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1 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.

1.1 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 *Product series*_CANopen.**

1.2 Support

If you have any questions, please contact our product support at support@novotechnik.de.
Electronic data sheets or user manuals for previous software versions are available on request.

1.3 Features

1.3.1 Basic information

Vendor ID: 386 = 0x0182 (Novotechnik)
Product code: TP1: 04035 = 0x0FC3, TH1: 04042 = 0x0FCA, TM1: 04228 = 0x1084, TF1: 04052 = 0x0FD4
Rev.-No.: f.e 196613 = 0x30005
Serial No.: see product label, “YYMMxxxx”

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

CAN Identifier	Standard 11 bits 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_8: 20 kBaud 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 1.6 LSS / Layer Setting Service)* or object 0x2001 *(see chapter 1.7 SDO Services)*
Node-ID	0x7F setting per LSS *(see chapter 1.6 LSS / Layer Setting Service)* or object 0x2000 (see chapter *1.7 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

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

Encoder class	☐ C1 ☒ C2
Encoder type	Absolute Linear Encoder
Max. bit bandwidth of position value	32 bits
Encoder Cams Channels to be detected Cams per channel Polarity Hysteresis	 Pos.ch1, Pos.ch2 (ch2: only product series TP1 / TH1) 4 invertable yes
Work Area Supervision channels	 Pos.ch1, Pos.ch2 (ch2: only product series TP1 / TH1)

1.3.4 Basics SDO communication

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

1.3.5 Basics PDO communication based on CiA 301, V4.2.0

PDO communication principle	Producer
TPDO‘s	TPDO1: • Event-driven transmission - only product series TP1 / TH1 / TM1: Synchronous to measurement cycle (measuring length dependent 0.5/1/2/4 ms with delay 100 µs) - Event Timer • Synchronous (SYNC Object) TPDO2: • Synchronous (SYNC Object)
PDO Mapping	dynamic
max. PDO Mappings per PDO	5

1.4 Object Library

1.4.1 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	0x000A0196	Device profile 406 multi-sensor encoder interface
1001	error register	unsigned8	ro	no	0x00	See chapter *1.9 Error Handling*
1002	manufacturer status register	unsigned32	ro	no	0x00000000	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	e.g. TP1-0100-101-614-105	Device name, see datasheet/ordering code
1009	hardware version	visible_ string	const	no	-	Only product series TM1 / TF1: hardware version
100A	software version	visible_ string	const	no	-	Only product series TM1 / TF1: software version
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 user data parameters
1010/5		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 user data 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	0x0000 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 1.3.1Basic information)*	Product code
1018/3		unsigned32	ro	no	*(see 1.3.1Basic information*)	Revision number
1018/4		unsigned32	ro		*(see 1.3.1Basic information)*	Serial number

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
1800	TPDO1 communication parameter	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 modes: TPDO off: 0 Event-driven transmission - Only product series TP1 / TH1 / TM1: Synchronous to meas. cycle: 255 - Event Timer: 254 Synchronous: 1 ... 240
1800/3		unsigned16	rw	no	0x0000	Inhibit Time in (multiples of) 100 µs
1800/4		unsigned8	rw	no	0x00	Compatibility entry
1800/5		unsigned16	rw	no	0x0000 disabled	Event timer in ms Disabled: 0 Enabled: Range 1 ... 65535
1801	TPDO2 communication parameter	PDO_COMM_PAR				It contains the communication parameters of the current PDO the device is able to transmit.
1801/1		unsigned32	rw	no	0x40000280 + Node ID	COB-ID of the PDO
1801/2		unsigned8	rw	no	0x01	Transmission mode TPDO off: 0 Synchronous: 1 ... 240
1801/3		unsigned16	rw	no	0x0000	Inhibit Time in (multiples of) 100 µs
1A00	TPDO1 mapping parameter	PDO_ MAPPING				Contains the mapping for the PDOs the device is able to transmit
1A00/0		unsigned8	rw	no	TM1 / TF1: 0x03 TP1 / TH1: 0x03[1)] 0x02[2)]	Number of entries
1A00/1		unsigned32	rw	no	0x60200120	Mapping entry 1, default: Position value channel 1
1A00/2		unsigned32	rw	no	TM1 / TF1: 0x60300110 TP1 / TH1: 0x60300110[1)] 0x60200220[2)]	Mapping entry 2, default: Speed value default: Speed value channel 1 [1)] default: Position value channel 2 [2)]
1A00/3		unsigned32	rw	no	0x63000108[1)]	Mapping entry 3 default: CAM Status channel 1 [1)]
1A00/4		unsigned32	rw	no	0x00000000	Mapping entry 4
1A00/5		unsigned32	rw	no	0x00000000	Mapping entry 5
1A01/0	TPDO2 mapping parameters	unsigned8	rw	no	TM1 / TF1: 0x03 TP1 / TH1: 0x03[1)] 0x02[2)]	Number of entries
1A01/1		unsigned32	rw	no	0x60200120	Mapping entry 1, default: Position value channel 1
1A01/2		unsigned32	rw	no	TM1 / TF1: 0x60300110 TP1 / TH1: 0x60300110[1)] 0x60200220[2)]	Mapping entry 2, default: Speed value default: Speed value channel 1 [1)] default: Position value channel 2 [2)]
1A01/3		unsigned32	rw	no	0x63000108[2)]	Mapping entry 3 default: CAM Status channel 1 [1)]
1A01/4		unsigned32	rw	no	0x00000000	Mapping entry 4
1A01/5		unsigned32	rw	no	0x00000000	Mapping entry 5
1F80	NMT startup	unsigned32	rw	no	0x00000000	This object determines the startup behavior of a device in the network. Bit 3 set: sensor starts in operational mode

[1)] for 1 position marker
[2)] for 2 position markers

1.4.2 Device Profile Area

* for 1 position marker: default value 0x01
** for 1 position marker and product series TM1 / TF1: not available

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
6000	operating parameter	unsigned16	rw	no	0x0000	This object contains the functions for code sequence and commissioning diagnostic control
6005	Linear encoder measuring step settings					Object sets the number of distinguishable steps over the total measuring range (total resolution)
6005/0		unsigned8	ro	no	0x02	Number of objects
6005/1		unsigned32	rw	no	TP1 / TH1 / TF1: 0x00003E8 TM1: 0x000186A0	Position measuring steps in 0.001 µm
6005/2		unsigned32	rw	no	0x0000064	Speed measuring step in 0.01 mm/s
6010	preset value					This object supports adaption of the encoder zero point to the mechanical zero point of the system
6010/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels 0x01: 1 position marker, 1 channel 0x02: 2 position markers, 2 channels
6010/1		integer32	rw	no	0x00000000	Preset value channel 1
6010/2		integer32	rw	no	0x00000000**	Preset value channel 2
6020	position value					This object defines the output position value
6020/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6020/1		integer32	ro	**yes**	0x00000000	Position value channel 1
6020/2		integer32	ro	**yes**	0x00000000**	Position value channel 2
6030	speed value					This object defines the output speed value
6030/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6030/1		integer16	ro	**yes**	0x0000	Speed value channel 1
6030/2		integer16	ro	**yes**	0x0000**	Speed value channel 2
6300	CAM state register					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		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6300/1		unsigned8	ro	**yes**	0x00	CAM state channel 1
6300/2		unsigned8	ro	**yes**	0x00**	CAM state channel 2
6301	CAM enable					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	unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6301/1		unsigned8	rw	no	0x00	CAM enable channel 1
6301/2		unsigned8	rw	no	0x00**	CAM enable channel 2
6302	CAM polarity register					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		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6302/1		unsigned8	rw	no	0x00	CAM polarity channel 1
6302/2		unsigned8	rw	no	0x00**	CAM polarity channel 2

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
6310	CAM 1 low limit					determines the lower limit of position for cam 1
6310/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6310/1		integer32	rw	no	0x00000000	CAM 1 low limit channel 1
6310/2		Integer32	rw	no	0x00000000**	CAM 1 low limit channel 2
6311	CAM 2 low limit					determines the lower limit of position for cam 2
6311/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6311/1		integer32	rw	no	0x00000000	CAM 2 low limit channel 1
6311/2		Integer32	rw	no	0x00000000**	CAM 2 low limit channel 2
6312	CAM 3 low limit					determines the lower limit of position for cam 3
6312/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6312/1		integer32	rw	no	0x00000000	CAM 3 low limit channel 1
6312/2		Integer32	rw	no	0x00000000**	CAM 3 low limit channel 2
6313	CAM 4 low limit					determines the lower limit of position for cam 4
6313/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6313/1		integer32	rw	no	0x00000000	CAM 4 low limit channel 1
6313/2		Integer32	rw	no	0x00000000**	CAM 4 low limit channel 2
6320	CAM 1 high limit					determines the higher limit of position for cam 1
6320/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6320/1		integer32	rw	no	max. pos. value	CAM 1 high limit channel 1
6320/2		Integer32	rw	no	max. pos. value**	CAM 1 high limit channel 2
6321	CAM 2 high limit	integer32				determines the higher limit of position for cam 2
6321/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6321/1		integer32	rw	no	max. pos. value	CAM 2 high limit channel 1
6321/2		Integer32	rw	no	max. pos. value**	CAM 2 high limit channel 2
6322	CAM 3 high limit	integer32				determines the higher limit of position for cam 3
6322/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6322/1		integer32	rw	no	max. pos. value	CAM 3 high limit channel 1
6322/2		Integer32	rw	no	max. pos. value**	CAM 3 high limit channel 2
6323	CAM 4 high limit	integer32				determines the higher limit of position for cam 4
6323/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6323/1		integer32	rw	no	max. pos. value	CAM 4 high limit channel 1
6323/2		Integer32	rw	no	max. pos. value**	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		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6330/1		unsigned16	rw	no	0x0000	CAM 1 hysteresis channel 1
6330/2		unsigned16	rw	no	0x0000**	CAM 1 hysteresis channel 2
6331	CAM 2 hysteresis	unsigned16				This object contains the delay setting of switch points for cam 2
6331/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6331/1		unsigned16	rw	no	0x0000	CAM 2 hysteresis channel 1
6331/2		unsigned16	rw	no	0x0000**	CAM 2 hysteresis channel 2
6332	CAM 3 hysteresis	unsigned16				This object contains the delay setting of switch points for cam 3
6332/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	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		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6333/1		unsigned16	rw	no	0x0000	CAM 4 hysteresis channel 1
6333/2		unsigned16	rw	no	0x0000**	CAM 4 hysteresis channel 2

Object description			Entry description			
Index/ subindex	Name	Data Type	Access	PDO Mapping	Default value	Comment
6400	Work area state register					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		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available work areas
6400/1		unsigned8	ro	**yes**	0x00000000	Work area state channel 1
6400/2		unsigned8	ro	**yes**	0x00000000**	Work area state channel 2
6401	work area low limit					This object contains the lower limit of the work area
6401/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available work areas
6401/1		integer32	rw	no	0x00000000	Low limit work area 1
6401/2		integer32	rw	no	0x00000000**	Low limit work area 2
6402	work area high limit					This object contains the higher limit of the work area
6402/0		unsigned8	ro	no	TM1 / TF1: 0x01 TP1 / TH1: 0x02*	Number of available channels
6402/1		integer32	rw	no	max. pos. value	High limit work area 1
6402/2		integer32	rw	no	max. pos. value**	High limit work area 2
6500	operating status	unsigned16	ro	no	0x0000	This gives information on encoder internal programmed parameters.
6501	measuring steps	unsigned32	ro	no	0x000003E8	Position measuring step in 0.001 µm

* for 1 position marker: default value 0x01
** for 1 position marker and product series TM1 / TF1: not available

1.4.3 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	250kBaud =0x00FA	CAN bit rate of the sensor in kbit/s CAUTION: Once the “reset all” operation is performed (see chapter 1.11 *Non-Volatile Storage and Data Restoration*, even if the delivery bit rate is a different one, the bit rate will be reset to default = 250kBaud
2002	chip temperature	integer16	ro	**yes**	-	Temperature from inside the µC in Celsius e.g. at ambient temperature
2003	number of position markers	unsigned8	rw	no	0x02	Only product series TP1 / TH1: Number of position markers 0x01: 1 position marker, 1 channel 0x02: 2 position markers, 2 channels
2004	custom					Manufacturer defined array, not writable for the user
2005	average	unsigned8	rw	no	0x00	Only product series TF1 / TM1: Average function for position and speed calculation. n = 0 ... 6: moving average across 2^n values Note: the average function influences the signal propagation delay

1.5 Explanations to Object Library

1.5.1 Object 0x6300 Encoder Cams

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

1.5.2 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 steps (0x6005). 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.

1.5.3 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.

1.5.3.1 Work Area Supervision

Each work area channel is fixedly linked to a position channel:

Position		**Work Area**
Index	Subindex	Channel
0x6020	1	1
0x6020	2	2

1.5.3.2 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.

1.6 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
0x7E5	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	0x01	0x00	0x00	0x00	0x00	0x00	0x00

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

1.6.1 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.

1.6.2 Configuration of Bit Rate

The Bit Rate can be programmed with LSS-Command **0x13**
Table Index: 0x07: 20 kBaud
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
0x7E5	8	Rx	0x13	Table Index	0x00	0x00	0x00	0x00	0x00	0x00
0x7E4	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

1.6.3 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
0x7E5	8	Rx	0x17	0x00	0x00	0x00	0x00	0x00	0x00	0x00
0x7E4	8	Tx	0x17	Err Code	0x00	0x00	0x00	0x00	0x00	0x00

1.7 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 *1.4 Object Library*) can be read, written or stored by means of SDO.

1.7.1 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 “set new node-ID” with 0x40

0x600+Node-ID	8	Rx	0x2F	0x00	0x20	0x00	0x40	0x00	0x00	0x00
0x580+Node-ID	8	Tx	0x60	0x00	0x20	0x00	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 (TP1/TH1) or 0x1010/4 (TF1). 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 (TP1/TH1) or 0x1010/4 (TF1). These changes will become effective after a communication restart or a power up.

1.7.2 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

1.7.3 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
0x06060000 access error
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			

1.8 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.

1.8.1 PDO Default Setting

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

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

1.8.2 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

Step 1: For changing of mapping, the sensor must be in properational mode and the MSB of PDO COB-ID has to be set to 1 to deactivate it.

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 (PDO2) => subindex 0x0 of object 1A00 (1A01) has to be set to 0x00.

Step 3: Mapping of objects into PDO

Example:
A PDO shall be mapped in a way that the "current position", the "current speed" and the "current chip temperature" are transmitted in one PDO .

Mapping #1 “current position”:
object 0x1A00/1 size: 32 bits = 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 bits = 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 bits = 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 (e.g. 0x03)

Step 5: For re-activating the PDO, the MSB of PDO COB-ID has 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.

1.9 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** Position value is set to 0x7FFFFFFF (beyond measuring range), speed value is set to 0x0000
	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 *1.7 SDO Services*

** details see chapter *1.9.1 Emergency Messages*

1.9.1 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.
0x5000	1	1	5	0	*Unexpected System Data* Cause: application received sensor-internal system data instead of process data during normal operation mode. Reaction: sensor changes into PRE-OPERATIONAL mode. System data is being computed as if power-up had occurred (system data are being checked and and serial number and product code, if correct, is being stored in EEPROM). If system data are correct, normal operation can continue afterwards.
0x5000	1	1	6	0	*No System Data* Cause: Sensor configuration is not detected internally. Reaction: sensor changes into PRE-OPERATIONAL mode. NMT Master cannot set the sensor into OPERATIONAL mode, until error has been eliminated and sensor has been reset through power off/on. Attempted setting into OPERATIONAL will result in repeated EMCY message sending.

Error-Code	Error-Register	Additional Byte			Description
Byte 0,1	Byte 2	Byte 3,4	Byte 5,6	Byte 7	
0x5000	1	2	1	0	*Invalid Serial Number in EEPROM* Cause: the serial number and product code stored in the FLASH is invalid. Reaction: sensor changes into PRE-OPERATIONAL mode. NMT Master cannot set the sensor into OPERATIONAL mode, until error has been eliminated and sensor has been reset through power off/on. Attempted setting into OPERATIONAL will result in repeated EMCY message sending.
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 / channel has changed. State is coded according to 0x6400. Reaction: none

1.10 Error Objects

1.10.1 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 *1.7 SDO Services*).

Bit	Definition (if bit value = 1)
17	Lifeguarding Error
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

Bit	Definition (if bit value = 1)
2	CAN Bus-Off Timer started
0-1	NMT Condition of Sensor %11 stopped %10 operational %01 pro-operational %00 initialisation

1.11 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 *1.6 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 *1.7 SDO Services*).

CAUTION: In case of custom programmed parameters like node-ID, averaging, bit rate etc. these will be reset to default in case of the corresponding reset command below (default values see chapter 1.4 *Object Library*).

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 (TP1/TH1)			X (TF1/TM1)
BitRate	X (TP1/TH1)			X (TF1/TM1)
Number of position markers (only TP1 / TH1)	X			
Custom (only TP1 / TH1)				X
Operating Parameters	X		X	
Linear Encoder Measuring Step Settings	X		X	
Preset Value	X		X	
CAM Enable	X		X	
CAM Polarity	X		X	
CAM Low Limit	X		X	
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” (0x6C6C696B) to object 0x1010.

• **Manufacturing Mode Object 0x1010**

- Only TM1 series:

  If the sensor is out of function and the signature “boot” 0x746F6F62 in object 0x1000 (device type) is active, the sensor is in manufacturing mode. This mode can be left by power off-on or via the operational command.

1.12 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

1.13 Document Changes

Revision	Changes	Date	Who
V00	First edition	16.07.14	VM/mm
V01	1.4.3.1 work area supervision added, 1.4.2 0x6001 replaced by 0x6005 measuring steps	17.06.16	VM/mm
V02	1.3.1 Object Index 1A00/2 and 1A01/2: 1) and 2) exchanged, 0x6030110 was 0x6030120.1.5 Switch Mode Global: correction of byte 0 and byte 1	09.01.17	VM/mm
V03	1.4.2 Note for cam operation with two position markers deleted	27.03.17	VM/mm
V04	New title, 1.2.2 Product code for product series TM1 / TF1 added, 1.2.2 Bit rate 10 kBaud removed, 1.2.5 description of transmission modes modified, 1.3.1 Object 1801/1 “+ Node ID” added, Object 1009/100A added (only for TM1) 1.3.2 Object 6005/2: unit for speed in mm/s (was µm), Object 6005/1 position measuring steps corrected (TP1/TH1 1 µm, TM1 100 µm), Object 6005/1 and 6005/2: rw was ro, Object 1A00/0 and 1A01/0: number of entries corrected, Object Object 6320/6321/6322/6223/6402 subindex/1 and /2: High limit: max. pos.value instead of 0x00003FFF (depends on measuring length), 1.3.3 temperature: default removed, 1.5 LSS: typo correctes (7E5, 7E4), 1.3.3 CAN bit rate: default value corrected (0xFA instead of 0x03) and note about “reset all” added (“Caution:...”), 1.7.1 description modified: event-driven instead of asynchronous, 1.8. process error: behaviour position value/speed value added, 1.10 note about “reset all” added	12.07.18	VM/mm
V05	1.8 Process error: Position value set to 0x7FFFFFFF also for product series TP1 and TH1. 1.6.1 Example new node-ID64: command 0x2F and byte 2 0x40 instead of 0x23 and 0x80.	30.10.18	VM/mm
V06	1.3.3 Object 2005: n=0...6 instead of 0...5 values; note added signal propagation delay added 1.6.1 SDO-Download: Example “set new node-ID”: subindex 00 instead of 01; object 0x1010/1 for TP1/TH1 series and object 0x1010/4 for TF1 series 1.10 TF1: Save command for Node ID/Bit Rate changed from subindex /1 to subindex /4	31.07.19 11.03.20	VM/mm
V07	1.2.5 / 1.3.1 object 1801x2: event driven transmission deleted for TPDO2. 1.3.1 objects: TPDO1 and TPDO2: name modified. 1.3. object 1800/2 and 1801/2 comment: synchronous 1...240 instead 1...239, TPDO off: 0 added	01.04.20	VM/mm
V08	1.3.1 object 1010/4 user parameter data instead of manufacturer defined parameters. 1.3.1 1010/5 added (Manufacturer data parameter). 1.10. signature kill 6C6C696B instead of 6B696C6C, comment regarding manufacturing mode added	21.01.21	VM/mm
V09	1.2 Support added, all further chapter numbers changed 1.8.3 Textual modifications	07.09.21 17.11.22	VM/mm

Revision	Changes	Date	Who
V10	1.7.1 Corrected example for setting the node ID	17.02.23	VM/mm
V11	Document history V1 … V10 completed	12.07.24	VM/mm
V12	1.11 Node-ID, BitRate: sudindex /4 added for TM1 series	5.11.24	VM/mm