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Automation GmbH & Co. KG

Technical Manual
Absolute Encoder WDGA with CANopen interface

CANopen

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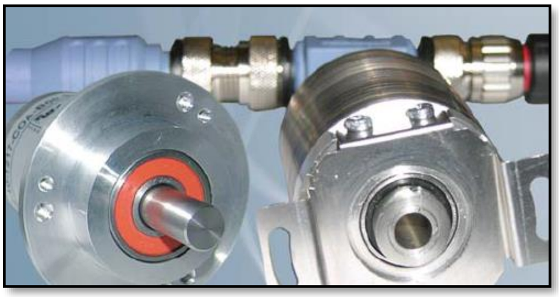

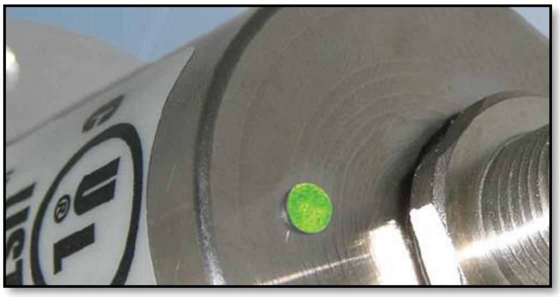

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List of abbreviations

autom.	automatic
approx.	approximately
CAN	Controller Area Network
CAN-ID	Main part of the arbitration of a CAN-frame
co	constant: parameter is read-only, doesn't change
COB-ID	Communication Object identifier, specifying the CAN-ID and additional parameters for the related communication object
comp.	Compare
DLC	Data Length Code
DS	Draft Standard
DSP	Draft Standard Proposal
dyn	dynamic; information changes depending on encoder features
EDS file	Electronic data sheet, standardised file describing a CANopen device
EMC	Electromagnetic Compatibility
Encoder	here synonym for absolute rotary encoder
e.g.	for example (exempli gratia)
etc.	et cetera, and so on
GND	Ground
i*	Wildcard character for encoder specific information
i.e.	that is (id est)
Idx	Sub-Index
LED	Light Emitting Diode
LSB	Least Significant Bit/Byte
LSS	Layer Setting Services
MSB	Most Significant Bit/Byte
MT	Multiturn
n.n.	not necessary
NMT	Network management
Node-ID	Part of CAN-ID; number of the encoder in the CAN network
OSI	Open Systems Interconnection Reference Model
p.	Page reference
PDO	Process Data Object. Communication object for transmission of process data
res.	reserved

ro	Read Only: but not constant
RTR	Remote Transmission Request
rw	Read/Write: parameter can be read and written
SDO	Service Data Object; communication object providing access to all entries of the object dictionary
ST	Singleturn
SYNC	Synchronisations telegram
wo	Write Only
xx**b**	Mark that (xx) is a binary representation
xx**d**	Mark that (xx) is a decimal representation
xx**h**	Mark that (xx) is a hexadecimal representation

1 Introduction

1.1 Encoder types

This manual is assigned to the following Wachendorff Automation encoders:

WDGA CANopen

It applies to all WDGA CANopen with Revision Number (Software version) 2.08 and less.

The Wachendorff Automation CANopen vendor id is: **0100 021Fh**

The Wachendorff Automation product code is: **WDGA= 5744 4741h**

The revision number and the serial number vary for each individual encoder and can be found on the encoder’s label:

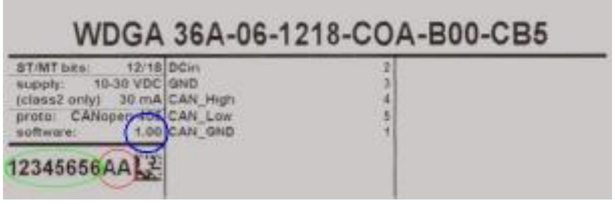


Figure 1.1: Encoder label

In the figure 1.1 the revision number is marked blue (here: 1.00). The revision is combined with a leading 0306 and fixed within the encoder firmware (e.g. Rev. 1.00 = 0306 0100h; Rev. 2.08 = 0306 0208h).

The serial number is marked green (here: "12345656"). This decimal value transferred into "hex" is used in the firmware (e.g. "12345656"="00BC 6138"h).

The hardware version is marked red (here: AA). The ASCII value transferred into hex is the hardware revision coded in the corresponding CANopen object.

1.2 About this manual

This technical manual describes the configuration and mounting possibilities for absolute-value encoders with a CANopen interface produced by Wachendorff Automation. It supplements the other publicly available Wachendorff automation documents, e.g. data sheets, assembly instructions, leaflets, catalogues and flyers.

Ensure that you read the manual before commissioning — check beforehand that you have the latest version of the manual.

When reading, pay particular attention to the information, important notices and warnings that are marked with the corresponding symbols (see 1.2.1).

Section 4 Quick start shows a way how to configure the encoder in a very general setting with minimal functionality. For optimal usage of the device, it is necessary to read all the following information. Abbreviations and specific wording is explained at the beginning of this manual.

This manual is intended for persons with technical knowledge in the handling of sensors, CANopen interfaces and automation elements. If you do not have any experience in this field, request the assistance of experienced personnel before proceeding.

Keep the information provided with our product in a safe place so that you can refer to it at a later date as necessary.

1.2.1 Symbols

ℹ	• The INFO symbol indicates a section that contains particularly important information for advanced use of the device.
⚠	• The IMPORTANT symbol is shown next to a section of text that describes a method for solving a particular problem.
⚠	• The WARNING symbol indicates that the adjacent instructions must be observed to ensure correct use of the device and to protect the user against hazards.

1.3 Specifications

An encoder is a sensor that is designed to detect angular positions (singleturn) and revolutions (multiturn). The measured data and variables are processed by the encoder and provided as electrical output signals for the connected peripherals.

The interface and protocol for the communication between encoder and attached equipment meets the CAN and CANopen specifications. The encoder is capable of CAN 2.0A and CAN 2.0B. The implemented CANopen protocol meets the CiA 406 encoder profile.

For an easy configuration of the encoder, EDS files (electronic data sheet) are provided at the download area at www.wachendorff-automation.com.

2 Safety information

2.1 General safety information

⚠	• When commissioning the encoder, ensure that you observe the assembly instructions, manual and data sheet. • Failure to observe the safety instructions may lead to malfunctions, property damage and personal injury! • Observe the operating instructions provided by the machine's manufacturer.

2.2 Intended use

Rotary encoders are components that are intended for installation in machines. Before commissioning (operation in accordance with the intended use), it must be determined that the machine as a whole corresponds to the EMC and Machine Directive.

A rotary encoder is a sensor that is designed to detect angular positions and revolutions and must only be used for this purpose! Wachendorff Automation manufactures and distributes encoders for use in non-safety-relevant industrial applications.

⚠	• The encoder must not be operated outside the specified limit parameters (see data sheet).

2.3 Safe working

The installation and mounting of the encoder must only be carried out by a qualified electrician.

For the construction of electrical installations, all relevant national and international regulations must be strictly observed.

Failure to commission the encoder correctly may result in malfunction or failure.

⚠	• All electrical connections must be tested before commissioning. • Appropriate safety measures must be taken to ensure that no persons are harmed and no damage to the system or operating equipment occurs in the event of a failure or malfunction.

2.4 Disposal

Devices that are no longer needed or are defective must be disposed by the user in proper compliance with the country-specific laws. It must be taken into consideration that this is a special waste of electronics and that disposal is not permitted via normal household waste.

There is no obligation by the manufacturer to take the device back. If you have any questions regarding proper disposal, contact a disposal specialist in your area.

3 Device description

3.1 Basic encoder design

Wachendorff Automation WDGA encoders are available in different mechanical versions. Key features are size and shape. The standard sizes are 36mm and 58mm flange diameter. Different types of shapes according to shafts and flanges are available. Examples of the different versions are shown in Figure 3.1:

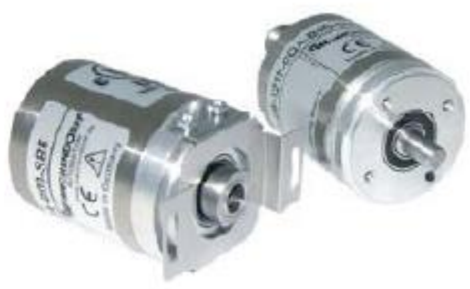


Figure 3.1: Encoder versions, shaft and hollow bore shaft

The shaft or the hollow bore shaft will be connected to the rotating part of which the angular position or rotation you want to measure. The encoder itself is mounted by several tapped bores or torque supports.

A stub cable or M12 sized connector provides the electrical connection to the CAN-network.

A bicolour status LED at the top indicates the different states of the encoder during use and helps with configuration and troubleshooting.

3.2 Predefined Connection Settings

Services	COB-ID
NMT	000h
SYNC	080h
EMCY	080h + Node-ID
PDO1(tx)	180h + Node-ID
PDO2(tx)	280h + Node-ID
PDO3(tx)	380h + Node-ID
SDO(rx)	600h + Node-ID
SDO(rx)	580h + Node-ID

Table 3.1: CAN-Identifier

By default all WDGA encoders are set on Node-ID=127h and Baudrate=Auto-Detection.

3.3 LED status indicator and signal codes

Definition of LED indication types:

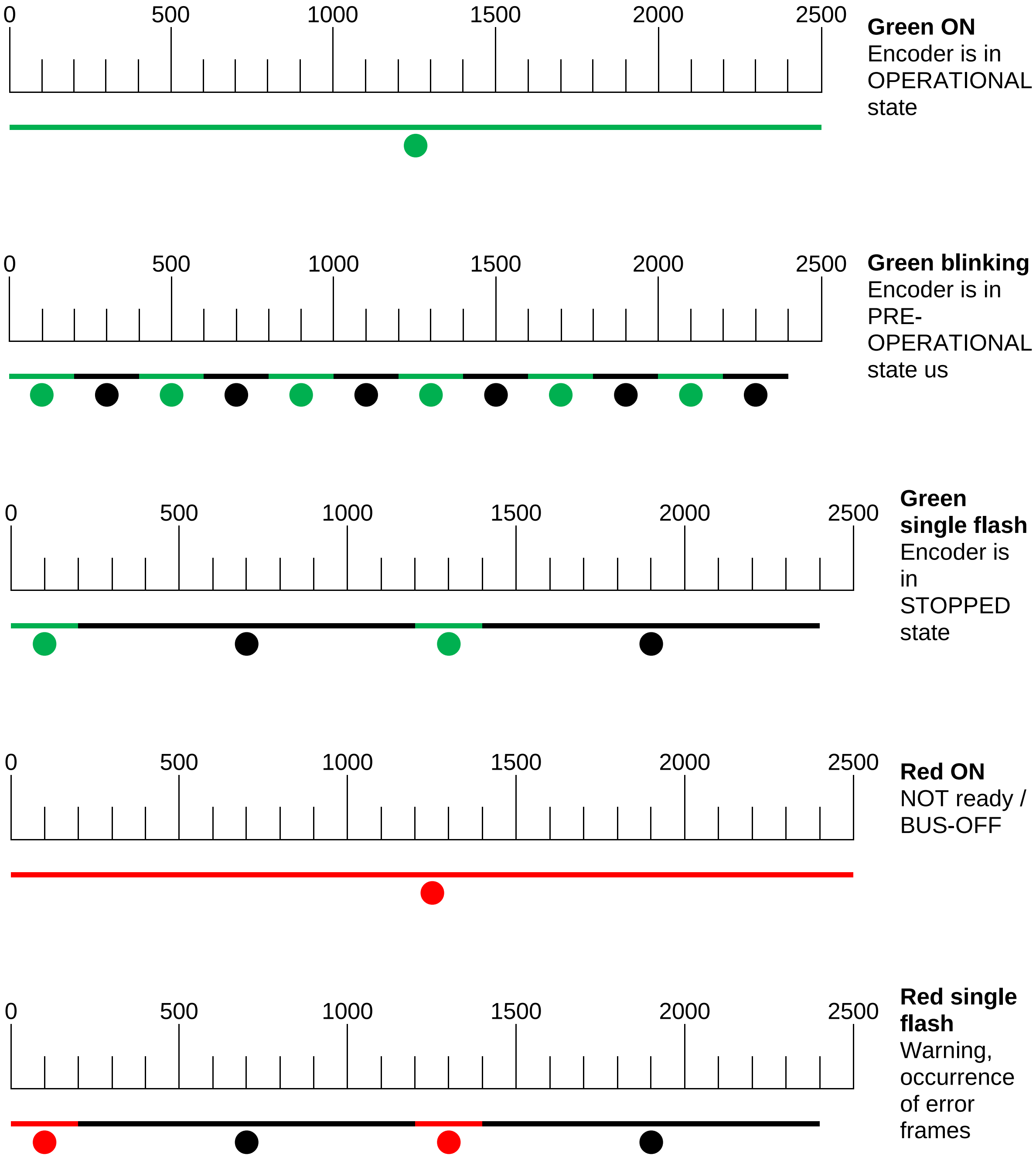
🔴 = red LED indications = "Physical Layer" information

🟢 = green LED indications = "NMT-Status" information

⚫ = LED off

→ = continue like first cycle

LED-Indications [ms]:



Green ON
Encoder is in OPERATIONAL state

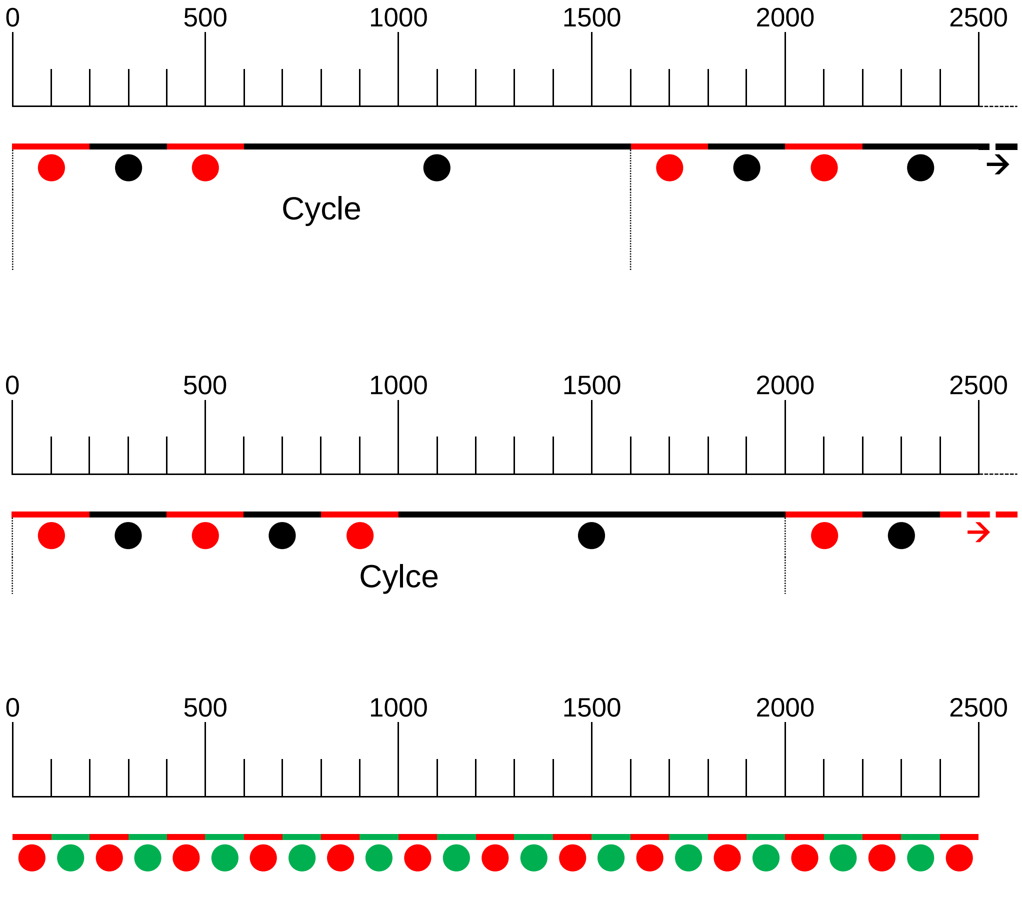
Green blinking
Encoder is in PRE-OPERATIONAL state us

Green single flash
Encoder is in STOPPED state

Red ON
NOT ready / BUS-OFF

Red single flash
Warning, occurrence of error frames

Figure 3.2: LED indications 1



Red double flash
Error, a guard event or a heart-beat event (heartbeat consumer) has occurred

Red tripple flash
Encoder is bus-passive

red-green flickering
Baudrate-Auto-Detection in progress or LSS config modus started

Figure 3.3: LED indications 2

4 Quick start

- The encoder indicates every status modification with its status-LED. See chapter 3.3 "LED status indicator and signal codes".

4.1 CAN network integration

The default node ID of Wachendorff Automation encoders (Object 2101h sub-Index: 00h) is 7Fh=127d.

For operating in a CAN-Network, the encoder’s baudrate has to be set. The common ways to set the baudrate is via LSS (CiA DSP-305) or a SDO command.

Wachendorff Automation WDGA encoders have the capability to detect the baudrate of the network automatically (object 2100h sub-Index: 00h value: 09h - Baudrate-auto-detection). So usually the baudrate setup is not necessary. To detect the valid baudrate the encoder stays passive and scans the communication at the bus. When the baudrate is detected, the encoder is set to this rate, sends its boot-up message and switches into pre-operational mode.

To prevent possible collisions in case double assigned node ID it is recommended to use a 1:1 connection with a bus master for configuration (e.g. a laptop computer with suitable hard- and software). Set the master on the intended baudrate and use SDO or LSS services to configure the encoder.

4.2 SDO command to set the node ID

After connecting the encoder WDGA with the CAN bus respectively the master (e.g. a laptop computer with suitable hard- and software) the LED starts "flickering red and green" (see Figure 3.3 LED indications 2).

First send one or more SYNC messages, which the encoder can use to detect the baudrate:

080h	8	00h	00h	00h	00h	00h	00h	00h	00h
CAN-ID	DLC	Command	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6

Table 4.1: SYNC-message

The encoder will detect and lock on the used baudrate. It will send its boot-up message and the LED starts to blink green (see Figure 3.2).

To set the encoders node ID the object 2101h, Sub-Index 00h has to be accessed. (Only possible in PRE-OPERATIONAL state!) Send a write-SDO-command with the intended node ID (in hex):

600h+ID	8	2Fh	01h	21h	00h	Node-ID	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 4.2: SDO-write command to set Node-ID

An example for a node ID might be:

Node-ID (d)	Node-ID (h)
1	01h
2	02h
…	…
4	04h
…	…
127	7Fh

Table 4.3: Node-ID in decimal and hexadecimal

The change of the node ID via SDO will be effective after a reset of the encoder (hard reset or NMT reset). The new node ID is stored into the EEPROM immediately and without a further command. The setting of the node ID via LSS is described in chapter 8.

- Changing the Node ID automatically adjusts the PDO and EMCY COB IDs. After the first manual storage, they are frozen at their current value and no longer automatically adjusted. Performing the "Restore Defaults" command will re-enable automatic adjustment.

4.3 Setting-up the encoder

Connect the encoder to the bus of application. Please mind the included mounting and safety advice documents. You can find additional information to this in chapter 8 "Setting-up".

When the encoder is completely integrated into the application you can switch it into OPERATIONAL mode by the "Start-All-Nodes-Command" (see chapter 7.1).

The encoder is now operational (LED shows green ON) and starts sending its data via the several process data objects (PDO). The encoders default configuration plans that the PDO1 is triggered once the position value changes.

The position value (object 6004h) is mapped in PDO1 and transmitted as an Unsigned32. By default PDO2 transmits the same value but synchronously on the reception of a SYNC message. Heartbeat is switched off and will not be transmitted by default. The encoder is now configured and ready for basic applications.

5 General information about CAN

5.1 CAN physical and transport layer

CAN is a field bus. It operates with the CSMA/CA (Carrier Sense Multiple Access / Collision Avoidance) method. It means that collisions during bus access are avoided by a so called bitwise arbitration. The bits are coded NRZ-L (Non Return to Zero - Low).

A cyclic redundancy check (CRC) and other safety mechanisms provide a secure transmission. For synchronisation a mechanism called "bit stuffing" is used. CAN is a multi-master system, i.e. several equal bus nodes can be connected without a bus master supervising the communication. In principle a CAN bus can be realized with copper wire or in fibre optic cable.

The common CAN implementation with copper wire operates with differential signals, transmitted via two wires: CAN_{HIGH}, CAN_{LOW}. Therefore CAN has a good common mode rejection ratio.

Data is transmitted with bits that can either be dominant or recessive. The dominant (0) always overwrites the recessive (1).

The topology of a CAN network is a line, which can be extended by stubs. The maximum length of a stub is limited to 0,5m.

The network always has to be terminated on both ends with 120Ohms each (between CAN_{HIGH} und CAN_{LOW}). Other locations or values are not allowed.

The arbitration mentioned before is used to control the bus access of the nodes by prioritization of the CAN-Identifier of the different messages. Every node monitors the bus. If more than on node wants access on the bus, the node with the highest priority of the messages ID succeeds and the other nodes retreat until there is "silence" on the bus (see Figure 5.1). Technically the first dominate bit of the ID send overwrites the corresponding recessive bit of the other IDs. In case that more than one node uses the same CAN-ID an error occurs only at a collision within the rest of the frame. On principle a CAN-ID should only be used by a single node!

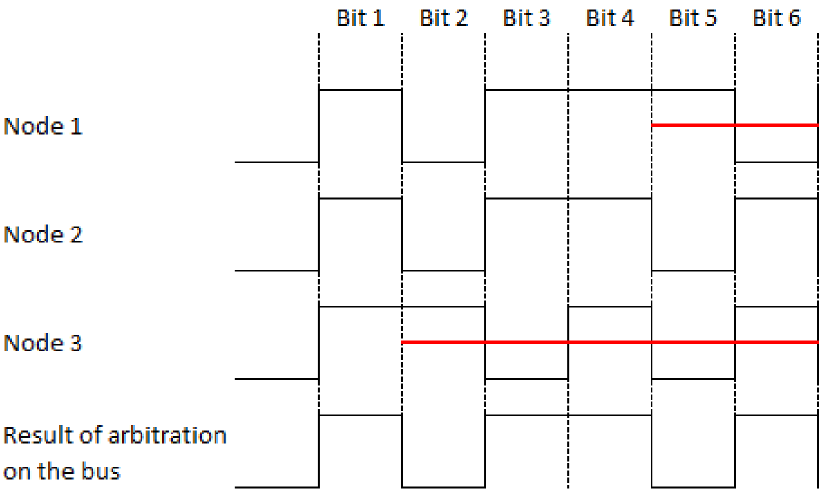


Figure 5.1: Example of the arbitration

Due to the arbitration there is a ranking of the messages. The message with the lowest ID has the highest priority and therefore it has almost instant access on the bus. The exception is that an ongoing transmission will not be interrupted. So time critical messages should be assigned to the high priority CAN-IDs, but even then there is no determination in the time of transmission (non-deterministic transmission).

For the arbitration all nodes have to be synchronised. Due to the lack of a separate clock signal, the transmission of many identical bits in line would lead to the loss of synchronisation. The so called bit-stuffing is used to prevent this case. After five equal bits a complementary bit will be inserted into the transmission (the application will not notice). So the nodes can keep up resynchronising on the bit flanks (see Figure 5.2).

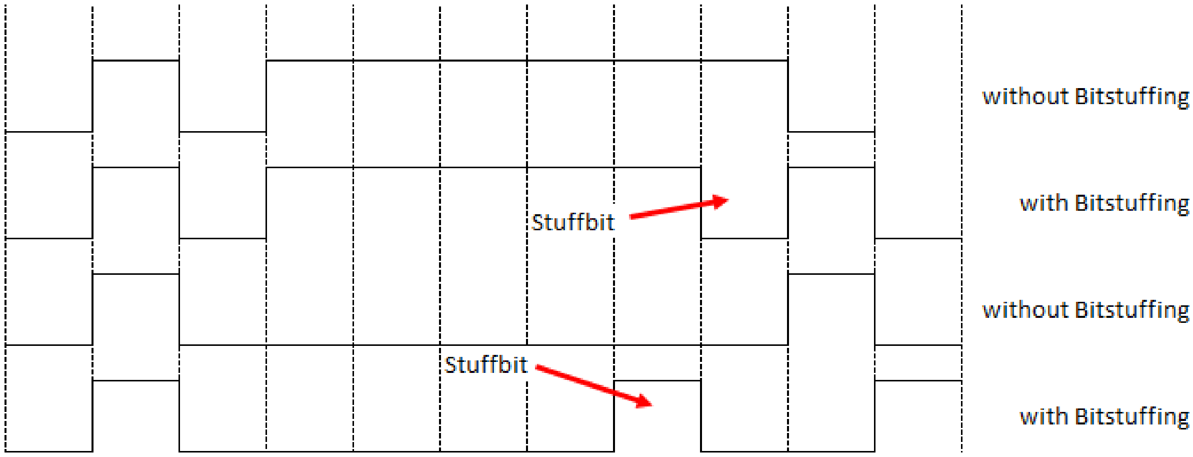


Figure 5.2: Bitstuffing

A CAN network can operate with baud rates up to 1 Mbit/s. Due to the necessary synchronisation of the nodes, the maximum delay caused by the length of the cable has to be limited. The limitation corresponds with the baudrate. There is a common recommendation of the maximum cable length at several baud rates.

Baud rates	Cable length
10 kBit/s	6,7 km
20 kBit/s	3,3 km
50 kBit/s	1,3 km
125 kBit/s	530 m
250 kBit/s	270 m
500 kBit/s	130 m
1 MBit/s	<40 m

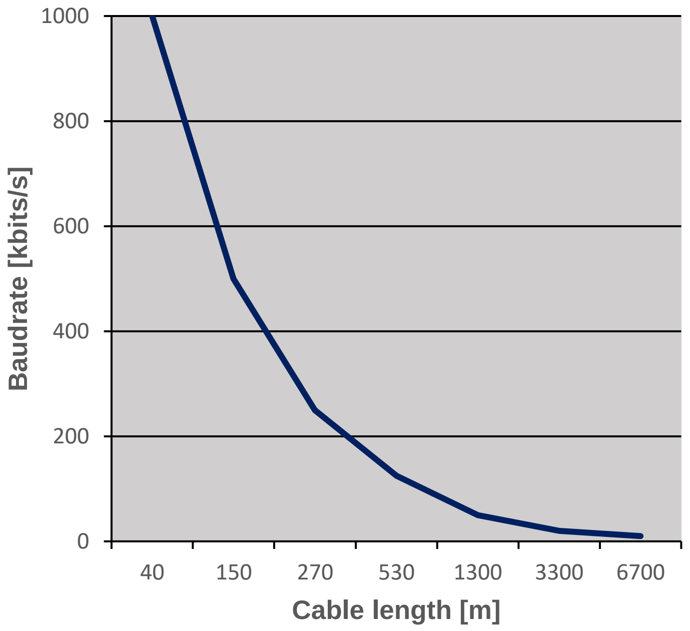


Table 5.1: CAN baud rates und recommended cable length limits

5.2 CANopen

CANopen is a specified higher protocol (layer 7 protocol) (Figure 5.3).

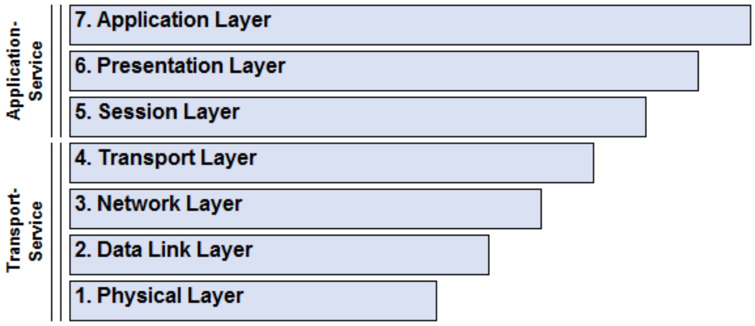


Figure 5.3: ISO-OSI-Modell

With CANopen it is possible to transfer larger amounts of data, emergency telegrams and process data. CANopen describes how the communication is performed. That means that parameters to configure a device are transmitted in a defined form (profile).

A CANopen profile defines objects representing the different functions of a device. These objects form a table called object dictionary.

The communication profile defines the basic services and parameters of a CANopen device (e.g. service data objects SDOs, process data objects PDOs, used CAN-IDs, etc.).

The device profile defines the specific functions of a device family (e.g. encoders, i/o devices, ...). For encoders the device profile is the encoder profile CiA 406.

5.3 Specifications and profiles

5.3.1 Overview

The CANopen specifications were defined by the CiA in Draft Standards. Concerning the WDGA encoders the following specifications are from special importance:

Specification	Description
CiA 301	Application Layer and Communication Profile
CiA 303	Cabling/pin assignment, Representation of units, Indicator specification
CiA 305	Configuration of baudrate und node ID via LSS
CiA 306	Electronic Data Sheet
CiA 406	Device-/Application-profile

Table 5.2: Draft Standards

5.3.2 Mechanisms of communication

There are several different CANopen communication services:

SDO Service Data Object

Use: for access to the object dictionary. There is one single SDO-channel.

Two identifiers are assigned to the SDO channel, one for each direction of transmission.

For SDO the 8 byte CAN frame is divided into 1 byte command, a multiplexor of 2 byte index and 1 byte sub index of the object dictionary, and 4 byte of payload. For bigger payloads either segmented or block transfer is used.

A SDO transmission will always be acknowledged by the receiver. In case of a failure an "abort message" is send. The internal delay time of the WDGA encoders is 1 millisecond maximum.

PDO Process Data Object

Use: for transmission of process data. The WDGA encoders provide up to four PDOs. A PDO uses the full length of the data area of a CAN frame (8 bytes) for the process data without additional overhead.

PDOs will not be acknowledged and are suitable for time critical applications.

By using the full 8 bytes for data, there is no additional information about transmitted objects. Therefore the PDO producer and the PDO consumer have to define the PDO-mapping.

PDOS can be sent on different ways:

- **On request:** A node sends a RTR frame to ID of the designated PDO and the encoder returns the PDO. (The CiA strongly recommends not to use RTR frames. Therefore RTR is not supported by Wachendorff Automation encoders!)

- **Synchronously:** On the reception of a SYNC message the node send its PDOs.

- **Asynchronously:** The sending of the PDOs is triggered by an internal event (e.g. the internal event timer).

5.3.3 Object dictionary

The object dictionary lists all data types, objects and functions of the communication and the device profile. There are also manufacturer specific objects listed. The objects are addressed by 16-bit indices (lines) and 8-bit sub-indices (columns).

Table 5.3 shows the structure of the object dictionary:

Index(hex)	Object description
0000	reserved
0001 001F	static data types
0020 003F	complex data types
0040 005F	manufacturer specific data types
0060 007F	profile specific static data types
0080 009F	profile specific complex data types
00A0 0FFF	reserved
1000 1FFF	communication profile objects
2000 5FFF	manufacturer specific objects
6000 9FFF	objects from the "Standard device profiles"
A000 AFFF	network variables
B000 FFFF	reserved / system variables

Table 5.3: Structure of the object dictionary

5.4 Network management (NMT)

A CANopen network always needs a network management master. The NMT master controls the NMT states of all connected nodes.

A node can be switched into three different states:

- Pre-Operational
- Operational
- Stopped

ℹ	• After a CANopen node is switched on and the communication and the internal application is initialised, the node switches into pre-operational state. From this state the NMT-Master can switch the node into the other states. To show that a node is ready after boot up, it sends a "boot-up message". These messages uses the CAN-ID of the Emergency service (EMCY). The message is permanently associated with the node ID.

Description of the NMT-states:

Pre-Operational	
Object	**Communication enabled**
SDO	yes
PDO	no
NMT	yes
SYNC	no
EMCY	yes
Heartbeat	yes
SDO communication is enabled. PDO communication is disabled.	

Table 5.4: Available communication – Pre-Operational

Operational	
Object	**Communication enabled**
SDO	yes
PDO	yes
NMT	yes
SYNC	yes
EMCY	yes
Heartbeat	yes
Device is in operational status and can send and receive PDOs.	

Table 5.5: Available communication – Operational

Stopped	
Object	**Communication enabled**
SDO	no
PDO	no
NMT	yes
SYNC	no
EMCY	no
Heartbeat	yes
The communication is almost completely disabled. The device only reacts on NMT commands (e.g. start node).	

Table 5.6: Available communication – Stopped

5.5 Heartbeat and Node-Guarding

There are two possible ways to supervise the operational availability of a CAN node during operation.

- Heartbeat
- Node-Guarding

The heartbeat protocol is independent from the master. It is the recommended mechanism. The device sends autonomous and cyclic a "life" message.

- Wachendorff Automation recommends the use of the heartbeat protocol.

When using the node guarding protocol, the NMT master sends RTR frames to the slaves, which have to answer within a defined time. If the answer is missing, this is detected by the master. This protocol leads to a high dependence on the master.

- A variation of the Heartbeat is the Bootup-Message. This type is sent out once the encoder is started and includes no information (Data is 00h). Only by interpreting the COB-ID of the message, the senders Node-ID is obvious (COB-ID = 700h + Node-ID).

5.6 Emergency messages

Failures of a CAN node are announced by emergency messages (EMCY message). The EMCY message contains an error code identifying the problem. A node also can be configured to send no EMCYs.

6 WDGA object dictionary

6.1 Communication objects

The communication objects comply with the CiA specification 301 v4.02 and have the object addresses 1000h to 1FFFh.

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
1000h p. 36	Device type	0h	(MSB) Encoder type (LSB) device profile no.	Unsigned32	co	no	Multiturn: 0002 0196h Singleturn: 0001 0196h
1001h p. 32	Error Register	0h	Indication of internal failures and part of an emergency object	Unsigned8	ro	yes	00h
1002h p. 33	Manufacturer status register	0h	General status register for manufacturer specific purpose	Unsigned32	ro	yes	dyn.
1003h	Predefined Error Field	00h	stores occurring errors indicated by EMCY; volatile;	Unsigned8	rw	no	dyn.
		01h	Standard error field 1	Unsigned32	ro		
		02h	Standard error field 2	Unsigned32	ro		
		03h	Standard error field 3	Unsigned32	ro		
		04h	Standard error field 4	Unsigned32	ro		
		05h	Standard error field 5	Unsigned32	ro		
1005h p. 36	COB-ID SYNC-Message	00h	COB-ID of the SYNC message	Unsigned32	rw	no	0000 0080h
1008h p. 36	Manufacturer device name	00h	Manufacturer device name	string256	co	no	WDGA-ST-CO WDGA-MT-CO
1009h	Manufacturer Hardware-Version	00h	Contains the hardware revision assigned by the manufacturer.	string16	co	co	i*
100Ah	Manufacturer Software-Version	00h	Contains the software revision assigned by the manufacturer.	string72	co	no	i*
100Ch	Guard time	00h	Defines the guard time in Milliseconds; 0h= node guard protocol disabled.	Unsigned16	rw	no	0000h
100Dh	Life time factor	00h	Contains the life time factor for the node guard protocol.	Unsigned8	rw	no	00h

Table 6.1: Object dictionary 1000h – 100Dh

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
1010h p. 68	Store Parameters	00h		Unsigned8	co	no	04h
		01h	Save all parameters	Unsigned32	rw		0000 0001h
		02h	Save communication param.	Unsigned32	rw		0000 0001h
		03h	Save application param.	Unsigned32	rw		0000 0001h
		04h	Save manufacturer param.	Unsigned32	rw		0000 0001h
1011h p. 69	Restore default Parameters	00h	Restores factory settings.	Unsigned8	co	no	04h
		01h	Restore all param.	Unsigned32	rw		0000 0001h
		02h	Restore communication param.	Unsigned32	rw		0000 0001h
		03h	Restore application param.	Unsigned32	rw		0000 0001h
		04h	Restore manufacturer param.	Unsigned32	rw		0000 0001h
1014h p. 32	COB-ID Emergency object	00h	Defines the COB-ID of the emergency object (EMCY).	Unsigned32	rw	no	0000 0080h+ Node-ID
1015h p. 33	Inhibit time EMCY	00h	Defines the minimum pause (in 100 µs steps) between single EMCYs	Unsigned16	rw	no	0000h
1016h p. 31	Consumer heartbeat time	00h	Defines the time frame within the heartbeat consumer awaits an incoming heartbeat otherwise triggering an EMCY.	Unsigned8	co	no	01h
		01h	Heartbeat-Consumer cycle time	Unsigned32	rw		0000 0000h
1017h p. 31	Producer heartbeat time	00h	Defines the heartbeat cycle time in steps of 1 ms. 0h = heartbeat disabled.	Unsigned16	rw	no	0000h
1018h p. 1	Identity Object	00h		Unsigned8	co	no	04h
		01h	Vendor-ID	Unsigned32	co		0100 021Fh
		02h	Product Code	Unsigned32	co		5744 4741h
		03h	Revision Number	Unsigned32			i*
		04h	Serial Number	Unsigned32			i*
1020h p. 38	Verify Configuration	00h	The time of the last configuration can be logged here. If the configuration was changed after setting this value, the object is set to zero autonomously.	Unsigned8	co	no	02h
		01h	Configuration date	Unsigned32	rw		0000 0000h
		02h	Configuration time	Unsigned32	rw		0000 0000h

Table 6.2: Object dictionary 1010h – 1020h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
1029h p. 37	Error behaviour	00h	Changing the encoders behaviour in case of a node-guarding or heartbeat event, etc.	Unsigned8	co	no	02h
		01h	Communication error	Unsigned8	rw		00h
		02h	Encoder Error	Unsigned8	rw		00h
1800h p. 57	Transmit PDO1 communication parameter	00h	Defines the communication parameters of the 1st TPDO	Unsigned8	co	no	05h
		01h	COB-ID or PDO	Unsigned32	rw		180h + Node-ID
		02h	Transmission Type	Unsigned8	rw		FEh
		05h	Event-Timer	Unsigned16	rw		0000h
1801h p. 57	Transmit PDO2 com. parameter	00h	Defines the com. parameters of the 2nd TPDO	Unsigned8	co	no	05h
		01h	COB-ID for PDO	Unsigned32	rw		280h + Node-ID
		02h	Transmission Type	Unsigned8	rw		01h
		05h	Event-Timer	Unsigned16	rw		0000h
1802h p. 57	Transmit PDO3 com. parameter	00h	Defines the com. parameters of the 3rd TPDO	Unsigned8	co	no	05h
		01h	COB-ID for PDO	Unsigned32	rw		380h + Node-ID
		02h	Transmission Type	Unsigned8	rw		01h
		05h	Event-Timer	Unsigned16	rw		0000h
1803h p. 57	Transmit PDO4 com. parameter	00h	Defines the com. parameters of the 4th TPDO	Unsigned8	co	no	05h
		01h	COB-ID for PDO	Unsigned32	rw		480h + Node-ID
		02h	Transmission Type	Unsigned8	rw		01h
		05h	Event-Timer	Unsigned16	rw		0000h
1A00h p. 61	TPDO1 mapping parameter	00h	Defines the PDO-mapping of the 1st TPDO	Unsigned8	rw	no	01h
		01h	Mapped application object 1	Unsigned32	rw		6004 0020h
	variable, depends on sub-index 00h	02h - 08h	Mapped application object 2 - 8	Unsigned32	rw		
1A01h p. 61	TPDO2 mapping parameter	00h	Defines the PDO-mapping of the 2nd TPDO	Unsigned8	rw	no	01h
		01h	Mapping von Objekt 1 in der Applikation	Unsigned32	rw		6004 0020h
	variable, depends on sub-index 00h	02h - 08h	Mapped application object 2 - 8	Unsigned32	rw		

Table 6.3: Object dictionary 1029h – 1A01h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
1A02h p. 61	TPDO3 mapping parameter	00h	Defines the PDO-mapping of the 3rd TPDO	Unsigned8	rw	no	01h
		01h	Mapped application object 1	Unsigned32	rw		6008 0020h
	variable, depends on sub-index 00h	02h - 08h	Mapped application object 2 - 8	Unsigned32	rw		
1A03h p. 61	TPDO4 mapping parameter	00h	Defines the PDO-mapping of the 4th TPDO	Unsigned8	rw	no	00h
	variable, depends on sub-index 00h	01h - 08h	Mapped application object 1 - 8	Unsigned32	rw		
1F80h p. 37	NMT-Start-up-behaviour	00h	Defines the start-up behaviour of encoder	Unsigned32	rw	no	0000 0000h

Table 6.4: Object dictionary 1A02h – 1F80h

(p. = page reference; ro / rw / co = access type; Map = PDO-Mapping; i = individual; dyn = dynamic; ST = singleturn; MT = multiturn)*

6.2 Device specific objects

The device specific objects comply with the CiA encoder profile specification 406 v3.2 and have the object addresses range 6000h to 9FFFh.

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
6000h p. 63	Operating Parameters	00h	Changing / Indicating the operating parameters	Unsigned16	rw	no	0004h
6001h p. 64	Measuring units per revolution	00h	Changing / Indicating the singleturn resolution (STR)	Unsigned32	rw	no	0000 4000h
6002h p. 64	Total measuring range	00h	Changing / Indicating the total measuring range	Unsigned32	rw	no	i*
6003h p. 64	Preset value	00h	Setting / Indicating the preset value to adapt the position value to the application	Unsigned32	rw	no	0000 0000h
6004h	Position value	00h	current position value	Unsigned32	ro	yes	dyn
6008h	High precision position value	00h	Current position value, when measuring range >32 bit	Unsigned64	ro	yes	dyn

Table 6.5: Device specific objects 6000h –6008h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
6009h	High precision Preset Value	00h	Setting/indicating the High-precision-preset-value. Access via segmented or block transfer	Unsigned64	rw	no	0000 0000 0000 0000h
6030h	Speed Value	00h	Rotation speed in units (bit) per second	Unsigned8	ro	yes	01h
		01h	Speed value	Signed16	ro		dyn
6040h	Acceleration Value	00h	Acceleration value in units(bit) per second^2	Unsigned8	ro	yes	01h
		01h	Acceleration value	Signed16	ro		dyn
6050h	Jerk Value	00h	Jerk value in units (bit) per second^3	Unsigned8	ro	yes	01h
		01h	Jerk value	Signed16	ro		dyn
6200h	Cyclic-Timer	00h	Changing / Indicating the transmission period of asynchronous TPDOs	Unsigned16	rw	no	0001h
6300h p. 34	CAM state register	00h	Status bits of the cams of the corresponding cam channel	Unsigned8	ro	yes	01h
		01h	Cam state channel1 0b=inactive 1h=active	Unsigned8	ro		00h
6301h p. 35	CAM enable register	00h	Changing / Indicating the cam enable bits of the corresponding cam channel	Unsigned8	ro	no	01h
		01h	Cam enable channel1 0b=inactive 1b=active	Unsigned8	rw		00h
6302h p. 35	CAM polarity register	00h	Changing / Indicating the inversion of the corresponding cam in (6300h)	Unsigned8	ro	no	01h
		01h	Cam polarity channel1 0b=cam state not inverted / 1b=cam state inverted	Unsigned8	rw		00h
6310h	CAM1 low limit	00h	Indicating the lower switching point of the 1st cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM1	Signed32	rw		0000 0000h

Table 6.6: Device specific objects 6009h –6310h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
6311h	CAM2 low limit	00h	Indicating the lower switching point of the 2nd cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM2	Signed32	rw		0000 0000h
6312h	CAM3 low limit	00h	Indicating the lower switching point of the 3rd cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM3	Signed32	rw		0000 0000h
6313h	CAM4 low limit	00h	Indicating the lower switching point of the 4th cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM4	Signed32	rw		0000 0000h
6314h	CAM5 low limit	00h	Indicating the lower switching point of the 5th cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM5	Signed32	rw		0000 0000h
6315h	CAM6 low limit	00h	Indicating the lower switching point of the 6th cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM6	Signed32	rw		0000 0000h
6316h	CAM7 low limit	00h	Indicating the lower switching point of the 7th cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM7	Signed32	rw		0000 0000h
6317h	CAM8 low limit	00h	Indicating the lower switching point of the 8th cam	Unsigned8	co	no	01h
		01h	Changing lower switching point CAM8	Signed32	rw		0000 0000h
6320h	CAM1 high limit	00h	Indicating the upper switching point of the 1st cam	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM1	Signed32	rw		0000 0000h
6321h	CAM2 high limit	00h	Indicating the upper switching point of the 2nd cam	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM2	Signed32	rw		0000 0000h
6322h	CAM3 high limit	00h	Indicating the upper switching point of the 3rd cam	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM3	Signed32	rw		0000 0000h

Table 6.7: Device specific objects 6311h –6322h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
6323h	CAM4 high limit	00h	Indicating the upper switching point of the 4th cam	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM4	Signed32	rw		0000 0000h
6324h	CAM5 high limit	00h	Indicating upper switching point CAM5	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM5	Signed32	rw		0000 0000h
6325h	CAM6 high limit	00h	Changing / Indicating the upper switching point of the 6th cam	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM6	Signed32	rw		0000 0000h
6326h	CAM7 high limit	00h	Changing / Indicating the upper switching point of the 7th cam	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM7	Signed32	rw		0000 0000h
6327h	CAM8 high limit	00h	Changing / Indicating the upper switching point of the 8th cam	Unsigned8	co	no	01h
		01h	Changing upper switching point CAM8	Signed32	rw		0000 0000h
6330h	CAM1 hysteresis	00h	Indicating the hysteresis for the 1st cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 1st cam	Unsigned32	rw		0000 0000h
6331h	CAM2 hysteresis	00h	Indicating the hysteresis for the 2nd cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 2nd cam	Unsigned32	rw		0000 0000h
6332h	CAM3 hysteresis	00h	Indicating the hysteresis for the 3rd cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 3rd cam	Unsigned32	rw		0000 0000h
6333h	CAM4 hysteresis	00h	Indicating the hysteresis for the 4th cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 4th cam	Unsigned32	rw		0000 0000h
6334h	CAM5 hysteresis	00h	Indicating the hysteresis for the 5th cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 5th cam	Unsigned32	rw		0000 0000h

Table 6.8: Device specific objects 6323h –6334h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
6335h	CAM6 hysteresis	00h	Indicating the hysteresis for the 6th cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 6th cam	Unsigned32	rw		0000 0000h
6336h	CAM7 hysteresis	00h	Indicating the hysteresis for the 7th cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 7th cam	Unsigned32	rw		0000 0000h
6337h	CAM8 hysteresis	00h	Indicating the hysteresis for the 8th cam	Unsigned8	co	no	01h
		01h	Changing the hysteresis for the 8th cam	Unsigned32	rw		0000 0000h
6400h	Area state register	00h	Indicating if the current position is in or outside the work area	Unsigned8	co	yes	01h
		01h	Status of the area state register: 00h=within area; 03h=outside work area 05h=outside work area	Unsigned8	ro		dyn
6401h	Work area low limit	00h	Number of sub-indices	Unsigned8	co	no	01h
		01h	Changing / Indicating the work area low limit	Signed32	rw		0000 0000h
6402h	Work area high limit	00h	Number of sub-indices	Unsigned8	co	no	01h
		01h	Changing / Indicating the work area high limit	Signed32	rw		0000 4000h
6500h	Operating-status	00h	Indicates the operating state of the device	Unsigned16	ro	no	dyn
6501h	Measuring units per revolution	00h	Indication of the singleturn resolution	Unsigned32	co	no	0000 4000h
6502h	Number of distinguish-able revolutions	00h	Indication of the multiturn resolution	Unsigned16	co	no	ST: 0001h MT: FFFFh
6503h p. 34	Alarms	00h	Alarm set by malfunction.	Unsigned16	ro	yes	dyn
6504h	Supported alarms	00h	Information about supported alarms.	Unsigned16	co	no	0001h

Table 6.9: Device specific objects 6335h –6504h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
6505h p. 34	Warnings	00h	Warning set on deviation of certain parameters.	Unsigned16	ro	yes	dyn
6506h	Supported warnings	00h	Information about supported warnings.	Unsigned16	co	no	7001h
6507h	Profile and software version	00h	Revision of the implemented encoder profile and software	Unsigned32	co	no	0105 0302h
6508h	Operating time	00h	not supported	Unsigned32	co	no	FFFF FFFFh
6509h	Offset value	00h	Offset value, calculated from the preset value (6003h)	Signed32	ro	no	0000 0000h
650Ah	Module identification	00h	Manufacturer specific offset	Unsigned8	co	no	03h
		01h	Manufacturer offset value	Signed32	co		00h
		02h	Manufacturer min.-position	Signed32	co		-
		03h	Manufacturer max.-position	Signed32	co		-
650Bh	Serial number	00h	serial number of the encoders, hard wired with object 1018h-04h	Unsigned8	co	no	01h
		01h	Serial number	Unsigned32	co		i*
6510h	Number of high-precision-revolutions	00h	Indicates the maximum possible high-precision multiturn resolution	Unsigned40	co	no	0080 0000 0000h

Table 6.10: Device specific objects 6505h –6510h

(p. = page reference; ro / rw / co = access type; Map = PDO-Mapping; i = individual; dyn = dynamic; ST = singleturn; MT = multiturn)*

6.3 Manufacturer specific objects

The objects 2000h to 5FFFh are manufacturer specific and not defined by the CiA.

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
2100h p. 54	Baudrate	00h	Setting the baudrate	Unsigned8	rw	no	09h
2101h p. 55	Node-ID	00h	Setting the node-ID	Unsigned8	rw	no	7Fh
2103h p. 37	BUS-Off Auto-Reset	00h	Defines the time in BUS OFF, before automatically resetting. 0h = no automatic reset, 01h-FFh = time in sec.	Unsigned8	rw	no	00h
2105h p. 65	Integration value	00h	Number of values for filtering speed, acceleration and jerk	Unsigned8	rw	no	02h
		01h	Integration-Position value filter	Unsigned8	rw		01h
		02h	Integration-Speed value filter	Unsigned32	rw		03E8h
2106h p. 65	Speed scaling	00h	Speed value scaling	Unsigned8	co	no	02h
		01h	Multiplier	Unsigned16	rw		0001h
		02h	Divisor	Unsigned16	rw		0001h
2107h p. 66	Frequency-Limit	00h	Limit for Speed value	Unsigned16	rw	no	FFFFh
2120h p. 38	Customer EEPROM area	00h	Object to store any customer data.	Unsigned8	co	no	08h
		01h	Customer data 1	Unsigned32	rw		FFFF FFFFh
		02h	Customer data 2	Unsigned32	rw		FFFF FFFFh
		03h	Customer data 3	Unsigned32	rw		FFFF FFFFh
		04h	Customer data 4	Unsigned32	rw		FFFF FFFFh
		05h	Customer data 5	Unsigned32	rw		FFFF FFFFh
		06h	Customer data 6	Unsigned32	rw		FFFF FFFFh
		07h	Customer data 7	Unsigned32	rw		FFFF FFFFh
		08h	Customer data 8	Unsigned32	rw		FFFF FFFFh
2500h p. 38	Temperature Object	00h	Monitoring the internal operating temperature	Unsigned8	co	yes	05h
		01h	Current temperature value	Signed16	ro		dyn
		02h	Upper Limit	Signed16	rw		100 (°C)
		03h	Lower Limit	Signed16	rw		-40 (°C)
		04h	Maximum value occurred	Signed16	ro		dyn
		05h	Minimum value occurred	Signed16	ro		dyn

Table 6.11: manufacturer specific objects 2100h –2500h

Object No.	Name	Sub Idx	Function	Data type	ro rw co	Map	Default value
2502h	Error History	00h	Non-volatile error history.	Unsigned32	co	no	dyn
		01h	Standard Error field 1	Unsigned32	ro		dyn
		02h	Standard Error field 2	Unsigned32	ro		dyn
		03h	Standard Error field 3	Unsigned32	ro		dyn
		04h	Standard Error field 4	Unsigned32	ro		dyn
		05h	Standard Error field 5	Unsigned32	ro		dyn
2503h	Alarms-History	00h	Logging of alarms occurred. Number of alarms.	Unsigned8	co	no	dyn
		01h	Alarm 1	Unsigned16	ro		dyn
		02h	Alarm 2	Unsigned16	ro		dyn
		03h	Alarm 3	Unsigned16	ro		dyn
		04h	Alarm 4	Unsigned16	ro		dyn
		05h	Alarm 5	Unsigned16	ro		dyn
2504h	Warnings-History	00h	Logging of warnings occurred. Number of warnings.	Unsigned8	rw	no	dyn
		01h	Warning 1	Unsigned16	ro		dyn
		02h	Warning 2	Unsigned16	ro		dyn
		03h	Warning 3	Unsigned16	ro		dyn
		04h	Warning 4	Unsigned16	ro		dyn
		05h	Warning 5	Unsigned16	ro		dyn

Table 6.12: manufacturer specific objects 2502h –2504h

(p. = page reference; ro / rw / co = access type; Map = PDO-Mapping; i = individual; dyn = dynamic; ST = singleturn; MT = multiturn)*

7 Object description

7.1 Network management (NMT) commands

To switch between the encoders states (STOPPED, PRE-OPERATIONAL, OPERATIONAL) or to trigger a soft reset, there are different NMT commands. The messages are 3 bytes each and will not be acknowledged. The CAN-ID of the NMT is always ZERO and therefor has the highest priority.

0	02h	Command	Node-ID
CAN-ID	DLC	Byte 0	Byte 1

Table 7.1: Structure of NMT-command

Command:

The command determines the intended reaction of the addressed node.

Command	**Wert**
Start Node	01h
Stop Node	02h
Pre-Operational	80h
Reset Node	81h
Reset Communication	82h

Table 7.2: Commands for NMT-command

Node-ID:

The node-ID determines, whether the NMT addresses a certain node or all nodes.

Command	**Wert**
all Nodes	00d
Valid Nod-IDs	01..127d
invalid Node-IDs	128..255d

Table 7.3: Node-ID values for NMT-commands

7.2 Heartbeat protocol

By default the heartbeat protocol is disabled.

The encoder can either send a heartbeat (producer heartbeat) or monitor the heartbeat of other nodes (consumer heartbeat):

Producer heartbeat (Encoder sends its heartbeat)

The producer heartbeat can be enabled by setting the producer heartbeat time in milliseconds respectively can be disabled by setting the producer heartbeat time to 00h. This is done by object 1017h, sub-index 0 (00h=OFF, time in milliseconds = 0..9999h).

Consumer Heartbeat (Encoder monitors an external heartbeat)

The object 1016h, sub-Index=01h, defines the consumer heartbeat time. The encoder uses this time to monitor another heartbeat producer. If the monitored heartbeat does not occur within this time (e.g. device broken), the encoder sends an EMCY message with error code 8130h (Life guard or heartbeat error).

The object also defines the node-ID to be monitored.

Bit 31-24	**Bit 23 -16**	**Bit 15 – 0**
reserved (00h)	Node-ID	Heartbeat Producer time

Table 7.4: monitor external heartbeat

A time value of 0 or a node value 0 or higher than 127 disables the function.

Example for monitoring the node 127d =7Fh with a heartbeat consumer time of 10000 milliseconds (=2710h). The WDGA is assumed to be node 1:

601h	8	23h	16h	10h	01h	10h	27h	7Fh
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Time L	Time H	Producer Node-ID

Table 7.5: Example configuration of a consumer heartbeat

7.3 Emergency messages (EMCY)

An emergency is sent when a failure occurs either on the bus or within the device. Within an EMCY message the error is coded.

Object 1014h defines the COB-ID of the emergency message. The default value is 80h + device node-ID (1 - 127). BasicCAN Frames or ExtendedCAN Frames can be used (Bit 29 = 1).

General structure of an emergency message:

80h+ID	8	Error Code L	Error Code H	Error Reg.	Info1	Info2
CAN-ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4

Table 7.6: Basic structure of an EMCY

Error Code (H,L)	Description
0000h	no error
4200h	Temperature out of tolerance
5000h	Hardware failure (EEPROM)
8110h	CAN overrun
8120h	CAN Error passive state
8130h	Heartbeat / Life guarding error
8140h	Bus Off recovery

Table 7.7: Emergency error code list

Error register:

Interpretation of object 1001h (bit interpretation, default = 00000000):

Bit:	7	6	5	4	3	2	1	0
Info:	co	co	co	Communication	Temperature	co	co	Generic error

Table 7.8: Error register

List info field:

The info field depends on the error codes:

Error Code	Field	Bit	Hex-value	Error description
4200h	Info field 1 (Byte3)	6	40h	Temp. Read Error
		5	20h	low limit exceeded
		4	10h	high limit exceeded

Error Code	Field	Bit	Hex-value	Error description
5000h	Info field 2 (Byte4)	0	01h	EEPROM error in init-phase
		3	08h	EEPROM Write-Timeout

ErrorCode	Field	Bit	Hex-value	Error description
8120h + 8100h	Info field 1 (Byte3) **Low** Nibble	0	1h	active, no Error
		1+2	6h	Bus-Warning
		0+1+2	7h	Bus-Passive
8120h + 8100h	Info field 1 (Byte3) **High** Nibble	0	1h	Bit
		1	2h	Stuffing-Error
		0+1	3h	Form
		2	4h	CRC
		0+2	5h	Ack

Table 7.9: Info field list

The low nibble describes the CAN state, the high nibble gives further information about the error.

The transmission of EMCY messages can be disabled by setting bit 31 (MSB) in object 1014h-00h.

By changing 1015h a minimum pause between two EMCYs can be defined (in steps of 100µs).

7.4 Error Objects

7.4.1 Manufacturer status register

Interpretation of object 1002h (assignment bit - meaning, standard = 00h):

Bit:	7	6	5	4	3	2	1	0
Info:	co	co	co	co	co	EEPROM*	MT*	ST*(1)

Bit:	15	14	13	12	11	10	9	8
Info:	ST*(8)	ST*(7)	ST*(6)	ST*(5)	ST*(4)	ST*(3)	ST*(2)	ST*(1)

Bit:	23	22	21	20	19	18	17	16
Info:	ST*(15)	ST*(14)	ST*(13)	ST*(12)	ST*(11)	ST*(10)	ST*(9)	ST*(8)

Bit:	31	30	29	28	27	26	25	24
Info:	MT*(9)	MT*(8)	MT*(7)	MT*(6)	MT*(5)	MT*(4)	MT*(3)	MT*(2)

Table 7.10: Manufacturer status register

*= Error type (number) | for detailed definitions please contact our technical support.

7.4.2 Alarms

Interpretation of object 6503h
(assignment bit - meaning, standard = 0000000000000000):

Bit:	15..1	0
Info:	co	Position Error

Table 7.11: Alarms - Object 6503h

7.4.3 Warnings

Interpretation of object 6505h
(assignment bit - meaning, standard = 0000000000000000):

Bit:	15	14	13	12	11..1	0
Info:	co	Temp. read failed	Undertemp.	Overtemp.	co	Frequency limit

Table 7.12: Warnings – Object 6505h

7.5 Electronic cam switch (CAM)

Encoders by Wachendorff Automation provide the possibility to configure an electronic cam switch with 8 cams in one single channel. Every cam is defined by its low and high limit, the hysteresis and the polarity.

7.5.1 CAM-state-register

The cam state register (object 6300h) represents the state of the 8 cam switches, one bit per cam. For example the cam state register has the value of 89h:

Position	7(MSB)	6	5	4	3	2	1	0(LSB)
Type	CAM 8	CAM 7	CAM 6	CAM 5	CAM 4	CAM 3	CAM 2	CAM 1
Value	1	0	0	0	1	0	0	1
Logic	High	Low	Low	Low	High	Low	Low	High

Table 7.13: CAM-state-register – Value 89h

That means that the cams 1, 4 and 8 are high and the rest are low. If e.g. the cam 4 toggles to low due to the change of the position value, the cam state register would become 81h:

Position	7(MSB)	6	5	4	3	2	1	0(LSB)
Type	CAM 8	CAM 7	CAM 6	CAM 5	CAM 4	CAM 3	CAM 2	CAM 1
Value	1	0	0	0	0	0	0	1
Logic	High	Low	Low	Low	Low	Low	Low	High

Table 7.14: CAM-state-register – Value 81h

The cams are independent to each other so the cam state register can take on 256 combinations to control a machine.

7.5.2 CAM-enable-register

Each cam can separately be enabled or disabled by the object 6301h sub-Index 01h. The cams are represented by the bits of the object, 1 = ON, 0 = OFF. For example CAM 2, CAM 4 and CAM 7 shall be enabled, so the configuration is:

Position	7(MSB)	6	5	4	3	2	1	0(LSB)
Type	CAM 8	CAM 7	CAM 6	CAM 5	CAM 4	CAM 3	CAM 2	CAM 1
Value	0	1	0	0	1	0	1	0

Table 7.15: CAM-enable-register – Value 4Ah

That means writing 4h to object 6301h sub-index 01h. The cams 2, 4 and 7 are now enabled and can switch depending on their configured limits and the position value.

7.5.3 CAM-polarity-register

The cam-polarity-register object 6302h sub-index 01h alters the polarity of the corresponding cam states in cam state register. By default all cams are high (=1b) when the position value is within the limits of the cam.

E.g. if the cam polarity register is set to 13h (=00010011b) the cams 1, 2 and 6 are inverted (Bit = 0b (Low), while position value inside limits).

Position	7(MSB)	6	5	4	3	2	1	0(LSB)
Type	CAM 8	CAM 7	CAM 6	CAM 5	CAM 4	CAM 3	CAM 2	CAM 1
Value	0	0	0	1	0	0	1	1
Logic	Default	Default	Default	Inverted	Default	Default	Inverted	Inverted

Table 7.16: Example CAM-polarity-register

7.5.4 CAM-Low-Limit

The object CAM-Low-Limit sets the lower switching position for a cam. Each cam has its own CAM-low-limit object. (See object dictionary 6310h...6317h). Within the low-limit objects the sub index represents a cam channel. WDGA provides one channel with 8 cams.

⚠	• The cam-high-limit always has to be lower than the corresponding low-limit. Therefore the high-limit must be usually configured before the corresponding low-limit!

7.5.5 CAM-High-Limit

The CAM-High-Limit defines the upper switching position for a cam, similar to the CAM-low-limit. Therefor each cam has its own high-limit-object (see object dictionary 6320h .. 6327h).

7.5.6 CAM-Hysteresis

The CAM-Hysteresis defines the width of the cam hysteresis for each single cam (see object dictionary 6320h...6327h).

7.6 Device profile

Object 1000h provides the number of the implemented device profile and the device type:

- 0001 0196h – singleturn encoder DS-406 device profile
- 0002 0196h – multiturn encoder DS-406 device profile

7.7 SYNC

1005h is the selected COB-ID on which the encoder awaits the SYNC message. BasicCAN frames and ExtendedCAN frames (Bit 29 = 1b) are supported. The encoder is a SYNC consumer, not a producer!

7.8 Encoder designation

Object 1008h delivers the encoder designation. Only sub index 0 is supported. The value of this object depends on the variant of the firmware.

- WDGA-ST-CO - singleturn CANopen
- WDGA-MT-CO - multiturn CANopen

7.9 Error behaviour

On a CAN communication error an OPERATIONAL encoder switches into PREOPERATIONAL. The behaviour on CAN bus errors can be changed by object 1029h sub-index 01h and the behaviour on encoder errors can be changed by sub-index 02h.

The following values are valid on sub-index 01h and 02h:

Value	Description
00h	Default behaviour, go PRE-OPERATIONAL
01h	Do not change current NMT state
02h	Go STOPPED

Table 7.17: Selection of encoder reaction on errors

7.10 NMT start-up behaviour

Index 1F80h determines the encoders NMT-start-up behaviour (only sub-index 0 is supported):

There are 3 options:

Value	Description
00h	Default behaviour, go PRE-OPERATIONAL
02h	Send NMT-command "Start All Nodes"
08h	Go "OPERATIONAL"

Table 7.18: Selection of start-up behaviour

By sending a "start all nodes"' the encoder takes the task of a basic NMT master.
The configuration has to be saved into the EEPROM.

7.11 Bus-Off Auto-Reset

Index 2103h configures the encoder behaviour when it enters Bus-off state. The default value "0" means that the encoder will remain bus-off until reset. By changing this value the time can be configured in seconds after which the encoder will automatically switch to CAN-Error Active. This feature has to be used with caution, because it can have a critical impact on the whole bus system!

7.12 Customer Data

The object 2120h provides the possibility to store up to 8 data objects (4 byte per object) into the internal EEPROM. Each data is accessed by a sub-index (1...8). The data is stored autonomous, a "save"’ command is not necessary.

7.13 Temperature

The 2500h provides the current internal temperature of the encoder, as well as the possibility to set temperature limits for the device. Sub-indices 0 to 5 are supported. The temperature value is updated every minute. The unit is °C. Crossing the temperature limits will set the error register (object 1001h-00h) to 1000b (=08h) and trigger a non-recurring EMCY message. The warning object (6505h) will also be effected. By default the limits are set to the maximum values allowed, but can be tightened.

7.14 Verify Configuration

You can write the time of the last valid configuration into object 1020h.

This object is also readable. Any change in the configuration will automatically reset this object to zero. Then the new time of configuration can be set.

- All change in parameters, unless otherwise specified, have to be saved into the EEPROM, e.g. by using the "Store All Parameters" command (see 8.12 "Saving parameters into EEPROM"). Otherwise the encoder will return to the last configuration saved after a reset.

8 Setting-up the encoder

8.1 Mechanical and electrical connection

⚠	• For mechanical and electrical connection please mind the included mounting instructions and information.

Shaft encoders:

💡	• Always use a suitable coupling to connect the encoder shaft with the application shaft. The coupling compensates the radial and axial tolerances of both shafts. Both shafts must not touch each other. Please mind the maximal permitted load of the shafts. Suitable accessories can be found on www.wachendorff-automation.com. • Use the threaded bores to screw the encoder flange onto a suitable mounting. • Another possibility for mounting is the use of clamping claws.

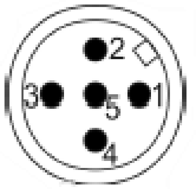
Hollow bore (blind) encoders:

💡	• Stick the encoder completely onto the application shaft. Use the set screw to arrest the encoder shaft with the application shaft. • The encoder has a mounted torque support. This torque support has to be screwed to the machine. The torque support is elastic so that vibrations and tolerances of the application shaft will not overload the encoder’s bearings.

Use the M12 sensor connector or the stub cable to connect the encoder with the bus. We recommend the use of a T-adapter. Terminations and other accessories are also available at www.wachendorff-automation.com.

Pin assignment (according to CiA 303):

(Variations possible (e.g. 58V))



Definition	**Wire colour (Encoder with cable)**	**Pin (Encoder with connector)**
Supply U_B (10-30V)	brown	2
Ground (GND)	white	3
CAN_{High}	green	4
CAN_{Low}	yellow	5
CAN_{GND}	grey	1

Table 8.1: Pin and cable assignment

8.2 Configuration via LSS

8.2.1 General settings

The Layer Setting Services Protocol is specified in the Draft Standard Proposal 305. The LSS allows to configure the encoder even when the node ID is not assigned correctly (e.g. the default node ID doesn't match the application before configuration). The WDGA encoder provides the following LSS services:

- Switch state global
- Switch state selective
- Configure baudrate service
- Configure node-ID service
- Store configuration service
- Identification and inquire services *(Node-ID, Vendor-ID, Product code, Revision number, Serial number)*

A LSS message has the following form:

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

Table 8.2: LSS-message

For the CAN-ID applies:

- LSS-Master -> LSS-Slave: 2021(7E5h)
- LSS-Slave) -> LSS-Master: 2020(7E4h)

To use LSS the encoder has to be **STOPPED** or **PRE-OPERATIONAL**. Then the encoder can be set into LSS mode by two ways:

- Switch Mode Global
- Switch Mode Selective

8.2.2 LSS configuration by "Switch Mode Global"

Connect the LSS master with the encoder. If possible start encoder before master. The baudrate used by the master will be detected by the encoder. Use the NMT command to switch the encoder into "STOPPED" mode. Send the following message:

7E5h	04h	01h	00h	00h	00h	00h	00h	00h

Table 8.3: Command to set encoder "Stopped"-Mode

The encoder is now in configuration mode and now you can configure baudrate and node ID of the encoder via LSS (see section 8.2.5 and 8.2.6).

8.2.3 LSS configuration by "Switch Mode Selective"

Connect the LSS master with the encoder. If possible start encoder before master. The baudrate used by the master will be detected by the encoder. Use the NMT command to switch the encoder into "STOPPED" mode. With the switch mode selective a certain device can be selected by sending four identification messages:

LSS-Command	Information	Description
40h	Vendor-ID	0100 021Fh
41h	Product code	5744 4741h
42h	Revision number	Revision of encoder
43h	Serial number	Serial number of encoder

Table 8.4: LSS-Selective-Identification-Commands

Detailed information about revision number and serial number can be found in chapter 1 "Introduction".

After the last of the four identification messages was send, the appendant encoder will respond with:

LSS-Command	Information	Description

44h	Mode	Mode = 1 -> Configuration mode
		Mode = 0 -> Operation mode

Table 8.5: Answer of encoder to LSS-Selective-Identification-Commands

The encoder is now in configuration mode. Now you can set the encoders baudrate and node ID using LSS (see chapter 8.2.5 und 8.2.6).

⚠	• As soon as the encoder has entered the LSS configuration mode (selective or global) baudrate and node ID can be changed by LSS. After changing the settings have to be stored and the configuration mode has to be deactivated. (see below "End LSS configuration mode").

8.2.4 End LSS configuration mode

When the configuration is completed the changed parameters must be stored and the encoder has to be switched into PRE-OPERATIONAL state by using the following message sequence and a final reset (e.g. a power reset):

Step 1 - store parameters:

7E5h	17h	00h	00h	00h	00h	00h	00h	00h

Table 8.6: End LSS configuration mode – Step 1 - store parameters

Step 2 - Leave configuration mode

7E5h	04h	00h	00h	00h	00h	00h	00h	00h

Table 8.7: End LSS configuration mode – Step 2 - Leave configuration mode

Step 3 - Reset (e.g. NMT "reset node" or power reset).

8.2.5 Baudrate setting

To set the baudrate send the following command:

7E5h	13h	00h	Baudrate	00h	00h	00h	00h	00h
CAN-ID	Command	Sub-Index	Baudrate	Byte2	Byte3	Byte4	Byte5	Byte6

Table 8.8: set Baudrate

The following baud rates can be selected:

Value	Baudrate
0	1 Mbit/s
1	800 kBit/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
9	Auto

Table 8.9: Baudrate-Coding

Check the LSS slaves answer to the command above:

7E4h	13h	00h	00h	00h	00h	00h	00h	00h
CAN-ID	Command	Error Code	Specific Error	Byte2	Byte3	Byte4	Byte5	Byte6

Table 8.10: Answer of LSS-slave

Error Code:

- 00h = OK
- 01h = Baudrate not supported

Specific Error:

- 00h = OK
- FFh = Application specific error

Possibly the communication with the encoder fails after the configuration because the configuration tool and the encoder might operate on different baud rates, so you have to change the baudrate configuration of your tool.

⚠	• Before changing the baudrate you have to check the baudrate of the application. Assure yourself that your configuration tool supports that baudrate! Make a note of the selected baudrate (i.g. in this manual or on the encoders label)

8.2.6 Node-ID setting

Use the following command to change the encoder's node ID:

7E5h	11h	Node-ID	00h	00h	00h	00h	00h	00h
CAN-ID	Command	Node-ID	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6

Table 8.11: set Node-ID

Valid Node IDs are 01h to 7Fh.

⚠	• Mind leaving the LSS configuration mode after configuration (see above 8.2.4)!

8.3 Configuration via SDO

⚠

- If not specified otherwise, all the following configurations have to be saved into the EEPROM (8.12.1 "Saving parameters into EEPROM").

8.3.1 SDO access on objects

You can use SDO communication to read or write on objects:

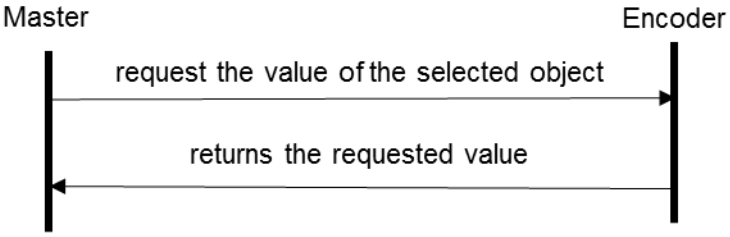

Master
Encoder
request the value of the selected object
returns the requested value

Figure 8.1: read object

The structure of a SDO message is:

Client (master) to server (encoder):

600h+ID	8	40h	04h	60h	00h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.12: Example SDO master to encoder

The payload of the SDO is 4 bytes of data (d1d2d3d4):

580h+ID	8	43h	04h	60h	00h	d4	d3	d2	d1
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.13: Example SDO answer

Table 8.14 shows the overview of the command values:

Command	Type	Description
22h	Write command	Parameter to encoder
23h	Write command	4 Byte Parameter to encoder
27h	Write command	3 Byte Parameter to encoder
2Bh	Write command	2 Byte Parameter to encoder
2Fh	Write command	1 Byte Parameter to encoder
60h	Acknowledge	Parameter received
40h	Read command	Parameter from Encoder
42h	Response	Parameter to SDO master
43h	Response	4 Byte Parameter to SDO master
47h	Response	3 Byte Parameter to SDO master
4Bh	Response	2 Byte Parameter to SDO master
4Fh	Response	1 Byte Parameter to SDO master
80h	Abort code	Failure / Failure code
41h	Response	SDO segmented transfer started (see CiA 301)

Table 8.14: Command definitions

Writing an object:

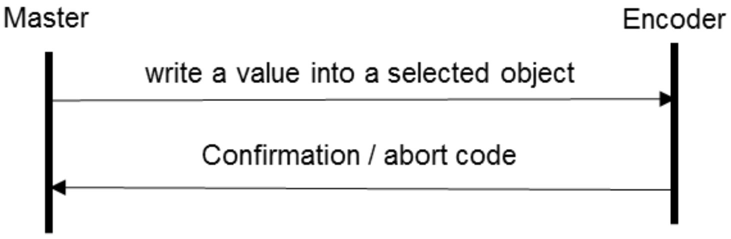

Master
Encoder
write a value into a selected object
Confirmation / abort code

Figure 8.2: write object

The following example shows the structure of a SDO telegram:

Master sends 1 byte of data (d1) to the Encoder:

600h+ID	8	2Fh	00h	21h	00h	d1	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.15: Example SDO send by master

The encoder acknowledges without data bytes:

580h+ID	8	2Fh	00h	21h	00h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.16: Example SDO answer

Table 8.14 shows the overview of the available commands.

8.3.2 SDO access on objects larger than 4 bytes

As seen in subsection 8.3.1 the payload of a single (expedited) SDO is 4byte. For larger data there is the possibility of a "normal" segmented SDO transfer or block transfer for up to 127 segments of 4 byte. For example you want to to read the "high precision preset position value (Obj. 6008h)" or perform a "high precision preset (Obj. 6009h)", so you have to use the segmented SDO transfer.

Segmented read access on an object:

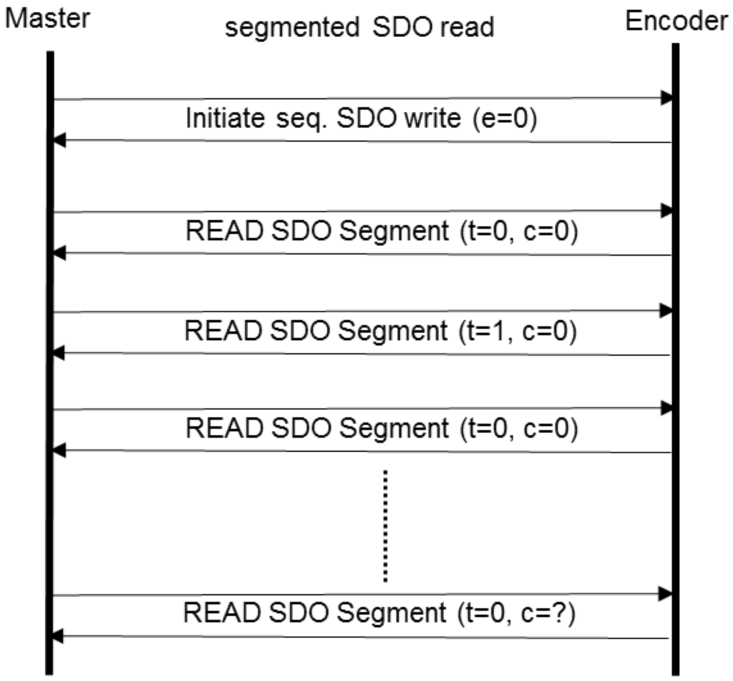

Master
segmented SDO read
Encoder
Initiate seq. SDO write (e=0)
READ SDO Segment (t=0, c=0)
READ SDO Segment (t=1, c=0)
READ SDO Segment (t=0, c=0)
READ SDO Segment (t=0, c=?)

Figure 8.3: Segmented SDO read access

In the following example the 8byte "High Precision Position Value" (object 6008h) is read:

600h+ID	8	40h 01000000b ccs=2,e=0, s=0	08h	06h	00h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.17: SDO read request on object 6008h

Initializing segmented read access:

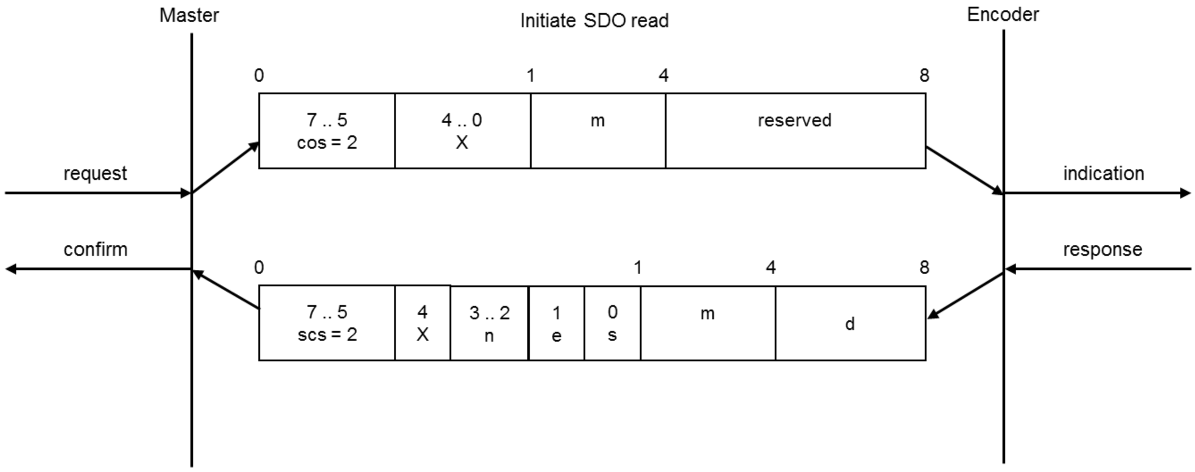


Figure 8.4: Initiate SDO read

ccs	client command specifier	2 = initiate read (upload) request
scs	server command specifier	2 = initiate read (upload) response
n	Indicates that bytes [8-n,7] don’t contain segmented data	Only valid if e=1 and s=1, otherwise 0.
e	Transfer type	0 = segmented transfer 1 = expedited transfer
s	size indicator	0 = data set size not indicated 1 = data set size indicated
m	multiplexor	index/sub index of data to be transferred
d	data	e=0, s=0 -> d is reserved. e=0, s=1 -> d = number of bytes to be read. e=1, s=1 -> d = data of length 4-n to be read. e=1, s=0 -> d = unspecified number of bytes to be read.
X	not used	always 0
	reserved	reserved for further use, always 0

Table 8.18: Declaration of used abbreviations in Figure 8.4

The encoders confirms a segmented SDO transfer of 8 bytes data:

580h+ID	8	41h 01000001b scs=2,e=0, s=1	08h	06h	00h	08h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.19: Confirm SDO read access of object 6008h

Read SDO segment:

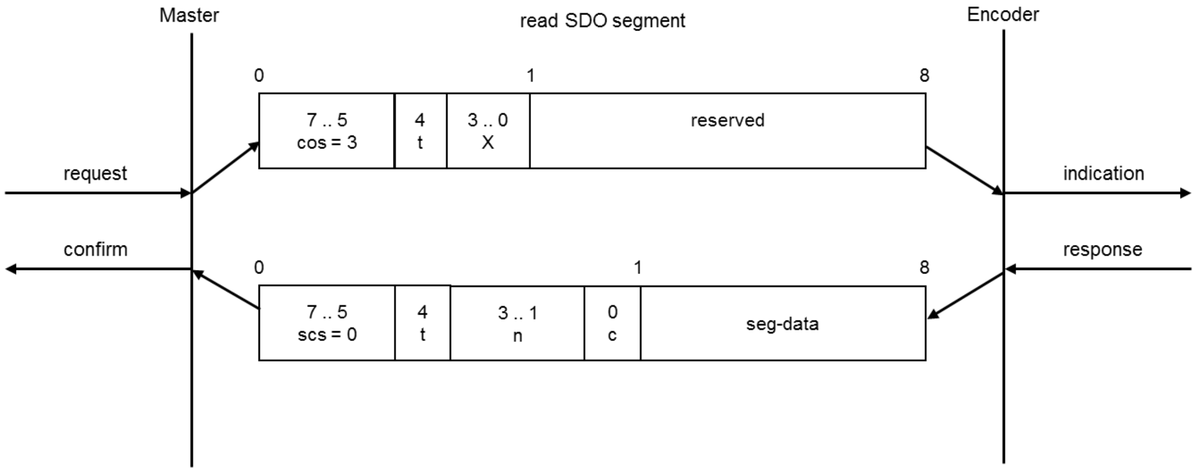


Figure 8.5: read SDO segment

ccs	client command specifier	3 = read (upload) segment request
scs	server command specifier	0 = read (upload) segment response
t	toggle bit	Must alternate for each subsequent segment with t=0 for the first segment. Equal for each pair of request and response.
c	more segments indicator	0 = more segments to be read (uploaded). 1 = no more segments to be read (uploaded).
seg-data	Segment data	At most 7 byte of segment data.
n	Number of bytes that don't contain segment data	Bytes [8-n;7] don't contain segment n = 0 if no segment size indicated
x	not used	always 0
	reserved	reserved for further use, always 0

Table 8.20: Declaration of used abbreviations in Figure 8.5

Then the first segment is requested:

600h+ID	8	60h 01100000b ccs=3, t=0	00h	00h	00h	08h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.21: read of first segment

The encoder answers with the first data segment:

580h+ID	8	00h 00000000b scs=0, t=0, n=0, c=0	data	data	data	data	data	data	data
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.22: answer with first segment

Then the next segment is requested:

600h+ID	8	70h 01110000b ccs=3, t=1	00h	00h	00h	08h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.23: Request next segment

The encoder answers with the next data segment:

580h+ID	8	1Dh 00011101b scs=0, t=1, n=6, c=1	data	x	x	x	x	x	x
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.24: Answer with next segment

Within this segment the encoder indicates that this was the last data segment and that only the first data byte contained valid data. The 7 data bytes of the first segment and the single valid data byte of the data bytes represent the 8 byte "High Precision Position value" (object 6008h).

Segmented write access on an object:

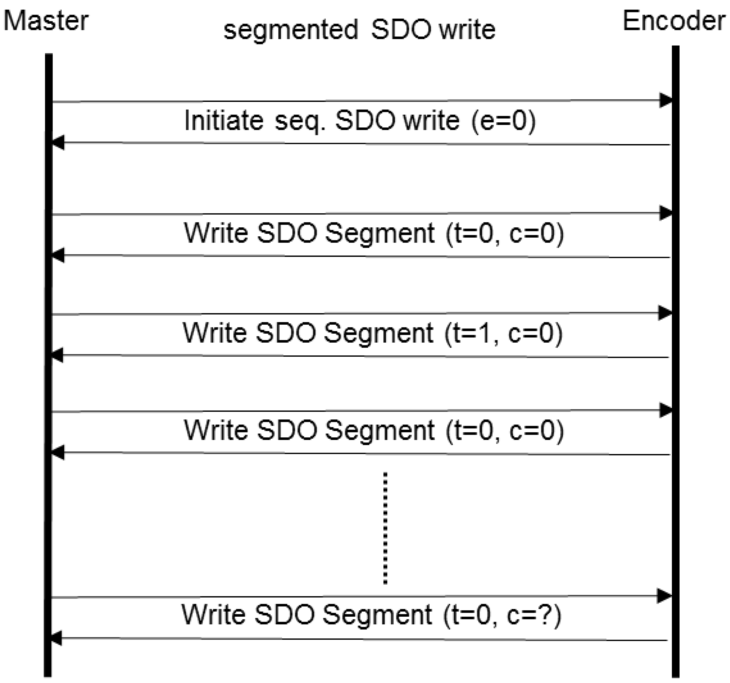

Master
segmented SDO write
Encoder
Initiate seq. SDO write (e=0)
Write SDO Segment (t=0, c=0)
Write SDO Segment (t=1, c=0)
Write SDO Segment (t=0, c=0)
Write SDO Segment (t=0, c=?)

Figure 8.6: Segmented-SDO write access

The next example shows how to use segmented SDO to write an 8 byte value into the "High precision preset value" (object 6009h). This preset value will set the corresponding "High Precision Position value" (6008h) to the designated value:

SDO write request for 8 bytes of data on object 6009h:

600h+ID	8	21h 00100001b ccs=1,e=0, s=1	09h	06h	00h	08h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.25: SDO write access of object 6009h

The encoder confirms the segmented SDO transfer and requests the first segment:

580h+ID	8	60h 01100000b scs=3	09h	06h	00h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.26: Acknowledgement of write access of object 6009h

Initializing segmented write access:

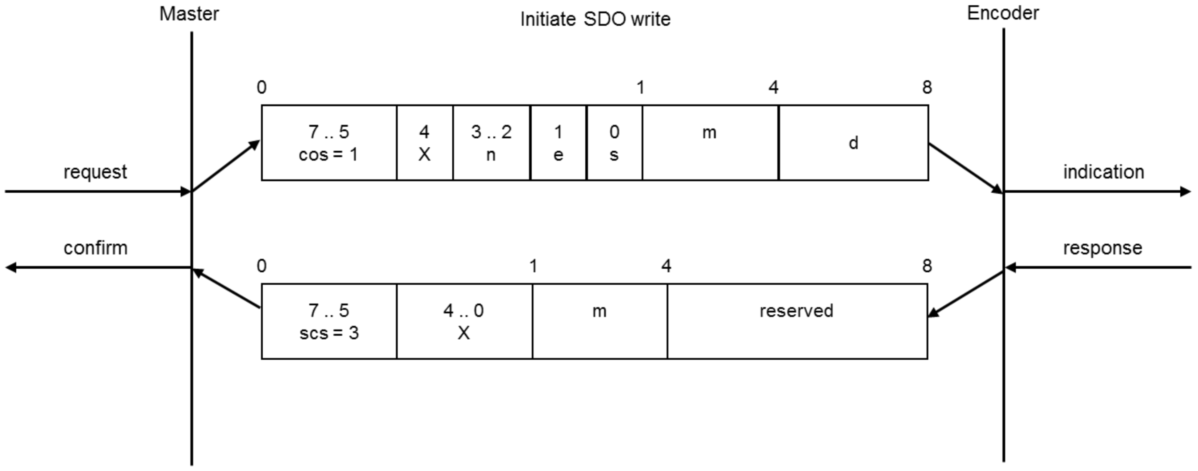


Figure 8.7: Initiate SDO write

ccs	client command specifier	1 = initiate write (download) request
scs	server command specifier	3 = initiate write (download) response
n	Indicates that bytes [8-n,7] don’t contain segmented data	Only valid if e=1 and s=1, otherwise 0.
e	Transfer type	0 = segmented transfer 1 = expedited transfer
s	size indicator	0 = data set size not indicated 1 = data set size indicated
m	multiplexor	index/sub index of data to be transferred
d	data	e=0, s=0 -> d is reserved. e=0, s=1 -> d = number of bytes to be written. e=1, s=1 -> d = data of length 4-n to be written. e=1, s=0 -> d = unspecified number of bytes to be written.
X	not used	always 0
	reserved	reserved for further use, always 0

Table 8.27: Declaration of used abbreviations in Figure 8.7

Then the first data segment is send:

600h+ID	8	00h 00000000b ccs=0, t=0, n=0, c=0	data	data	data	data	data	data	data
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.28: send first segment

The encoder confirms and requests the next segment:

580h+ID	8	20h 00100000b scs=1, t=0	data	data	data	data	data	data	data
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.29: Acknowledgement send by the encoder

Write SDO segment:

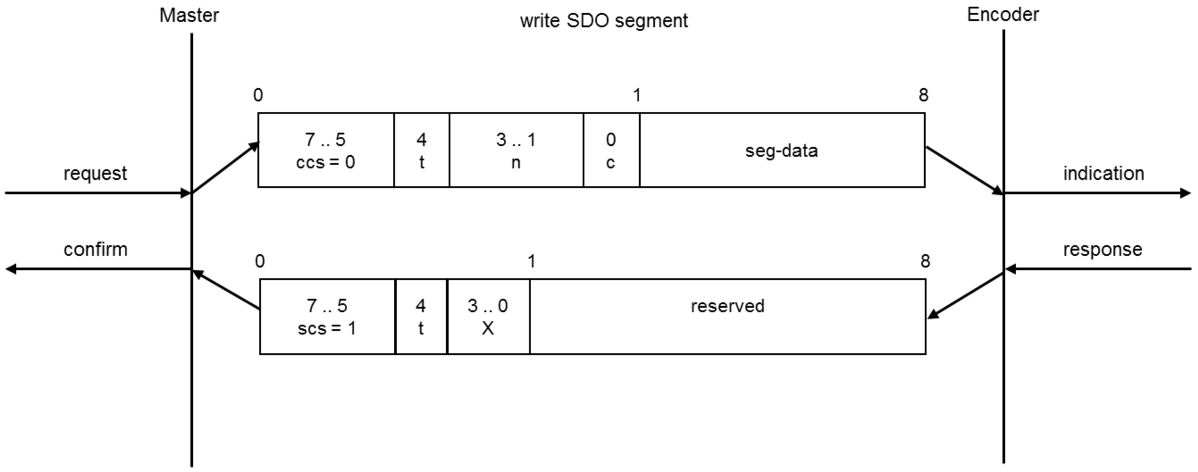


Figure 8.8: write SDO segment

ccs	client command specifier	0 = write (download) segment request
scs	server command specifier	0 = write (download) segment response
t	toggle bit	Must alternate for each subsequent segment with t=0 for the first segment. Equal for each pair of request and response.
c	more segments indicator	0 = more segments to be written (downloaded). 1 = no more segments to be written (downloaded).
seg-data	Segment data	At most 7 byte of segment data.
n	Number of bytes that don't contain segment data	Bytes [8-n;7] don't contain segment n = 0 if no segment size indicated
x	not used	always 0
	reserved	reserved for further use, always 0

Table 8.30: Declaration of used abbreviations in Figure 8.8

Now the next data segment can be send:

600h+ID	8	1Dh 00011101b ccs=0, t=1, n=6, c=1	data	x	x	x	x	x	x
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.31: send next segment

Within this segment it is indicated that this was the last data segment and that only the first data byte contained valid data.

The encoder confirms:

580h+ID	8	20h 00100000b scs=1, t=1	data	x	x	x	x	x	x
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.32: Acknowledgement send by the encoder

The 7 data bytes of the first segment and the single valid data byte of the data bytes represent the 8 byte "High Precision Position Preset Value" (object 6009h).

8.3.3 Baudrate selection

The encoders WDGA by Wachendorff Automation provide an automatic baudrate detection. It is also possible to use a fixed baudrate which can be set by either LSS (as described above) or SDO.

The configuration of the encoder is only possible in Pre-Operational mode. To alter the baudrate you have to change the object 2100h into Sub-Index 00h. This can be achieved with a simple SDO write command with the target baudrate as data.

600h+ID	8	2Fh	00h	21h	00h	Baud	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.33: SDO command – set baudrate

The following values represent the valid baud rates:

Value	Baudrate
0	1 Mbit/s
1	800 kBit/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
9	Auto

Table 8.34: Baudrate-coding

⚠	- The new baudrate will become effective after a reset of the encoder (hard reset or NMT reset). Writing on object 2100h is not protected and the change will be immediately stored in the internal EEPROM. It is not necessary to perform a "save parameters".

8.3.4 Node-ID selection

It is possible to change the node ID of the encoder by SDO. To set the node ID the object 2101h, sub-Index 00h, has to be changed (only possible in Pre-Operational state!) with a simple SDO write command:

600h+ID	8	2Fh	01h	21h	00h	Node	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.35: Node-ID selection

Valid node IDs can be:

Encoder number (d)	Node-ID (h)
1	01h
2	02h
…	…
127	7Fh

Table 8.36: Valid Node-IDs

⚠	- The new node ID will become effective after an encoder reset (hard reset or NMT reset). Writing on object 2101h is not protected and the change will be immediately stored in the internal EEPROM. It is not necessary to perform a "save parameters".

ℹ	- Changing the Node ID automatically adjusts the PDO and EMCY COB-IDs. After the first manual storage, they are set to their current value and will be no longer automatically adjusted. Performing the "Restore Defaults" command will re-enable automatic adjustment.

8.3.5 Basic NMT commands

This subsection describes several basic NMT commands. Basic information are available at 5.4.

To set the encoder into **Operational state**, the "Start remote node" command is used:

0	02h	01h	0 – 127
CAN-ID	DLC	Command Byte	Node-ID

Table 8.37: NMT command - Start remote node

To change the encoder into **Stopped state**, the "Stop remote node" command is used:

0	02h	02h	0 – 127
CAN-ID	DLC	Command Byte	Node-ID

Table 8.38: NMT command - Stop remote node

To switch the encoder into **Pre-Operational state**, the "Enter Pre-Operational State" command is used:

0	02h	80h	0 – 127
CAN-ID	DLC	Command Byte	Node-ID

Table 8.39: NMT command - Enter Pre-Operational-state

A **reset of communication** with a change into Pre-Operational after re-initialisation will be achieved by:

0	02h	82h	0 – 127
CAN-ID	DLC	Command Byte	Node-ID

Table 8.40: NMT command - Reset node communication

To perform a **soft reset** of the encoder, the "Reset Remote Node" is used. After the reset the encoder will send his boot-up message and enter Pre-Operational by default:

0	02h	81h	0 – 127
CAN-ID	DLC	Command Byte	Node-ID

Table 8.41: NMT command - Reset remote node

8.4 Heartbeat settings

To configure and start the producer heartbeat (e.g. heartbeat every 5000 milliseconds; 5000d=1388h) use SDO on object 1017h:

600h+ID	8	2Bh	17h	10h	00h	88h	13h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.42: Example of heartbeat setting

This is the structure of a heartbeat message:

700h+ID	1	d	NMT-Status
CAN-ID	DLC	Data/Remote	Byte 0

Table 8.43: Structure of heartbeat message

NMT-state:

NMT-Status	Code
Boot-up	00h
Stopped	04h
Pre-Operational	7Fh
Operational	05h

Table 8.44: Heartbeat NMT-state-coding

8.5 PDO Configuration

8.5.1 PDO parameters

Four PDOs can be parameterised. The configuration of the PDO payload is called "PDO mapping". The default configuration is:

Object	PDO	Default configuration (scheduling)	“Mapped” process data
1800h	PDO1	asynchronous / on change of position value	Position-value
1801h	PDO2	synchronous / on every SYNC	Position-value
1802h	PDO3	synchronous / on every SYNC	High Precision-value
1803h	PDO4	disabled	

Table 8.45: Default PDO configuration

There are five different types of transmission for every PDO:

Sub-Index 2	Sub-Index 5	Description
01h-F0h	n.n.	PDO synchronous / on a SYNC
FFh	0000h	PDO disabled
FEh	0001h-FFFFh	PDO asynchronous / triggered by event timer AND change in position value
FEh	0000h	PDO asynchronous / triggered by change of position value
FFh	0001h-FFFFh	PDO asynchronous / triggered by event timer

Table 8.46: Selectable PDO transmission types

- Parameters can be changed in Pre-Operational only and have to be saved into EEPROM!

To completely disable a PDO, you have to change the MSB of the PDO-COBID object:

PDO	Object	COB-ID object PDO enabled	COB-ID object PDO disabled
1	1800h	4000 0181h	C000 0181h
2	1801h	4000 0281h	C000 0281h
3	1802h	4000 0381h	C000 0381h
4	1803h	4000 0481h	C000 0481h

Table 8.47: PDO-Deactivation

For example PDO1 shall be disabled by this SDO write command:

600h+ID	8	23h	00h	18h	01h	81h	01h	00h	C0h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.48: Example - PDO1 deactivation

- Advanced parameterisation of the PDO COB-ID (objects 1800h-01h, objects 1801h-01h, objects 1802h-01h, objects 1803h-01h) is possible. As long as no "save communication objects" or "save all parameters" has been performed, a change of the node ID will automatically effect the COB IDs.
- After a save command, the PDO COB-IDs have to be changed manually or perform a "restore all parameters".

8.5.2 Synchronous PDO

A PDO can be configured for synchronous transmission, i.e. to respond on a SYNC message. The sub index 2 of the transmission type parameter determines after which number of SYNCs received the PDO will be transmitted. (e.g.: If set to 05h, the device transmits only on every 5. SYNC). Here PDO1 is configured 01h in 1800h-02h:

600h+ID	8	2Fh	00h	18h	02h	01h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.49: Parametrization of PDO1 Sub-Index 2

Therefore transmission type for PDO1 is now synchronous. In Operational state the PDO1 will be sent as a response on every SYNC message received.

8.5.3 Asynchronous PDO

Cyclic (triggered by internal event timer):

PDOs can be configured for asynchronous cyclic transmission.

Therefor the transmission type in object 1800h-02h (respectively 1801h-02h, 1802h-02h, 1803h-02h) has to be set to FFh. Sub index 5 of the same object is the cycle time in milliseconds.

Example: PDO1 transmitting asynchronously cyclic:

600h+ID	8	2Fh	00h	18h	02h	FFh	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.50: Parametrization of PDO1 Sub-Index 2

Example: PDO1 with a cycle time of 30 milliseconds (1Eh):

600h+ID	8	2Bh	00h	18h	05h	1Eh	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.51: Parametrization of PDO1 Sub-Index 5 to 30ms

PDO1 is now in asynchronous mode and will be sent every 30 milliseconds when the encoder is in Operational state.

Triggered by a manufacturer specific event (change of position value):

To use this transmission type, sub-index 2 has to be FEh and the event timer in sub-index 5 has to be disabled (00h), e.g.:

600h+ID	8	2Fh	00h	18h	02h	FEh	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.52: Parametrization of PDO1 Sub-Index 2

600h+ID	8	2Bh	00h	18h	05h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.53: Parametrization of PDO1 Sub-Index 5

After resetting, the encoder’s PDO1 will be in asynchronous mode and be sent out if the measuring value changes.

⚠

- The use of this setting may cause heavy bus load. Therefor we recommend the use of synchronous or timer triggered transmission.

8.5.4 Variable PDO-mapping

Variable PDO-mapping means that the PDO payload can be configured by the user. This mapping must match between encoder and receiver. The maximum payload for a PDO is 8 bytes. The mapping is also limited by the size of the objects to be mapped. E.g. you can map the "position value" (4 bytes), the "speed value" (2 bytes) and the "acceleration" value (2 bytes) into the same object. Due to the fixed size of a CAN frame this produces less bus load than transmitting the three objects by 3 individual PDOs. This table shows a possible PDO mapping:

Object no	Sub-Index	Datatype	Size	Description
6004h	00h	Unsigned32	4 Byte	Position value
6030h	01h	Integer16	2 Byte	Speed value
6040h	01h	Integer16	2 Byte	Acceleration value

Table 8.54: Example of a mapping-table

The data 1, 2 und 3 (see mapping, Table 8.54) are spread over the PDOs 8 payload bytes. The current payload is 4byte + 2 byte + 2byte = 8 byte. So the PDO is used with 100% efficiency!

The resulting PDO has this structure:

PDO1:

180h+ID	8	1d	1c	1b	1a	2b	2a	3b	3a
CAN-ID	DLC	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7

Table 8.55: Structure of PDO1 (content -> Table 8.54)

1a, 1b, 1c, 1d = 4 bytes of information 1; 2a, 2b = 2 bytes of information 2; 3a, 3b = 2 bytes der information 3.

- To use the WDGA PDO mapping the mapping parameters for the transmit PDO have to be configured (see object dictionary, Table 6.1 ff.).

- **Step 1:** Delete current mapping
- **Step 2:** Re-mapping the PDO
- **Step 3:** Activating the new mapping

For example to change the PDO1 mapping you have to access the PDO1 mapping parameter object 1A00h.

Step 1: Delete current mapping

First the sub-index 0 of the Mapping parameter object has to be set to zero:

600h+ID	8	2Fh	00h	1Ah	00h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.56: Mapping parameter

The encoder is now ready for remapping.

Step 2: Re-mapping the PDO

Mapping of the **position value**: (No.:1 (Size 32 bit = 20h) into object 1A00h sub-index 1 for PDO1):

600h+ID	8	23h	00h	1Ah	01h	20h	00h	04h	60h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.57: Mapping position value

The SDO command contains the object to be mapped and its size (object 6004h, sub-index 0, Size 20h = 4 Byte).

Mapping of **speed value** (No.:2 (Size 16 bit = 10h) into object 1A00h sub-index 2 for PDO1):

600h+ID	8	23h	00h	1Ah	02h	10h	01h	30h	60h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.58: Mapping speed value

The SDO command contains the object to be mapped and its size: (Object 6030h, sub-index 1, Size 10h = 2 Byte).

Mapping of **acceleration value** (No.:3 (Size 16 bit = 10h) into object 1A00h sub-index 3 for PDO1):

600h+ID	8	23h	00h	1Ah	03h	10h	01h	40h	60h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.59: Mapping acceleration value

The SDO command contains the object to be mapped and its size: (Object 6040h, sub-index 1, Size 10h = 2 Byte).

Step 3: Activating the new mapping

To activate the new mapping, the new number of mapped objects must be written into sub-index 0 of the mapping parameter object. In our example three objects are mapped, therefor sub-index 0 has to be set to 03h.:

600h+ID	8	2Fh	00h	1Ah	00h	03h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.60: Mapping parameter – activate new mapping

The re-mapping of PDO1 is now completed and valid, but it should be saved into the EEPROM (see 8.12).

8.6 Changing resolution and direction

- To change resolution and direction of the encoder the scaling option has to be activated.
- While activating the scaling you can change the counting direction (clockwise (CW) or counter-clockwise (CCW) in one step (default setting is CW)).
- The counting direction is referred to the movement of the axis when looking onto the flange side of the encoder.

The object for this configuration is 6000h sub-index 00h. Here is the list of possible settings:

Code Byte 0	Scaling	Direction
00h	OFF	Clockwise (CW)
01h	OFF	Counter-clockwise (CCW)
04h *(default)*	**ON**	**Clockwise (CW)**
05h	ON	Counter-clockwise (CCW)

Table 8.61: Counting direction and scaling parameters

This is an example how to set the "operating parameters" object 6000h to "scaling ON" and "CCW":

600h+ID	8	2Bh	00h	60h	00h	05h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.62: Example setting operating parameters

The encoder responds with a standard SDO acknowledge. Now scaling is active and the two scaling parameters "measuring range per revolution" and "total measuring range" are applied. Singleturn resolution and total measuring range can now be changed.

- The measuring range per revolution or singleturn resolution is the number of units (bit) per revolution.

- The total measuring range is the singleturn resolution multiplied with the number of countable revolutions (multiturn resolution).

Example: Singleturn resolution: 4096 steps per revolution = 12 bit = 10 00h Total measuring range: 536 870 912 units = 29 bit = 20 00 00 00h) => Max. Multiturn resolution: 29 Bit - 12 Bit = 17 Bit = 131072 revolutions (02 00 00h)

The singleturn resolution is editable in object 6001h:

600h+ID	8	23h	01h	60h	00h	00h	10h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.63: Change of singleturn-resolution by SDO

00 00 10 00h represent the designated singleturn resolution. The encoder responds with a SDO acknowledge.

The total measuring range can be changed similarly by object 6002h. In the example a 29 bit total measuring range is selected. With a 12 bit singleturn resolution 17 bit rotations are counted before returning to zero:

600h+ID	8	23h	02h	60h	00h	00h	00h	00h	20h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.64: Change of total measuring range by SDO

20 00 00 00h is the designated total measuring range.

Singleturn resolution and total measuring range do not have to match the bit grid. Every value between 1 and the maximum is valid. The total measuring range cannot be less than the singleturn resolution. The result of an invalid setting will be an abort code.

- From revision number (software version) 1.12, it is no longer possible to scale object 6004 to 32 bits. Only devices, ordered as a 32-bit device (default resolution = 32-bit) provide full 32-bit resolution. Object 6002 has a "0". For all other variants, only a scaling to $2^{32 -1}$ is possible.

8.7 Position preset

With object 6003h the encoder position can be shifted to a preset value. E.g. you can set the zero position of your application without time-consuming mechanical alignment. Just mount the encoder and set the preset object 6003h to the designated position value (p1-p4):

600h+ID	8	23h	03h	60h	00h	p1	p2	p3	p4
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.65: Set position preset

- To set the zero position: p1, p2, p3, p4 = 00h, 00h, 00h, 00h

You don’t have to use PDOs to check the current position value. You can also perform a SDO read access on the position value object 6004h:

600h+ID	8	40h	04h	60h	00h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.66: Check current position

The encoder will respond with the current position value.

8.8 Position value filtering

The encoder provides an internal filtering for the position value. Sub-index 1 of object 2105h is the filter parameter for the internal " IIF"-filter (infinite impulse response filter). 01h for the filter parameter deactivates the filter. The maximum value is 04h. A filtered position value is more stable at the cost of less dynamic.

8.9 Change speed-integration and speed scaling

The encoder uses an "**integration time**" to calculate the speed value. This time interval can be adjusted by object 2105h, sub-Index 2. The unit for this time is milliseconds. The default value of 1000 milliseconds is suitable for most applications.

The change of the integration time will result in a more or less dynamic behaviour of the speed value, similar (but independent) to the filtering of the position value.

The **speed scaling** can be edited by object 2106h. The Sub-Indices 1 (= numerator) and 2 (= denominator) form a scaling factor (here: "z") for the speed scaling. Default value is "1". The speed value is always given in *Increments per second*.

Object 2106h is a signed16 value with the limits of ±32767 representing ±120 revolutions per minute.

For example the speed shall be scaled to a maximum of ±2500 rpm:

$$z = \text{Skaling factor} \qquad \Rightarrow z = \frac{k}{n} \tag{1}$$

$$n = \text{Max revolutions per minute} \quad \Rightarrow z = \frac{120}{2500} \tag{2}$$

$$k = \text{Calculation factor} = 120 \qquad \Rightarrow z = \frac{6}{125} \tag{3}$$

So object 2106h-01h must be set to 6d = 06h and 2106h-02h set to 125d=7Dh, so the limits of ±32767 are scaled to ±2500 U/min.

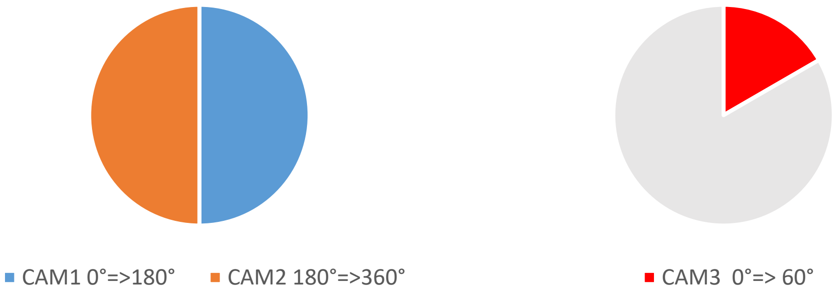
Applying this scaling, the limits ±32767 corresponds with ±2500 rpm.

8.10 Frequency limit

If the speed value exceeds the frequency limit 2107h a warning flag is set (no EMCY). The valid area is 1 to 65535 representing the maximum allowed rotation speed (e.g. 2520 rpm = 42 rotations per second = 002Ah as frequency limit).

8.11 CAM-configuration

This section gives an example how to configure the cam-channel:



That means for single cams:

CAM	Angular area	lower CAM-limit	upper CAM-limit	Hysteresis
1	0°..180°	0	2048	0
2	180°..360°	2049	4095	0
3	0°..60°	0	682	0

Table 8.67: Example CAM-configuration

⚠

- The configuration must be done in Pre-Operational state.

To enable the individual cams the CAM-enable-register (object 6301h-01h) is used. For example the setting 00000111b = 07h enables the first three cams.

600h+ID	8	23h	01h	63h	01h	07h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.68: Enable first three cams

Now the cam-high-limits 1, 2, and 3 can be set as in the table above:

CAM 1 = 2048 = 0800h

600h+ID	8	23h	20h	63h	01h	00h	08h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.69: CAM-High-Limit 1

CAM 2 = 4095 = 0FFFh

600h+ID	8	23h	21h	63h	01h	FFh	0Fh	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.70: CAM-High-Limit 2

CAM 3 = 682 = 02AAh

600h+ID	8	23h	23h	63h	01h	AAh	02h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.71: CAM-High-Limit 3

The setting of the CAM-Low-Limits 1, 2 und 3 is similar:

CAM 1 = 0 = 00h

600h+ID	8	23h	10h	63h	01h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.72: CAM-Low-Limit 1

CAM 2 = 2049 = 0801h

600h+ID	8	23h	11h	63h	01h	01h	08h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.73: CAM-Low-Limit 2

CAM 3 = 0 = 00h

600h+ID	8	23h	12h	63h	01h	00h	00h	00h	00h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.74: CAM-Low-Limit 3

In our example the CAM-Hysteresis shall be 0, so there is no change necessary.

With the CAM-Polarity-Register the polarity of the cams can be inverted.

Using object 6300h Sub-Index 1 the CAM-state-register can be read. The CAM-state-register is also PDO mappable! For more details see 7.5.1 CAM-state-register. To save the configuration into the EEPROM, see 8.12.1 "Saving parameters into EEPROM”.

8.12 Non-volatilely storage of parameters

8.12.1 Saving parameters into EEPROM

Non-volatile storage of parameters using object 1010h:

Sub-Index	Access mode	Description
0	co	Number of objects
1	wo	Save all parameters
2	wo	Save communication objects
3	wo	Save application objects
4	wo	Save manufacturer objects

Table 8.75: Saving parameters

⚠

- To trigger the storage operation the "ASCII" value for "save" (in hex: 65766173h) has to be written into the dedicated sub-index.

E.g. "Save all Parameters":

600h+ID	8	23h	10h	10h	01h	73h	61h	76h	65h
CAN-ID	DLC	Command	Object L	Object H	Sub-Index	Byte0	Byte1	Byte2	Byte3

Table 8.76: Example – Save all parameters

8.12.2 Restoring default parameters from EEPROM

Restoring default settings by using object 1011h:

Sub-Index	Access mode	Description
0	co	Number of objects
1	wo	Restore all parameters
2	wo	Restore communication objects
3	wo	Restore application objects
4	wo	Restore manufacturer objects

Table 8.77: Restoring parameters

⚠

- To restore the default settings the "ASCII" value "load" (in hex: 64616F6Ch) has to be written to the dedicated sub-index of the object.
- Attention: The baudrate and node-ID settings, as well as the customer data object, will not be restored!

9 Error diagnosis

9.1 Encoder configurations

Error description	Check
Encoder doesn’t work, the LED stays dark.	Check connections, power supply and pin assignment.
Encoder is connected correctly, but doesn’t work.	Use a CAN monitoring tool to check if the encoder sends its boot-up message when started.
No communication with the encoder.	Check node ID and baudrate.
Status LED is shining orange, no communication.	Check the correct termination (2 terminations, 120 Ohms each, at the ends), and the length of the bus lines and stub cables.
The bus load exceeds 85%.	Too many error messages on the bus. Check terminations and length of stubs.
After connection the encoder goes bus-passive or bus-off immediately.	Check baudrate and node IDs of all nodes, if connected.
There are irregular failures during transmission.	Encoder is stuck in its initiation due to a hardware failure. Please contact our technical support.

Table 9.1: Error diagnosis – Encoder configuration

10 Support

Technical application advisor

Do you have any questions about this product?

Our technical application advisor will be pleased to help you.

Tel.:	+49 (0) 67 22 / 99 65 414
E-Mail:	support-wa@wachendorff.de

Notes: