Baumer

Passion for Sensors

Manual

Absolute encoder with CANopen®

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04.20
Subject to modification in technic and design.
Errors and commissions excepted

Contents

1 Version overview 4

2 Safety and operating instructions 5

3 Product Assignment 6

3.1 Absolute encoder 6

4 System Overview 7

4.1 General 7

4.2 Supported Profiles 7

4.3 Supported CANopen Services 7

4.4 Function Principle 7

4.4.1 Overview 7

4.4.2 Scaling 7

4.4.3 Position Range 8

4.4.4 Speed range 8

4.4.5 Accleration range 9

4.4.6 Electronic gear function 9

4.5 Encoder with redundant design 10

4.5.1 Baudrate 10

4.5.2 Node Id 11

4.6 Encoder as standard component with embedded software used in safety functions 11

5 NMT Service 12

5.1 Supported commands 12

5.1.1 NMT Reset 12

5.1.2 NMT Communication Reset 12

5.2 Boot-up message 12

6 SDO service 13

6.1 General 13

6.2 SDO examples 14

6.3 Save/load parameters 14

6.3.1 Save 14

6.3.2 Load 14

6.3.3 Safe non-volatile operation 14

7 PDO Service 15

7.1 General 15

7.2 PDO transmission types 15

7.3 COB-ID 15

7.4 PDO mapping 15

7.4.1 Mappable objects 15

7.4.2 Default mapping of absolute encoder 16

7.5 Timing 16

7.6 Exceptions of accurate calculation of process data 16

8 Emergency Service 17

8.1 General 17

8.2 COB-ID 17

8.3 Emergency message 17

8.4 Error register 17

8.4.1 Communication error 17

8.4.2 Temperature error 17

8.4.3 Generic error ... 17

9 Alarms, warnings, errors, emergency messages and error behavior ... 18
9.1 Non-redundant encoder ... 18
9.2 Redundant encoder ... 19
9.3 Error behavior ... 19
9.4 Error Injection ... 20
9.5 Encoder Diagnostic Sources ... 21

10 Heartbeat Service ... 22
10.1 General ... 22
10.2 COB-ID ... 22
10.3 Timing ... 22

11 LSS slave ... 23
11.1 General ... 23
11.2 Supported commands ... 23
11.3 LSS address ... 23

12 Object directory ... 24
12.1 Communication Profile Area ... 24
12.2 Manufacturer Specific Profile Area ... 25
12.3 Standardized Device Profile Area ... 27

13 Applications ... 29

14 Discrepancies to the CIA specifications ... 30

A. Appendix ... 31
a. Pin Assignments ... 31

1 Version overview

This document is subject to changes. In order to have the most current version please download on www.baumer.com

Document index	Date	Firmware version	CANopen Revision Number Obj. 1018	Author	Changes
0001	11.07.17	From V01-03	0003.0000h	blk	Initial version replaces all draft documents
0002	11.9.17	From V01-04	0003.0000h	bwm	- Scaling function expanded up to 16Bit ST - New „speed Filter time“ default value of 50ms (Object 4001h) range reduced from 4000 ms to 500 ms - Comment “Emergencies are not resent after NMT reset” removed in chapter 5.1.1
0003	12.03.18	From V01-05	0003.0000h	zest	- New profile version identification - Comment “Emergencies are not resent after NMT communication reset” removed chapter 5.1.2 - New function electronic gear, chapter 4.4.5 (Obj. 2001h) - Reworked chapter 8 and 9 - New function error injection, chapter 9.4 - Added chapter 4.5.2 Node Id for redundant Encoder
0004	29.03.18	From V01-05	0003.0000h	zest	- fixed wrong sub-indexes in chapter 9.4 - fixed data flow of magnetic field strength and magnetic field sequence in Figure 6 - fixed wrong object number in table of chapter 7.4.1 - comment added electronic gear function for non-redundant encoders
0005	18.02.19	From V01-07	0003.0000h	Bwm, gyc	- Add acceleration - Add Safety word - Add need reboot information for electronic gear - Corrected LSS Service Names according to CIA 305
0006	24.04.19	From V01-07	0003.0000h	egt	- Add explanation SDO in chapter 6.1 - Add examples SDO, chapter 6.2
0007	22.05.19	From V01-07	0003.0000h	egt	- Replace cycle time in Object 1800h of 0 ms with 100 ms
0008	17.06.19	From V01-07	0003.0000h	egt	- Fixed software version in object 6507h and chapter 4.2
0009	18.07.19	From V01-07	0003.0000h	egt	- Corrected object number for speed in capter 4.4.4
0010	19.08.19	From V01-07	0003.0000h	egt	- Corrected default values in chapter 12.1, object 1800h-5 event timer 100 ms instead of 0 ms and object 1801h-2 PDO type 2 instead of 1 - Corrected link of object 6200h to 1800h-5 instead of 1800h-2 in chapter 12.3
0011	10.01.20	From V01-07	0003.0000h	egt	- Corrected names of eds-fils
0012	31.03.20	From V01-07-02	0003.0000h	wge	- Change of behavior at reversal of rotation direction and acceleration in object 6000h Bit0 - Customer-specific adaptability for direction of rotation and acceleration in object 2110h Bit0 added - Mistake was present in V01-03 to V01-07-01 - Chapter 7.4.1: Mapping entry safety word corrected - Object 2001-01h: corrected value U16 to U8

2 Safety and operating instructions

Intended use

- The encoder is a precision measuring device that is used to record positions and speeds. It provides measuring values as electronic output signals for the subsequently connected device. It must not be used for any other purpose. Unless this product is specially labeled, it may not be used for operation in potentially explosive environments.
- Make sure by appropriate safety measures, that in case of error or failure of the encoder, no danger to persons or damage to the system or operating facilities occurs.

Personnel qualification

- Installation and assembly of this product may be performed only by a person qualified in electronics and precision mechanics.

Maintenance

- The encoder is maintenance-free and must not be opened up nor mechanically or electronically modified. Opening up the encoder can lead to injury.

Disposal

- The encoder contains electronic components. At its disposal, local environmental guidelines must be followed.

Mounting

- Solid shaft: Do not connect encoder shaft and drive shaft rigidly. Connect drive and encoder shaft with a suitable coupling.
- Hollow shaft: Open clamping ring completely before mounting the encoder. Foreign objects must be kept at a sufficient distance from the stator coupling. The stator coupling is not allowed to have any contact to the encoder or the machine except at the mounting points.

Electrical commissioning

- Do not proceed any electrical modifications at the encoder.
- Do not proceed any wiring work while encoder is live.
- Do not remove or plug on connector whilst under power supply.
- Ensure that the entire system is installed in line with EMC/EMI requirements. Operating environment and wiring have an impact on the electromagnetic compatibility of the encoder. Install encoder and supply cables separately or far away from sources with high emitted interference (frequency converters, contactors, etc.).
- When working with consumers with high emitted interference provide separate encoder supply voltage.
- Completely shield encoder housing and connecting cables.
- Connect encoder to protective earth (PE) using shielded cables. The braided shield must be connected to the cable gland or connector. Ideally, aim at dual connection to protective earth (PE), i.e. housing by mechanical assembly and cable shield by the downstream devices.

Supplementary information

- The present manual is intended as a supplement to already existing documentation (e.g. catalogues, data sheets or mounting instructions).

3 Product Assignment

3.1 Absolute encoder

Product	Product-Code	Device Name	EDS-file
Absolute encoder multiturn (single channel and redundant version)	0x0070	EAMxxx MT	EAMxxx_0x0070_V03.00.eds
Absolute encoder singleturn	0x0071	EAMxxx ST	EAMxxx_0x0071_V03.00.eds

4 System Overview

4.1 General

The encoder is a rotary measuring system with a CANopen interface. It supports scaling and presetting.
In consideration of “CAN in Automation” (CiA) Profile 406 for Encoders, it’s an Absolute rotary encoder - Class C2.
The redundant encoders are galvanically isolated, for non-redundant encoders galvanical isolation on request.

4.2 Supported Profiles

Following CANopen profiles are supported:

- CiA 301 / Version 4.2 (Communication)
- CiA 305 / Version 2.2 (LSS)
- CiA 406 / Version 4.0 (Encoder Profile)

4.3 Supported CANopen Services

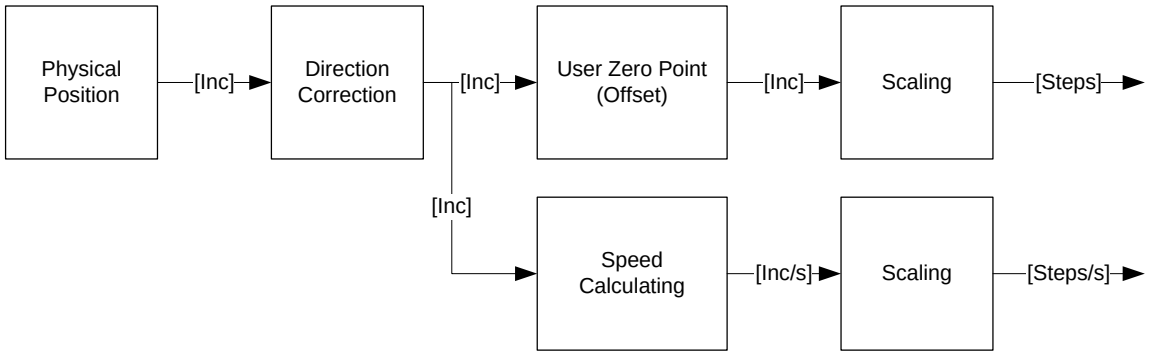
Following CANopen services are supported:

- 1 Network Management (according to CiA 301)
- 1 SDO Server (according to CiA 301)
- 2 TPDOs (according to CiA 301/CiA 406)
- 1 Emergency Producer (according to CiA 301/CiA 406)
- 1 Heartbeat Producer (according to CiA 301)
- 1 Node guarding (according to CiA 301)
- 1 LSS Client (according to CiA 305)

4.4 Function Principle

4.4.1 Overview

Figure 1: Function principle overview



4.4.2 Scaling

The scaling of speed and position objects can be adapted in the object 6001h or object 6002h.

Relationship between object 6001h and 6002h:

Total measuring range	=	*Measuring units per revolution*	*x*	*Number of distinguishable revolutions*
(Value Object 6002h)	=	*(Value Object 6001h)*	*x*	*(Value Object 6502h)*

4.4.3 Position Range

The range of the position is depending on the position step setting (object 6001h-0 and Object 6002h-0). The total range can be read from object 6002h-0. The range is 0…(Value Object 6002h)-1.

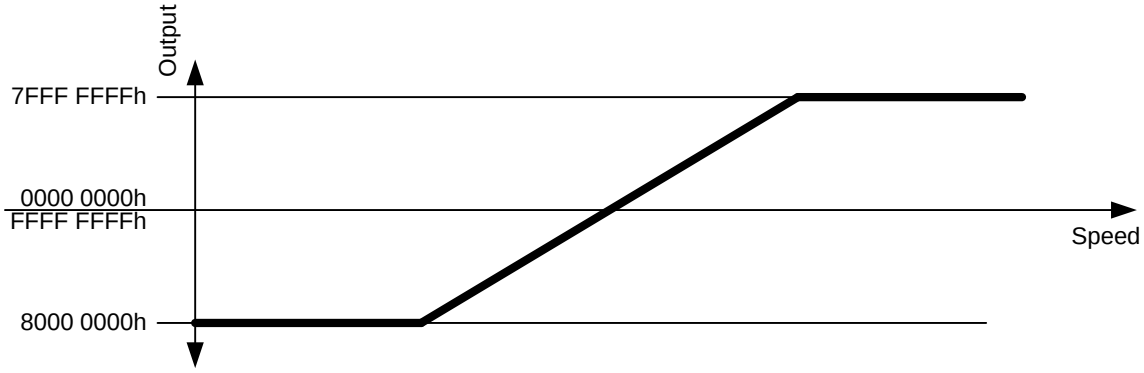
4.4.4 Speed range

There are two objects, which can be used for the speed information.

0x6030-1

This object provides a 32-Bit Speed information, which has the unit [Steps/sec].
The range for object 6030h-1 Speed encoder A is -8000'0000h…7FFF'FFFFh.
If the scaled speed value exceeds this range, the output is -8000'0000h or 7FFF'FFFFh (Saturated Logic).

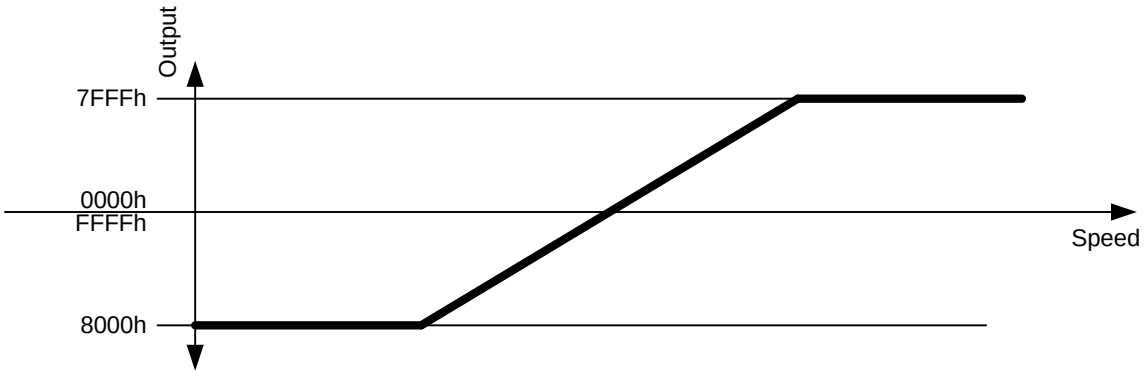
Figure 2: Speed range



0x2118

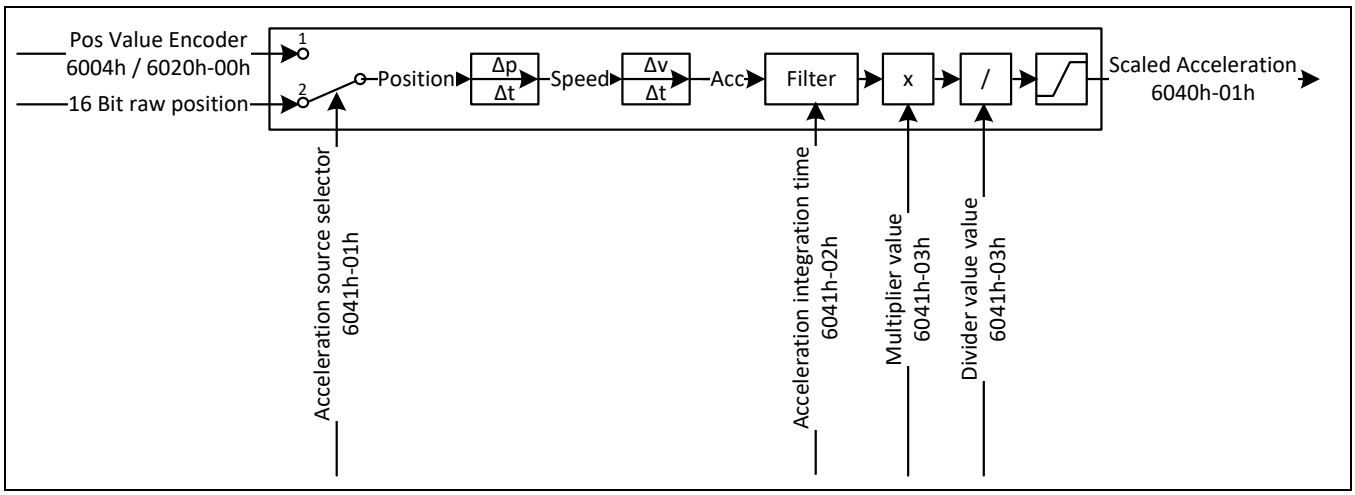
This object provides a 16-Bit Speed information, which has the unit [rpm].
The range for object 2118h- Speed encoder A is -8000h…7FFF'h.
If the scaled speed value exceeds this range, the output is -8000h or 7FFFh (Saturated Logic).

Figure 3: Speed range



4.4.5 Accleration range

In encoder rotary profile the encoder supports acceleration output on object 6004h-01h. As the acceleration value is a highly dynamic value, the user should adapt scaling and filtering to his application. As the output value is an 16Bit value only the user has to take care about limits.



Acceleration value unit

The acceleration value is derived from the position value. Find below a calculation example, with acceleration calculated from 16Bit raw position. The example shows a speed change of 6000rpm in one second.

6000 = rpm/s (Rounds per minute per second)
100 = r/s^2 (Rounds per $second^2$)
$100*2^{16}$= $Steps/s^2$ (Steps per $second^2$)

4.4.6 Electronic gear function

The electronic gear function divides the position value by the gear factor. Therefore it transforms the position value into the view of the application:

$$application\ position = \frac{encoder\ position}{i}$$

The gear factor (i) is defined as followed:

$$i = \frac{GearValue1}{GearValue2}$$

There are three objects that should be configured to use the electronic gear function.

0x2001-1 Enable

Set this object to the value “2” to enable the electronic gear function, while the value “1” disable it.

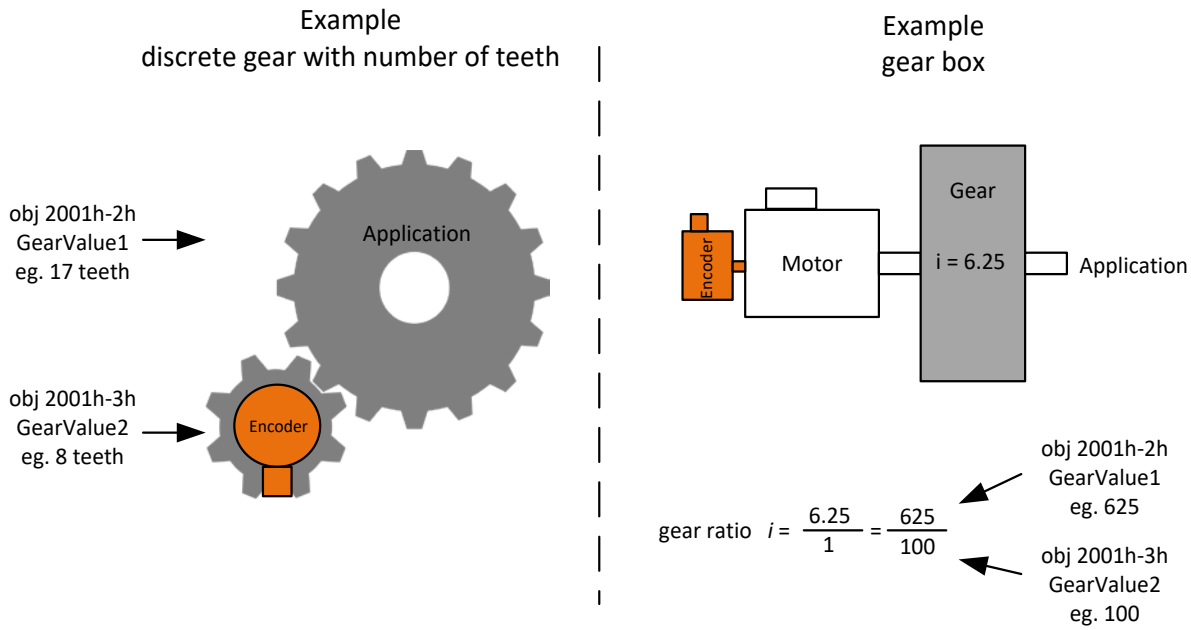
0x2001-2 Gear Value 1

This Object defines the numerator of the gear factor.
The range of this integer value is 1…32767.

0x2001-3 Gear Value 2

This Object defines the denominator of the gear factor.
The range of this integer value is 1…32767.

Figure 4: Example configuration of gear values



Limitations

A useful gear ratio is greater than 0.125, while a gear ratio smaller than 1 may result in higher signal noise.
The maximum encoder turns in unpowered operation must be smaller than 2^{29} (536'870'912) turns.
The electronic gear function is useful for multiturn encoders. In case of singleturn encoders, the position value gets lost after a power cycle.
After setting and storing the gear parameters, the encoder has to restarted to activate the gear function.

4.5 Encoder with redundant design

In case of redundant design both encoder channels are connected with the same connector to the network. This means both nodes do acknowledge the message of each other, without being connected to a network.

For encoders with redundant design the battery voltage is monitored during power off. Following minimum power off time is required for proper detection:

Warning	0x6505	**BattLow**: Batterie low charge	Minimum power-off time: 11 seconds
Alarm	0x6503	**BattEmpt**: Battery empty	Minimum power off time: 1 second

4.5.1 Baudrate

Both encoders shall be configured with the same baudrate to avoid bus collisions.

Note:

In the case that the encoders are configured with different baudrates, do following sequence:

1. Configure CAN Master with the higher baudrate of the encoder
2. Reconfigure the node with this higher baudrate to the lower baudrate again (object 0x2100)
3. Save the baudrate according chapter 6.3.1
4. Performing a NMT Reset
5. Reconfigure CAN Master with lower baudrate (object 0x2100)
6. Reconfigure both nodes to the desired baudrate
7. Save both baudrates according chapter 6.3.1

4.5.2 Node Id

Both encoders shall be configured with different Node Id's which are not reserved by other nodes, to avoid bus collisions.

Note:
In case the encoders are configured with the same node id, do following sequence:

1. Configure CAN Master with the used baudrate and node id of the encoders
2. Request a parameter restore to factory default (object 0x1011-01) according chapter 6.3.2
3. Performing a NMT Reset
4. Reconfigure CAN Master with the factory default baudrate
5. Reconfigure both nodes to the desired, different node id's
6. Save both node id's according chapter 6.3.1

4.6 Encoder as standard component with embedded software used in safety functions

If this standard encoder is used in safety functions, please request the according "Application Note MAGRES EAM" for further information.

5 NMT Service

5.1 Supported commands

Following NMT commands are supported:

NMT Command	Byte 0
NMT Start	0x01
NMT Preoperational	0x80
NMT Stop	0x02
NMT Reset	0x81
NMT Communication Reset	0x82

NMT Frame:

COB ID	Byte 0
node ID	xx

5.1.1 NMT Reset

This NMT command performs a complete reset of the encoder, which can take up to 170 ms until the new bootup-message is sent (restarting of the micro controller, be aware that all unsaved configurations will be lost).

5.1.2 NMT Communication Reset

This NMT command performs a restarting of the CAN Controller, which can take up to 5 ms until the new bootup-message is sent (be aware that all unsaved configurations will be lost).

5.2 Boot-up message

After a power-on or NMT reset, the device will send a Boot-up message.

COB ID	Byte 0
700h + node ID	00

6 SDO service

6.1 General

The device supports 1 SDO server (Expedited read/write, segmented read)

Structure of an **SDO telegram**:

COB ID	DLC	Command	Object L	Object H	Subindex	Data 0	Data 1	Data 2	Data 3

A SDO-**COB ID** is composed as follows:
Master -> Encoder : 600h + Node-ID
Encoder -> Master : 580h + Node-ID

DLC describes the length of the telegram. This is composed as follows:
1 byte command + 2 bytes object + 1 byte subindex + no. of data bytes (0…4).

The **command** byte defines whether data is read or set, and how many data bytes are involved.

SDO command	**Description**	**Data length**	
22h	Download request	Max. 4 byte	Transmits parameter to code
23h	Download request	4 byte	
2Bh	Download request	2 byte	
2Fh	Download request	1 byte	
60h	Download response	-	Confirms receipt to master
40h	Upload request	-	Requests parameter from encoder
42h	Upload response	Max. 4 byte	Parameter to master with max. 4 byte
43h	Upload response	4 byte	
4Bh	Upload response	2 byte	
4Fh	Upload response	1 byte	
80h	Abort message	-	Encoder signals error code to master

An **abort message** indicates an error in the CAN communication. The SDO command byte is 80h. The object and subindex are those of the requested object. The error code is contained in bytes 8…5.

COB ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
580h + Node-ID	8	80h	Object L	Object H	Subindex	ErrByte 0	ErrByte 1	ErrByte 2	ErrByte 3

Byte 8…5 reults in the SDO abort message (byte 8 = MSB).
The following messages are supported:

05040001h	Command byte is not supported
06010000h	Incorrect access to an object
06010001h	Read access to write only
06010002h	Write access to read only
06020000h	Object is not supported
06090011h	Subindex is not supported
06090030h	Value outside the limit
06090031h	Value too great

08000000h	General error
08000020h	Incorrect save signature
08000021h	Data cannot be stored

6.2 SDO examples

Request of a value by the master from the slave
A frequent request will be a request for position: Object 6004h

COB ID	DLC	Command	Object L	Object H	Subindex	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	8	40h	04h	60h	0	x	x	x	x

Response by the slave to the request for a value
The position is 4 bytes long, the precise values can be found under object 6004h.

COB ID	DLC	Command	Object L	Object H	Subindex	Data 0	Data 1	Data 2	Data 3
580h + Node-ID	8	43h	04h	60h	0	a	b	c	d

Writing a value by the master into the slave
Position setting can be performed with preset. Object 6003h

COB ID	DLC	Command	Object L	Object H	Subindex	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	8	22h	03h	60h	0	a	b	c	d

Slave's response to the writing of a value

COB ID	DLC	Command	Object L	Object H	Subindex	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	8	22h	03h	60h	0	a	b	c	d

6.3 Save/load parameters

The device supports saving parameters to a non-volatile memory.

6.3.1 Save

Writing "save" to 1010h-x saves the corresponding objects to the non-volatile memory. After a reset or power-on, the parameters are loaded from the non-volatile memory.
The SDO request to 1010h-x is answered after the saving of the parameters is performed.

6.3.2 Load

Writing "load" to 1011h-x restores the corresponding objects. The parameters are restored after a reset or power-on.

6.3.3 Safe non-volatile operation

To ensure safe non-volatile operation, the user must ensure no power interruption immediately after sending of the save command to object 1010h-x (otherwise, the factory values are restored at the next power up).

7 PDO Service

7.1 General

The device supports TPDO1 and TPDO2. PDOs are only transmitted in NMT operational mode.

7.2 PDO transmission types

The following transmission types are supported (object 180xh-2):

- Synchronous transmission (1-240)
- Asynchronous transmission (255)
- Manufacturer transmission (254)
- RTR-only transmission, event-driven (253)

Both PDOs support all transmission types.

Transmission type 253:	The PDO is only transmitted on request (remote transmission request).
Transmission type 255 and 254:	The PDO is transmitted timer driven. The time interval between 2 PDOs can be adapted in the object 180xh-5
Transmission type 1-240:	The PDO is transmitted after the n-th sync frame.
Transmission type 1:	The PDO is transmitted after one sync frame.
Transmission type 2:	The PDO is transmitted after two sync frames.

etc.

7.3 COB-ID

The COB-ID for both PDOs is changeable (in Object 180xh-1)
Default Values are:
TPDO1: 180h + node ID
TPDO2: 280h + node ID
Changes will be applied immediately.

The COB-ID is stored internally as a difference to the default COB-ID. Example:

Node ID: 1	*COB-ID TPDO1: 181h*	*(Default value)*
	COB-ID TPDO1: 187h	*(Changed by user)*
Node ID: 9	*COB-ID TPDO1: 189h*	*(Adapted automatic)*

7.4 PDO mapping

The encoder supports dynamic mapping.

7.4.1 Mappable objects

The following objects are mappable:

Mapping content	Mapping entry	Description
Position encoder	0x60040020	Object 6004h Subindex 00h, data length 32 Bit
Speed encoder	0x60300120	Object 6030h Subindex 01h, data length 32 Bit
Alarms	0x65030010	Object 6503h Subindex 00h, data length 16 Bit
Warnings	0x65050010	Object 6505h Subindex 00h, data length 16 Bit
Diagnostic	0x21170010	Object 2117h Subindex 00h, data length 16 Bit
Speed [rpm]	0x21180010	Object 2118h Subindex 00h, data length 16 Bit
Time Stamp	0x21200010	Object 2120h Subindex 00h, data length 16 Bit
Acceleration	0x60400110	Object 6040h Subindex 01h, data length 16 Bit
Safety Word	0x21220010	Object 2122h Subindex 00h, data length 16 Bit

To change PDO mapping, disabling the mapping by writing 0 to 0x1A0x-0 is required first. Write the desired mapping entry and enable the mapping again by writing the number of PDO contents to 0x1A0x-0.

7.4.2 Default mapping of absolute encoder

The mappings for both PDOs are the same. The position will be transmitted in byte 0..3.

ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3
181h/281h	4	xx	xx	xx	xx

Byte 0...3: Position (Object 6004h)

7.5 Timing

The minimal cycle time for TPDOs is 1 ms.

7.6 Exceptions of accurate calculation of process data

The following operations could interrupt the accurate calculation of process data such as position, speed, warnings and alarms:

- Changing the scaling parameters

8 Emergency Service

8.1 General

If there is an error on the device, the device commits an emergency message and sets the corresponding bits in the error register (Object 1001h).
Error codes are accessible by the error field (object 1003h-x). A history of maximal 8 error codes is stored in the error field.

8.2 COB-ID

The COB-ID for the emergency message can be modified in object 1014h.
Default Value: 80h + node ID
Changes will be applied immediately.

The COB-ID is stored internally as a difference to the default COB-ID. Example:
Node ID: 1 COB-ID Emergency: 81h (Default value)
COB-ID Emergency: 87h (Changed by user)
Node ID: 3 COB-ID Emergency: 89h (Adapted automatic)

8.3 Emergency message

The format of the emergency messages is according to CiA 301. Additionally, the encoder sends the warning and alarm fields (object 6503h, 6505h).
The emergency message is transmitted if an error is indicated in the error register.

COB-ID	**DLC**	**Byte0**	**Byte 1**	**Byte 2**	**Byte 3**	**Byte 4**	**Byte 5**	**Byte 6**	**Byte 7**
80h+node ID	8	Error code		Error register (object 1001h)	Manufacturer specific				
					Alarms 6503h		Warning 6505h		Not used

8.4 Error register

Error register (object 1001h)							
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-	-	-	Communication error	Temperature error			Generic error

8.4.1 Communication error

Communication errors are indicated if the internal CAN message buffers are overflowed or there are malformed CAN frames on the bus. After a communication error the corresponding operation (described in object 1029h-1) is executed.

8.4.2 Temperature error

This error is indicated, when the internal temperature of the encoder is above a certain threshold level, at which the position can't be guaranteed.

8.4.3 Generic error

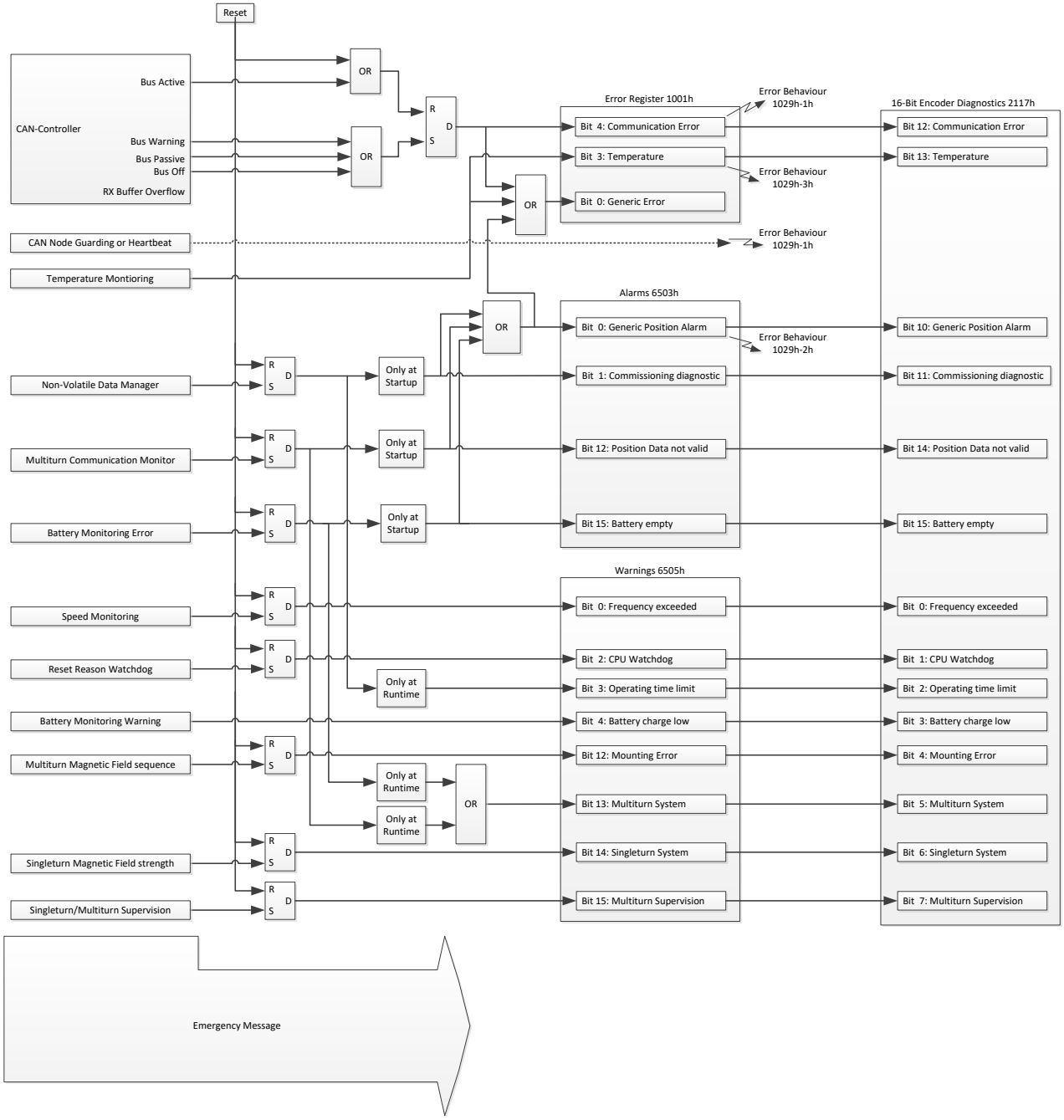
A generic error is indicated for all other errors.
An encoder specific alarm or error will also cause a generic error.
After a generic error the corresponding operation (described in object 1029h-2) is executed.

9 Alarms, warnings, errors, emergency messages and error behavior

Figure 5 and Figure 6 show the surveillance mechanisms. If one of them fails, an alarm or warning will be indicated. The behavior upon an error can be defined and is described in chapter 8.3.

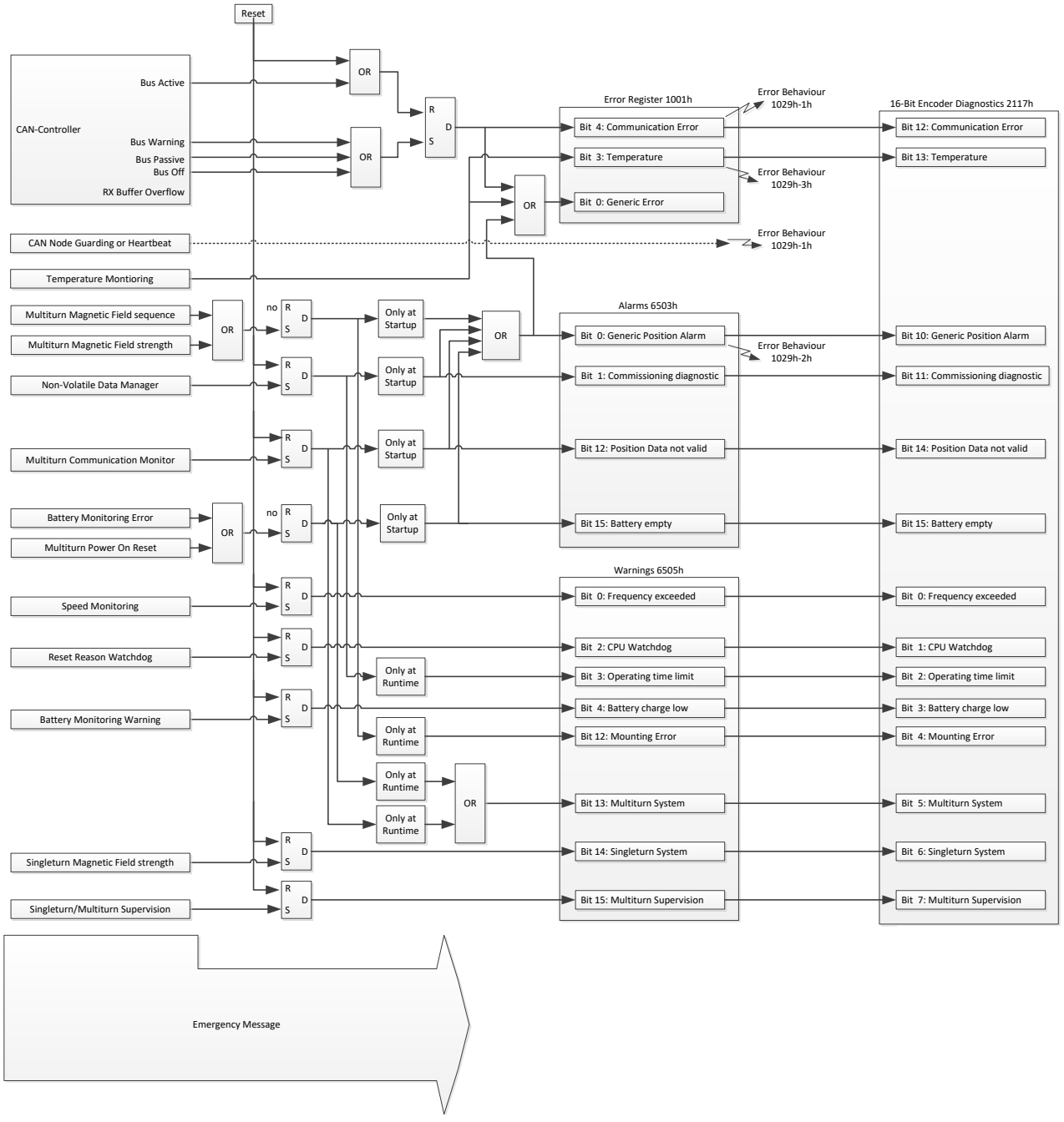
9.1 Non-redundant encoder

Figure 5: Dataflow of Error, Alarm, Warning, Diagnostic and Emergency messages



9.2 Redundant encoder

Figure 6: Dataflow of Error, Alarm, Warning, Diagnostic and Emergency messages (each node)



9.3 Error behavior

The error behaviors are executed when the corresponding bit in object 1001 Error register is set and the device is in the NMT-State Operational.

Example:
The error behavior 1029h-2 is set to “Change to Pre-Operational” (0). The device is in NMT state Operational

1. Generic error bit is set.
   → The device changes to Pre-Operational
2. The device is forced to NMT state Operational with NMT command Start
   → The device changes again to Pre-Operational if the generic error bit is not cleared.

9.4 Error Injection

The error injection allows testing a system behavior in case of an encoder malfunction.
There are two objects that can be used for test purposes to simulate different encoder behaviors.

0x2116-1 Diagnostic Injection
An error injection code, written on this object simulates a diagnostic source according to chapter 9.5.and activates the corresponding signaling. For error injection codes please refer to chapter 9.5.

0x2116-2 Position Offset Injection
The value written to this object is added to the encoder position value, for test purposes

9.5 Encoder Diagnostic Sources

The following tables provide a summary of all diagnostic sources supported by the encoder.

Source Diagnostic Source
Description Additional Information
Emergency Error Code Error Code transmitted within the emergency message
Signaling Object and bit number where the diagnostic source gets visible
Appearance Describes when the signaling may occur
Reset Behavior Describes when the signaling of a diagnostic source gets reset
Error Injection Code Error injection code to simulate a diagnostic source for object 2116-2h

Source	Description	Emergency Error Code	Appearance	Signaling	Reset Behavior	Error Injection Code
Error reset or no error	An emergency message with error code 0x0000 will be transmitted when no more errors are present	0x0000	at runtime	-	-	0x0000'0000
Temperature Monitoring	Temperature out of range	0x4200	at runtime	0x1001 Error, Bit 0,3	at runtime	0x0008'0020
Non-Volatile Data Manager	Problem with the non-volatile memory.	0x5100	at startup	0x1001 Error, Bit 0 0x6503 Alarms, Bit 0,1	at reboot	0x0001'0024
			at runtime	0x6505 Warning, Bit 3	at reboot	0x0008'0024
Reset Reason Watchdog	SW-reset due to a watchdog timer issue	0x6100	at runtime	0x6505 Warning, Bit 2	at reboot	0x0008'0025
CAN-Controller Bus Warning	Communication error (bus warning)	0x8100	at runtime	0x1001 Error, Bit 4	at runtime	-
CAN-Controller RX Buffer Overflow	CAN receive buffer overflow	0x8110	at runtime	-	at runtime	-
CAN-Controller Bus Passive	CAN in error passive mode	0x8120	at runtime	0x1001 Error, Bit 4	at runtime	-
CAN-Controller Bus Off	CAN in bus-off mode	-	at runtime	0x1001 Error, Bit 4	at runtime	-
Lifeguard or Heartbeat	Life guard error or heartbeat error	0x8130	at runtime	-	at runtime	-
Battery Monitoring Warning (non-redundant encoder)	Battery low of the Multiturn system. Encoder should be replaced	0xFF00	at runtime	0x6505 Warning, Bit 4	at runtime	0x0008'0005
Battery Monitoring Warning (redundant encoder)	Battery low of the Multiturn system. Encoder should be replaced	0xFF00	at startup	0x6505 Warning, Bit 4	at reboot	0x0004'001C
Battery Monitoring Error (Battery Empty)	Battery of the Multiturn system is empty. Absolute position can be incorrect after restart, encoder should to be replaced	0xFF01	at startup	0x1001 Error, Bit 0 0x6503 Alarms, Bit 0,15	at reboot no reset (*1	0x0001'0004
			at runtime	0x6505 Warning, Bit 13	at reboot no reset (*1	0x0008'0004
Multiturn Magnetic Field sequence (non-redundant encoder)	Incorrect sequence of the magnetic field (i.e. due to weak or disturbed magnetic field)	0xFF02	at startup	0x6505 Warning, Bit 12	at reboot	0x0004'0003
			at runtime	0x6505 Warning, Bit 12	at reboot	0x0008'0003
Multiturn Magnetic Field sequence (redundant encoder)	Incorrect sequence of the magnetic field (i.e. due to weak or disturbed magnetic field)	0xFF02	at startup	0x1001 Error, Bit 0 0x6503 Alarms, Bit 0	no reset	0x0001'001A
			at runtime	0x6505 Warning, Bit 12	no reset	0x0008'001A
Multiturn Magnetic Field strength (redundant encoder)	Magnetic field too low	0xFF03	at startup	0x1001 Error, Bit 0 0x6503 Alarms, Bit 0	no reset	0x0001'001B
			at runtime	0x6505 Warning, Bit 12	no reset	0x0008'001B
Multiturn Communication Monitor	Internal communication error	0xFF04	at startup	0x1001 Error, Bit 0 0x6503 Alarms, Bit 0,12	at reboot	0x0001'0009
			at runtime	0x6505 Warning, Bit 13	at reboot	0x0008'0009
Speed Monitoring	Maximum rotation speed exceeded	0xFF05	at runtime	0x6505 Warning, Bit 0	at reboot	0x0008'0021
Singleturn Magnetic Field strength	Amplitude of Singleturn sensor out of range (i.e. due to weak or disturbed magnetic field)	0xFF06	at runtime	0x6505 Warning, Bit 14	at reboot	0x0008'0022
Singleturn/Multiturn Supervision	Multiturn- and Singleturn-sensor out of sync	0xFF07	at runtime	0x6505 Warning, Bit 15	at reboot	0x0008'0023
Multiturn Power On Reset (redundant encoder)	Power-on-reset during powered- or unpowered operation (i.e. when battery is empty). Absolute position can be incorrect after restart, encoder should to be replaced.	0xFF17	at startup	0x1001 Error, Bit 0 0x6503 Alarms, Bit 0,15	no reset	0x0001'0014
			at runtime	0x6505 Warning, Bit 13	no reset	0x0008'0014
-	Manufacturer reserved error codes	0xFF0A… 0xFF16 0xFF17… 0xFFFF	-	-	-	-

Remark: In case of any diagnostic source appeared, absolute position may be incorrect.

(*1: No reset of diagnostic source in case of encoder with redundant design

10 Heartbeat Service

10.1 General

The device supports a heartbeat producer according CiA 301.

10.2 COB-ID

The COB-ID for the heartbeat message is 700h + node ID.

10.3 Timing

The minimal cycle time for heartbeat messages is 1 ms, which can be configured with object 1017h-0

11 LSS slave

11.1 General

The baudrate and node ID can be configured by LSS (according to CiA 305). Another possibility to change the baudrate and node ID is to access to the objects 2100h and 2101h (see object directory).
The LSS service is only available in NMT Stopped Mode.

11.2 Supported commands

- Switch state global
- Switch state selective
- Activate bit timing parameters
- Configure bit timing parameters
- Configure node ID protocol
- Store configuration
- Inquire LSS address
    - Inquire identity vendor-ID
    - Inquire identity product code
    - Inquire identity revision number
    - Inquire identity serial number
- Inquire node ID
- LSS Identify slave
- LSS Identify non-configured remote slave
- LSS Identify non-configured slave
- LSS Fastscan

11.3 LSS address

The needed values for LSS addressing as vendor ID, revision number, product code and serial number are printed on a label on the encoder housing.

12 Object directory

The following tables provide a summary of all SDO objects supported by the encoder.

Object Object number in Hex
Name Object name
Format U/I = Unsigned/Integer, No. = no of bits, ARR = Array, REC = Record, STR = String
Access ro = read only, wo = write only, rw = read write, m = mappable
Default Default value on first init
Save X = can be stored in the EEPROM
Description Additional information

12.1 Communication Profile Area

Object	Sub-Index	Name	Format	Access	Default	Save	Description
1000h		Device Type	U32	ro			Single turn Encoders: 0001'0196h Multi turn Encoders: 0002'0196h
1001h		Error Register	U8	ro	0h		Bit0 = Generic error Bit3 = Temperature error Bit4 = Communication error
1003h		PreDefined ErrorField	ARR				
	00h	Largest Subindex	U8	rw	0h		Number of stored messages (0 - 8)
	01h	Last Entry	U32	ro			Newest Error Code
	..	..	..	..	..		…
	08h	Oldest Entry	U32	ro			Oldest Error Code
1005h		Sync COB-ID	U32	rw	80h	X	COB ID of the sync object
1008h		DeviceName	STR	ro			Devicename = "EAMxxx MT" "EAMxxx ST"
1009h		Hardware Version	STR	ro			Hardware version in ASCII
100Ah		Software Version	STR	ro			Software version in ASCII
100Ch		Guard time	U16	rw	0h	X	Guard time (actual guard time is Object 100Ch*100Dh [ms])
100D		Life time factor	U8	rw	0h	X	Life time factor
1010h		Store parameters	ARR				
	00h	Largest Subindex	U8	ro	4h		No. of save possibilities 4
	01h	Save all parameters	U32	rw	1h		="evas " (0x65766173) to save
	02h	Communication parameters	U32	rw	1h		="evas " (0x65766173) to save
	03h	Application parameters	U32	rw	1h		="evas " (0x65766173) to save
	04h	Manuf. specific parameters	U32	rw	1h		="evas " (0x65766173) to save
1011h		Restore default parameters	ARR				
	00h	Largest Subindex	U8	ro	4h		No. of reset possibilities = 4
	01h	All parameters	U32	rw	1h		="daol" (0x64616F6C) to load
	02h	Communication parameters	U32	rw	1h		="daol" (0x64616F6C) to load
	03h	Application parameters	U32	rw	1h		="daol" (0x64616F6C) to load
	04h	Manufacturer specific parameters	U32	rw	1h		="daol" (0x64616F6C) to load
1014h		Emergency COB-ID	U32	rw	80h + Node-ID	X	COB ID of the emergency object
1017h		Producer heartbeat time	U16	rw	0h	X	Producer heartbeat time in ms (0 = disabled)
1018h		Identity object	REC	ro			
	00h	Largest subindex	U8	ro	4h		
	01h	Vendor ID	U32	ro	5Fh		Vendor ID
	02h	Product code	U32	ro			Product code: 70h = EAMxxx Multiturn Encoder 71h = EAMxxx Singleturn Encoder
	03h	Revision number	U32	ro			Product revision number
	04h	Serial number	U32	ro			Serial No.
1029h		Error behaviour	ARR				
	00h	Largest Subindex	U8	ro	2h		
	01h	Communication error	U8	rw	1h	X	0h = Change to pre-operational mode 1h = No state change 2h = Change to stopped mode
	02h	Generic error	U8	rw	1h	X	
	03h	Temperature error	U8	rw	1h	X	

1800h		Transmit PDO1 parameter	REC			X	
	00h	Largest Subindex	U8	ro	5h	X	
	01h	COB ID	U32	rw	180h+ID	X	COB ID for TPDO 1
	02h	PDO type	U8	rw	FEh	X	Transmission type
	05h	Event timer	U16	rw	100	X	Cycle time in ms
1801h		Transmit PDO2 parameter	REC			X	
	00h	Largest Subindex	U8	ro	5h	X	
	01h	COB ID	U32	rw	280h+ID	X	COB ID for TPDO 2
	02h	PDO type	U8	rw	2h	X	Transmission type
	05h	Event timer	U16	rw	0	X	Cycle time in ms
1A00h		Transmit PDO1 mapping	ARR			X	
	00h	Largest Subindex	U8	rw	1	X	Maximum value is 8
	01h	1st mapping parameter	U32	rw	6004'0020h	X	Position encoder
1A01h		Transmit PDO2 mapping	ARR			X	
	00h	Largest Subindex	U8	rw	1	X	Maximum Value is 8
	01h	1st mapping parameter	U32	rw	6004'0020h	X	Position encoder
1F80h		NMTStartup	U32	rw	0	X	0h = NMT slave needs to be started by NMT master 8h = NMT slave enters the NMT state *Operational* autonomously (self starting)

12.2 Manufacturer Specific Profile Area

Object	Sub-Index	Name	Format	Access	Default	Save	Description
2001h		Electronic Gear	ARR				Configuration of electronic gear function (for non-redundant encoders)
	00h	Largest Subindex	U8	ro	3		
	01h	Enable	U8	rw	1	X	1 = electronic gear function disabled 2 = electronic gear function enabled
	02h	Gear Value1	U16	rw	1	X	Numerator of the gear factor, Range 1…32767
	03h	Gear Value2	U16	rw	1	X	Denominator of the gear factor, Range 1…32767
2100h		Baudrate	U8	rw	2h	X	0=10 kBit/s 1=20 kBit/s 2=50 kBit/s 3=100 kBit/s 4=125 kBit/s 5=250 kBit/s 6=500 kBit/s 7=800 kBit/s 8=1000 kBit/s The baudrate is activated after a reset or power-on (if parameter is saved to non volatile memory)
2101h		Node ID	U8	rw	1h	X	Node number 1...127 possible The new node ID is activated after a reset or power-on (if parameter is saved to non volatile memory)
2110h		Feature control	U16	rw	0008h	X	Bit 0: Dir Flags Ignore 1= Ignore dir settings from 6000h for speed (Bit0/3) 0 = Normale use Object 6000 Bit 3: CAN Bus Off behavior 1 = Automatic CANopen restarting 0 = Encoder behaves according obj. 1029h
2114h		Manufacturer Reserved	U32	rw	0		
2116h		Error Injection	ARR				Simulation of encoder errors for test purposes
	00h	Largest Subindex	U8	ro	2		
	01h	Diagnostic Injection	U32	rw	0		An error injection code, written on this object simulates a diagnostic source and activates the corresponding signaling according to chapter 9.5.
	02h	Position Offset Injection	U32	rw	0		A temporary position offset could be injected to test a position cross-check in a PLC for example.

Object	Sub-Index	Name	Format	Access	Default	Save	Description
2117h		Encoder diagnostic	U16	ro, m			Encoder diagnostic bits Bit0 = Frequency exceeded Bit1 = CPU watchdog Bit2 = Operating time limit Bit3 = Battery charge low Bit4 = Mounting Error Bit5 = Multiturn System Bit6 = Singleturn System Bit7 = Multiturn Supervision Bit10= Generic Position Alarm Bit11= Commissioning diagnostic Bit12= Communication Error Bit13 = Temperature Bit14 = Position Data not valid Bit15 = Battery empty
2118h		Speed	S16	ro, m			Speed value of Encoder in [rpm]
2120h		Time stamp	U16	ro, m			Time stamp in [us] of current position acquisition
2300h		Customer EEPROM	ARR				Customer EEPROM to save any data
	00h	Largest Subindex	U8	ro	4		
	01h	CustomerEEPROM[0]	U32	rw	0	X	
	02h	CustomerEEPROM[1]	U32	rw	0	X	
	03h	CustomerEEPROM[2]	U32	rw	0	X	
	04h	CustomerEEPROM[3]	U32	rw	0	X	
4001h		Speed sampling interval	U16	rw	50	X	The speed sampling interval sets up the sampling interval of the speed calculation Range 1…500ms

12.3 Standardized Device Profile Area

Object	Sub-Index	Name	Format	Access	Default	Save	Description
6000h		Operating parameter	U16	rw	4h	X	Bit0 = 0 Position CW 1 Position CCW Bit 2 = 0 Scaling function disabled 1 Scaling function enabled
6001h		Measuring units per revolution [Step/rev]	U32	rw	4000h	X	Measuring units per revolution. Allowed range 4…65'536 Writing this object will adjust object 6502. 6502h = 6002h / 6001h
6002h		Total measuring range	U32	rw	0h	X	Total measuring range in Steps. Writing to this object will adjust object 6502h. 6502h = 6002h / 6001h Only values 6001h * 2^n are allowed Exception: Value 0h means 1'0000'0000h Steps
6003h		Preset value encoder	U32	rw	0h	X	Preset in steps for encoder A → Offset (Internally linked to object 6020h-1)
6004h		Position encoder	U32	ro m			Position in steps for encoder A (Internally linked to object 6020h-1)
6010h		Preset Value	Array				
	00h	Largest Subindex	U08	ro	1		
	01h	Preset for encoder A	U32	rw	0		Preset in steps for encoder A
6030h		Speed Values	Array				
	00h	Largest Subindex	U08	ro	1		
	01h	Speed encoder A	I32	ro,m			Speed in steps/second for encoder A
6040h		Acceleration Value					
	00h	Available Channels	U08	ro	1		
	01h	Acceleration value	I16	ro			Acceleration value scaled with settings of object 6041h. Value is in Steps/s^2
6041h		Acceleration parameter					
	00h	NrOfObjects	U08	ro	4		
	01h	Acceleration source selector	U08	rw	2	X	Selects the position from where the acceleration is derived. This influences the unit of the acceleration value. 1 = ST position scaled 2 = 16 Bit raw position
	02h	Acceleration integration time	U16	rw	200	X	Filter in 1…500 ms
	03h	Multiplier value	U16	rw	1	X	Output value multiplier
	04h	Divider value	U16	rw	1092	X	Output value divider
6200h		Cyclic timer PDO1	U16	rw	100		In milliseconds, internally linked to object 1800h-5
6500h		Operating Status	U16	ro	4h		Bit0 = 0 Position CW 1 Position CCW Bit2 = 0 Scaling function disabled 1 Scaling function enabled
6501h		Used single turn resolution [step/rev]	U32	ro	4000h		
6502h		Number of distinguishable revolutions	U32	ro	40000h		
6503h		Alarms	U16	ro,m	0h		The following alarms are evaluated: Bit0 = Generic Position Alarm Bit1 = Commissioning Diagnostic Bit12 = Position Data not valid Bit15 = Battery Empty
6504h		Supported alarms	U16	ro	Standard: 9001h		The following alarms are supported: Bit0 = Generic Position Alarm Bit1 = Commissioning Diagnostic Bit12 = Position Data not valid Bit15 = Battery Empty
6505h		Warnings	U16	ro,m	0h		The following warnings are evaluated: Bit0 = Frequency exceeded Bit2 = CPU watchdog Bit3 = Operating time limit Bit4 = Battery charge low Bit12= Mounting error Bit13 = Multiturn System Bit14 = Singleturn System Bit15 = Multiturn Supervision
6506h		Supported warnings	U16	ro	F00Dh		The following warnings are supported: Bit0 = Frequency exceeded Bit2 = CPU watchdog Bit3 = Operating time limit Bit4 = Battery charge low Bit12= Mounting error Bit13 = Multiturn System Bit14 = Singleturn System Bit15 = Multiturn Supervision
6507h		Profile & software version	U32	ro			Byte 0…1: Profile-Version, e. g. 4.2 = 0402h Byte 2: Software minor version Byte 3: Software major version

Object	Sub-Index	Name	Format	Access	Default	Save	Description
6508h		Operating time	U32	ro	0h		Always FFFF'FFFFh
6509h		Offset encoder	I32	ro	0h		Offset encoder [step] (Internally linked to object 650Ch-1)
650Ah		Module identification	Array				
	00h	Largest Subindex	U08	ro	1		
	01h	Manufacturer offset	I32	ro	0		
650Bh		Serial number	U32	ro			Internally linked to object 1018h-4h
650Ch		Offset values	Array				
	00h	Largest subindex	U08	ro	1		
	01h	Offset encoder	I32	ro	0h	X	Offset encoder A [step]

13 Applications

Changing the node ID and baud rate with LSS
The node ID and baud rate can be changed without having to use these to address the encoder. With the LSS service, the sensors are addressed and configured via the product code, revision no., vendor ID and serial number.

Changing the node ID (node no.)
The node ID can be changed in object 2101h between 1 and 127. A save routine should then be executed using object 1010h. On the next initialization, the encoder logs on with the new node ID.

Changing the baud rate
The baud rate can be changed in the object 2100h. An index is written into the object, not the effective baud rate.

The baud rate now still has to be saved using object 1010-1. On next initialization, the encoder logs on to the new baud rate. However, before this the baud rate of the master should be changed.

14 Discrepancies to the CIA specifications

Object	Sub-Index	Name	Discrepancy
0x1029	1	Error behavior	Default Value is 1 instead of 0 (Do not change NMT-State on Communication-Errors.
	3	Error behavior	Default Value is 1 instead of 0 (Do not change NMT-State on Communication-Errors.
0x6030	1	Speed value	Datatype is Signed 32 instead of Signed16 to provide speed information up to 6000rpm with a 14-Bit ST-Resolution
0x6502	0	Number of distinguishable revolutions	Unsigned 32 instead of Unsigned 16 due to 18-Bit MT-Resolution
LSS		LSS Identify remote slave	Service is not implemented

A. Appendix

a. Pin Assignments

Assignment cable (connection – L)

Cable color	signal		
	CANopen Non-redundant	CANopen redundant	CANopen + Inc. Non-redundant
grey	CAN_GND	CAN_GND	A+
brown	+Vs	+Vs	+Vs
white	0 V	0 V	0 V
green	CAN_H	CAN_H	CAN_H
yellow	CAN_L	CAN_L	CAN_L
pink	-	-	A-
blue	-	-	B+
red	-	-	B-

Pin assignment connector 1 x M12 (connection – N or – B)

Cable color	signal		
	CANopen Non-redundant	CANopen redundant	CANopen + Inc. Non-redundant
1	CAN_GND	CAN_GND	0 V
2	+Vs	+Vs	+Vs
3	0 V	0 V	CAN_H
4	CAN_H	CAN_H	CAN_L
5	CAN_L	CAN_L	A+
6	-	-	A-
7	-	-	B+
8	-	-	B-

