R67042.0002 - 6

Manual

Draw-wire encoder C100
Draw-wire encoder D125

CANopen

pulses for automation

Table of Contents

1 Document

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2 General Information

Please read this document carefully before working with the product, mounting it or starting it up.

2.1 Target Group

The device may only be planned, mounted, commissioned and serviced by persons having the following qualifications and fulfilling the following conditions:

- Technical training.
- Briefing in the relevant safety guidelines.
- Constant access to this documentation.

2.2 Symbols used / Warnings and Safety instructions

⚠ DANGER	**Classification:** This symbol, together with the signal word **DANGER**, warns against immediately imminent threat to life and health of persons. The non-compliance with this safety instruction will lead to death or severe adverse health effects.

⚠ WARNING	**Classification:** This symbol, together with the signal word **WARNING**, warns against a potential danger to life and health of persons. The non-compliance with this safety instruction may lead to death or severe adverse health effects.

⚠ CAUTION	**Classification:** This symbol, together with the signal word **CAUTION**, warns against a potential danger for the health of persons. The non-compliance with this safety instruction may lead to slight or minor adverse health effects.

ATTENTION	**Classification:** The non-compliance with the **ATTENTION** note may lead to material damage.

NOTICE	**Classification:**
	Additional information relating to the operation of the product, and hints and recommendations for efficient and trouble-free operation.

3 Product Description

3.1 Technical Data C100

Measuring range	1 …. 5 m
Measuring wire material	Nylon-coated AISI304 steel wire
Diameter	ø 0.9 mm
Wire fastening	Eyelet
Inside diameter	ø 8 mm
Outside diameter Height	ø 15 mm
Height	2 mm
Max. wire pull-out speed	max. 1 m/s
Acceleration	max. 10 m/s^2
Pull-in force	typ. 2 N
Pull-out force	typ. 8 N
Drum circumference	245 mm
Type of connection	M12 connector, 5-pin
	Cable, 2 m
Housing	Glass fiber reinforced polycarbonate
Protection level	IP67
Temperature range	-40°C ... +85°C

Supply voltage	9 ... 30 V DC, 5 V DC ±10 %
Electromagnetic compatibility	acc. to EN 61326-1, EN 61326-3-1

3.2 Technical Data D125

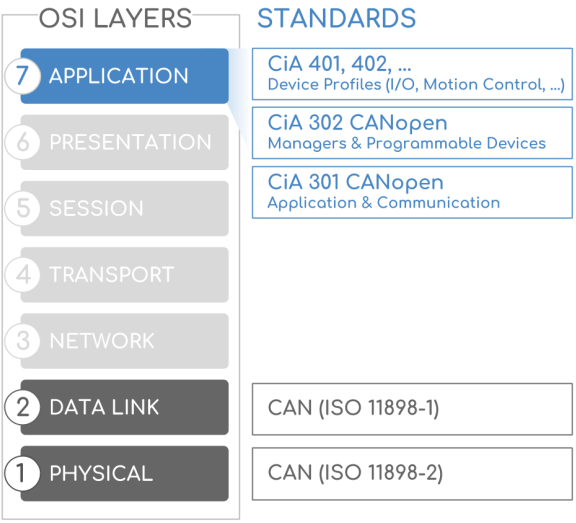
Measuring range	6.0 ... 10.0 m
Measuring wire material	Nylon-coated AISI304 steel wire
Diameter	ø 0.9 mm
Wire fastening	Eyelet
Inside diameter	ø 8 mm
Outside diameter Height	ø 15 mm
Height	2 mm
Max. wire pull-out speed	max. 1 m/s
Acceleration	max. 10 m/s^2
Pull-in force	typ. 4.5 N
Pull-out force	typ. 9 N
Type of connection	M12 connector, 5-pin
Housing	Glass fiber reinforced polycarbonate
Protection level	IP67
Temperature range	-40°C ... +85°C
Weight	approx. 0.97 kg
Shock resistance according to EN 60068-2-27	300 m/s^2, 11 ms
Vibration resistance according to EN 60068-2-6	100 m/s^2, 10 ... 500 Hz

Supply voltage	9 ... 30 V DC, 5 V DC ±10 %
Electromagnetic compatibility	acc. to EN 61326-1, EN 61326-3-1

3.3 Interface Description CANopen

The CANopen protocol is a standardized layer 7 protocol for the CAN bus. The CANopen protocol defines on the one hand the "How" of the communication, that is to say with which telegrams (i.e. identifiers) the devices can be addressed. CANopen implements as well mechanisms for the exchange of process data in real-time as the transmission of large data volumes or the sending of alarm telegrams. On the other hand, CANopen defines the "What" of the communication, that is to say a parameter for setting a device is addressed via a defined interface (profile).

These so-called CANopen profiles are organized in the form of a table (object directory). The so-called "communication profile", which allows querying or setting basic device data, is common to all device profiles. This data includes for example the device designation, the hardware and software version, the error status, the used CAN identifiers and many other parameters. The device profiles describe the specific abilities or parameters of a "class" of devices. So far, device profiles have been defined for digital or analog EIA devices, drives, operating devices, sensors and controllers, programmable controls, encoders, medical technology, local public transport, batteries and extrusion systems. Many other profiles are in preparation.



Source: MicroControl Systemhaus für Automatisierung 2003, Uwe Koppe

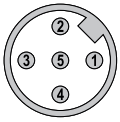
4 Installation

4.1 Electrical Installation

4.1.1 General Information for the Connection

ATTENTION	**Destruction of the device** Before connecting or disconnecting the signal cable, always disconnect the power supply and secure it against switching on again.
NOTICE	**General safety instructions** Make sure that the whole plant remains switched off during the electrical installation. • Make sure that the operating voltage is switched on or off simultaneously for the device and the downstream device. • Use a PELV supply voltage source according to EN 60204-1 with the proper operating voltage and the maximum permissible output current.
NOTICE	**Interference susceptibility** Connect the shield to the encoder housing. Comply with the maximum cable length for stub lines and for the total length of the bus network. If possible, mount all cables with traction relief. Check the maximum supply voltage on the device.

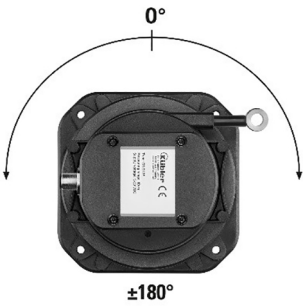
4.1.2 Terminal Assignment

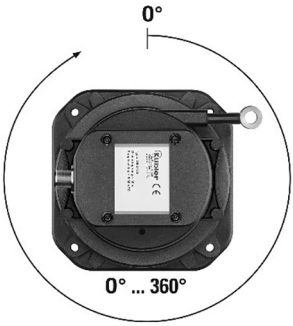
Pin	Description	Pin arrangement, M12 connector
1	CAN-GND	
2	+V	
3	GND (0V)	
4	CAN_H	
5	CAN_L	

4.2 Mechanical Installation

4.2.1 Sensor Orientation

During mechanical installation, take care to the orientation and to the angle range of the sensor.


0°
±180°


0°
0° ... 360°

5 Commissioning and Operation

5.1 Quick Start Guide

5.1.1 Default Settings

All parameters are created as objects in CANopen.

The original standard values (default values at the delivery) can be loaded again with Object 1011h (parameters restoration) and with the command load (0x6C6F6164).

To save modified parameters in a voltage failure-safe manner, they must be transferred in the EEPROM with Object 1010h (save parameters).

All data previously saved in the EEPROM is overwritten.

NOTICE	**Termination**
	The device has no termination. If necessary, termination must be added separately. Termination is recommended even for short lines with low bit rates. Reflections may occur without termination. Ideally, the bus is terminated at both ends (and only there) with 120 ohms.

5.1.1.1 Manufacturer-Specific Objects

Objects - DS406

Index	Name	Access	Type	Standard value	Meaning
0x3000	Baud rate	RW	unsigned8	0x3	250 kbit/s
0x3001	Node address	RW	unsigned8	0x04	
0x3003	Angle direction	RW		0x01	Clockwise (cw)
0x3004	Angle measuring range	RW		0x00	360°
0x3005	Behavior of the redundant angle signals	RW		0x01	Opposite direction
0x3010	Angle zero position	RW		0x00	0
0x5000	Angle	RO		-	Current sensor angle

5.1.2 Network Management Services

The following NMT services are available to the user for parameterizing and commissioning:

Service	COB-ID	DLC	D0	D1
Start remote node	0x000	2	0x01	ID
Stop remote node	0x000	2	0x02	ID
Enter Pre-operational mode	0x000	2	0x80	ID
Reset node	0x000	2	0x81	ID
Reset communication	0x000	2	0x82	ID

For a precise definition of the commands NMT Commands [▶ 18].

NOTICE	**Broadcast**
	If a NMT service is to address all nodes, it is also possible to send 0x00 for D1.

5.1.3 Setting the Baud Rate

The baud rate can be adapted with Object 3000h:

	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Request	0x600 + ID	8	0x2F	0x00	0x30	0x00	BR	0x00	0x00	0x00
Re-sponse	0x580 + ID	8	0x60	0x00	0x30	0x00	0x00	0x00	0x00	0x00

The following baud rates are available to the user:

BR	Baud rate
0	1 Mbit/s
2	500 kbit/s
3	250 kbit/s
4	125 kbit/s
5	100 kbit/s
6	50 kbit/s
7	20 kbit/s
8	10 kbit/s

5.1.4 Setting the Node Address

The node number can be adapted with Object 3001h:

	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Request	0x600 + ID	8	0x2F	0x01	0x30	0x00	Node ID	0x00	0x00	0x00
Re-sponse	0x580 + ID	8	0x60	0x01	0x30	0x00	0x00	0x00	0x00	0x00

NOTICE	**Valid node IDs**
	Node ID‘s in the range 1 … 127 are allowed.

5.2 Protocol Features

5.2.1 CANopen Communication Profile DS 301 V4.02

CANopen uses four communication objects (COB) with various features

1. Process Data Objects (PDO) for real-time data
2. Service Data Objects (SDO) for parameters and program transmission
3. Network Management (NMT, Life-Guarding, Heartbeat)
4. Predefined objects (for synchronization, timestamp, emergency)

All device parameters are saved in an object dictionary. This object dictionary contains the description, data type and structure of the parameters, as well as the address (index).

The directory is divided into the following sections:

- Communication profile
- Device profile
- Manufacturer profile

5.2.2 LSS services DS 305 V2.0

CiA DSP 305 CANopen Layer Setting Service and Protocol (LSS) were created to read and modify the following parameters via the network:

1. Node address
2. Baud rate
3. LSS address

These abilities increase the "plug-and-play" compatibility of the device and the configuration possibilities have been considerably simplified. The LSS master is responsible for the configuration of these parameters for one or several slaves in the network.

LSS hardware requirements (LSS address)

All LSS slaves must have a valid object entry in the objects dictionary for the Identity object [1018h] in order to be able to carry out a selective configuration of the node. This object consists of the following sub-indices:

- Manufacturer ID
- Product code
- Revision number
- Serial number

- LSS master CAN-ID 2021
- LSS slave CAN-ID 2020

A product code, a revision number and a serial number are set by the manufacturer. The LSS address must be unequivocal in the network.

LSS operative restrictions

In order to ensure trouble-free LSS functionality, all devices in the network must support the LSS services. Furthermore, the following applies:

- There can be only one LSS master.
- All nodes must start with the same baud rate.
- LSS communication can only take place in StoppED mode or in Pre-operational mode.

5.2.3 Data Transmission

With CANopen, data is transferred using two different communication types (COB=Communication Object) with different characteristics:

- Process Data Objects (PDO - real-time capable)
- Service Data Objects (SDO)

The Process Data Objects (PDO) are used for highly-dynamic exchange of real-time data with a maximum length of 8 bytes (e.g. encoder position, speed, status of the compared positions) . This data is transferred with high priority (low COB identifier). PDOs are broadcast messages and make their real-time data available simultaneously to all desired recipients. PDOs can be mapped. 4 position bytes and 2 speed bytes can be combined in one 8-byte data word.

The Service Data Objects (SDO) are the communication channel for the transmission of device parameters (e.g. programming of the encoder resolution). As these parameters are transmitted acyclically (e.g. only once when starting the network up), the SDO objects have a low priority (high COB identifier).

5.2.3.1 Process Data Transmission - PDO

Up to three PDO services, PDO1 (tx), PDO2 (tx) and PDO3 (tx) are available for CANopen devices. A PDO transfer can be triggered by various events (see object dictionary Index 1800h):

1. Synchronous pulse, triggered by an internal cyclic device timer (event timer) or by a process value change of the sensor data.
2. Synchronous pulse as an answer to a SYNC telegram.
   A SYNC command prompts all CANopen nodes to save synchronously their values, and to send them subsequently one after the other on the bus according to the set priority)
3. Pulse as a response to an RTR telegram.
   Exactly the message with the transmitted identifier is queried per remote frame (recessive RTR bit).

NOTICE	**PDO combinations**
	Any other PDO combination with other objects is also possible, provided the maximum data length of 8 bits is not exceeded.

5.2.3.2 Service Data Transmission - SDO

DO-COB-ID

The following identifiers are available as a standard for the SDO services:

- SDO (tx) (slave→master): 580h (1408) + node number
- SDO (rx) (master→slave): 600h (1536) + node number

The SDO identifiers cannot be modified.

The command byte describes the type of the SDO message:

Command	Type	Function
0x23	SDO (rx), Initiate Download Request	Send parameters to the device (max. 4 bytes)
0x27	SDO (rx), Initiate Download Request	Send parameters to the device (max. 3 bytes)
0x2B	SDO (rx), Initiate Download Request	Send parameters to the device (max. 2 bytes)
0x2F	SDO (rx), Initiate Download Request	Send parameters to the device (max. 1 byte)
0x60	SDO (rx), Initiate Download Request	Confirmation of the acceptance to the master
0x40	SDO (rx), Initiate Download Request	Request parameters from the device
0x43	SDO (rx), Initiate Download Request	Parameters to master with data length = 4 bytes (unsigned 32)
0x4B	SDO (rx), Initiate Download Request	Parameters to master with data length = 2 bytes (unsigned 16)
0x4F	SDO (rx), Initiate Download Request	Parameters to master with data length = 1 byte (unsigned 8)
0x80	SDO (rx), Initiate Download Request	Device sends error code to master

NOTICE	**Error messages**
	In case of an error, an error message (command 80h) replaces the normal confirmation (response). The error message includes errors in the communication protocol (e. g. wrong command byte) as well as access errors to the objects dictionary (e. g. wrong index, attempt to write a read-only object, wrong data length). The error codes are described in the CANopen profile (DS 301) or in the device profile (DSP 406). See General CANopen Error Codes [▶ 31].

5.2.3.3 PDO Transmission Types

The PDOs can be transmitted in various ways:

Code (dec.)	Transmission type				
	cyclic	acyclic	synchronous	asynchronous	RTR only
0		X	X		
1 … 240	X		X		
241 … 251	reserved				
252			X		X
253				X	X
254				X	
255				X	

Transmission type definition:

0:	After SYNC, but only in the event of a value change since the last SYNC.
1 ... 240:	Send value according to 1. ... 240. SYNC. The number of the transmission type indicates the number of SYNC pulses required to send the PDOs.
252:	SYNC leads to internal saving of the value, but the value must be collected per RTR.
253:	The value is updated and sent upon RTR.
254:	The event is triggered depending on the application, while number 255 is depending on the device. In addition, a time-controlled event timer can be used for number 245/255. The value range for the timer ranges from 1 ms ... 65535 ms.

Acyclic synchronous

PDOs of transmission type 0 operate synchronously, but not cyclically. A device whose TxPDO is configured for transmission type 0 determines its input data when receiving the SYNC (synchronous process image). It then sends the data, if it corresponds to an event such as for example the change of an input. Transmission type 0 combines the reason for triggering the transmission in an "event-driven" way with the sending or processing moment SYNC reception.

Cyclic synchronous

With transmission type 1 … 240, the PDO is sent cyclically after every n-th SYNC (n=1...240). Since the transmission type can be combined not only in the network, but also in a device, it is possible for example to define a fast cycle for positions (n=1), while for example the temperature data is transmitted in a slower cycle (e.g. n=10). The cycle time (SYNC rate) can be monitored (Object 0x1006). In the event of a SYNC failure, the device reacts according to the definition of the device profile and for example switches its outputs in the fault state.

RTR only

Transmission types 252 and 253 apply to process data objects, which are transmitted exclusively upon request by a remote frame. 253 is asynchronous. Data is determined here continuously and sent upon request. This transmission type is not recommended, as some CAN controllers only support partially input data collection. Since some of the CAN controllers answer remote frames automatically (without requesting previously up-to-date input data), the up-to-dateness of the polled data may possibly be doubtful.

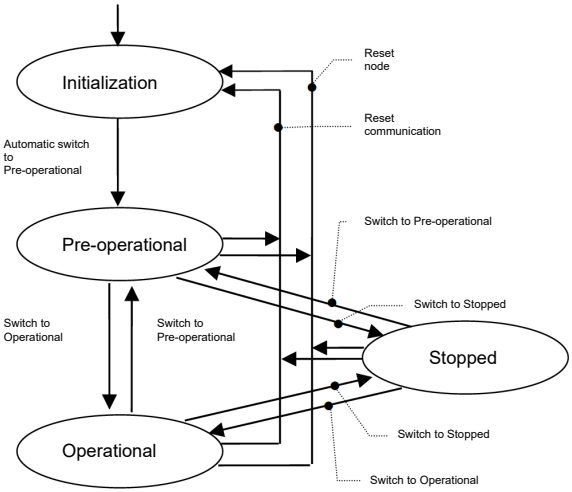
Asynchronous

Transmission types 254 and 255 are asynchronous, or also event-driven. For transmission type 254 the event is defined manufacturer-specifically and in the device profile for transmission type 255. In the simplest case, the event is the change of an input value. Therefore every value change is transmitted. The asynchronous transmission type can be coupled with the event timer

and thus supplies input data also if no event occurred currently. It must be noted for TT 255 that inhibit time > 100 must be set. Otherwise a CAN overrun error may occur, since the position of the last digit is constantly changing.

5.2.4 Network Management

The following status diagram according to DS 301 shows the various node statuses and the corresponding network commands (controlled by the network master via NMT services):



Initialization

After power supply is applied or after a reset, the device is in the original status Initialization. After performing the reset/initialization routines, the node switches automatically to the Pre-operational status. The LEDs display the momentary status.

Pre-operational

The CAN node can now be addressed by SDO messages or NMT commands under the standard identifier. Then follows the programming of the encoder or communication parameters.

Operational

The node is active. Process values are supplied via the PDOs. All NMT commands can be evaluated.

Prepared or Stopped

In this status, the node is no longer active, i.e. neither SDO nor PDO communication is possible. The node can be set to Operational or Pre-operational status by means of NMT commands.

5.2.4.1 NMT Commands

All NMT commands are transferred as an unconfirmed NMT Object. Because of the broadcast (network-wide) communication model, the NMT commands are recognized by each participant.

An NMT Object is structured as follows:

Byte 0	Byte 1
2^7… 2^0	2^{15}… 2^8

COB-ID = 0

Byte 0 = Command byte

Byte 1 = Node number (e.g. 3F or 00 for all participants)

The COB ID of the NMT object is always 0

The node is addressed via the node numbers. With node number 0 all nodes are addressed.

Command byte	Description
01_h	Start_Remote_Node: Switch to Operational
02_h	Stop_Remote_Node: Switch to Prepared
80_h	Enter_Pre-Operational_State: Switch to Pre-operational
81_h	Reset_Node: Reset the node
82_h	Reset_Communication: Reset the communication

All parameters of the whole object dictionary are set to power-on values.

Only the parameters in section Communication profile of the object dictionary are set to power-on values.

5.3 CANopen Object Dictionary

The object dictionary describes the whole range of functions (parameters) of a CANopen device and is organized in the form of a table. The object dictionary not only contains the standardized data types and objects of the CANopen communication profile and the device profiles, but also, if applicable, manufacturer-specific objects and data types.

The description of the object directory entries is structured as follows:

Index (hex)	Sub index (hex)	Object	Name	Type	Attr.	M/O

Index

16-bit address of the entry

Sub index

8-bit pointer to a subentry

- Is only used with complex data structures (e. g. record, array).
- If there is no subentry: Sub index=0.

Object

- NULL entry without data

- DOMAIN larger variable volume of data, e. g. program code
- DEFTYPE data types definition, e. g. boolean, float, unsigned16
- DEFSTRUCT definition of a record entry, e. g. PDO mapping structure
- VAR single data value, e. g. boolean, float, unsigned16, string
- ARRAY field with similar data, e. g. unsigned16 data
- RECORD field with arbitrarily mixed data types

Name

Short description of the function

Type

Data type, e. g. boolean, float, unsigned16, integer

Attribute

Specifies the access rights for the object:

- rw read and write access
- ro only read access
- const only read access, value = constant

M/O

- M Mandatory: The object must be implemented in the device.
- O Optional: The object must not be implemented in the device.

5.3.1 Structure of the object dictionary

The whole object dictionary is subdivided into several areas:

Index range	Use
0000_h	Unused
$0001\text{-}009F_h$	Data types (special case)
$00A0\text{-}0FFF_h$	Reserved
$1000\text{-}1FFF_h$	Communication profile
$2000\text{-}5FFF_h$	Manufacturer-specific area
$6000\text{-}9FFF_h$	Up to 8 standardized device profiles
$A000\text{-}AFFF_h$	Process images of IEC61131 devices
$B000\text{-}BFFF_h$	Process images of CANopen gateways according to CiA 302-7
$C000\text{-}FFFF_h$	Reserved

VAR	Variable
ARRAY	Array of variables
RW	Read/Write
RO	Read only
Const	Constant
Name	Object name
M/O	Mandatory or optional

5.3.2 Communication Objects

Objects - Communication profile

Index	Name	Access	Type	Standard value	Meaning
0x1000	Device type	CONST	Unsigned32	406: Encoders	Sensor Type
0x1001	Error register	RO	Unsigned8	0	Error designation
0x1008	Manufacturer device name	CONST	visible string	Kuebler	Sensor name
0x1009	Manufacturer hardware version	CONST	visible string	1.0	Sensor HW version
0x100A	Manufacturer software version	CONST	visible string	5.x	Sensor SW version
0x1010	Store parameters (device profile)	RW	Unsigned32	-	Store all parameters
0x1011	Restore parameters (device profile)	RW	Unsigned32		Restore default parameters
0x1017	Producer heartbeat time	RW	Unsigned16		
0x1018	Identity Object	RO	PDOComPar	Object 1018h - Identity object [▶ 23]	Manufacturer identification Product code Revision No. Serial No.
0x1800	1st transmit PDO comm. par.	RW	PDOComPar		
0x1801	2nd transmit PDO comm. par.	RW	PDOComPar		
0x1A00	1st transmit PDO mapping par.	RW	PDOMapping		
0x1A01	2nd transmit PDO mapping par.	RW	PDOMapping		

5.3.3 Manufacturer-Specific Objects

Objects - DS406

Index	Name	Access	Type	Standard value	Meaning
0x3000	Baud rate	RW	unsigned8	0x3	250 kbit/s
0x3001	Node address	RW	unsigned8	0x04	
0x3003	Angle direction	RW		0x01	Clockwise (cw)
0x3004	Angle measuring range	RW		0x00	360°
0x3005	Behavior of the redundant angle signals	RW		0x01	Opposite direction
0x3010	Angle zero position	RW		0x00	0
0x5000	Angle	RO		-	Current sensor angle

5.3.4 Device-Specific Objects

Objects - Device parameters DS406

Index	Name	Access	Type	Standard value	Meaning
6020h	Position	RO	unsigned32	-	Current sensor position

5.4 Description of the Objects

5.4.1 Object 1010h Save Parameters

Parameter 1010h saves the desired bus parameters permanently in the flash memory. This object serves as an additional protection against accidental changes of the baud rate and node address.

Only targeted saving with parameter "save“ will save permanently the bus parameters baud rate, node address and termination.

COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
0x600 + ID	8	0x23	0x10	0x10	0x01	0x73	0x61	0x76	0x65

Value range: "save" in hexadecimal 0x65766173

Command bytes: 23 10 10 01 73 61 76 65

Response: 60 10 10 01 00 00 00 00 for successful saving

5.4.2 Object 1011h - Load factory settings

The default values can be restored with a specific command. In order to prevent accidental loading of the standard values, the command is only carried out when the code word string LOAD is entered in this subindex.

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	23	11	10	01	6C	6F	61	64
Response	60	11	10	01	00	00	00	00

Byte 4: 0x6C (ASCII code for L)

Byte 5: 0x6F (ASCII code for O)

Byte 6: 0x61 (ASCII code for A)

Byte 7: 0x64 (ASCII code for D)

5.4.3 Object 1017h Producer Heartbeat Time

This object defines the heartbeat cycle of the CAN device. If this function is not required, time must be set to 0. This function is activated with a time as from 1 ms (max. 65535 ms).

The originator of the request (heartbeat producer) transmits the message cyclically with the set time. The content of the data byte corresponds to the status of the CAN node (Pre-op, Operational, Stopped).

5.4.4 Object 1018h - Identity object

The identity object contains information about the manufacturer and the device:

Sub Index	Designation	Contents
0h	Supported Subindices	4
1h	Vendor ID	Vendor-ID (000000013h) Fritz Kübler GmbH
2h	Product Code	z. B. 0x58682001 CANopen Sensor
3h	Revision Number	Software revision number (e. g. 102) Subindex 4h: "read" only
4h	Serial Number	8-digit serial number of the device

5.4.5 Object 3000h - Baud Rate

This object allows modifying the baud rate by software. As standard, the value is set to FFh, that is to say that the setting shows for LSS a reconfigured node. If the value is set between 0...8 and the parameter is saved using object 1010h, the device will boot with the modified baud rate at the following powering or Reset Node. The currently set baud rate is displayed.

	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Setting	0x600 + ID	8	0x2B	0x00	0x30	0x00	0x03	0x00	0x00	0x00

Data content:

Byte 0
$2^7 \ldots 2^0$

Value	Baud rate in kbit/s
0	1000
2	500
3	250
4	125
5	100
6	50
7	20
8	10

A new node number is only taken over at the following booting (reset/power-on) of the device or via a NMT Reset Node command.
All other settings in the objects table remain retained.

5.4.6 Object 3001h - Node Address

This object allows modifying the node address by software. As standard, the value is set to 0xFFh, that is to say that the setting shows for LSS a reconfigured node. If the value is set between 1...127 and the parameter is saved using object 1010h, the device will boot with the modified node address at the following powering or Reset Node. The currently set address is displayed.

	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Setting	0x600 + ID	8	0x2B	0x01	0x30	0x00	0x29	0x00	0x00	0x00

Data content:

Byte 0
$2^7 \ldots 2^0$

Values range 1 ...127 or 1..7Fh

NOTICE	**Node address 0**
	Node address 0 is reserved and shall not be used by any node. The resulting node numbers are in the range 1...7Fh hexadecimal or 1...127. A new node number is only taken over at the following booting (reset/power-on) of the encoder or via a NMT Reset Node command. All other settings in the objects table remain retained.

5.4.7 Object 3003h - Inclinometer Direction Change

The direction of the inclinometer (cw/ccw) can be modified by Object 3003h.

COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
0x600 + ID	8	0x2F	0x03	0x30	0x00	DR	0x00	0x00	0x00

DR	Direction
0	Counter clockwise (ccw)
1	Clockwise (cw)

5.4.8 Object 3004h - Angle Measurement Range

The angle measurement range is set in Object 3004h. It can be defined as follows:

0x01 = ± 180°

0x00 = 360°

	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
±180°	0x600 + ID	8	0x2F	0x04	0x30	0x00	0x01	0x00	0x00	0x00
360°	0x600 + ID	8	0x2F	0x04	0x30	0x00	0x00	0x00	0x00	0x00

5.4.9 Object 3005h – Behavior of the redundant angle signals

NOTICE	**Redundant angle signals**
	Object 3005h has an effect only if the sensor includes 2 inclinometers, since only the behavior of angle signal <z2> is modified.

Object 3005h allows defining how the two redundant angle signals behave. They can run in the same direction or in opposite directions. For example, in the case of a clockwise angle direction and opposite signals, angle <z1> will increase while <z2> will decrease by the same amount when the sensor is rotated clockwise.

0x01 = opposite angle signals

0x00 = same-direction angle signals

	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Opposite direction	0x600 + ID	8	0x2F	0x05	0x30	0x00	0x01	0x00	0x00	0x00
Same direction	0x600 + ID	8	0x2F	0x05	0x30	0x00	0x00	0x00	0x00	0x00

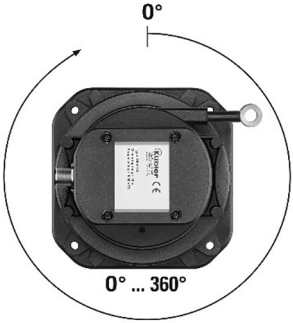
5.4.10 Object 3010h - Setting / resetting the 0° point

The 0° point of the sensor can be set through Object 3010h.

When the command SET is carried out, the sensor takes over its current position with respect to the gravitation vector as 0°.

The command RESET always sets the sensor back to the default setting.

	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Set	0x600 + ID	8	0x2B	0x10	0x30	0x00	0x01	0x00	0x00	0x00
Reset	0x600 + ID	8	0x2B	0x10	0x30	0x00	0x00	0x00	0x00	0x00



5.4.11 Objects not mentioned

All objects not mentioned are used for additional information and can be found in the respective CANopen profile.

5.5 PDO Mapping

PDO-Mapping is the image of the application objects (real-time data) from the object dictionary in the process data objects. The CANopen device profiles provide for every device type a default mapping that is suitable for later applications. The default mapping maps the outputs according to their physical sequence in the transmit process data objects.

The current mapping can be read via the corresponding entries in the object dictionary, the so-called mapping tables. The first position of the mapping table (subindex 0) contains the number of mapped objects, which are listed subsequently. The tables for the TxPDOs are in the object dictionary at index 0x1A00h.

5.5.1 Mapping Parameters - TPDO1-2

Signal	Position	Angle
Mapping	TPD01 1800_h	TPDO2 1801_h
Mapping object	$1A00_h$	$1A01A_h$
Transmission type	Asynchronous	Asynchronous

1800h TPD01 Communication parameters

Sub-index	Name	R/W	Value	Default
0x01	COB-ID	RW	180h + node number	
0x02	Transmission type	RW	255 (asynch)	
0x03	Inhibit time	RW	0 (step 100 µs)	
0x05	Event timer	RW	0 (step 1 ms)	0x64

1801h TPD02 Communication parameters

Sub-index	Name	R/W	Value	Default
0x01	COB-ID	RW	280h + node number	
0x02	Transmission type	RW	255 (asynch)	
0x03	Inhibit time	RW	0 (step 100 µs)	
0x05	Event timer	RW	0 (step 1 ms)	0x00

5.5.2 PDO Mapping Position

Draw-wire encoder C100

Signal	COB-ID	DLC	D0	D1	D2	D3
Position	0x180 + ID	4	0xAA (LSB)	0xAA (MSB)	0xBB (LSB)	0xBB (MSB)

Draw-wire encoder D125

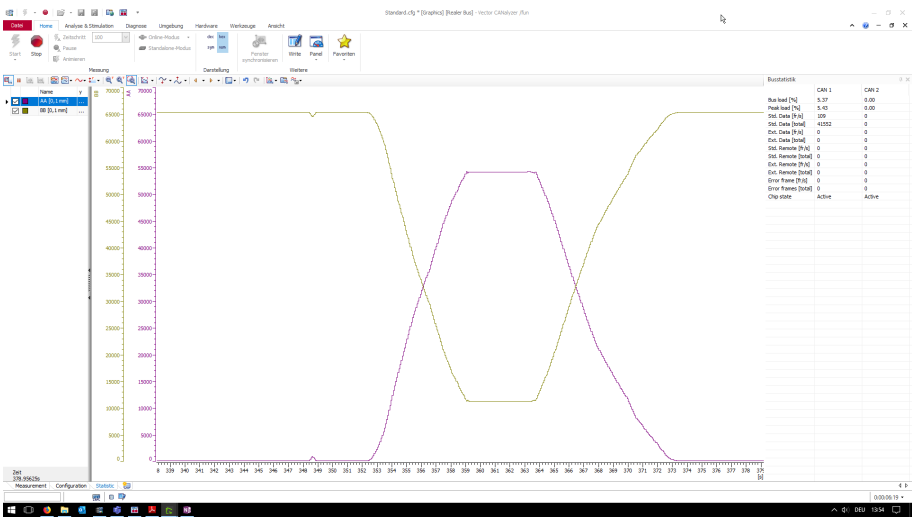
Signal	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Position	0x180 + ID	8	0xAA (LSB)	0xAA	0xAA	0xAA (MSB)	0xBB (LSB)	0xBB	0xBB	0xBB (MSB)

The sensor transmits the signals with a resolution of 0.1 mm. Depending on the sensor type, 2 bytes (C100) or 4 bytes (D125) are available in the PDO.

Position A and B

The suffixes 0xAA and 0xBB represent channels A and B. Channel B is here the negated signal A.

Channel B behaves the same way, but typically in the reverse order. This means that the ZERO position has the value 4700 mm and the end position has the value 0.



Example for a resolution of 0.1 mm:

Signal	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Position	0x180 + ID	8	0x10 (LSB)	0x27	0x00	0x00 (MSB)	0xBB (LSB)	0xBB	0xBB	0xBB (MSB)

P = 0x00002710 (10000 decimal) = 1000 mm

5.5.3 PDO Mapping Angle

Angles Z1 and Z2

The suffixes 0xZ1 and 0xZ2 represent channels Z1 and Z2.

Channel Z2 is here the negated signal Z1.

Draw-wire encoder C100

Signal	COB-ID	DLC	D0	D1	D2	D3
Angle	0x280 + ID	4	0xZ1 (LSB)	0xZ1 (MSB)	0xZ2 (LSB)	0xZ2 (MSB)

Draw-wire encoder D125

Signal	COB-ID	DLC	D0	D1	D2	D3	D4	D5	D6	D7
Angle	0x280 + ID	8	0xZ1 (LSB)	0xZ1 (MSB)	0xZ2 (LSB)	0xZ2 (MSB)	0x00	0x00	0x00	0x00

5.6 Examples

5.6.1 Example: basic parameterizing

Baud rate

✓ Set baud rate to 0x05 through index 3000h subindex 00

a) Perform a power off/power on cycle or a Reset Node

b) Set the network to the new baud rate

⇨ The device is now connected to the bus with the set baud rate

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	23	00	30	00	05	00	00	00
Response	60	00	30	00	00	00	00	00

8 = 10 kBit/s; 7 = 20 kBit/s; 6 = 50 kBit/s; 5 = 125 kBit/s; 4 = 125 kBit/s; 3 = 250 kBit/s; 2 = 500 kBit/s; 0 = 1000 kBit/s

Node address

✓ Set node address to 0x3F through index 3001h subindex 00

a) Perform a power off/power on cycle or a Reset Node

⇨ The device now communicates on the bus with the set node address

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	2F	01	30	00	3F	00	00	00
Response	60	01	30	00	00	00	00	00

Saving all bus objects

Saving all bus objects through index 1010h subindex 01

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	23	10	10	01	73	61	76	65
Response	60	10	10	01	00	00	00	00

Event timer

Setting the position event time to 0xA through index 1800 subindex 05

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	2F	00	18	05	0A	00	00	00
Response	60	00	18	00	00	00	00	00

Setting the angle event timer to 0xa through index 1801 subindex 05

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	2F	01	18	05	0A	00	00	00
Response	60	01	18	00	00	00	00	00

Inclinometer direction

Setting the inclinometer direction to ccw 0x00 through index 3004 subindex 00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	2F	04	30	00	00	00	00	00
Response	60	04	30	00	00	00	00	00

Same-direction angle signals

Setting same-direction angle signals 0x00 through index 3005 subindex 00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	2F	05	30	00	00	00	00	00
Response	60	05	30	00	00	00	00	00

Setting the 0° point

Setting the 0° point 0x01 through index 3010 subindex 00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	2F	10	30	00	01	00	00	00
Response	60	10	30	00	00	00	00	00

Angle measuring range

Setting the angle measuring range to ± 180° through index 3004 subindex 00

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	2F	04	30	00	01	00	00	00
Response	60	04	30	00	00	00	00	00

6 General CANopen Error Codes

Error Code	Description
0x0503 0000	Toggle bit not changed
0x 0504 0000	SDO protocol timeout
0x 0504 0001	Client / server command specifier invalid or unknown
0x 0504 0002	Invalid block size (only block mode)
0x 0504 0003	Invalid sequence number (only block mode)
0x 0504 0004	CRC error (only block mode)
0x 0504 0005	Out of memory
0x 0601 0000	Unsupported access to an object
0x 0601 0001	Attempt to read a write-only object
0x 0601 0002	Attempt to write a read-only object
0x 0602 0000	Object does not exist in the object dictionary
0x 0604 0041	Object cannot be mapped to the PDO
0x 0604 0042	The number and length of the objects to be mapped would exceed PDO length
0x 0604 0043	Reason for parameter incompatibility
0x 0604 0047	General internal incompatibility in the device
0x 0606 0000	Access failed due to hardware error
0x 0607 0010	Data type does not match. Service length parameter does not match
0x 0607 0012	Data type does not match. Service time parameter too high
0x 0607 0013	Data type does not match. Service time parameter too low
0x 0609 0011	Subindex not found
0x 0609 0030	Parameter value range exceeded (only for write access)
0x 0609 0031	Value of parameter written too high
0x 0609 0032	Value of parameter written too low
0x 0609 0036	Maximum value is less than minimum value
0x 0800 0000	General error
0x 0800 0020	Data cannot be transferred or stored to the application
0x 0800 0021	Data cannot be transferred or stored to the application because of local control
0x 0800 0022	Data cannot be transferred or stored to the application because of the current device state
0x 0800 0023	Dynamic generation of the object dictionary fails or no object dictionary present (e.g. object dictionary is generated from file and generation fails because of a file error)

Example of an error code

	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
Request	23	00	50	00	01	00	00	00
Response	80	00	50	00	02	00	01	06

The device sends an error because of the attempt to write Object 0x5000, which can only be read.

7 Annex

7.1 Decimal / Hexadecimal conversion table

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
0	*0*	51	*33*	102	*66*	153	*99*	204	*CC*
1	*1*	52	*34*	103	*67*	154	*9A*	205	*CD*
2	*2*	53	*35*	104	*68*	155	*9B*	206	*CE*
3	*3*	54	*36*	105	*69*	156	*9C*	207	*CF*
4	*4*	55	*37*	106	*6A*	157	*9D*	208	*D0*
5	*5*	56	*38*	107	*6B*	158	*9E*	209	*D1*
6	*6*	57	*39*	108	*6C*	159	*9F*	210	*D2*
7	*7*	58	*3A*	109	*6D*	160	*A0*	211	*D3*
8	*8*	59	*3B*	110	*6E*	161	*A1*	212	*D4*
9	*9*	60	*3C*	111	*6F*	162	*A2*	213	*D5*
10	*0A*	61	*3D*	112	*70*	163	*A3*	214	*D6*
11	*0B*	62	*3E*	113	*71*	164	*A4*	215	*D7*
12	*0C*	63	*3F*	114	*72*	165	*A5*	216	*D8*
13	*0D*	64	*40*	115	*73*	166	*A6*	217	*D9*
14	*0E*	65	*41*	116	*74*	167	*A7*	218	*DA*
15	*0F*	66	*42*	117	*75*	168	*A8*	219	*DB*
16	*10*	67	*43*	118	*76*	169	*A9*	220	*DC*
17	*11*	68	*44*	119	*77*	170	*AA*	221	*DD*
18	*12*	69	*45*	120	*78*	171	*AB*	222	*DE*
19	*13*	70	*46*	121	*79*	172	*AC*	223	*DF*
20	*14*	71	*47*	122	*7A*	173	*AD*	224	*E0*
21	*15*	72	*48*	123	*7B*	174	*AE*	225	*E1*
22	*16*	73	*49*	124	*7C*	175	*AF*	226	*E2*
23	*17*	74	*4A*	125	*7D*	176	*B0*	227	*E3*
24	*18*	75	*4B*	126	*7E*	177	*B1*	228	*E4*
25	*19*	76	*4C*	127	*7F*	178	*B2*	229	*E5*
26	*1A*	77	*4D*	128	*80*	179	*B3*	230	*E6*
27	*1B*	78	*4E*	129	*81*	180	*B4*	231	*E7*
28	*1C*	79	*4F*	130	*82*	181	*B5*	232	*E8*
29	*1D*	80	*50*	131	*83*	182	*B6*	233	*E9*
30	*1E*	81	*51*	132	*84*	183	*B7*	234	*EA*

Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex	Dec	Hex
31	*1F*	82	*52*	133	*85*	184	*B8*	235	*EB*
32	*20*	83	*53*	134	*86*	185	*B9*	236	*EC*
33	*21*	84	*54*	135	*87*	186	*BA*	237	*ED*
34	*22*	85	*55*	136	*88*	187	*BB*	238	*EE*
35	*23*	86	*56*	137	*89*	188	*BC*	239	*EF*
36	*24*	87	*57*	138	*8A*	189	*BD*	240	*F0*
37	*25*	88	*58*	139	*8B*	190	*BE*	241	*F1*
38	*26*	89	*59*	140	*8C*	191	*BF*	242	*F2*
39	*27*	90	*5A*	141	*8D*	192	*C0*	243	*F3*
40	*28*	91	*5B*	142	*8E*	193	*C1*	244	*F4*
41	*29*	92	*5C*	143	*8F*	194	*C2*	245	*F5*
42	*2A*	93	*5D*	144	*90*	195	*C3*	246	*F6*
43	*2B*	94	*5E*	145	*91*	196	*C4*	247	*F7*
44	*2C*	95	*5F*	146	*92*	197	*C5*	248	*F8*
45	*2D*	96	*60*	147	*93*	198	*C6*	249	*F9*
46	*2E*	97	*61*	148	*94*	199	*C7*	250	*FA*
47	*2F*	98	*62*	149	*95*	200	*C8*	251	*FB*
48	*30*	99	*63*	150	*96*	201	*C9*	252	*FC*
49	*31*	100	*64*	151	*97*	202	*CA*	253	*FD*
50	*32*	101	*65*	152	*98*	203	*CB*	254	*FE*
								255	*FF*

8 Contact

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Glossary

Baud Rate

The baud rate is the transmission rate. It is related with the nominal bit timing. The maximum possible baud rate depends on many factors that influence the signal propagation time on the bus. There is a substantial link between the maximum baud rate and the bus length and cable type. Various baud rates are defined between 10 kbit/s and 1 Mbit/s in CANopen.

Bit rate

Ratio of a data volume versus a time period. Measured in bits per second. Bit/s

CAL

CAN Application Layer. Application layer (layer 7) in the CAN communication model

CAN

Controller Area Network

CANopen

CANopen is a CAN-based protocol developed originally for industrial control systems. The specifications include various device profiles as well as the framework for specific applications. CANopen networks are also used in off-road vehicles, marine electronics, medical appliances and trains. The very flexible application layer and the many optional features are ideal for customized solutions. A wide range of configuration tools is moreover available. The user can define on this basis application-specific device profiles. Further information about CANopen can be found in the Internet at the address www.can-cia.org.

ccw

counterclockwise, counting direction

CiA

CAN in Automation. International association of CAN products users and manufacturers

CiA 406

The CANopen device profile 406 describes the standardized interface for incremental and absolute, linear and rotary encoders. It also specifies the safety functions for encoders.

CMS

CAN Message Specification. Service element of CAL

COB

Communication Object. Transport unit in the CAN network (CAN message). Data is sent through the network in a COB.

COB-ID

COB Identifier. Univocal designation of a CAN message. The identifier determines the priority of the COB in the network.

CRC

Cyclic Redundancy Check

cw

clockwise, counting direction

DBT

Distributor. Service element of CAL, responsible for the dynamic allocation of identifiers.

DR

Direction

DS

Draft Standard

DSP

Draft Standard Proposal

EDS File

The EDS (Electronic Data Sheet) file is provided by the manufacturer of a CANopen device. It has a standardized format for the description of devices. The EDS file contains information about: • File description (name, version, creation date, etc.) • General device information (manufacturer name and code) • Device name and type, version, LMT address • Supported baud rates and boot-up capability • Description of the supported objects by their attributes.

ID

Identifier, see COB-ID

LMT

Layer Management. Service element of CAL, responsible for the configuration of the parameters in the various layers of the communication model.

LSB

Least Significant Bit

LSS

Layer Setting Service - Dynamic node number allocation

MSB

Most Significant Bit

NMT

Various tasks are to be performed in a distributed system in connection with the configuration, initialization and monitoring of the network participants. The service element "Network Management (NMT)" defined in CANopen provides this functionality.

Node number

Within a CanOpen network, every device is defined by its node number (node ID). The permissible node numbers are in the range of 1-127 and can only be used once within a network.

OSI

Open Systems Interconnection. Layers model for describing the functional areas in a data communication system.

PDO

The process data objects (PDO) are the actual means of transport for the transfer of process data (application objects). A PDO is sent by a producer and can be received by one or several consumers.

PDO Mapping

The size of a PDO can reach 8 bytes. It can be used to transport several application objects. The PDO mapping describes the arrangement of the application objects within the data field of the PDO.

RTR

Remote Transmission Request; data request telegram

SDO

Service data objects (SDO) are used for the confirmed transfer of data of any length between two network participants. Data transfer takes place in client-server mode.

SYNC

Synchronization telegram Bus participants answer the SYNC command with their process value.

TPDO

Transmit PDO. A PDO transmitted via a CANopen device.

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