network based on the CAN bus.
CANopen Safety-CP protocol	CANopen Safety customized protocol that means standard CANopen Safety protocol with some modifications.
CCW	Counter-clockwise
CiA	CAN In Automation, organization of manufacturers and users of devices that operate on the CAN bus.
COB	Elementary communication object on the CAN network. All data is transferred using a COB.
COB-ID	COB-Identifier. Identifies an object in a network. The ID determines the transmission priority of this object. The COB-ID consists of a function code and a node number.
CW	Clockwise

E

EDS file	Standardized file containing the description of the parameters and the communication methods of the associated device.

F

FAQ	Frequently Asked Questions
FC Function code.	Determines the type of message sent via the CAN network.

L

Line terminator	Resistor terminating the main segments of the bus.
LMT	Network management object. This is used to configure the parameters of each layer in the CAN. M“ste““ “”cti””e” device within the network, that can send data without having received a request. It controls data exchange and communication management.

N

NMT	Network management object. This is responsible for managing the execution, configuration and errors in a CAN network.
NN	Node number

P

PCV	Process Value
PDO	Communication object, with a high priority for sending process data.
PV	Preset Value: Configuration value

R

RO	Read Only: Parameter that is only accessible in read mode.
ROMAP	Read Only MAPable: Parameter that can be polled by the PDO.

RW Read/Write: Parameter that can be accessed in read or write mode.

S

SDO Communication object, with a low priority for messaging (configuration, error handling, diagnostics). Slave Bus node that sends data at the request of the master. The encoders are always slaves.

SRDO-CP Safety-Related Data Object – Customer Protocol, data protocol according to EN50325-5, but with customer protocol modification.

W

WO Write Only: Parameter that is only accessible in write mode.

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Appendix C: List of figures

No table of figures entries found.

Appendix D : Document history

Number of modification	Version of Document	Information of modification or new entry
0	00	Initial official release of document
1	01	Chapter 1.1.2. renaming claim level 2 into claim limit
2	01	Chapter 2.1.2. added information: “The directive EN61326-3-2 (Industrial applications with specified electromagnetic environment) is valid!”
3	01	Chapter 9. UDS Update tool: Added information about verification and validation of update process.
4	01	Chapter About this Manual: Added the remark about certified original version in English.
5	01	In footer added information about Original Version and updated date of release and version
6	02	Chapter 2.1.2. changed naming directive to standard for EN61326-3-2.
7	02	Chapter 9. UDS Update Tool: Reference to machine directive was deleted.
8	02	Chapter 3. Technical Data: Added the information that the data sheet is part of the Original Instructions.
9	02	Chapter General Security Advise: Phrasing corrected, that this document is part of a type approval
10	02	In footer changed “Original Version” to “Original Instructions”.

Number of modification	Version of Document	Information of modification or new entry
11	02	Chapter General Security Advise: Added information, that the Original Instructions is a set of documents delivered on a CD.
12	03	Chapter 2 Installation: Added warning hint about misuse with strong external magnetic fields.

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0	06.11.2013
1	20.12.2013
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