ABSOLUTE ROTARY ENCODER WITH CANOPEN INTERFACE
DIVERSE REDUNDANT ENCODER - TCR
USER MANUAL

Main Features

- Compact and heavy-duty industrial design
- Interface: CANopen (DS406)
- Housing: 58 mm ∅
- Solid shaft: 6 or 10mm∅
- Blind hollow shaft: 12, 15mm∅
- Max. 65536 steps per revolution (16 Bit)
- Max. 16384 revolutions (14 Bit)
- Code: Binary
- Velocity Output

Programmable Parameters

- Direction of rotation (complement)
- Resolution per revolution
- Total resolution
- Preset value
- Two limit switches and eight cams
- Baud rate and CAN-identifier
- Transmission mode: Polled mode, cyclic mode, sync mode

Mechanical Structure

- Aluminium flange and housing
- Nickel-plated steel or aluminium housing

Stainless steel shaft

Precision ball bearings

Electrical Features

- Polarity inversion protection
- Over-voltage-peak protection
- Galvanic Isolation

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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.

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

About this Manual

Background

This user manual describes how to install and configure an IXARC absolute rotary encoder with CANopen interface.

The product documentation consists of this user manual, datasheet and instruction leaflet and shall be considered all together!

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 with CANopen interface applicable for both military and industrial applications with CANopen interface. The products are compliant with standard DS406.

Be aware, that this product is not safety certified and the user is responsible for integration in safety applications.

1.1 Measuring System

The TCR encoder exists of complete independent optical and magnetic encoder built up in one housing and flange with shaft. With this design a redundant and diverse design is realized, which makes the product suitable for safety applications.

1.1.1 Measurement principle of the magnetic encoder:

Magnetic rotary encoder determines positions using the Hall effect sensor technology developed for the automotive mass market. A permanent magnet fixed to the shaft generates a magnetic field that is sampled by the Hall sensor, which translates the measured value into a unique absolute position value.

To register revolutions even when no voltage is applied, energy from the turning of the shaft must suffice for proper operation. An innovative, patented technology makes this feasible even at low rotational speeds and through long standstill periods – a Wiegand wire ensures that the magnetic field can only follow the turning of the shaft in discrete steps. A coil wound on the Wiegand wire receives only brief, strong voltage spikes, which prompt the reliable recognition of each revolution.

1.1.2 Measurement principle of the optical encoder:

The position within one revolution is measured by an ASIC with optical sensing elements. For the optical measurement of the number of revolutions a mechanical gearing with code wheels is used. There is no mechanical limitation in the gearing, if the shaft of the encoder is operated endless only in one direction.

Both encoders, optical and magnetic encoder, measure the position value absolute also in non-powered mode. No battery is used.

This makes the sensor suited also for harsh environmental conditions like broad temperature ranges.

1.1.3 Naming of Encoder

The redundant diverse encoder has the short type key TCR and contains the optical encoder part from the OCD series and the magnetic encoder part from the UCD series. In the following chapters of the user manual you will find several times the short form description TCR, OCD and UCD to allow a fast reading.

1.1.4 Redundant diverse design

The block diagram in figure 1 shows the structure of the redundant diverse design of the TCR encoder. The flange with ball bearings and shaft is built up by a 1 channel principle. It is important to keep the specified forces in the data sheet as organisational measure.Then in the upper part you can see several green colored blocks indicating the OCD (optical sensor) related parts. The lower blue block part is showing the magnetic encoder UCD.

Diverse principle:

- Both encoders are working with different measurement principles
- Different microcontrollers and CAN controllers are used
- Different compilers
- Different SW modules, same CAN stack
- Each channel has its own power supply
- No connection between both encoders beside the CAN interface

If a housing with 2 connetors is used, then inside the housing a daisy chane wiring structure is realized. In principle it is also possible to feed the CAN and power signals from each encoder to a separate external connector to realize complete physical independent bus lines for increased availability.

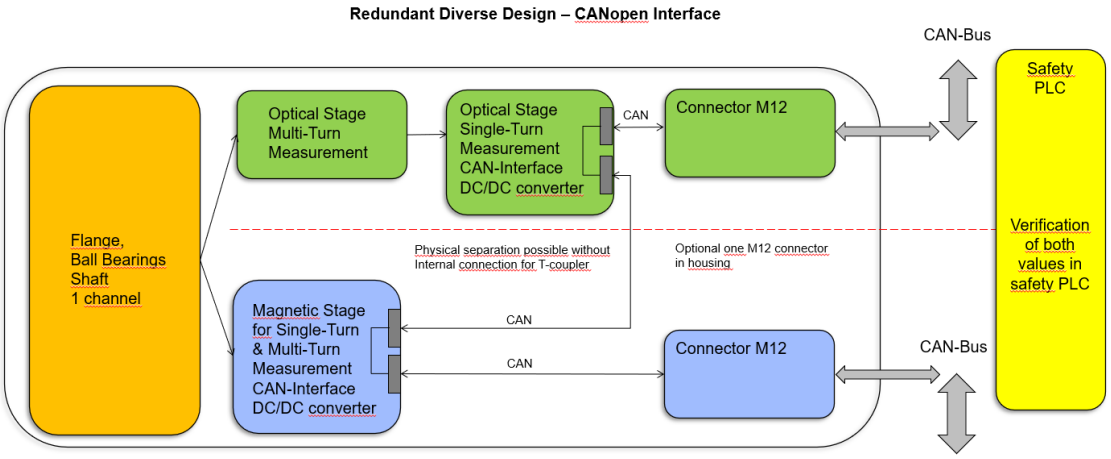


Figure 1

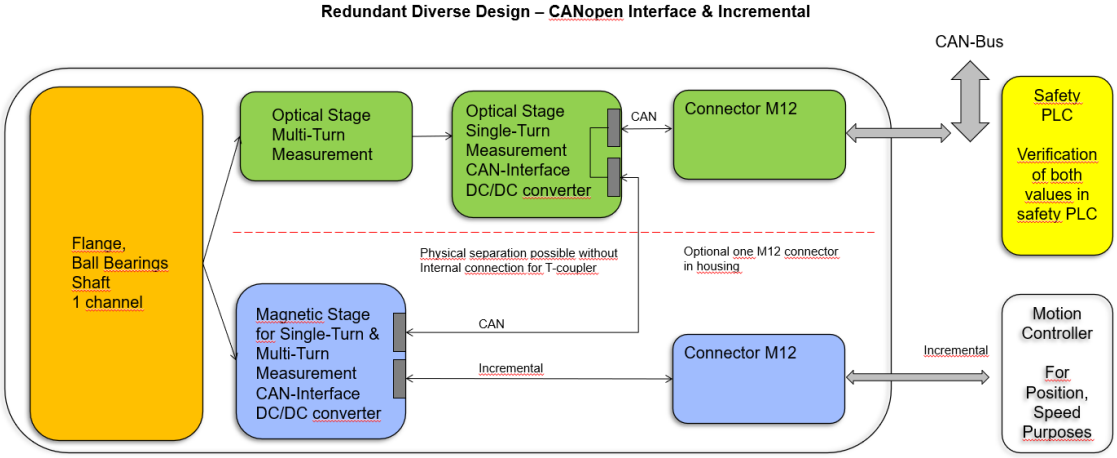


Figure 2

In figure 2 the block diagram shows an encoder with CAN and incremental interface. The CAN bus is available via one 5 pin connector on the housing and both independent encoder cores (magnetic and optical) are internally connected after the CAN transceiver. From the magnetic encoder the generated incremental signals are provided via a 8 pin connector on the housing. The power supply feeding is realized from the 5 pin M12 connector via the CAN bus to both encoder modules.

1.1.5 MTTF Values for encoder parts

In the following figure you can see the denotation of MTTFd for each channel related to the MTTFd of each channel. By limitation of MTTFd to maximum of 100 years in the standard ISO 13849-1 it shall be prevented, that with one very high MTTF value another other bad channel is compensated.

Denotation of MTTFd of each channel	Range of MTTFd of each channel
Low	3 years <= $MTTF_d$ < 10 years
Medium	10 years <= $MTTF_d$ < 30 years
High	30 years <= $MTTF_d$ < 100 years

- Related to MTTFd a maximum value of 100 years can be used, even the calculated value is higher.

- MTTF for Optical Multi-Turn Encoder with Connector Version: 250 years @ 40°C ambient temperature
- MTTF for Magnetic Multi-Turn Encoder with Connector Version: 380 years @ 40°C ambient temperature

Figure 3

In the following figure 4 you can see the calculation of a parallel hardware structure. The TCR encoder achieves a MTTFd value of 100 years at 40°C ambient temperature.

$$MTTF_D = \frac{2}{3}\left(MTTF_{DC1} + MTTF_{DC2} - \frac{1}{\frac{1}{MTTF_{DC1}} + \frac{1}{MTTF_{DC2}}}\right)$$

- Calculation Formula for 2 redundant channels above is used to calculate MTTFd for redundant diverse encoder
- Optical Multi-Turn Encoder with Connector Version: MTTFDC1 = 100 years @40°C ambient temperature
- Magnetic Multi-Turn Encoder with Connector Version: MTTFDC2 = 100 years @40°C ambient temperature
- MTTFd for redundant encoder

  MTTFd = 2/3 * [100 years + 100 years – (1 / (1/100years + 1/100 years))]

  MTTFd = 100 years @40°C ambient temperature

Figure 4

1.1.6 Diagnostic coverage

As you can see in the figure 5 a DCavg of low is sufficient, if a redundant channel is used and MTTFd of each channel denotiated as high to achieve a PL d. In practise the DCavg value of low is reachable in the PLC with arguable effort. Some of these measures could be:

- cross check of both position value
- plausibility check of the expectation, e.g. drive is turning right, then the encoder shall turn left (mirrored) and check of the travel.
- Usage of diverse data allows a deep check of the processing path. It is recommended to use for the TCR encoder different position values in each channel. For example by usage of a preset value in channel 1 and channel 2 a defined offset of 150° allows an easy realization of diverse data transmission and processing. Here 180° as offset is not used to prevent a undetected high failure by bit flipping.

Category	**B**	**1**	**2**	**2**	**3**	**3**	**4**
DC_{avg}	**none**	**none**	**low**	**medium**	**low**	**medium**	**high**
$MTTF_D$ of each channel							
Low	a	Not cov-ered	a	b	b	c	Not cov-ered
Medium	b	Not cov-ered	b	c	c	d	Not cov-ered
High	Not cov-ered	c	c	d	d	d	e

Figure 5

With a hardware design built up as 2 channel and MTTFd high for each channel, the DCavg can be low / medium as indicated with the green circles in figure 5 to achieve performance level PL d.

1.1.7 Common Cause Failue (CCF)

According to safety standard ISO 13849 the common cause failure shall be considered. ´This was done on manufacturer side for the specification in the datasheet of the TCR encoder like environmental conditions and shock, vibration, temperature and humidity as also magnetic field. It is important that the datasheet of the encoder is verified with the application requirements.

Measure Against CCF
Table F.1 in EN ISO 13849-1

Measure	Points	Points
1. Deviation complete redundant encoder	15	15
2. Diversity Magnetic/Optical Sensors and different HW like MPU	20	20
3. Design/Application/Experience		
3.1 Protection against overvoltage 0-60V permanent voltage ramp, 120V few ms, no fire during/after overload	15	0
6. Environment		
6.1. EMC, higher requirements for SIL	25	25
6.2 Temperature, shock, humidity	10	10
Sum	**85**	**70**

Probably this is not required to be fulfilled because of battery powered system. Then 15 points can be assumed.

CCF shall be higher than 65 points.

1.1.8 Intended Usage

Typical Industrial Applications for the TCR encoder:

- Packing Machines
  Aerial platforms
- Mobile Machines
- Wind Mills
- Medical Equipment

The requirements of each application shall be verified, if these are fulfilled by this sensor product according to the datasheet for example like EMC, shock and vibration or temperature. The standards applied for the encoder product design are mentioned in the datasheet and considered industrial standard. It is the customer's responsibility to verify if the product is suited for the environment and applied product or safety standard in the application.

This product is not safety certified and the customer is responsible to ensure the correct use of this product in a safety application.
Related to safety standard ISO 13849 the MTTF value of the sensor and necessary diagnostic measures on safety PLC side shall be considered. Maximum achievable performance level: PL d. The CCF (common cause failure) is fulfilled by the product, if the mentioned standards in the datasheet fulfill the application requirements.
It is recommended to involve a notified body to get an approval for the system out of safety PLC, TCR encoder and further elements in the safety chain.

1.2 General CANopen Information

The CANopen system is used in industrial applications. It is a multiple access system (maximum: 127 participants), which means that all devices can access the bus. In simple terms, each device checks whether the bus is free, and if it is the device is able to send messages. If two devices try to access the bus at the same time, the device with the higher priority level (lowest ID number) has permission to send its message. Devices with the lowest priority level must delay their data transfer and wait before retrying 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:

- Polled mode: The position value is only sent on request.
- Cyclic mode: The position value is sent cyclically (regular, adjustable interval) on the bus.
- SYNC mode: The position value is sent 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 2 encoder profile (DS 406 in which the characteristics of encoder with CANopen interface are defined). The node number and speed in bauds are determined by their corresponding object dictionary entries.

The transmission speed can range from 20kBaud up to 1Mbaud (30m cable for a maximum speed of 1Mbaud, 1000m cable for a maximum speed of 20 kbaud). 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.

Further information is available at:

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

(*) 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 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.com

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

2. Installation

2.1 Electrical Connection

Please refer for details to the data sheet, which can be downloaded from the website www.posital.com.

Configuration setting shall be done only by trained staff!

Running CAN network can be disturbed by wrong configuration or encoder can be configured to a locked state like different baud rate used for optical and magnetic encoder part at the same time! Be careful e.g. when changing baudrate or node number setting.

Setting Node Number via SDO Objects

The node number has to be adjusted via SDO objects. The manufacturer default node number setting is:

- Optical encoder (OCD) 32 decimal.
- Magnetic encoder (UCD) 31 decimal

To set the node number, object 3000h has to be written. For further information regards chapter 5.5 Object Dictionary.

It is useful to set the node number for OCD and UCD close to each other like 32 & 31 or 10 & 9 to reduce effects during transmission by message priority.

Setting Baud Rate via SDO Objects

Optical and magnetic encoder can be configured in a different way!

For the magnetic encoder part UCD:

The baud rate has to be adjusted via SDO object 3001h, if auto baud feature is not activated or is not possible to use because of network start up behavior. The manufacturer default setting for baud rate is 125 kBd in case of auto baud detection is deactivated or not successful conducted within the time out period or if the device was started in the past successful, then the last stored configuration setting is used. For manual configuration baud rate object 3001h has to be written. For further information please regard chapter 5.5 Object Dictionary object 3001h baud rate and 3003h auto baud detection. Manufacturer default setting is active auto baud detection which means the user has not to configure this setting.

For the optical encoder part OCD:

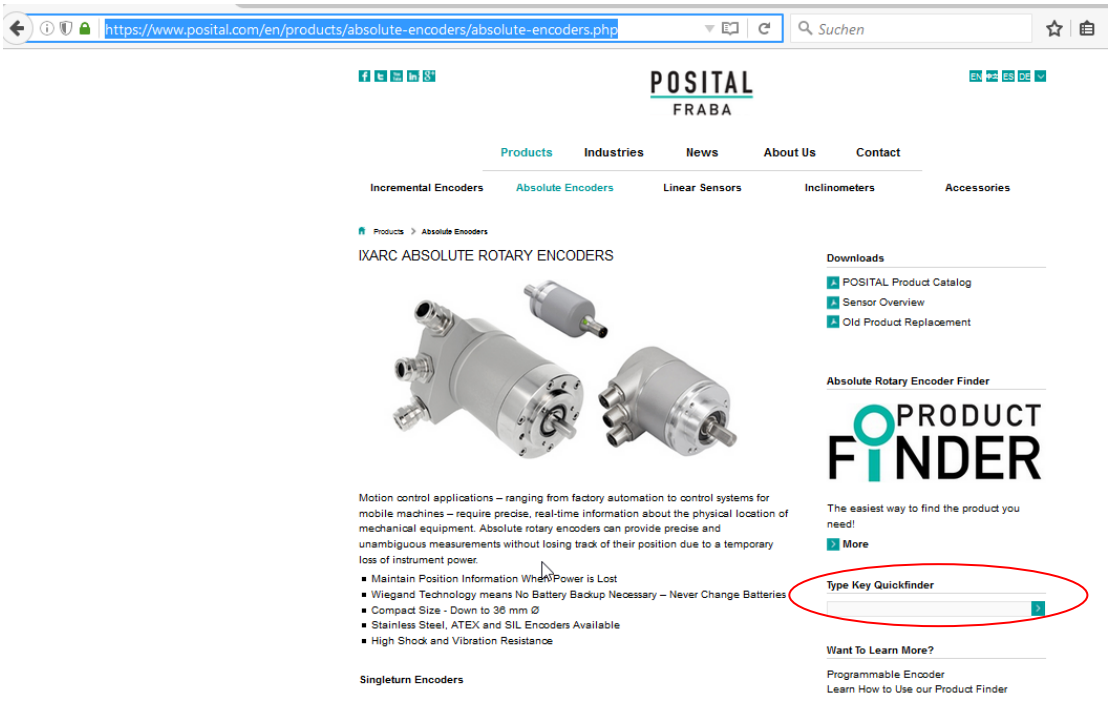
This device doesn't support a auto baud detection and the baud rate shall be configured by a SDO telegram on object 3001h. For further information please regard chapter 5.5 Object Dictionary.

2.3 Technical Data

For technical data regarding

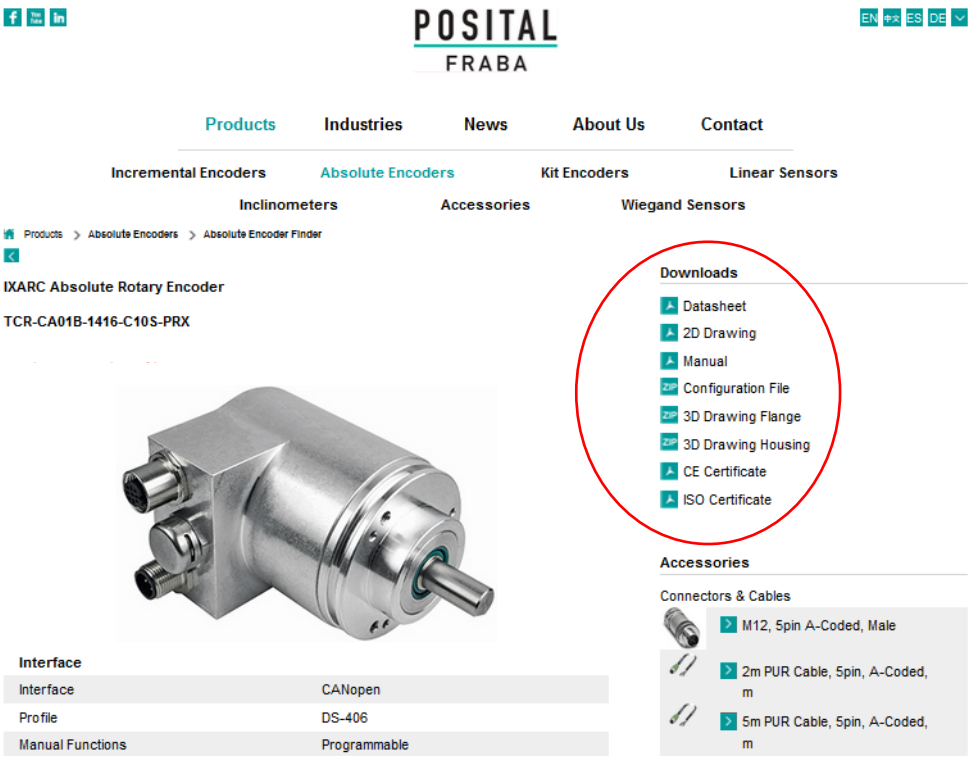
- interface,
- electrical data,
- sensor data ,
- environmental condition,
- mechanical data and
- connection plan

please refer to the website www.posital.com. Just select there the product category “Absolute Encoders” and enter immediately the type key you find on the type label on the encoder or select the right product by using the product finder.



On the company's website you can find additional relevant informations as direct download like:

- mechanical drawings,
- online data sheet,
- manual,
- configuration files EDS.



By using website information you have the great advantage of actual information for the specific product holding in your hands out of a portfolio of more than million products.

3. Quick Installation Guide

Intention of this chapter is to help the user getting an encoder very easy and fast to operate. The user is still responsible to configure the encoder in the right way and reading the whole manual carefully.

With the following sequence a normal procedure is described to configure a device for standard applications. It shall guide you roughly through this process.

3.1 Configure the device for integration into a CAN network.

For this purpose you need to setup the node number and the baud rate first.

The magnetic encoder (UCD) has the auto baud detection activated by manufacturer default setting and just the node number has to be set to customer specific demand.

For the optical encoder (OCD) the baud rate and node number must be set, because this encoder part is not supporting auto baud detection.

Manufacturer default setting for TCR:

Baud rate: 125Kbd

node number 20h for OCD and 1Fh for UCD.

If your running network uses a different baud rate or the node number is already in use, then you shall make a point to point connection to the encoder TCR with a configuration tool to prevent a crash of the different configured running network.

Connect the encoder with a configuration tool and set the baud rate to 125 KBd. Power on the encoder. You will see two boot up message in case of a trace tool is used from OCD and UCD encoder part.

All values given in the following tables are hex coded!

Node number setting for the optical encoder (OCD) and magnetic encoder (UCD) shall be different and not identical! Otherwise the TCR encoder is not useable anymore!

Message received from Encoder: Boot Up (here: optical encoder with node number 20h)

Identifier	Service/Process data							
NN = 20	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
700 + NN = 720	00							

NN = node number of encoder

Message received from Encoder: Boot Up (here: magnetic encoder with node number 1Fh)

Identifier	Service/Process data							
NN = 1F	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
700 + NN = 71F	00							

NN = node number of encoder

The following sequences could also be programmed for the magnetic encoder UCD. Description shows the configuration of an optical encoder OCD.

Configuration of node number:

Object 3000h

Example:

Resulting node number = Value in object 3000h + 1h = Ah + 1h = Bh

The encoder itself adds the value 1 to the configured node number. This method is used to prevent an identifier value of 0. Don't use identical node number for OCD and UCD!

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 20		Download	3000h		00h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 620	8	22	00	30	00	0A	00	00	00

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	3000h		00h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 5A0	8	60	00	30	00	00	00	00	00

Configuration of baud rate:

Object 3001h

Example: 500 KBd -> 05

(Hint: for UCD only in case auto baud feature is not used. Auto baud detection is activated for UCD by manufacturer default setting)

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 20		Download	3001h		00h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 620	8	22	01	30	00	05	00	00	00

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	3001h		00h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 5A0	8	60	01	30	00	00	00	00	00

Store Configuration:

Object 1010h, Sub-Index 01

Signature “save” -> “73617665”

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 20		Download	1010h		01h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 620	8	22	10	10	01	73	61	76	65

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	1010h		00h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 5A0	8	60	10	10	01	00	00	00	00

The new network configuration of the encoder will be activated with a power cycle or NMT reset.

Add the encoder to the network or go ahead with the configuration.

3.2 Configure application specific encoder parameter

For adaption of the encoder in your application you may use objects to configure the resolution per revolution and the total resolution. Especially the preset value is relevant to adjust the position value of the encoder to a desired value in the machine after mechanical installation. It is useful to store the configuration in the device and not to re-configure the different parameters after each power cycle or NMT reset. In the following tables the new configured node number is assumed.

Configuration of measuring units per revolution:

Object 6001h

Example: 3600 dec -> 00000E10h

Explanation: The encoder will output 3600 steps per revolution that means 0.1° resolution.

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = B		Download	6001h		00h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 60B	8	22	01	60	00	10	0E	00	00

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	6001h		00h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 58B	8	60	01	60	00	00	00	00	00

Configuration of total measuring range:

Object 6002h

Example:7200 dec -> 00001C20h

Explanation: The encoder will output 7200 steps within 2 revolution and starts again with 0. There is no mechanical limitation, if the encoder is driven continously in one direction. Value must be lower or equal than given on the type label.

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = B		Download	6002h		00h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 60B	8	22	02	60	00	20	1C	00	00

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	6002h		00h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 58B	8	60	02	60	00	00	00	00	00

Configuration of preset value:

Object 6003h

Example:10 dec -> 0000000Ah

Explanation: You set the encoder output position value to a desired position value in your machine. The value is set in the encoder, when the telegram is sent and confirmed. Do this operation during standstill of the encoder shaft to increase the accuracy, because the device is calculating itself an offset value. If you set the preset dynamically, which is not recommended, then you have also to take bus latency time into consideration and encoder internal cycle time. (Hint: It is recommended to set different prest values for OCD and UCD at the same location to generate diverse data.)

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = B		Download	6003h		00h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 60B	8	22	03	60	00	0A	00	00	00

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	6003h		00h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 58B	8	60	03	60	00	00	00	00	00

If preset value is used, then please execute the store configuration, otherwise you will see a position jump after power cycle. It is in general recommended to store after a changed configuration.

Transmission of Position Value: sync

If you want, that the encoder transmits its position value after receive of a SYNC message from the PLC/CAN master, then configure the following object TPDO2.

Remark: By default the value is set to 1, that means the position value is transmitted after each SYNC message, so you have to do no modifications and you can skip this step.

Object 1801h, sub-index 2h

Example:1 dec -> 01h

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = B		Download	1801h		02h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 60B	8	22	01	18	02	01	00	00	00

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	1800h		02h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 58B	8	60	01	18	02	00	00	00	00

Store Configuration:

Object 1010h, Sub-Index 01

Signature “save” -> “73617665”

Message sent to encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN = 20		Download	1010h		01h	Byte 4	Byte 5	Byte 6	Byte 7
600 + NN = 620	8	22	10	10	01	73	61	76	65

Message received from Encoder

Identifier	DLC	Command	Index		Subindex	Service/Process data			
NN		Download	1010h		00h	Byte 4	Byte 5	Byte 6	Byte 7
580 + NN = 5A0	8	60	10	10	01	00	00	00	00

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 powerup 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 PDOs in pre-operational mode.

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:

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.

4.1.2 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.

4.1.3 Recommended communication process

In figure 6 you can see a signal time diagram showing a simple bus cycle.

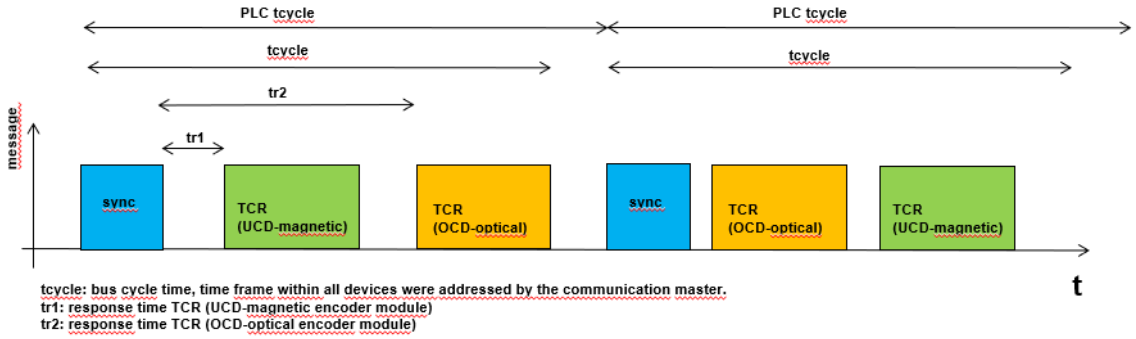


Figure 6

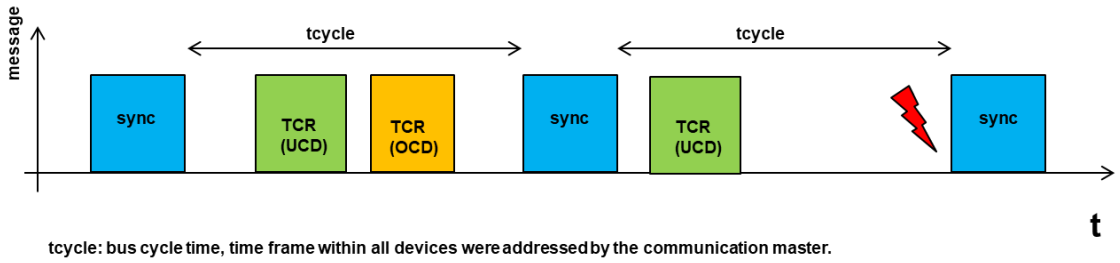
tr1: response time of TCR (UCD magnetic encoder part)

tr2: response time of TCR (OCD optical encoder part)

In general it is strongly recommended to use the SYNC operation mode, because then the bus load is reduced for reading the sensor data and the synchronization of communication is done network wide by usage of this broadcast message type.
Be aware that the response time of the devices is depending on several conditions like:

- device internal handling time of CAN messages
- priority of message
- general bus load

In figure 7 you can see 2 bus cycles, whereby in the first cycle both encoder parts are transmitting their position data. PLC is sending it's sync message and TCR is responding like shown with the green symbol for UCD and orange for OCD. In the second cycle the answer from OCD is missing. The safety PLC shall also evaluate, if the answer from both channels are transmitted and how many bus cycles are toleranced with unsuccessful or incomplete transmissions. It is the application engineer's responsibility to take this also into account. This covers safety requirements and availability of the machine.
Furthermore the sequence of responses is not guaranteed related to above reasons. This has to be taken into consideration on the safety PLC side for evaluation of the position values. It is strongly recommended to use consecutive node numbers to have both telegrams quite close to each other.



tcycle: bus cycle time, time frame within all devices were addressed by the communication master.

Figure 7

4.1.4 Verification of position value

The verification of position values from each encoder channel shall be executed in a safety PLC or equivalent solution.

Reason for deviation of position values:

- accuracy of magentic and optical encoder
- time related dependencies as written in chapter 4.1.3
- environmental conditions like shock and vibration
- speed of the shaft

For diagnostic coverage reason a plausibility check shall be done for the difference of both position values in a safety PLC. Within the optical (OCD) and magnetic (UCD) encoder parts the position value is measured asynchronous to the bus communication. Processing time for position measurement is for both encoder parts below 200µs. In most cases the bus cycle time is in applications even higher like 1 ms or 10 ms, 20 ms. The encoder handles in parallel to position processing the bus communication via the CAN stack and this cycle time is below 1ms for both encoder parts inside TCR. In worst cases the cycle time for UCD and OCD are complete asynchronous and the time deviation could be up to 2ms for updated position value. This has to be considered for position difference evaluation on safety PLC side.

Example:
Time difference of transmitted values: 2ms (assumed value)
Resolution per revolution of both encoders: 16 bit, 65536 steps / revolution (see type label on encoder)
Shaft speed: 10 rpm (assumed value in application)

Position difference = v * t,
v = velocity of encoder shaft
t = time difference

Position difference = [10 rpm * 65536 steps / revolution * (min / 60s) * (1s/1000ms)] * 2ms ~ 22 steps
This is the minimum position difference between both position values, which can be increased by topics mentioned above leading to higher response times like priority or bus load.

It is the application enginees responsibility to determine the allowed position difference in his specific application! Above example just gives an indication how the value can be calculated.

Influence of environmental conditions

The TCR encoder is tested regarding shock and vibration according to the standards and test levels as defined in the datasheet. The functionality of the encoder is ensured to the specification limits and depending on the shock or vibration load the position difference could slightly increase by a few steps. This additional deviation could lead not to a unsafe state, if the limit value for allowed position difference is not considering these effects, but may be a reduced availability could result. The advantage of verification in a safety PLC is, that the user is able to decide with his knowledge of machine and application requirements and hazardous situation, which position difference can be allowed or not to transit in the safe state. May be the allowed position difference is much higher than above mentioned effects.

Temperature can lead to an additional slight position difference inside the encoder. On interest the related test results can be provided.

In general the user has to take care of the whole mechanical setup like for example influence of coupling, mounting brackets, chain extension related to wear or length variation in relation to temperature.

Extended diagnostic functionality

With a use of plausibility control of expected behavior the user of the TCR encoder can increase the diagnostic coverage to detect a failure in the encoder device.

Furthermore with a combination of other actor or sensor signals in a safety plc the failed channel could be detected. In this case it is may be possible to still operate the machine in a specific operation mode like assistance mode with limited working area or limited speed with user permission. But this has to be evaluated very carefully and the operation time of this mode shall be limited as another following failure may be not detected. It is the responsibility of the user and project engineer to decide, if this is possible or not. In this user manual a general guideline can not be given!

Beside normal setup of both encoder channels having the same position value, it is also possible to use a certain offset between OCD (optical encoder channel) and UCD (magnetic encoder channel) like 150° to verify on PLC side, if the offset is still kept with additional allowed tolerance window.

4.2 Normal Operating

Polled Mode	By a remote-transmission-request telegram the connected host calls for the current process value. The encoder reads the current position value, calculates eventually set-parameters and sends back the obtained process value by the same identifier.
Cyclic Mode	The encoder transmits cyclically – without being called by the host – the current process value. The cycle time can be programmed in milliseconds for values between 1 ms and 65536 ms.
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. 1 CAN Transmission Mode Description

4.3 Storing Parameter

4.3.1 List of storable Parameter

Object Index	Object Description
1005h	COB-ID Sync
100Ch	Guard Time
100Dh	Life Time Factor
1016h	Consumer Heartbeat Time
1017h	Producer Heartbeat Time
1020h	Verify configuration
1800h	Communication parameter PDO 1
1801h	Communication parameter PDO 2
1A00h	Transmit PDO1 Mapping Parameter
1A01h	Transmit PDO2 Mapping Parameter
2100h	Operating Parameters
2101h	Resolution per Revolution
2102h	Total Resolution
2103h	Preset Value
2104h	Limit Switch, min.
2105h	Limit Switch, max.
2160h	Customer Storage
2200h	Cyclic Timer
3000h	Node Number
3001h	Baud rate
3002h	Termination Resistor
3003h	Auto Baud Detection
3005h	Auto Boot Up
3030h	Backward Compatibility Mode
4010h	PPR Incremental Encoder (only available for encoder type TCR-CH, TCR-CT)
4020h	A/B Phase Shift (only available for encoder type TCR-CH, TCR-CT)
6000h	Operating Parameter
6001h	Steps per Revolution
6002h	Total Resolution
6003h	Preset Value
6200h	Cyclic Timer

Tab. 2 List of Storable Parameters

4.3.1 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 one burn cycle to the E^2PROM

by the parameter memory transfer. The stored parameters are copied after a RESET (Power on, NMT-Reset) from the E^2PROM to the RAM (volatile memory).

Storing without Reset

By using the object 1010h from the communication profile related object dictionary you can store the parameters into the non-volatile memory without a reset.

Storing with Reset

By using the object 2300h from the manufacturer specific object dictionary you can store the parameters into the non-volatile memory. After storing the parameters a reset of the device is performed.

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 not overwritten. Only after a new store command the default parameters are stored in the non-volatile memory. To restore the default parameter the following telegram is used. 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 before you store them to the non-volatile memory.

4.5 Usage of Layer Setting Services (LSS)

To configure the encoder via LSS the encoder will be the LSS slave device and the control has to support LSS master device functionality.

The LSS master device requests services, that are performed by the LSS slave devices (encoder). The LSS master device requests the LSS address (vendor-id, product-code, revision-number, serial-number) from the LSS slave device. After receiving this information the control can unequivocally identify the encoder and the node number and baud rate can be set.

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

Tab. 3 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. 4 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:

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. 5 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 a unused node number, it will start up into the pre-operational mode and send a bootup massage to the master.

5.1.1 Set Encoder Preset Value

Master to Encoder with Node Number 1

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 Preset Values

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 1000h – 1FFFh

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

Object	Supported by UCD (magnetic)	Supported by OCD (optic)	Description
1000h	X	X	Device type
1001h	X	X	Error register
1003h	X	X	Pre-defined error field
1005h	X	X	COB-ID SYNC-message
1006h	X	X	ComCyclePeriode
1008h	X	X	Device name
1009h	X	X	Hardware version
100Ah	X	X	Software version
100Ch	X	X	Guard Time
100Dh	X	X	Life Time Factor
1010h	X	X	Store parameters
1011h	X	X	Restore default parameters
1012h	X	X	COB-ID Time Stamp
1013h	X	X	High Resolution Time Stamp
1014h	X	X	COB-ID Emergency
1016h	X	X	Consumer Heartbeat Time
1017h	X	X	Producer Heartbeat Time
1018h	X	X	Identity Object
1020h	X	X	Verify Configuration
1029h	X	X	Error Behaviour
1800h	X	X	Communication parameter PDO 1
1801h	X	X	Communication parameter PDO 2
1A00h	X	X	Transmit PDO1 Mapping Parameter
1A01h	X	X	Transmit PDO2 Mapping Parameter
1F50h	X	-	Download Program Area
1F51h	X	-	Program Control

Tab. 6 Object Dictionary 1000h-1FFFh

5.3 Manufacturer specific objects 2000h – 5FFFh

Object	Supported by UCD (magnetic)	Supported by OCD (optic)	Description
2000h	X	X	Position Value
2100h	X	X	Operating Parameters
2101h	X	X	Resolution per Revolution
2102h	X	X	Total Resolution
2103h	X	X	Preset Value
2104h	X	X	Limit Switch, min.
2105h	X	X	Limit Switch, max.
2160h	X	X	Customer Storage
2200h	X	X	Cyclic Timer PDO1
2300h	X	X	Save Parameter with reset
3000h	X	X	Node Number
3001h	X	X	Baudrate
3003h	X	-	Auto Baud Detection
3005h	X	-	Auto Boot Up
3010h	X	X (only speed enable)	Speed Control
3011h	X	X	Speed Value
3020h	X	X	Acceleration Control
3021h	X	X	Acceleration Value (not supported)
3030h	X	-	Backward Compatible Mode
3040h	X	-	Life Cycle Counter
3050h	X	-	Time Stamp Position Value
4000h	x	-	Bootloader Control
4010h	X	-	PPR Incremental Encoder
4020h	X	-	A/B Phase shift Incremental Encoder

Tab. 7 Object Dictionary 2000-5FFF

5.4 Application specific objects 6000h – 67Feh

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

Object	Supported by UCD (magnetic)	Supported by OCD (optic)	Description
6000h	X	X	Operating Parameters
6001h	X	X	Measuring units per revolution
6002h	X	X	Total measuring range in measuring units
6003h	X	X	Preset value
6004h	X	X	Position Value
6008h	X	-	High Precision Position Value
6030h	X	X	Speed Value
6040h	X	X	Acceleration Value
6200h	X	X	Cyclic Timer
6300h	X	X	Cam state register
6301h	X	X	Cam enable register
6302h	X	X	Cam polarity register
6310h-6317h	X	X	Cam 1-7 low limit
6320h-6327h	X	X	Cam 1-7 high limit
6330h-6337h	X	X	Cam 1-7 hysteresis
6400h	X	X	Area state register
6401h	X	X	Work area low limit
6402h	X	X	Work area high limit
6500h	X	X	Operating status
6501h	X	X	Single-turn resolution
6502h	X	X	Number of distinguishable revolutions
6503h	X	X	Alarms
6504h	X	X	Supported alarms
6505h	X	X	Warnings
6506h	X	X	Supported warnings
6507h	X	X	Profile and software version
6508h	X	X	Operating time
6509h	X	X	Offset value

Object	Supported by UCD (magnetic)	Supported by OCD (optic)	Description
650Ah	X	X	Module identification
650Bh	x	x	Serial number

Tab. 8 Object Dictionary 6000h-6FFFh

5.5 Object Descriptions

In the following chapter you will find detailed information of the object dictionary related to the encoder device.

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	Restore after BootUp
0	-	Unsigned 32	N/A	ro	no

MCD absolute rotary encoder single turn: 10196h
MCD 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	Restore after BootUp
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	Restore after BootUp
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	Restore after BootUp
0	-	Unsigned 32	80000080h	rw	no

Object 1008h: Manufacturer Device Name

This object contains the device name.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
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	Restore after BootUp
0	-	String	“POS100”	ro	no

There is one actual version of circuit boards for UCD:

- POS100 (encoder type : UCD-Cxxxx-xxxx-xxxx-xxx)

Object 100Ah: Manufacturer Software Version

This object contains the manufacturer software version. Currently the version is as data type string “1.xx”, whereby x stands as place holder.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	String	“1.xx”	ro	no

Object 100Ch: Guard Time

This object contains the guard time in milliseconds.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 16	0	rw	yes

Object 100Dh: Life Time Factor

This object contains the life time factor parameters. The life time factor multiplied with the guard time gives the life time for the node guarding protocol.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 8	0	rw	yes

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	Restore after BootUp
0	Number of sub indices	Unsigned 8	2	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.

	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	Restore after BootUp
0	Number of sub indices	Unsigned 8	2	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.

Object 1012h: COB-ID Time Stamp Object

This object contains the COB-ID of the Time Stamp object.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 32	100h	rw	no

Object 1013h: High Resolution Time Stamp

This object contains a time stamp with a resolution of 1µs.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 32	0	rw	no

Object 1014h: COB-ID Emergency Object

This object contains the EMCY emergency message identifier.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	-	Unsigned 32	80h + Node ID	rw	no

Object 1016h: Consumer Heartbeat Time

The consumer heartbeat time defines the expected heartbeat cycle time in ms. The device can only monitor one corresponding device. If the time is set to 0 the monitoring is not active. The value of this object must be higher than the corresponding time (object 1017) of the monitored device.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of indices	Unsigned 8	1	ro	no
1	Consumer heartbeat time	Unsigned 32	0	rw	yes

The context of subindex 1 is as follows:

Bit	31 to 24	23 to 16	15 to 0
Value	0h (reserved)	Address of monitored device	Monitoring time (ms

Object 1017h: Producer Heartbeat Time

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	Restore after BootUp
0	-	Unsigned 16	0	rw	yes

Object 1018h: Identity Object

This object contains the device information.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of entries	Unsigned 8	4	ro	no
1	Vendor ID	Unsigned 32	42h	ro	no
2	Product Code	Unsigned 32		ro	no
3	Revision Number	Unsigned 32		ro	no
4	Serial Number	Unsigned 32		ro	no

Object 1020h: Verify configuration

This object indicates the downloaded configuration date and time.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of entries	Unsigned 8	2h	ro	no
1h	Configuration date	Unsigned 32		rw	no
2h	Configuration time	Unsigned 32		rw	no

Object 1029h: Error behaviour

This object indicates the error behavior.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of entries	Unsigned 8	1h	ro	no
1h	Communication error	Unsigned 8		rw	no

Object 1800h: 1st Transmit PDO Communication Parameter

This object contains the communication parameter of the 1st transmit PDO.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	5	ro	yes
1	COB-ID	Unsigned 32	180h + Node ID	rw	yes
2	Transmission Mode	Unsigned 8	FEh	rw	yes
3	Inhibit Time	Unsigned 32	0	rw	yes
4	Not available				
5	Event Timer	Unsigned 32	0	rw	yes

Object 1801h: 2nd Transmit PDO Communication Parameter

This object contains the communication parameter of the 2nd transmit PDO.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	5	ro	yes
1	COB-ID	Unsigned 32	280h + Node ID	rw	yes
2	Transmission Mode	Unsigned 8	1	rw	yes
3	Inhibit Time	Unsigned 32	0	rw	yes
4	Not available				
5	Event Timer	Unsigned 32	0	rw	yes

Transmission Mode

The transmission mode can be configured as described below:

Transfer Value (decimal)	Transmission Mode					Notes
	Cyclic	Acyclic	Synchronous	Asynchronous	RTR only	
0		X	X			Send PDO on first Sync message following an event
1-240	X		X			Send PDO every x Sync messages
241-251	reserved					
252			X		X	Receive SYNC message and send PDO on Remote Request
253					X	Update data and send PDO on Remote Request
254				X		Send PDO on event
255				X		Send PDO on event

Inhibit Time

For "Transmit PDOs", the "inhibit time" for PDO transmissions can be entered in this 16 bit field. If data is changed, the PDO sender checks whether an "inhibit time" has expired since the last transmission. A new PDO transmission can only take place if the "inhibit time" has expired. The "inhibit time" is useful for asynchronous transmission (transmission mode 254 and 255), to avoid overloads on the CAN bus.

Event Timer

The "event timer" only works in asynchronous transmission mode (transmission mode 254 and 255). If the data changes before the "event timer" expires, a temporary telegram is sent. If a value > 0 is written in this 16-bit field, the transmit PDO is always sent after the "event timer" expires. The value is written in subindex 5 of a transmit PDO. The data transfer also takes place with no change to data. The range is between 1-65536 ms.

Object 1A00h: 1st Transmit PDO Mapping Parameter

This object contains the mapping parameter of the 1st transmit PDO.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	2	ro	yes
1	1st mapped object	Unsigned 32	60040020h	rw	yes

Object 1A01h: 2nd Transmit PDO Mapping Parameter

This object contains the mapping parameter of the 2nd transmit PDO.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Number of sub indices	Unsigned 8	2	ro	yes
1	2nd mapped object	Unsigned 32	60040020h	rw	yes

Object 1F50h: Download Program Area

This is a special object that has functionality for the bootloader feature. (see Bootloader chapter)

Use this entry to download your Intel hex file with the programming data. Detailed information about Domain download and Block transfer in CiA Draft Standard 301 Application Layer and communication Profile.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	2h	ro	Yes
1h		DOMAIN		wo	yes

Object 1F51h: Program Control

This is a special bootloader object, to update the firmware (see Bootloader chapter).

This array controls the programs residing at index 0x1F50.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of program control entries	Unsigned 8	2h	ro	yes
1h		Unsigned 32		rw	yes

Sub-index 1h and higher control the memory block functionality. They can have the following values:

for writing:

1 - start downloaded program

4 - erase flash

Object 2000h: Position Value

This object contains the position value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Position Value	Unsigned 32	-	ro	n.a.

Object 2100h: Operating Parameters

As operating parameters the code sequence (Complement) can be selected and the limit switches can be turned on or off.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Operating Parameters	Unsigned 8	0h	rw	yes

The parameter code sequence (Complement) determines the counting direction, in which the output process value increases or decreases (CW = Clockwise, CCW = Counterclockwise). The code sequence is determined by Bit 0 in Index 2100h. Additionally, the two limit switches, Min. and Max. can be turned on or off in Index 2100h.

Bit 0	Code sequence	Code	Bit 1	Limit switch, min.	Bit 2	Limit switch, max.
0	CW	increasing	0	off	0	off
1	CCW	increasing	1	on	1	on

Calculation Example: Target: Absolute rotary encoder with direction CCW increasing, limit switch min enabled and limit switch max disabled.
Bitmatrix:
Bit 0 = 1 Direction increasing CCW
Bit 1 = 1 Limit switch min. enabled
Bit 2 = 0 Limit switch max. disabled
Result = 011b = 3h

Object 2101h: Resolution per Revolution
This object contains the desired steps per revolution of the encoder.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Resolution per Revolution	Unsigned 32	see type label	rw	yes

If the desired value exceeds the hardware resolution of the encoder, it will be out of range and the error code is used “06090030h: Value range of parameter exceeded” will appear.

Object 2102h: Total Resolution

This object contains the desired total resolution of the encoder.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Total Resolution	Unsigned 32	see type label	rw	yes

This parameter is used to program the desired number of measuring units over the total measuring range. This value must not exceed the total resolution of the absolute rotary encoder, which is printed on the type sign of the encoder.

Attention:

Following formula letter will be used:

PGA	Physical total resolution of the encoder	(see type sign)
PAU	Physical resolution per revolution	(see type sign)
GA	Total resolution (customer parameter)	
AU	Resolution per revolution (customer parameter)	

Please use the following formula to calculate the total resolution of the encoder:

If the desired resolution per revolution is less than the really physical resolution per revolution of the encoder, then the total resolution must be entered as follows:

Total resolution:

Calculation example:
Customer handicap: AU = 2048
Encoder type sign:
PGA=24 bit, PAU=12bit

If the total resolution of the encoder is less than the physical total resolution, the parameter total resolution must be a multiple of the physical total resolution:

Object 2103h: Preset Value

The preset value is the desired position value, which should be reached at a certain physical position of the axis. The position value is set to the desired process value by the parameter preset. The preset value must not exceed the parameter total resolution to avoid run-time errors. If the parameter value exceeds the total resolution of the encoder a SDO “Out of range” message is generated.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Preset Value	Unsigned 32	0	rw	yes

Object 2104h: Limit Switch, min.

Two position values can be programmed as limit switches. By reaching this value, one bit of the 32 bit process value is set to high. Both programmed values must not exceed the parameter total resolution to avoid run-time errors. If the parameter value exceeds the total resolution of the encoder a SDO “Out of range” message is generated.

Bit 30 = 1: Limit Switch, Min. reached or passed under

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Limit Switch, min.	Unsigned 32	0	rw	yes

The limit switch, Min sets Bit 30=1 with the next message telegram, if the process value reaches or passes under the value of the limit switch:

Function	Status bits		Process value																												
Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	0	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Object 2105h: Limit Switch, max.

Two position values can be programmed as limit switches. By reaching this value, one bit of the 32 bit process value is set to high. Both programmed values must not exceed the parameter total resolution to

avoid run-time errors. If the parameter value exceeds the total resolution of the encoder a SDO “Out of range” message is generated.

Bit 31 = 1: Limit Switch, Max. reached or passed beyond

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Limit Switch, max.	Unsigned 32	0	rw	yes

The limit switch, max sets Bit 31=1 with the next message telegram, if the process value reaches or passes under the value of the limit switch:

Function	Status bits		Process value																												
Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
	1	0	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Object 2160h: Customer storage

This object provides for the customer the possibility to store any value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	4h	ro	
1h	Customer Storage1	Unsigned 32		rw	
2h	Customer Storage2	Unsigned 32		rw	
3h	Customer Storage3	Unsigned 32		rw	
4h	Customer Storage4	Unsigned 32		rw	

Object 2200h: Cyclic Timer PDO

This object contains cyclic time of the event timer in ms (of PDO 1).

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Event Time in ms	Unsigned 16	0h	ro	yes

The object 2200h is hard-wired to the objects 1800h subindex 5h and 6200h and provide the cycle time for the cyclic mode. (See chapter Cycle Time and Event Timer)

Object 2300h: Save Parameter with Reset

With this object all parameters can be stored in the non volatile memory. After storing the parameters a reset is executed.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Access code	Unsigned 32	55AAAA55h	wo	no

Object 2600h: High Resolution Position Value

This object contains a high resolution position value up to 16 bit for single-turn and 31 bit for multi-turn measurement. See type label to get the information about the maximum resolution of your device.

The object 2600h is not influenced by the object 2102h Total resolution or object 6002h Total measuring range, because of their limited data type of unsigned 32 bit.
But object 2101h Resolution per revolution and object 6001h measuring units per revolution will affect the high resolution position value. With object 2103h / 6003h Preset value a desired position can be also set for the high resolution position value, but only within the value range of unsigned 32 bit. With this method the user has a downward compatible device, but also in parallel a device with higher capability of resolution and the existing software in the PLC can be kept.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	High Resolution Position Value	Unsigned 64	-	romap	

Object 3000h: Node Number

This object contains the node number of the device. The POSITAL standard node number is 32 decimal.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Node Number	Unsigned 8	1Fh	rw	NO

NOTE: To avoid the node number 0, one will be added to the value of this object!
E.g.: 1Fh+1h = 20h = 32 (dec)

Ensure, that the node number exist unique in the network, otherwise unexpected behavior of the devices will occur. This conflict can't be detected in a CAN network by protocol. This is valid for all CANopen devices!

Object 3001h: Baudrate

This object contains the baudrate of the device.

For devices with active Auto Baud Detection this setting is not relevant, if the baud rate is detected within the Time Out interval. See object 3003h. The successful result of the auto baud mode is stored automatically in this object.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0	Baudrate	Unsigned 8	-	rw	NO

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

Baudrate in kBit/s	Byte
20	00h
50	01h
100	02h
125	03h
250	04h
500	05h
800	06h
1000	07h

Object 3002h: Termination Resistor

Subindex	Description	Data Type	Default Value	Access	Restore after

					BootUp
0	Termination Resistor	Unsigned 8	-	rw	NO

By writing 01h to this object the internal galvanic isolated termination resistor is activated.

Note that the resistor is only activated when the device is powered. If you have more CAN nodes on the Bus be sure to power them approx 700ms after the device with the programmed termination Resistor. Otherwise reflections could occur and network quality is probably reduced.

Object 3003h: Auto Baud Detection

This object controls the baud rate measurement of the device after power up or NMT reset. With this feature the user can add the encoder to a network without knowing the baud rate. Just the specified baud rates in CANopen are supported and also 100Kbd as listed in object 3001h Baudrate.

If the auto baud detection is enabled, then after power up the encoder is just listening to the network und tries to identify within the Time Out (3003h, 2h) a valid CAN message. When this is done successfully, then the device is sending the boot up message and enters the pre-operational state.

For devices with LED in the M12 connector the active auto baud mode is indicated by flickering alternative a red and green LED.

Reason for non-successful baud rate detection:

- Within the time out period no valid CAN message is sent
  Corrective action: increase the time out value to a value that for minimum 1 message is sent or better more. Check, if the power up time of the other devices is synchronously switched on like for the encoder. Perhaps you have to take this different power up time also into consideration.
- EMC effects
  If a non valid CAN frame is detected, then the encoder retries to measure a valid CAN frame within the time out period.
  Corrective action: check the shielding of the cables, connections, termination in the CAN network. If no improvement is realized, then deactivate temporary the auto baud detection and set the baud rate by use of object 3001h. Then further investigations are possible to find the root cause in combination with a trace tool.
- Errorframes
  Disturbances in the CAN network communication.
  Corrective action: Find the communication problem in the network by selective use of nodes and consecutive adding further one.

Reaction in case of non-successful baud rate detection:

When the baud rate can't be measured within the time out period, then the encoder is using the last "known" baud rate:

- If the encoder is used out of the box, then the value is 125 KBd.
- If the encoder was already in use, then the last successful baud rate is stored automatically in object 3001h and taken in this case.

Object 3003h:

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	2h	Ro	
1h	Enable	Unsigned 8	1h	rw	Yes
2h	Time Out	Unsigned 32	2BF20h	rw	yes

Sub-Inxex 1, Enable:

Value 0: Auto Baud Mode is disabled.

Value 1: Auto Baud Mode is enabled.

Sub Index 2, Time Out:

Value in ms defines the time period after power up or NMT reset for finding a valid CAN message to measure the baud rate. If the value 0 is used, then an infinite time period is used.

Object 3005h: Auto Boot Up

With this flag the start up behavior of the encoder is defined.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Auto Boot Up	Boolean	0	rw	yes

True: Encoder enters after power up autonomously the state operational without receiving a NMT start command.

False: Encoder enters after power up the state Pre-Operational. This is the standard behavior of CANopen devices.

Object 3010h: Speed Control

This object contains the speed control. The speed measurement is disabled by default.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	2h	ro	
1h	Speed Unit	Unsigned 8	0h	rw	yes
2h	Speed Filter	Unsigned 8	0h	rw	yes

Speed Unit, Sub-Index 1:

Value Functionality

0h: Disabled, no measurement

1h: Speed measurement enabled and unit in steps per second

2h: Speed measurement enabled and unit in RPM

3-4: reserved

Speed Filter, Sub-Index 2:

0h: Filter mode is moving average filter with length of 10 values

1h: Filter mode is moving average filter with length of 100 values

2h: Filter mode is moving average filter with length of 1000 values

Object 3011h: Speed Value

This object contains speed value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Speed value	integer 32		romap	no

Object 3020h: Acceleration Control

This object contains the acceleration control. Acceleration output is not supported by this device. This object is present only for compatibility reasons.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	2h	Ro	
1h	Enable Acceleration	Unsigned 8	0h	rw	Yes
2h	Acceleration modus	Unsigned 8	0h	rw	yes

Object 3021h: Acceleration Value

Acceleration output is **not** supported by this device. This object is present only for compatibility reasons.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Acceleration Value	INTEGER32		romap	

Object 3030h: Backward Compatible Mode

This object contains the acceleration control. Acceleration output is not supported by this device. This object is present only for compatibility reasons.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	2h	Ro	
1h	Security Code	Unsigned 32	0h	rw	yes
2h	MCD Mode	Unsigned 32	0h	rw	yes

Security Code:

A specific signature has to be written first to this sub-index to access 2nd sub index MCD Mode.

Sequence is used to prevent misusage by unintended access.

Signature = “MBYT”

(high->low byte)

MCD Mode:

In the MCD mode new objects implemented in UCD can’t be accessed and will be responded with abort code “object does not exist”.

Signature+”0”: UCD mode with all features accessible

Signature+”1”: MCD mode with only old features available.

Signature = “BCM”

(high->low byte)

Example: BCM + “1” -> 0x42434D01 , MCD mode is active

Object 3040h: Life Cycle Counter

Diagnostic value to monitor, if the position value is updated compared to last transmission. This feature is interesting for safety applications to detect for example, if the value in the CAN controller is frozen. The value starts at power up with 0 and is continuously incremented. When overflow is reached, then it starts again with 0. It is not expected, that the transmitted value is incremented, because the life cycle counter is

handled in the function when the position value is measured and this process is asynchronous to the CAN communication.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Life Cycle Counter	Unsigned32	-	romap	

Object 3050h: Time Stamp Position Value

This time stamp is generated when the position value is measured. Like the life cycle counter this value can be used for safety purposes to detect stuck at effects. Another feature is to calculate the velocity on PLC side with accurate time stamp values to achieve high accuracy for individual requirements. It offers more flexibility than the encoder internal pre-defined velocity measurement.

Time resolution is 1 µs.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Time Stamp Position Value	Unsigned32	-	romap	

Object 4000h: Bootloader Control

This object controls the Bootloader functionality (see Bootloader chapter). Writing the security code to this object causes erasing the EEPROM and application information in the flash memory and resets the device. After a power-up, the Bootloader checks the user application and detects no more information. The Bootloader starts up with a pre-defined CANopen node ID of 1 (0x1) and a fixed CAN baud rate of 125 kbits.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Bootloader Control	Unsigned32		wo	

NOTE:

Activating the Bootloader courses a deep reset of the device. After this only a few objects are still available, the device does not behave like an encoder and waits for new programming. That is the reason why the security code is not published in this document. Please contact POSITAL to obtain the code.

Object 4010h: PPR Incremental Encoder (optional, only for encoder type TCR-CH or TCR-CT)

The incremental pulses are only provided by the magnetic sensor inside the TCR encoder.

This object controls the incremental resolution per revolution as pulses per channel for A and B.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	PPR Incremental Encoder	Unsigned16	400h	rw	Yes

If a value of 400 hex is configured, then you will see 1024 decimal pulses on each channel A and B per revolution. Maximum possible value is 14 bit, which means 16384 pulses per revolution PPR.

The type key specifies different physical level of the incremental interface.

TCR-CT means a physical level acc. to RS-422 or TTL.

TCR-CH means a physical level GND up to power supply range.

The configuration of this object is overtaken regarding output signals only after NMT reset or power cycle.

Object 4020h: A/B Phase Shift (optional, only for encoder type TCR-CT, TCR-CH)

The incremental pulses are just provided by the magnetic sensor inside the TCR encoder.

This object controls the phase shift between channel A and B.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	A/B Phase Shift	Unsigned8	0h	Rw	Yes

Value	Function
0	Channel A before B
1	Channel B before A

The configuration of this object is overtaken regarding output signals only after NMT reset or power cycle.

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	Restore after BootUp
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 Description:

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 Up, 1 = CCW Up)

Code Sequence (CS Bit 0) is hardwired to Code Sequence (CS Bit 0) in object 2100h.

Object 6001h: Measuring units per revolution

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

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

Hardwired with 2101h.

Object 6002h: Total measuring range in measuring units

This object shall indicate the number of distinguishable steps over the total measuring range.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
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	Restore after BootUp
0h	Preset Value	Unsigned 32	0h	rw	yes

Object 6004h: Position value

This object contains the process value of the encoder.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Process Value	Unsigned 32	-	romap	yes

Hardwired with Object 2000h.

Object 6008h: High Resolution Position Value

This object contains a high resolution position value up to 16 bit for single-turn and 31 bit for multi-turn measurement. See type label to get the information about the maximum resolution of your device.

The object 6008h is not influenced by the object 2102h Total resolution or object 6002h Total measuring range, because of their limited data type of unsigned 32 bit.

But object 2101h Resolution per revolution and object 6001h measuring units per revolution will affect the high resolution position value. With object 2103h / 6003h Preset value a desired position can be also set for the high resolution position value, but only within the value range of unsigned 32 bit. With this method the user has a downward compatible device, but also in parallel a device with higher capability of resolution and the existing software in the PLC can be kept.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	High Resolution Position Value	Unsigned 64	-	romap	

Object 6030h: Speed Value

This object contains the speed value of the encoder.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	1h	ro	
1h	Speed value channel1	Integer 16	-	romap	yes

If the velocity exceeds the data type, the speed value is frozen to the maximal possible value.
The customer can use the 3010h (32 bit) object.

Object 6040h: Acceleration Value

This object contains the acceleration value of the encoder.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	1h	ro	
1h	Acceleration value channel1	Integer 16	-	romap	yes

Object 6200h: Cyclic timer

This object contains the value of the event timer of the corresponding TPDOs. The value can be changed between 1-65538 ms.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Cyclic Time	Unsigned 16	64h	rw	yes

The object 6200h is hard-wired to the objects 1800h subindex 5h and 2200h and provide the cycle time for the cyclic mode. (See chapter Cycle Time and Event Timer)

Object 6300h: Cam state register

This object contains the cam state register. The subindices 1h to FEh contain the cam state of channel 1 to 254.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	1h	ro	
1h	Cam state channel 1	Unsigned 8	4h	romap	yes

Object 6301h: Cam enable register

This object contains the cam enable register

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	1h	ro	
1h	Cam enable channel 1	Unsigned 8		rw	yes

Object 6302h: Cam polarity register

This object contains the cam enable register

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	1h	ro	
1h	Cam polarity channel 1	Unsigned 8	0h	rw	yes

List of Cam objects						
6310h			Cam1 low limit		rw	
	0h	VAR	Highest sub-index supported	U32	ro	0x1
	1h	VAR	Cam1 low limit channel1		rw	
6311h			Cam2 low limit		rw	
	0h	VAR	Highest sub-index supported	U32	ro	0x1
	1h	VAR	Cam2 low limit channel1		rw	
6312h			Cam3 low limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam3 low limit channel1		rw	
6313h			Cam4 low limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam4 low limit channel1		rw	
6314h			Cam5 low limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam5 low limit channel1		rw	
6315h			Cam6 low limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam6 low limit channel1		rw	
6316h			Cam7 low limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam7 low limit channel1		rw	
6317h			Cam8 low limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam8 low limit channel1		rw	
6320h			Cam1 high limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam1 high limit channel1		rw	
6321h			Cam2 high limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam2 high limit channel1		rw	
6322h			Cam3 high limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam3 high limit channel1		rw	
6323h			Cam4 high limit		rw	

	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam4 high limit channel1		rw	
6324h			Cam5 high limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam5 high limit channel1		rw	
6325h			Cam6 high limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam6 high limit channel1		rw	
6326h			Cam7 high limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam7 high limit channel1		rw	
6327h			Cam8 high limit		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam8 high limit channel1		rw	
6330h			Cam1 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam1 hyteresis channel1		rw	
6331h			Cam2 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam2 hyteresis channel1		rw	
6332h			Cam3 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam3 hyteresis channel1		rw	
6333h			Cam4 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam4 hyteresis channel1		rw	
6334h			Cam5 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam5 hyteresis channel1		rw	
6335h			Cam6 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam6 hyteresis channel1		rw	
6336h			Cam7 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam7 hyteresis channel1		rw	

6337h			Cam8 hyteresis		rw	
	0h	VAR	Highest sub-index supported	U8	ro	0x1
	1h	VAR	Cam8 hyteresis channel1		rw	

Object 6400h: Area state register

This object contains the area state register

The object provides the actual area status of the encoder position. Figure 9 specifies the object structure and Table 106 specifies the value definition.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Unsigned 8	1h	ro	
1h	Work area state channel	Unsigned 8		romap	yes

7	6	5	4	3	2	1	0
R	r	r	r	r	Range underflow	Range overflow	Out of range
MSB							LSB

Signal	Value	Definition
out of range	0 1	Position between low and high limit Position out of range (refer to module identification object, 650Ah) is reached
range overflow	0 1	No range overflow Position is lower than the position value set in object 6402h „work area low limit“
range underflow	0 1	No range underflow Position is higher than the position value set in object 6401h „work area high limit“
r	0	Reserved

Object 6401h: Work area low limit

This object indicates the position value, at which bit 2 of the according work area state channel in object 6400h shall flag the underflow of the related work area.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Integer 32	1h	ro	
1h	Work area low limit channel 1	Integer 32	0h	rw	yes

This object is hardwired with 2104h (Limit Switch Min).

Object 6402h: Work area high limit

This object indicates the position value, at which bit 1 of the according work area state channel in object 6400h shall flag the overflow of the related work area.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Number of sub indices	Integer 32	1h	ro	
1h	Work area high limit channel 1	Integer 32	0h	rw	yes

This object is hardwired with 2105h (Limit Switch Max).

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	Restore after BootUp
0h	Operating status	Unsigned 16	-	ro	no

The operating status object corresponds to the value of the object 6000h and 2100h.

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	Restore after BootUp
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	Restore after BootUp
0h	Number of Revolutions	Unsigned 16	see type sign	ro	no

Object 6503h: Alarms

Additionally to the emergency messages in /CiA301/, this object shall provide further alarm messages. An alarm shall be set if a malfunction in the encoder could lead to incorrect position value. If an alarm occurs, the according bit shall indicate the alarm til the alarm is cleared and the encoder is able to provide an accurate position value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Alarms	Unsigned 16	-	romap	no

Bit structure of the alarms

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	R	R	CD	PE

Table Description:

MS: Manufacturer Specific Alarm (not supported)

R: Reserved for future use

CD: Commissioning diagnostic control (not supported)

PE: Position Error (not supported)

Object 6504h: Supported alarms

The object shall provide the supported alarms of the device. Please refer to the bit structure table to find more details about the supported alarms.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Supported Alarms	Unsigned 16	1000h	ro	no

The CA-encoder supports the position error alarm.

Object 6505h: Warnings

This object shall provide the warnings. Warnings indicate that tolerance for certain internal parameters of the encoder have been exceeded. In contrast to alarm and emergency messages warnings do not imply incorrect position values. All warnings shall be cleared if the tolerances are again within normal parameters.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Warnings	Unsigned 16	-	romap	no

Bit structure of the warnings

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	RP	BC	OT	CP	LC	FE

Table Description:

MS: Manufacturer Specific Warnings (not supported)
R: Reserved for future use
RP: Reference Point reached/not reached (not supported)
BC: Battery charge (not supported)
OT: Operating Time limit (not supported)
CP: CPU watchdog status (not supported)
LC: Light control reserve (not supported)
FE: Frequency warning (not supported)

Object 6506h: Supported warnings

The object provides the supported warnings of the device. Please refer to the bit structure table to find more details about the supported warnings.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Supported Warnings	Unsigned 16	1000h	ro	no

Currently there are not supported warnings available for an Optocode absolute rotary encoder.
The CA-encoder supports the manufacture specific warning (Bit 12).

Object 6507h: Profile and software version

This object provides the implemented encoder device profile version and the manufacturer-specific software version.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Profile and Software Version	Unsigned 32	04040302h	ro	no

The value is divided into the profile version part and the Software version part. Each part is divided in upper version and lower version.

MSB LSB

Software Version 4.4		Profile Version 3.2	
Upper Software Version	Lower Software Version	Upper Profile Version	Lower Profile Version
04	04	03	02

Object 6508h: Operating time

This object indicates the operating time of the device. Currently the operating time is not supported and the value of this object will always be FFFFFFFFh.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Operatiung time	Unsigned 32	FFFFFFFFh	ro	no

Object 6509h: Offset value

This object contains the offset value. It is been calculated by the preset function and shifts the physical position value with the desired value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Offset value	Integer 32	-	ro	no

Object 650Ah: Module identification

This object shall provide the manufacturer-specific offset value, the manufacturer-specific minimum and maximum position value.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Highest supported subindex	Integer 32	3	ro	no
1h	Manufacturer offset value	Integer 32	-	ro	no
2h	Man. min. position value	Integer 32	-	ro	no
3h	Man. max. position value	Integer 32	-	ro	no

Object 650Bh: Serial number

This object contains the serial number of the device. The serial number is also supported in object 1018h subindex 4h.

Subindex	Description	Data Type	Default Value	Access	Restore after BootUp
0h	Serial Number	Unsigned 32	See type sign	ro	no

6. Diagnosis

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:

- The encoders have the default baud rate 125kbaud. Adapt your PLC setting accordingly.
- Reprogram the encoders baud rate
- Restart encoder so the new baud rate setting will be valid.

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 node has 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 node has the same baud rate. If one node has another baud rate error frames are produced automatically.

6.2.4 Limit switches without function

Problem:
The encoder didn't transmit the bits for the limit switches.

Possible solution:
The limit switch functionality has to be activated once. Please follow the description you can find at 4.5.

6.2.5 Baudrate and Node Number changes

Notice: The changing of baud rate and node number are only valid after a new power up, NMT Reset or the store parameters command.

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.
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. Master "Active" 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.

W

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

Appendix B: List of tables

Appendix C: Document history

Version	Date (ddmmyyyy)	Comment
02/09	03.02.09	Initial version
10/10	05.10.10	Removed entries related to event triggered PDO; added cable gland in type key; Changed default Baudrate to 125 kBaud; added internal termination resistor; Acceleration output is no longer supported
20130328	23.08.2013	changed picture title page, deleted electrical installation because of data sheet specification
20160727	27.07.2016	added quick installation guide and hints about integration into a network. New features for UCD are described compared to former MCD.
20181012	12.10.2018	Added objects 4010h, 4020h for incremental signals. Changed product picture on front page. Overview table for implemented objects added 4010h, 4020h.
20200608	08.06.2020	Figure 5 updated Chapter 1.1.4: additional information in section diverse principle Chapter About Manual: set of documentation Chapter 2.3: deleted product life cycle Chapter 4.1.3: restructured information, update of figure 6 Chapter 4.1.4: added new chapter and take over of some information from chapter 4.1.3. Additional info about influence of environmental conditions and extended functionality.

Version	Date (ddmmyyyy)	Comment
20230105	05.01.2023	Added some information under intended usage, corrected formula for MTTFd calculation figure 4, added chapter for CCF, updated block diagram in figure 1 and figure 2. Updated figure 6 and 7. In Chapter 4.1.4. some minor modifications.