Content

5 CANopen

This document reflects the Novotechnik sensor protocol implementation of the standard CANopen protocol.
A basic knowledge of the CAN Bus is required for a proper understanding of this document.
Most of the definitions made are according to the following CiA Standard specifications.
For making use of all the features that these specifications offer, a knowledge about them is absolutely necessary.
The sensor supports the CANopen Communication profile DS-301, V4.2.0, Encoder profile DSP-406, V3.2 and Layer Setting Services (LSS) DSP-305, V1.1.2.

5.1 EDS Files

For integration in a common CANopen projecting tool, electronic data sheet (*.eds) files are provided.
These files can be downloaded from the Novotechnik Web Site, see Downloads/Operating manuals where also this document can be found.

⇨ **Electric data sheet see file RFC48.eds**

5.2 Features

5.2.1 Basic information

Vendor ID: 386 = 0x0182 (Novotechnik)
Product code: 03040 = 0x0BE0
Rev.-No.: f.e 65539 = 0x10003, see product label “XXXXX” (5 characters)
Serial No.: see product label, “B/N XXXXXX/YYY” (6+3 characters)

5.2.2 Basics based on CiA DS-301, V4.2.0

CAN Identifier	Standard 11 bit according to pre-defined connection set: Services — COB-ID NMT — 0x00 SYNC — 0x080 EMCY — 0x080 + Node-ID PDO1 (Tx) — 0x180 + Node-ID PDO2 (Tx) — 0x280 + Node-ID SDO (Rx) — 0x600 + Node-ID SDO (Tx) — 0x580 + Node-ID
CAN Bit rates	Bit rate is defined in the ordering code: 6_7: 50 kBaud 6_5: 125 kBaud 6_4: 250 kBaud 6_3: 500 kBaud 6_2: 800 kBaud 6_1: 1000 kBaud setting per LSS *(see chapter 5.5 LSS / Layer Setting Service)* or object 0x2001 *(see chapter 5.6 SDO Services)*
Node-ID	0x7F setting per LSS *(see chapter 5.5 LSS / Layer Setting Service)* or object 0x2001 (see chapter *5.6 SDO Services)*
SYNC	Consumer
Time Stamp	no
Emergency Messages	Producer
Node Guarding	yes
Heartbeat	Producer
Non-volatile storage	yes
Program Download	no
NMT Service	Slave

5.2.3 Basics based on CiA DSP-406, V3.2

Encoder class	☐ C1 ☒ C2
Encoder type	Absolute Rotary Multi Sensor Encoder Interface
Max. bit bandwidth of position value	14 bit
Encoder Cams Channels to be detected Cams per channel Polarity Hysteresis	 Pos.ch1, Pos.ch2 4 invertable yes
Work Area Supervision channels	 Pos.ch1, Pos.ch2

5.2.4 Basics SDO communication

SDO communication	1 Server
expedited transfer	yes
segmented transfer	no
Block transfer	no

5.2.5 Basics PDO communication

PDO communication principle	Producer	
TPDO's	TPDO1: TPDO2:	asynchronous with Event Timer, synchronous synchronous
PDO Mapping	dynamic	
max. PDO Mapping logs per PDO	5	

5.3 Object Library

5.3.1 Communication Profile Area based on DS 301 V4.2.0

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
1000	device type	unsigned32	const	no	0x00010196	Device profile 406 multi-sensor encoder interface
1001	error register	unsigned8	ro	no	0x00	See chapter *5.8 Error Handling*
1002	manufacturer status register	unsigned32	ro	no	0	Additional manufacturer spec. status register
1005	COB-ID SYNC	unsigned32	rw	no	0x00000080	COB-ID SYNC message (CAN-identifier)
1008	manufacturer device name	visible_ string	const	no	f.e. RFC-4801-214-614-511	Device name, see datasheet/ordering code
1009	manufacturer hardware version	visible_ string	const	no	f.e. V 1.00	Hardware version release
100A	manufacturer software version	visible_ string	const	no	f.e. V 1.03	Software version release
100C	guard time	unsigned16	rw	no	0x00000000 disabled	Time base (in ms), which gives combined with 100D the time in which the response of the node guard is expected
100D	life time factor	unsigned8	rw	no	0x00000000 disabled	The life time factor multiplied with the guard time gives the life time for the device.
1010	store parameter field	unsigned32				This entry supports saving of parameters in non volatile memory. With a read access the device provides information about its saving capabilities. **For saving the signature "save" (0x65766173) must be written.**
1010/1	store parameter field	unsigned32	rw	no	0x00000000	Save all parameters
1010/2		unsigned32	rw	no	0x00000000	Save communcation parameters
1010/3		unsigned32	rw	no	0x00000000	Save application parameters
1010/4		unsigned32	rw	no	0x00000000	Save manufacturer defined parameters
1011	restore default parameters	unsigned32				This entry supports restoring of default parameters. With a read access the device provides information about its capabilities to restore these values. **For restoring the signature "load" (0x64616f6c) must be written.**
1011/1		unsigned32	rw	no	0x00000000	Restore all default parameters
1011/2		unsigned32	rw	no	0x00000000	Restore communication default parameters
1011/3		unsigned32	rw	no	0x00000000	Restore application default parameters
1011/4		unsigned32	rw	no	0x00000000	Restore manufacturer defined parameters
1014	COB-ID EMCY	unsigned32	ro	no	0x00000080 + Node-ID	COB-ID used for emergency message (Emergency Server).
1017	producer heartbeat time	unsigned16	rw	no	0x00000000 disabled	Heartbeat time periode in ms. Range 0...0xFFFF
1018	identify object	identity				General information about the device. This information is also used as the LSS address when using “switch mode selective” command
1018/1		unsigned32	ro	no	0x00000182	Vendor ID
1018/2		unsigned32	ro	no	0x0 *(see 5.2.1Basic information)*	Product code
1018/3		unsigned32	ro	no	*(see 5.2.1Basic information*)	Revision number
1018/4		unsigned32	ro		*(see 5.2.1Basic information)*	Serial number

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
1800	transmit PDO communication parameter 1	PDO_COMM _PAR				It contains the communication parameters of the current PDO the device is able to transmit.
1800/1		unsigned32	rw	no	0x40000180 + Node ID	COB-ID of the PDO
1800/2		unsigned8	rw	no	0xFE =254	Transmission type, asynchronous 254, synchronous 1...239 acc. CiA DS 301
1800/3		unsigned16	rw	no	0x0	Inhibit Time in 100µs
1800/4		unsigned8	rw	no	0x00	Compatibility entry
1800/5		unsigned16	rw	no	0x0 disabled	Event timer in ms Range 1...65535
1801	transmit PDO communication parameter 2	PDO_COMM _PAR				It contains the communication parameters of the current PDO the device is able to transmit.
1801/1		unsigned32	rw	no	0x40000280	COB-ID of the PDO
1801/2		unsigned8	rw	no	0x1	Transmission type, synchronous
1801/3		unsigned16	rw	no	0x0	Inhibit Time in 100µs
1A00	TPDO mapping parameter 1	PDO_ MAPPING				Contains the mapping for the PDOs the device is able to transmit
1A00/0		unsigned8	rw	no	0x02	Number of entries
1A00/1		unsigned32	rw	no	0x60200120	Mapping entry 1, default: Position value channel 1
1A00/2		unsigned32	rw	no	0x60200220[1)] 0x60300120[2)]	Mapping entry 2, default: Position value channel 2 [1)] default: Speed value channel 1 [2)]
1A00/3		unsigned32	rw	no	0x00000000	Mapping entry 3
1A00/4		unsigned32	rw	no	0x00000000	Mapping entry 4
1A00/5		unsigned32	rw	no	0x00000000	Mapping entry 5
1A01	TPDO mapping parameter 2	PDO_ MAPPING				Contains the mapping for the PDOs the device is able to transmit
1A01/0	TPDO mapping parameter 2	unsigned8	rw	no	0x02	Number of entries
1A01/1		unsigned32	rw	no	0x60200120	Mapping entry 1, default: Position value channel 1
1A01/2		unsigned32	rw	no	0x60200220[1)] 0x60300120[2)]	Mapping entry 2, default: Position value channel 2 [1)] default: Speed value channel 1 [2)]
1A01/3		unsigned32	rw	no	0x00000000	Mapping entry 3
1A01/4		unsigned32	rw	no	0x00000000	Mapping entry 4
1A01/5		unsigned32	rw	no	0x00000000	Mapping entry 5
1F80	NMT startup	unsigned32	rw	no	0x0	This object determines the startup behavior of a device in the network. Bit 3 set: sensor starts in operational mode

[1)] for one-channel version
[2)] for two-channel version

5.3.2 Device Profile Area

* for one-channel version: default value 0x01
** for one-channel version: not available

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
6000	operating parameter	unsigned16	rw	no	0x0	This object contains the functions for code sequence, commissioning diagnostic control and scaling function control
6001	measuring units per revolution	unsigned32	rw	no	0x4000	Object sets the number of distinguishable steps per revolution (singleturn resolution)
6002	total measuring range in measuring units	unsigned32	rw	no	0x4000	Object sets the number of distinguishable steps over the total measuring range (total resolution)
6010	preset value	integer32				This object supports adaption of the encoder zero point to the mechanical zero point of the system
6010/0			ro	no	0x02*	Number of available channels
6010/1		integer32	rw	no	0x0	Preset value channel 1
6010/2		integer32	rw	no	0x0**	Preset value channel 2
6020	position value	integer32				This object defines the output position value
6020/0			ro	no	0x2*	Number of available channels
6020/1		integer32	ro	**yes**	0x0	Position value channel 1
6020/2		integer32	ro	**yes**	0x0**	Position value channel 2
6030	speed value	unsigned				This object defines the output speed value
6030/0			ro	no	0x2*	Number of available channels
6030/1		integer16	ro	**yes**	0x0	Speed value channel 1
6030/2		integer16	ro	**yes**	0x0**	Speed value channel 2
6200	cyclic timer value	unsigned16	rw	no	0x0	defines the transmission period (in ms) for asynchronous PDO, mapped to object 0x1800/5
6300	CAM state register	unsigned8				defines the status bit of the cam in a cam channel. The bit value 0 means "cam inactive". The bit value 1 means "cam active". If the polarity bit of a cam is set the actual cam state will be inverted.
6300/0			ro	no	0x2*	Number of available channels
6300/1		unsigned8	ro	**yes**	0x0	CAM state channel 1
6300/2		unsigned8	ro	**yes**	0x0**	CAM state channel 2
6301	CAM enable	unsigned8				This object contains the calculation state for 4 cams for one position channel. If the enable bit is set to 1, the cam state will be calculated by the device. In the other case the cam state of the related cam will be set permanently to 0.
6301/0	CAM enable		ro	no	0x2*	Number of available channels
6301/1		unsigned8	rw	no	0x0	CAM enable channel 1
6301/2		unsigned8	rw	no	0x0**	CAM enable channel 2
6302	CAM polarity register	unsigned				This object contains the actual polarity settings for 4 cams for one position channel. If the polarity bit is set to 1, the cam state of an active cam will signal by setting the related cam state bit to zero. In the other case the cam state of the related cam will not be inverted.
6302/0			ro	no	0x2*	Number of available channels
6302/1		unsigned8	rw	no	0x0	CAM polarity channel 1
6302/2		unsigned8	rw	no	0x0**	CAM polarity channel 2
6310	CAM 1 low limit	integer32				determines the lower limit of position for cam 1
6310/0			ro	no	0x2*	Number of available channels
6310/1		integer32	rw	no	0x00	CAM 1 low limit channel 1
6310/2		Integer32	rw	no	0x00**	CAM 1 low limit channel 2

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
6311	CAM 2 low limit	integer32				determines the lower limit of position for cam 2
6311/0			ro	no	0x2*	Number of available channels
6311/1		integer32	rw	no	0x00	CAM 2 low limit channel 1
6311/2		Integer32	rw	no	0x00**	CAM 2 low limit channel 2
6312	CAM 3 low limit	integer32				determines the lower limit of position for cam 3
6312/0			ro	no	0x2*	Number of available channels
6312/1		integer32	rw	no	0x00	CAM 3 low limit channel 1
6312/2		Integer32	rw	no	0x00**	CAM 3 low limit channel 2
6313	CAM 4 low limit	integer32				determines the lower limit of position for cam 4
6313/0			ro	no	0x2*	Number of available channels
6313/1		integer32	rw	no	0x00	CAM 4 low limit channel 1
6313/2		Integer32	rw	no	0x00**	CAM 4 low limit channel 2
6320	CAM 1 high limit	integer32				determines the higher limit of position for cam 1
6320/0			ro	no	0x2*	Number of available channels
6320/1		integer32	rw	no	0x3FFF	CAM 1 high limit channel 1
6320/2		Integer32	rw	no	0x3FFF**	CAM 1 high limit channel 2
6321	CAM 2 high limit	integer32				determines the higher limit of position for cam 2
6321/0			ro	no	0x2*	Number of available channels
6321/1		integer32	rw	no	0x3FFF	CAM 2 high limit channel 1
6321/2		Integer32	rw	no	0x3FFF**	CAM 2 high limit channel 2
6322	CAM 3 high limit	integer32				determines the higher limit of position for cam 3
6322/0			ro	no	0x2*	Number of available channels
6322/1		integer32	rw	no	0x3FFF	CAM 3 high limit channel 1
6322/2		Integer32	rw	no	0x3FFF**	CAM 3 high limit channel 2
6323	CAM 4 high limit	integer32				determines the higher limit of position for cam 4
6323/0			ro	no	0x2*	Number of available channels
6323/1		integer32	rw	no	0x3FFF	CAM 4 high limit channel 1
6323/2		Integer32	rw	no	0x3FFF**	CAM 4 high limit channel 2
6330	CAM 1 hysteresis	unsigned16				This object contains the delay setting of switch points for cam 1
6330/0			ro	no	0x2*	Number of available channels
6330/1		unsigned16	rw	no	0x0	CAM 1 hysteresis channel 1
6330/2		unsigned16	rw	no	0x0**	CAM 1 hysteresis channel 2
6331	CAM 2 hysteresis	unsigned16				This object contains the delay setting of switch points for cam 2
6331/0			ro	no	0x2*	Number of available channels
6331/1		unsigned16	rw	no	0x0	CAM 2 hysteresis channel 1
6331/2		unsigned16	rw	no	0x0**	CAM 2 hysteresis channel 2
6332	CAM 3 hysteresis	unsigned16				This object contains the delay setting of switch points for cam 3
6332/0			ro	no	0x2*	Number of available channels
6332/1		unsigned16	rw	no	0x0	CAM 3 hysteresis channel 1
6332/2		unsigned16	rw	no	0x0**	CAM 3 hysteresis channel 2
6333	CAM 4 hysteresis	unsigned16				This object contains the delay setting of switch points for cam 4
6333/0			ro	no	0x2*	Number of available channels
6333/1		unsigned16	rw	no	0x0	CAM 4 hysteresis channel 1
6333/2		unsigned16	rw	no	0x0**	CAM 4 hysteresis channel 2
6400	area state register	unsigned8				This object contains the actual area status of the encoder position. Bit meaning 0 out of range 1 range overflow 2 range underflow
6400/0			ro	no	0x2*	Number of available work areas
6400/1		unsigned8	ro	**yes**	0x0	Work area state channel 1
6400/2		unsigned8	ro	**yes**	0x0**	Work area state channel 2
6401	work area low limit	integer32				This object contains the lower limit of the work area
6401/0			ro	no	0x2*	Number of available work areas
6401/1		integer32	rw	no	0x00	Low limit work area 1
6401/2		integer32	rw	no	0x00**	Low limit work area 2

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
6402	work area high limit	integer32				This object contains the higher limit of the work area
6402/0			ro	no	0x2*	Number of available channels
6402/1		integer32	rw	no	0x3FFF	High limit work area 1
6402/2		integer32	rw	no	0x3FFF**	High limit work area 2
6500	operating status	unsigned16	ro	no	0x0	This gives information on encoder internal programmed parameters.
6501	measuring units per resolution	unsigned32	ro	no	0x4000	This object gives the number of steps per revolution that are output for the absolute singleturn position value.
6502	number of distinguishable revolutions	unsigned16	ro	no	Singleturn: 0x1 Multiturn: f.e 0x16	This object contains the number of distinguishable revolutions that the multiturn-encoder can output. f.e. Multiturn with 16 revolutions
6503	alarms	unsigned16	ro	**yes**	0x0	This object shows, which alarm is active
6504	supported alarms	unsigned16	ro	no	0x1001	This object informs on alarms supported by the encoder
6505	warnings	unsigned16	ro	**yes**	0x0	This object reports warnings.
6506	supported warnings	unsigned16	ro	no	0x1000	This object informs on warnings supported by the encoder
6507	profile and software version	unsigned32	ro	no	f.e. 0x01020302	This object reports the versions: byte 3-2: software version byte 1-0: profile version
650C	offset value	integer32				The offset value is calculated by the preset function in object 6010 and shifts the position value with the calculated value. The offset value is stored and can be read from the encoder for diagnostics.
650C/1		integer32	ro	no	0x0	Offset value channel 1
650C/2		integer32	ro	no	0x0	Offset value channel 2

* for one-channel version: default value 0x01
** for one-channel version: not available

5.3.3 Manufacturer specific Area

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
2000	node-ID	unsigned8	rw	no	0x7F	Node-ID of the sensor Range 1...127
2001	CAN bit rate	unsigned16	rw	no	See datasheet/ odering code f.e. 250=0x03	CAN bit rate of the sensor in kbit/s f.e. RFC-4801-214-614-511 250kBaud
2002	chip temperature	integer16	ro	**yes**	f.e. 37	Temperature from inside the µC in Celsius f.e. at ambient temperature
2003	ordering	unsigned16				Manufacturer defined array
2004	custom	unsigned16				Manufacturer defined array, not writable for the customer

5.4 Explanations to Object Library

5.4.1 Object 0x6000 Operating Parameter

This object contains the function for **the counting direction.**
The counting direction clockwise (cw) or counterclockwise (ccw) is defined whether the signal values are rising or falling when sensor shaft or position marker is rotated cw (view on the position marker or shaft).

Bit 0 = 0: counting direction cw
Bit 0 = 1: counting direction ccw

This object also includes the **switching on and off of the scaling function**, which is required to change the sensor resolution.

Bit 2 = 0: scaling off
Bit 2 = 1: scaling on (further scaling is done by objects 0x6001 or 0x6002)

This object also includes the **moving average function for position and speed calculation:**

Bit 14...12 = 0: moving average function off
Bit 14...12 = n: moving average over 2^n values (n= 1...7)

5.4.2 Object 0x6001 Measuring Step per Revolution

This object sets the number of distinguishable steps per revolution.
Writing is only possible if scaling (0x6000 / Bit 2) is on. Changes of this objects also changes object 0x6002.
The default value is 0x3FFF (14bit) is the maximum step size per revolution. The resolution can only be reduced.

5.4.3 Object 0x6002 Total Measuring Range in measuring units

This object sets the number of distinguishable steps over the total measuring range. Writing is only possible if scaling (0x6000 / Bit 2) is on. Changes of this objects also changes object 0x6001.
The default value is 0x3FFF (14bit) is the maximum total step size. The resolution can only be reduced.

5.4.4 Object 0x6300 Encoder Cams

Encoder cams are used to indicate if a position falls below or exceeds a defined value.

5.4.5 Cam state registers

Cam active: the current position value is between the higher and lower cam-limit
Cam inactive: the current position value is not between the higher and lower cam-limit.

The values for low limit (0x631x) and high limit (0x632x) regard the values for preset (0x6010) and measuring units per resolution (0x6001). The value of hysteresis (0x633x) is added in direction of motion.

Note: The cam high limit value can have a lower value than the cam low limit

A change in cam state causes an EMCY message.
The cam state objects (0x6300) are able to be mapped to the TPDOs.

5.4.6 Object 0x6400 Work Area

It is possible for encoders to define a so-called user defined working area.
The main purpose for a work area is to get a high-priority information (via EMCY message) when the transducer's position leaves its predefined working area.
The actual work area information with work area low limit and work area high limit may be stored in object 0x6401 and 0x6402. This way, the area state object (0x6400) may also be used as software limit switches.

5.4.6.1 Work Area Supervision

5.4.6.2 Work Area State

Condition	**State register 0x6400**
Position < Work Area Low Limit Position >= Work Area Low Limit	Bit 2 = 1 Bit 2 = 0
Position > Work Area High Limit Position <= Work Area High Limit	Bit 1 = 1 Bit 1 = 0
Position <= Preset Value or Position >= Sensor length otherwise	Bit 0 = 1 Bit 0 = 0

The values for low limit (0x6401) and high limit (0x6402) regard the values for preset (0x6010) and scaling (0x6501, 0x6502).

A change in work area state causes an EMCY message.
The work area state objects (0x6400) are able to be mapped to the TPDOs.

5.5 LSS / Layer Setting Service

To configure the encoder via the LSS (according CiA DS 305) the encoder is handled as a slave, the PLC must have a LSS master functionality.

A LSS-message is composed as follows:

COB-ID	DLC	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6

This applies to the COB-ID:
- LSS-Master ⇒ LSS-Slave: 2021 (0x7E5)
- LSS-Slave ⇒ LSS-Master: 2020 (0x7E4)

LSS can only be used when the encoder is in the stopped status or pre-operational status.
The NMT command for setting the encoder in stopped status is:

COB-ID	DLC	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x7E5	8	0x04	0x00	0x00	0x00	0x00	0x00	0x00	0x00

To program via LSS the sensor has to be switched to LSS configuration state.
There are two possible ways to do so:

- **Switch Mode Selective**:

only the addressed CANopen device is switched to the LSS configuration state

LSS requires data content in the following objects:

Example:

Vendor-ID	(see index 1018/1)	0x0182	LSS-Command 0x40
Product code	(see index 1018/2)	0x0BE0	LSS-Command 0x41
Rev.No.	(see index 1018/3)	0x10003	LSS-Command 0x42
Serial-No.	(see index 1018/4)	0x12345678	LSS-Command 0x43

After receiving the identification objects, the encoder answers with LSS-Command **0x44**.

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x7E5	8	Rx	0x40	0x82	0x01	0x00	0x00	0x00	0x00	0x00
0x7E5	8	Rx	0x41	0xE0	0x0B	0x00	0x00	0x00	0x00	0x00
0x7E5	8	Rx	0x42	0x03	0x00	0x01	0x00	0x00	0x00	0x00
0x75E	8	Rx	0x43	0x78	0x56	0x34	0x12	0x00	0x00	0x00
0x7E4	8	Tx	0x44	0x00	0x00	0x00	0x00	0x00	0x00	0x00

• **Switch Mode Global:** all CANopen devices supporting LSS are switched to the LSS configuration state

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x7E5	8	Rx	0x04	0x82	0x01	0x00	0x00	0x00	0x00	0x00

When the CAN devices are in configuration state the Node-ID and/or the baud rate can be changed.

5.5.1 Configuration of Node-ID

The Node-ID can be programmed with the LSS-Command **0x11**
N ID: new Node-ID in the range of 1...127
Err Code: 0: protocol successfully completed / 1: Node-ID out of range

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x7E5	8	Rx	0x11	N ID	0x00	0x00	0x00	0x00	0x00	0x00
0x7E4	8	Tx	0x11	Err Code	0x00	0x00	0x00	0x00	0x00	0x00

Change of Node-ID will cause:
- Automatic alteration of COB-ID's for SDO1, EMCY and Heartbeat and TPDOs.
- Non-volatile Node-ID storage through „Store Configuration" in the LSS mode configuration.

5.5.2 Configuration of Bit Rate

The Bit Rate can be programmed with LSS-Command **0x13**
Table Index: 0x06: 50 kBaud
0x04: 125 kBaud
0x03: 250 kBaud
0x02: 500 kBaud
0x01: 800 kBaud
0x00: 1000 kBaud
Err Code: 0: protocol successfully completed 1: Bit timing not supported

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x75E	8	Rx	0x13	Table Index	0x00	0x00	0x00	0x00	0x00	0x00
0x74E	8	Tx	0x13	Err Code	0x00	0x00	0x00	0x00	0x00	0x00

Change of Bit rate will cause:
- The bit rate gets active
- Non-volatile CAN bit rate storage through „Store Configuration" in the LSS mode configuration

5.5.3 Store Configuration Data

The LSS configuration data (Node-ID and Bit Rate) are stored to the non-volatile memory of the sensor using LSS-Command **0x17**

Err Code: 0: protocol successfully completed 2: storage media access error

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x75E	8	Rx	0x17	0x00	0x00	0x00	0x00	0x00	0x00	0x00
0x74E	8	Tx	0x17	Err Code	0x00	0x00	0x00	0x00	0x00	0x00

5.6 SDO Services

Service Data Objects SDO (according to CiA DS 301) manage the parameter data exchange, e.g. the non-cyclical execution of the preset function.

Parameters of device object library (object index/subindex see chapter *5.3 Object Library*) can be read, written or stored by means of SDO.

5.6.1 SDO Download

The SDO download service is used to configure the parameters.

Command 0x2_: 0x22 write command, parameter to encoder
0x23 write command, 4 Byte parameter to encoder
0x27 write command, 3 Byte parameter to encoder
0x2B write command, 2 Byte parameter to encoder
0x2F write command, 1 Byte parameter to encoder
Command 0x60: confirmation: parameter received

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x600+Node-ID	8	Rx	0x2_	Index		Sub-index	Data LSB	Data	Data	Data MSB
0x580+Node-ID	8	Tx	0x60	Index		Sub-index	0x00	0x00	0x00	0x00

Example: object index 0x1010 subindex 01 “store all parameters”

0x600+Node-ID	8	Rx	0x23	0x10	0x10	0x01	0x73	0x61	0x76	0x65
0x580+Node-ID	8	Tx	0x60	0x10	0x10	0x01	0x00	0x00	0x00	0x00

Example: object index 0x1011 subindex 01 “restore all parameters”

0x600+Node-ID	8	Rx	0x23	0x11	0x10	0x01	0x6C	0x6F	0x61	0x64
0x580+Node-ID	8	Tx	0x60	0x11	0x10	0x01	0x00	0x00	0x00	0x00

Example: object index 0x2000 subindex 01 “set new node-ID” with 64

0x600+Node-ID	8	Rx	0x23	0x00	0x20	0x80	0x00	0x00	0x00	0x00
0x580+Node-ID	8	Tx	0x60	0x00	0x20	0x01	0x00	0x00	0x00	0x00

NODE-ID
Using writing to object 0x2000, non-volatile storage has to be done by writing the“save”- signature (0x65766173) on object 0x1010/1. These changes will become effective after a communication restart or a power up.
Changing the Node-ID will affect all COB-IDs according to the “predefined connection set”.
Example: COB-ID TPDO1 = 0x180 + (Node-ID)

BIT-RATE
Using writing to object 0x2001; non-volatile storage has to be done by writing the“save”- signature (0x65766173) on object 0x1010/1. These changes will become effective after a communication restart or a power up.

5.6.2 SDO Upload

The SDO upload service is used to read the parameters.

Command 0x40: read command, parameters from encoder
Command 0x4_: 0x42 read command, parameter to encoder
0x43 read command, 4 Byte parameter to encoder
0x47 read command, 3 Byte parameter to encoder
0x4B read command, 2 Byte parameter to encoder
0x4F read command, 1 Byte parameter to encoder

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x600+Node-ID	8	Rx	0x40	Index		Sub-index	0x00	0x00	0x00	0x00
0x580+Node-ID	8	Tx	0x4_	Index		Sub-index	Data LSB	Data	Data	Data MSB

5.6.3 SDO Abort

If the SDO download or SDO upload service fails for any reason, the sensor responds with a SDO abort protocol.

Abort Code: 0x06090011 subindex does not exist
0x06090030 value exceeded
0x06020000 object does not exist
0x06010001 object is write only
0x06010002 object is read only
0x08000020 data transport error
0x08000000 general error
0x08000022 wrong state

COB-ID	DLC	Rx/ Tx	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6
0x580+Node-ID	8	Tx	0x80	Index		Sub-index	Abort code			

5.7 Process Data PDO

Process Data Objects (according CiA DS 301) manage the process data exchange, f.e the cyclical transmission of the position value. The process data exchange with the CANopen PDOs is a very slim process without protocol overhead.

5.7.1 PDO Default Setting

2 Transmit PDOs (TPDO) with each max. 8 bytes are provided:

0x1800 TPDO1: default: asynchronous with event timer switched off (changeable to synchronous)
0x1801 TPDO2: default: synchronous

5.7.2 PDO Parameter Setting

The contents of the encoder-specific TPDOs can be configured by variable mapping according to customer´s requirements. This mapping has to be performed for the encoder as well as for the receiver. The PDO is limited to a maximum size of 8 bytes and 5 mappings per each PDO.

Mappable objects	
Index/Subindex Entry	Byte
0x6020/1 Position value ch. 1	4
0x6020/2 Position value ch. 2	4
0x6030/1 Speed value ch. 1	2
0x6030/2 Speed value ch. 2	2
0x6300/1 Cam state ch. 1	1
0x6300/2 Cam state ch. 2	1
0x6400/1 Work area ch. 1	1
0x6400/2 Work area ch. 2	1
0x2002 Chip temperature	1
0x6503 Alarms	2
0x6505 Warnings	2

Step 1: For mapping of further objects, the PDO must be completely disabled and the MSB of PDO COB-ID have to be set to 1.

PDO	Object	COB-ID for active PDO	COB-ID for disabled PDO (MSB set to 1)
1	0x1800	0x40000xxx	0xC0000xxx
2	0x1801	0x40000xxx	0xC0000xxx

Step 2: Clearing entries in mapping table of PDO1 => subindex 0x0 of object 1A00 has to be set to 0x00.

Step 3: Parameter setting of selected mappings

Example:
A PDO can be mapped in the way that the "current position", the "current speed" and the "current chip temperature" are transmitted in one information without producing more than necessary bus load.

Mapping #1 “current position”:
object 0x1A00/1 size: 32 bit = 4 byte => 0x20 position value = object 0x6020/1

				destination object			size	source object		
COB-ID	DLC	Rx/ Tx	Command	Byte0 (object)	Byte1 (object)	Byte2 (subindex)	Byte3	Byte4 (subindex)	Byte5 (object)	Byte6 (object)
0x600+Node-ID	8	Rx	0x23	0x00	0x1A	0x01	0x20	0x01	0x20	0x60

Mapping #2 “current speed”:
object 0x1A00/2 size: 16 bit = 2 byte => 0x10 speed value = object 0x6030/1

				destination object			size	source object		
COB-ID	DLC	Rx/ Tx	Command	Byte0 (object)	Byte1 (object)	Byte2 (subindex)	Byte3	Byte4 (subindex)	Byte5 (object)	Byte6 (object)
0x600+Node-ID	8	Rx	0x23	0x00	0x1A	0x02	0x10	0x01	0x30	0x60

Mapping #3: “current chip temperature”.
object 0x1A00/3 size: 8 bit = 1 byte => 0x08 temperature value = object 0x2002

				destination object			size	source object		
COB-ID	DLC	Rx/ Tx	Command	Byte0 (object)	Byte1 (object)	Byte2 (subindex)	Byte3	Byte4 (subindex)	Byte5 (object)	Byte6 (object)
0x600+Node-ID	8	Rx	0x23	0x00	0x1A	0x03	0x08	0x00	0x02	0x20

Step 4: Setting entries in mapping table => subindex 0x0 of object 1A00 has to be set to the numbers of mapping entries
(f.e. 0x03)

Step 5: For activating the PDO the MSB of PDO COB-ID have to be set to 0.

PDO	Object	COB-ID for disabled PDO	COB-ID for enabled PDO (MSB cleared)
1	0x1800	0xC0000xxx	0x40000xxx
2	0x1801	0xC0000xxx	0x40000xxx

Note:
TPDO1 value for Event Timer must always be higher than the value for Inhibit Time (except for value 0).

Failed sending of TPDOs can occur if:
- more TPDOs shall be sent than the CANbus may accept due to insufficient CAN bit rate compared to TPDO/Event Timer
- excessive bus load or unfavourable setting of COB-ID in the CANopen network prevents TPDO sending
- Object 0x1800/5- event timer- is set to 0.

5.8 Error Handling

Depending on the type of error occured, the sensor will react accordingly:

Error Class	**Error**	**Error Message from Sensor**
Protocol error	SDO protocol error, corrupted data received via SDO	Abort SDO Transfer*
	PDO protocol error, corrupted data received via PDO	Not relevant, sensor does support TPDOs only
Communication error	CAN bus off CAN error passive CAN overrun CAN buffer overflow	EMCY message**
Process error	Position or sensor error	EMCY message**
	Data error	Abort SDO Transfer* or EMCY message**
Change of state	According to Cams and Work Areas	EMCY Message**

* according to DS-301, see chapter *5.6 SDO Services*

** details see chapter *5.8.1 Emergency Messages*

5.8.1 Emergency Messages

COB-ID EMCY	DLC	Rx/ Tx	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x80+Node-ID	8	Tx	See next table							

COB-ID EMCY in object 0x1014.
Error-Register in object 0x1001.

0x50xx Device Hardware
0x60xx Device Software
0x80xx Monitoring
0x90xx External Error

Error-Code	Error-Register	Additional Byte			Description
Byte 0,1	Byte 2	Byte 3,4	Byte 5,6	Byte 7	
0x0000	0	0	0	0	*Sensor Error resetted, no Error*
0x5000	1	1	1	0	*Sensor Error* Cause: An internal error bit is set. The current process values stay in the object directory; the cam and work area states stay unchanged. If the internal error bit is reset to 0, an EMCY with 0x0000 is sent.
0x6000	1	1	0	0	*Insufficient Event Timer Value* Cause: CAN bit rate has been set to a low value and an insufficient Event Timer value has been set for TPDO1 accordingly. Reaction: TPDO1 sending will occur partially.
0x8110	1	1	0	0	*CAN Controller Overflow , CAN Overrun* Cause: data buffers of CAN controller are still holding data and cannot accept new entries. Data is being lost. Reaction: none
0x8110	1	2	0	0	*CAN Buffer Overflow* Cause: data buffers of CANopen library are still holding data and cannot accept new entries. Data is being lost. Reaction: none
0x8120	1	0	0	0	*CAN Error Passive* Cause: CAN controller has detected communication errors and is reporting error passive. Reaction: none
0x8140	1	0	0	0	*CAN Recovered From Bus-Off* Cause: CAN controller registered too many sending errors. CAN communication could be restored afterwards. Reaction: none
0x9080	1	ch.	cam	state	*Encoder CAM* Cause: the state of cam / channel has changed. State is coded according to 0x6300. Reaction: none
0x9090	1	ch.	0	state	*Work Areas* Cause: the state of Work Area / chan. has changed. State is coded according to 0x6400. Reaction: none

5.9 Error Objects

5.9.1 Manufacturer-specific Status

The object 0x1002 shows the sensor status bit code and is used for internal process control purposes.
For servicing this information can be requested via SDO (see chapter *5.6 SDO Services*).

Bit	Definition (if bit value = 1)
16	sensor receiving process data
15	TPDO1 Event Timer Value insufficient for set CAN bit rate
6	CAN Controller Overflow
5	CAN Buffer Overflow
4	CAN Error Passive
3	CAN Bus-Off
2	CAN Bus-Off Timer started
0-1	NMT Condition of Sensor %11 stopped %10 operational

Bit	Definition (if bit value = 1)
	%01 pro-operational %00 initialisation

5.9.2 Alarms

Interpretation of object 0x6503:

Bit	Definition (if bit value = 1)
12	No magnet, position reading failed
0	2-channel version: difference between positions is out of range

5.9.3 Warnings

Interpretation of object 0x6505:

Bit	Definition (if bit value = 1)
12	Magnet out of operation distance

5.10 Non-Volatile Storage and Data Restoration

Default values for all data objects are stored in the non-volatile program memory.
Data encryption to the non-volatile memory is only admitted in the pre-operational status.

- **Storage via LSS:**

Data must be stored through the LSS Service Configuration/Store while in LSS Configuration Mode (see chapter *5.5 LSS / Layer Setting Service*)

- **Storage via SDO:**

Object 0x1010:

Data is stored in the non-volatile memory during encryption of object 0x1010 with „save“ signature (0x65766173).

Object 0x1011:

Encryption of object 0x1011 with the signature „load“ (0x64616F6C) will upload data from the non-volatile memory.
Default settings are being restored (see chapter *5.6 SDO Services*).

Object 0x1010 Object 0x1011	Subindex /1 All	Subindex /2 Communication	Subindex /3 Application	Subindex /4 Manufacturer
COB-ID Sync				
Guard Time	X	X		
Life Time Factor	X	X		
Heartbeat Timer	X	X		
TPDO COB-ID	D	X		
TPDO Trans Typ	X	X		
TPDA Inhibit Time	X	X		
TPDO Event Timer	X	X		
TPDO Mapping	X	X		
NMT Startup	X	X		
Node-ID	X			
BitRate	X			
Ordering				X
Custom				X
Operating Parameters	X		X	
Measurement units per Revolution	X		X	
Total Measurement Range	X		X	
Preset Value	X		X	
CAM Enable	X		X	
CAM Polarity	X		X	
CAM Low Limit	X		X	

Object 0x1010 Object 0x1011	Subindex /1 All	Subindex /2 Communication	Subindex /3 Application	Subindex /4 Manufacturer
CAM High Limit	X		X	
CAM Hysterese			X	
Work Area Low Limit			X	
Work Area High Limit			X	

X: data saved or restored

D: data set to default value

• Delete via SDO:

Object 0x1010:

Additionally to the functionality defined in CiA standard DS-301, CANopen library offers the possibility to delete data in the non-volatile memory. Delete process is initiated by sending the signature “kill” (0x6B696C6C) to object 0x1010.

5.11 Abbreviations

CAN	Controller Area Network
ch	channel
COB-ID	Communication Object Identifier
const	constant parameter, only readable
DLC	Data Length Code
DS	Draft Standard
EMCY	Emergency Service
NMT	Network-Management
PDO	Process Data Object
Pos	Position (value)
ro	read only, parameter can change
rw	read/write
Rx	Novotechnik sensor is consumer of the CAN data frame
RTR	Remote Transmission Request
SDO	Service Data Object
SYNC	Synchronisation message
TPDO	Transmit Process Data Object
Tx	Novotechnik sensor is producer of the CAN data frame

5.12 Document Changes

Revision	Changes	Date	Who
V_00	• First edition	30.06.14	VM/mm
V_01	•		
V_02	•		
V_03	•		
V_04	•		
V_05	•		