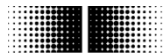


# Manual

## Absolute encoder with CANopen<sup>®</sup>

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# 1 Version overview

This document is subject to changes. In order to have the most current version please download on [www.baumer.com](http://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	<ul style="list-style-type: none"> <li>- Scaling function expanded up to 16Bit ST</li> <li>- New „speed Filter time“ default value of 50ms (Object 4001h) range reduced from 4000 ms to 500 ms</li> <li>- Comment “Emergencies are not resent after NMT reset” removed in chapter 5.1.1</li> </ul>
0003	12.03.18	From V01-05	0003.0000h	zest	<ul style="list-style-type: none"> <li>- New profile version identification</li> <li>- Comment “Emergencies are not resent after NMT communication reset” removed chapter 5.1.2</li> <li>- New function electronic gear, chapter 4.4.3 (Obj. 2001h)</li> <li>- Reworked chapter 8 and 9</li> <li>- New function error injection, chapter 9.4</li> <li>- Added chapter 4.6.2 Node Id for redundant Encoder</li> </ul>
0004	29.03.18	From V01-05	0003.0000h	zest	<ul style="list-style-type: none"> <li>- fixed wrong sub-indexes in chapter 9.4</li> <li>- fixed data flow of magnetic field strength and magnetic field sequence</li> <li>- comment added electronic gear function for non-redundant encoders</li> </ul>
0005	18.02.19	From V01-07	0003.0000h	bwm, gyc	<ul style="list-style-type: none"> <li>- Add acceleration</li> <li>- Add Safety word</li> <li>- Add need reboot information for electronic gear</li> <li>- Corrected LSS Service Names according to CIA 305</li> </ul>
0006	24.04.19	From V01-07	0003.0000h	egt	<ul style="list-style-type: none"> <li>- Add explanation SDO in chapter 6.1</li> <li>- Add examples SDO, chapter 6.2</li> </ul>
0007	22.05.19	From V01-07	0003.0000h	egt	<ul style="list-style-type: none"> <li>- Replace cycle time in Object 1800h of 0 ms with 100 ms</li> </ul>
0008	17.06.19	From V01-07	0003.0000h	egt	<ul style="list-style-type: none"> <li>- Fixed software version in object 6507h and chapter 4.2</li> </ul>
0009	18.07.19	From V01-07	0003.0000h	egt	<ul style="list-style-type: none"> <li>- Corrected object number for speed in chapter 4.4.4</li> </ul>
0010	19.08.19	From V01-07	0003.0000h	egt	<ul style="list-style-type: none"> <li>- 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</li> <li>- Corrected link of object 6200h to 1800h-5 instead of 1800h-2 in chapter 12.3</li> </ul>
0011	10.01.20	From V01-07	0003.0000h	egt	<ul style="list-style-type: none"> <li>- Corrected names of eds-fils</li> </ul>
0012	31.03.20	From V01-07-02	0003.0000h	wge	<ul style="list-style-type: none"> <li>- Change of behavior at reversal of rotation direction and acceleration in object 6000h Bit0</li> <li>- Customer-specific adaptability for direction of rotation and acceleration in object 2110h Bit0 added</li> <li>- Mistake was present in V01-03 to V01-07-01</li> <li>- Chapter 7.4.1: Mapping entry safety word corrected</li> <li>- Object 2001-01h: corrected value U16 to U8</li> </ul>
0013	29.03.21	From V01-07-02	0003.0000h	wge	<ul style="list-style-type: none"> <li>- extension by EAM300</li> </ul>
0014	12.08.21	From V01-07-02	0003.0000h	zest	<ul style="list-style-type: none"> <li>- extension by bearingless encoder EB360</li> </ul>

0015	29.03.23	From V01-09-01	0003.0000h	wick	- bearingless encoder EB360 removed - New firmware version 1.09.01
0016	20.12.23	From V01-09-02	0003.0000h	wick	- New firmware version 1.09.02

## 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_V04.00.eds
Absolute encoder singleturn	0x0071	EAMxxx ST	EAMxxx_0x0071_V04.00.eds

## 4 System Overview

### 4.1 General

The encoder is a rotary measuring system with CANopen interface, which supports position encoding, scaling and presetting, heartbeat and diagnostic functions with alarm and warning capabilities.

In consideration of "CAN in Automation" (CiA) device profile for encoders DSP406, it is an rotary absolute singleturn and multiturn encoder - class C2. In addition, it supports high resolution position object.

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 3.0.0 (LSS)
- CiA 406 / Version 4.1.0 (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)
- 3 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

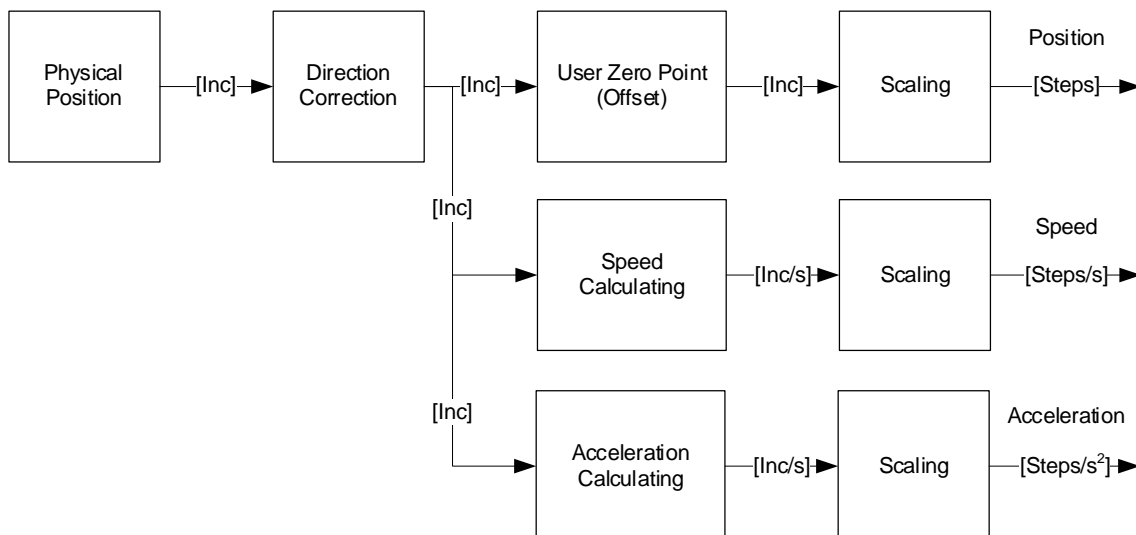
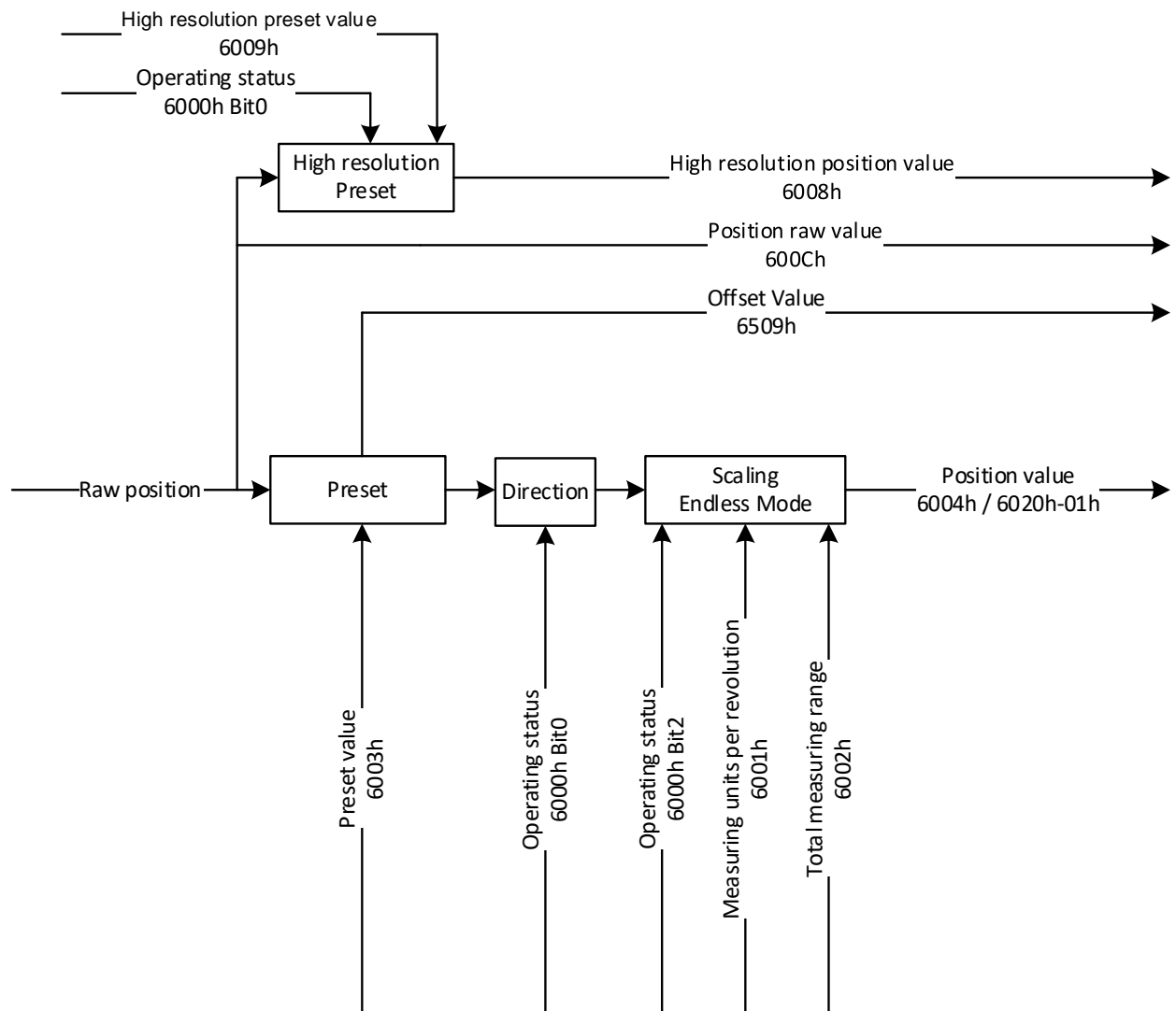


Figure 1: Function principle overview



#### 4.4.1 Position values / Scaling

Setting of position resolution / scaling is used to adjust the encoder settings to the application.



**Figure 2: Position value / scaling**

##### Position value (6004h)

The position value (6004h) depends on the position step settings (object 6001h and object 6002h). Scaling is enabled when operating status 6000h Bit2 = 1. The counting direction is affected by object operating status 6000h Bit0.

##### Measuring units per revolution (6001h)

The measuring units per revolution can be configured with object 6001h. The range is 0 or 2...65'536 steps per revolution.

##### Total measuring range (6002h)

The total measuring range in measuring units can be configured with object 6002h. (range 0... $2^{32}-1$ ).

Whereby value 0h means  $2^{32}$  steps or 4'294'967'296dec or 1'0000'0000h steps.

For singleturn encoders the range is limited to 2...value of object 6001h.

**Limitation**

Depending on the setting of measuring units per revolution (6001h), total measuring range (6002h) and the maximum possible revolutions of the encoder ( $2^{30} = 1'073'741'824$  turns) the encoder automatically operates in endless mode. Condition for endless mode operation:

$$2^{30} \frac{\text{measuring units per revolution (6001h)}}{\text{total measuring range (6002h)}} \neq 2^x$$

$$x \in \mathbb{N} (1, 2, 3, \dots)$$

In case of endless mode operation, the maximum encoder revolutions, while the encoder is unpowered or the power on time is shorter than 5 minutes, must be smaller than  $2^{29}$  (536'870'912) turns. If this number of revolutions is exceeded, the encoder has to be referenced (see preset value, 6003h) after every power-up.

Example 1: Parameter combination where the encoder operates without limitation:

Maximum possible revolutions:	1'073'741'824 (30 bit multiturn)
Measuring units per revolution:	3'600
Total measuring range:	29'491'200
Calculation:	$1'073'741'824 \times 3'600 / 29'491'200 = 131'072 (= 2^{17})$

Example 2: Parameter combination where the encoder automatically operates in endless mode:

Maximum possible revolutions:	1'073'741'824 (30 bit multiturn)
Measuring units per revolution:	3'600
Total measuring range:	100'000
Calculation:	$1'073'741'824 \times 3'600 / 100'000 = 38'654'705.664 (\neq 2^x)$

**Number of distinguishable revolutions (6502h)**

The number of distinguishable revolutions are calculated by dividing the total measuring range by the measuring units per revolution (rounded down to integer) and can be read from Index 6502h:

$$\text{number of distinguishable revolutions (6502h)} = \left\lfloor \frac{\text{total measuring range (6002h)}}{\text{measuring units per revolution (6001h)}} \right\rfloor$$

For singleturn encoders the number of distinguishable revolutions (6502h) is 1.

**Preset value (6003h)**

To preset the position value (6004h), write the desired value to the object preset value (6003h). The preset becomes effective immediately. To ensure that the calculated offset value (6509h) is also effective after a device restart, a parameter store via object 1010h is required.

**High resolution position value (6008h)**

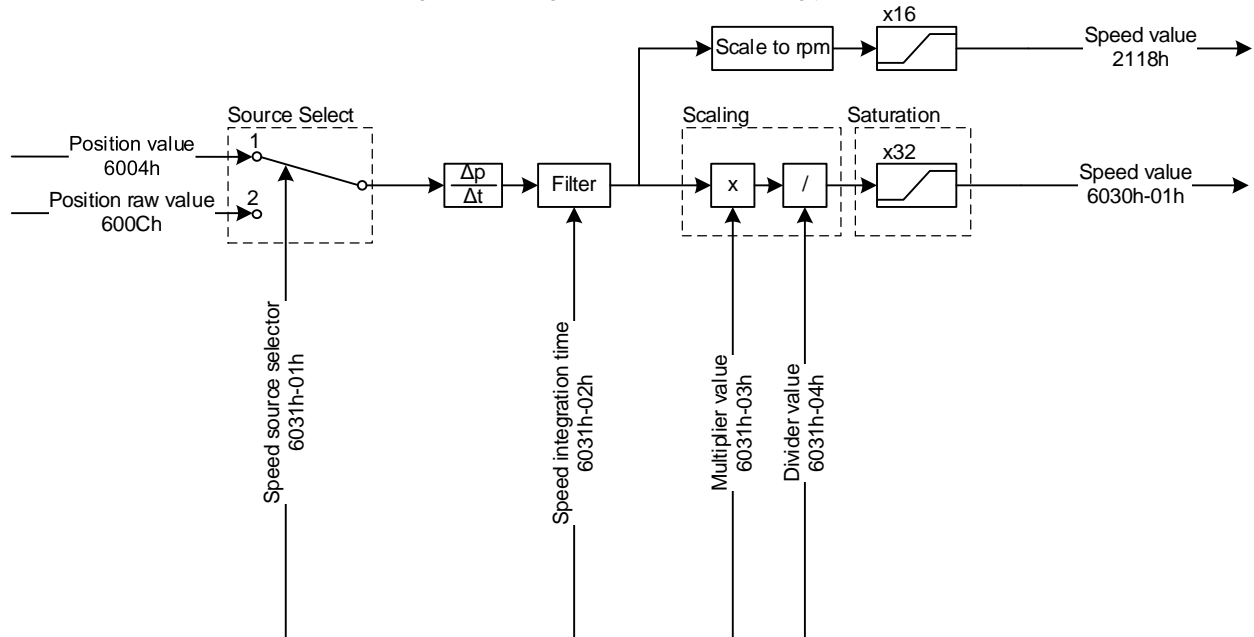
The high resolution position value (6008h) provides 16 bit singleturn resolution and in case of multiturn encoders 30 bit multiturn information in addition. The counting direction is affected by object operating status 6000h Bit0. To preset the high resolution position value, write the desired value to the object high resolution preset value (6009h). The preset becomes effective immediately. To ensure that it is also effective after a device restart, a parameter store via object 1010h is required. The high resolution position value is not affected by scaling

**Position raw value (600Ch)**

The position raw value (600Ch) provides 16 bit singleturn resolution and in case of multiturn encoders 16 bit multiturn information in addition. The raw position value is not affected by scaling, preset or direction of rotation correction.

#### 4.4.2 Speed range

The two objects 6030h-01h and 2118h provide speed value output. Since speed value and range highly depend on the application, the user should adapt scaling and filtering (6031h-02h) accordingly.



**Figure 3: Speed values**

#### Speed value (6030h-01h)

The object 6030h-01h provides a 32 bit speed information with unit steps per second [steps/sec].

The range for object 6030h-01h is 8000'0000h...7FFF'FFFFh (-2'147'483'648...2'147'483'647dec or -2<sup>31</sup>...2<sup>31</sup>-1). If the scaled speed value exceeds the above range, the output is 8000'0000h or 7FFF'FFFFh (saturated logic).

Scaling can be used to adjust the speed range depending on the selected position source (6031h-01h), if applicable the measuring units per revolution (6001h) and the application speed range.

#### Speed scaling example:

Selected position source (6031h-01h):	Position value (6004h)
Measuring units per revolution:	16384 (2 <sup>14</sup> ) steps
Application speed range in [rpm]:	+/- 3000 rpm (3000/60=50 1/s)
Desired range of speed value:	+/- 30'000 steps/s

Calculation of speed scaling factor:

$$\text{Speed scaling factor} = \frac{3000 \frac{\text{steps}}{\text{s}}}{\frac{3000}{60 \text{ s}} * 16384 \text{ steps}} = 0.0366 = \frac{1}{27.307} = \frac{\text{Multiplier value (6031h - 03h): } 1'000}{\text{Divider value (6031h - 04h): } 27'307}$$

#### Speed value (2118h)

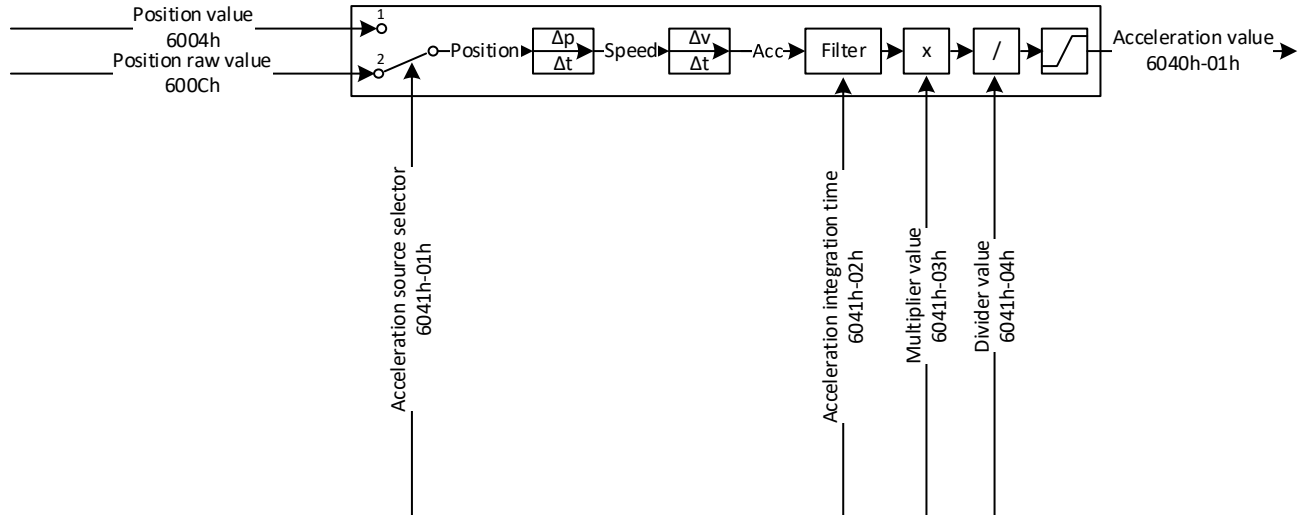
The object 2118h provides a 16 bit speed value with a fixed unit of revolutions per minute [rpm].

The range for object 2118h is 8000h...7FFFh (-32768...32767dec or -2<sup>15</sup>...2<sup>15</sup>-1).

If the scaled speed value exceeds the above range, the output is 8000h or 7FFFh (saturated logic).

### 4.4.3 Acceleration value

In the rotary encoder device profile, the encoder supports acceleration output on object 6040h-01h. As the acceleration value is a highly dynamic value, the user should adapt scaling and filtering (6041h-02h) to his application.



**Figure 4: Acceleration value**

#### Acceleration value (6040h-01h)

The object 6040h-01h provides a 16 bit acceleration information with unit steps per second<sup>2</sup> [steps/sec<sup>2</sup>].

The range for object 6040h-01h is 8000h...7FFFh (-32768...32767dec or -2<sup>15</sup>...2<sup>15</sup>-1).

Scaling can be used to adjust the acceleration range depending on the selected position source (6041h-01h), if applicable the measuring units per revolution (6001h) and the application speed range.

#### Acceleration scaling example:

Selected position source (6031h-01h):	Position raw value (600Ch)
Measuring units per revolution:	65536 (2 <sup>16</sup> ) steps
Application acceleration range in [rpm/s]:	+/- 30'000 rpm/s (30000/60=500 1/s <sup>2</sup> )
Desired range of acceleration value:	+/- 30'000 steps/s <sup>2</sup>

Calculation of acceleration scaling factor:

$$\text{Acceleration scaling factor} = \frac{30'000 \frac{\text{steps}}{\text{s}^2}}{65536 \text{ steps} * \frac{30'000}{60\text{s}^2}} = 915.750 * 10^{-6} = \frac{1}{1092} = \frac{\text{Multiplier value (6041h - 03h): 1}}{\text{Divider value (6041h - 04h): 1'092}}$$

#### 4.5 Electronic gear function

The electronic gear function (2001h) divides the encoder position value by the gear factor. Therefore it transforms the encoder position value into the view of the application:

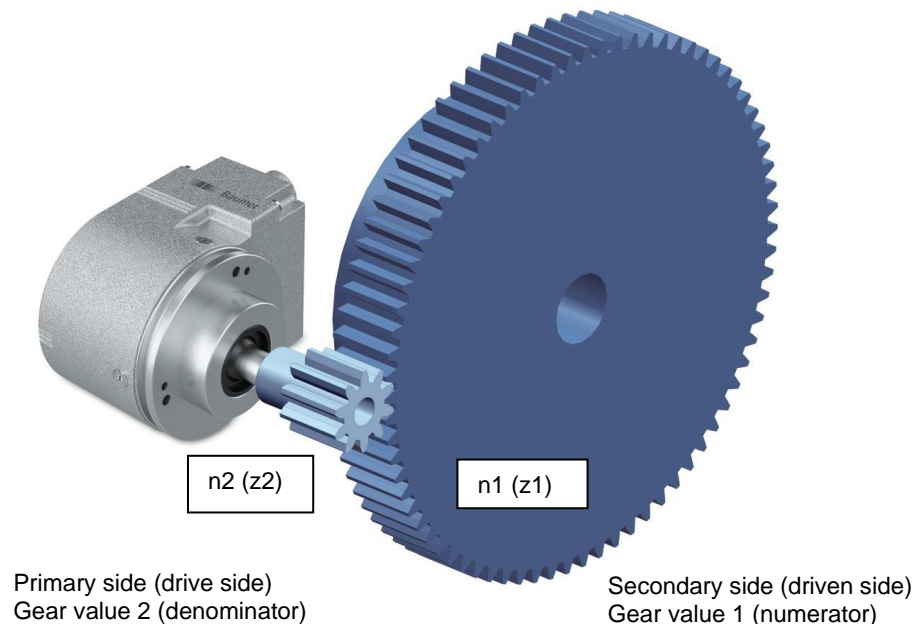
$$\text{Application position} = \frac{\text{Encoder position}}{i}$$

The electronic gear function is also called numerator/denominator scaling or round axis function.

With electronic gear function enabled, the encoder can be mechanically mounted on the primary / input side (drive side) of a gearbox, while it outputs position data as if it was mounted on the secondary / output side (driven side) of the gearbox.

The parameter "measuring units per revolution" (6001h) defines the number of requested steps for one revolution, the parameter „total measuring range“ (6002h) defines the total measuring range in measuring units on the secondary side of the gear box.

To get a position value 6004h that describes the position within only one revolution of the secondary side of the gear box, set both parameters (6001h & 6002h) on the same value.



- **Figure 5: Electronic gear function (2001h)**

The gear ratio or gear factor  $i$  is defined as:

$$\text{Gear factor } i = \frac{\text{Gear value 1}}{\text{Gear value 2}} = \frac{\text{Numerator}}{\text{Denominator}} = \frac{\text{Speed at drive side (n2)}}{\text{Speed at driven side (n1)}} = \frac{\text{Number of teeth at driven side (z1)}}{\text{Number of teeth at drive side (z2)}}$$

Gear value 1 (numerator, 2001h-02h) and gear value 2 (denominator, 2001h-03h) of the gear factor  $i$  directly result from the number of teeth / gear ratio in the application. In the above example, the number of teeth at the driven side is 75. At the drive side, the number of teeth is 10.

- 

#### Example

The gear factor shall be 75:10 (means  $i = 7,5$ ).

The resolution on the secondary side of the gearbox shall be "1 revolution = 10000 steps".

The numerator is 75 and the denominator is 10.

Only integer values are admissible for numerator and denominator. The total measuring range is 10000.

**Electronic gear enable / disable (2001h-01h)**

Set object 2001h-01h to value 2h to enable the electronic gear function, while value 1h disables it (further details see table 12.2).

NOTE: A change of object 2001h-01h Electronic gear enable / disable clears internal position offsets (if any). In this case, the current absolute multiturn position reference is lost and the encoder has to be referenced (see preset value, 6003h).

**Gear value 1 (2001h-02h)**

This object defines the numerator of the gear factor.  
The range of this integer value is 1...32'767.

**Gear value 2 (2001h-03h)**

This object defines the denominator of the gear factor.  
The range of this integer value is 1...32'767.

NOTE: After setting and storing the electronic gear function setting, the encoder has to be restarted to activate the electronic gear function.

**Limitations**

A useful gear factor is greater than 0.125, while a gear ratio smaller than 1 may result in higher signal noise.  
Valid combinations of numerator, denominator and total measuring range fulfill following condition:

$$\text{total measuring range (6002h)} * \frac{\text{denominator (2001h - 03h)}}{\text{numerator (2001h - 02h)}} \leq 65536$$

The maximum encoder revolutions when the encoder is unpowered or power on time is shorter than 5 minutes must be smaller than  $2^{29}$  (536'870'912) turns. If this number of revolutions is exceeded, the encoder has to be referenced (see preset value, 6003h) after every power-up.

The electronic gear function is useful for multiturn encoders. In case of singleturn encoders, the position value gets lost after a power cycle.

## 4.6 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 <b>BattLow:</b> Batterie low charge	Minimum power-off time: 11 seconds
Alarm	0x6503 <b>BattEmpt:</b> Battery empty	Minimum power off time: 1 second

### 4.6.1 Baud rate

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

**Note:**

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

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

### 4.6.2 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 baud rate 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 baud rate
5. Reconfigure both nodes to the desired, different node id's
6. Store both node ID's according chapter 6.3.1

## 4.7 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 specifier	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
--------	-----	-------------------	------------	------------	-----------	--------	--------	--------	--------

A SDO-**COB-ID** is composed as follows:

Client / consumer -> Server / encoder : 600h + node-ID

Server / encoder -> Client / consumer : 580h + node-ID

**DLC** describes the length of the telegram. This is composed as follows:

1 byte command specifier + 2 bytes object + 1 byte sub-index + no. of data bytes (0...4).

The **command specifier** 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 consumer
40h	Upload request	-	Requests parameter from encoder
42h	Upload response	Max. 4 byte	Parameter to consumer 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 consumer

An **abort message** indicates an error in the CAN communication. The SDO command specifier is 80h. The object and sub-index are those of the requested object. The error code is contained in bytes 4...7.

COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
580h + Node-ID	8	80h	Object LSB	Object MSB	Sub-index	ErrByte 0	ErrByte 1	ErrByte 2	ErrByte 3

Byte 4...7 results in the SDO abort message (byte 7 = MSB).

The following messages are supported:

05040001h	Command specifier 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	Sub-index 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 consumer from the producer

A frequent request will be a request for position: Object 6004h

COB-ID	DLC	Command specifier	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + node-ID	8	40h	04h	60h	0	x	x	x	x

Response by the producer 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 specifier	Object LSB	Object MSB	Sub-index	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 consumer into the producer

Position setting can be performed with preset. Object 6003h

COB-ID	DLC	Command specifier	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	8	22h	03h	60h	0	a	b	c	d

Producer's response to the writing of a value

COB-ID	DLC	Command specifier	Object LSB	Object MSB	Sub-index	Data 0	Data 1	Data 2	Data 3
600h + Node-ID	8	22h	03h	60h	0	a	b	c	d

## 6.3 Store/restore parameters

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

### 6.3.1 Store

Writing "save" to 1010h-x stores 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 storing of the parameters is performed.

### 6.3.2 Restore

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

### 6.3.3 Reliable store and restore operation

To ensure reliable store and restore operation to and from non-volatile memory, the user must ensure continuous electric power to the device with any power interruption.

## 7 PDO Service

### 7.1 General

The device supports 3 PDOs (TPDO1, TPDO2, TPDO3). PDOs are only transmitted in NMT operational mode.

### 7.2 PDO transmission types

The following transmission types are supported (object 1800h-2h, 1801h-2h, 1802h-2h):

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

All PDOs support all transmission types.

Transmission type 253: PDO is only transmitted on request (remote transmission request).

Transmission type 255 and 254: PDO is transmitted timer driven. The time interval between PDOs can be adapted in object 1800h-5h, 1801h-5h, 1802h-5h

Transmission type 1-240: PDO is transmitted after the n<sup>th</sup> SYNC frame

Transmission type 1: PDO is transmitted after one SYNC frame

Transmission type 2: PDO is transmitted after two SYNC frames

etc.

### 7.3 COB-ID of PDOs

The COB-ID for PDOs can be changed (object 1800h-1h, 1801h-1h, 1802h-1h)

Default Values are:

TPDO1: 180h + node-ID

TPDO2: 280h + node-ID

TPDO3: 380h + node-ID

Changes will be applied immediately.

---

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

<i>Node-ID: 1</i>	<i>COB-ID TPDO1: 181h</i>	<i>(Default value)</i>
<i>Node-ID: 3</i>	<i>COB-ID TPDO1: 183h</i>	<i>(Change of node-ID by user, automatic adaption of COB-ID)</i>
	<i>COB-ID TPDO1: 187h</i>	<i>(Change of COB-ID by user)</i>
<i>Node-ID: 9</i>	<i>COB-ID TPDO1: 187h</i>	<i>(Change of node-ID by user, no automatic change of COB-ID, Re-enable COB-ID auto adaption by reset to factory default settings)</i>

---

## 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 value	6004'0020h	Object 6004h sub-index 00h, data length 32 bit
Position value for multisensor devices	6020'0120h	Object 6020h sub-index 01h, data length 32 bit
Speed value [steps/s]	6030'0120h	Object 6030h sub-index 01h, data length 32 bit
Alarms	6503'0010h	Object 6503h sub-index 00h, data length 16 bit
Warnings	6505'0010h	Object 6505h sub-index 00h, data length 16 bit
Encoder diagnostic	2117'0010h	Object 2117h sub-index 00h, data length 16 bit
Speed value [rpm]	2118'0010h	Object 2118h sub-index 00h, data length 16 bit
Time stamp [us]	2120'0010h	Object 2120h sub-index 00h, data length 16 bit
Acceleration value	6040'0110h	Object 6040h sub-index 01h, data length 16 bit
Safety word	2122'0010h	Object 2122h sub-index 00h, data length 16 bit
Direction information	2124'0108h	Object 2124h sub-index 01h, data length 8 bit
Empty dummy	2124'0208h	Object 2124h sub-index 02h, data length 8 bit
High resolution position value	6008'0040h	Object 6008h, sub-index 00h, data length 64 bit

To change PDO mapping, disabling the mapping by writing 0 to 1A00h-0h, 1A01h-0h, 1A02h-0h is required first. Write the desired mapping entry and enable the mapping again by writing the number of PDO contents to 1A00h-0h, 1A01h-0h, 1A02h-0h.

### 7.4.2 Default mapping of absolute encoder

The default mappings for all three TPDOs are the same. The position will be transmitted in byte 0..3.

COB-ID	DLC	Byte 0	Byte 1	Byte 2	Byte 3
180h + node ID/ 280h + node ID/ 380h + node ID	4	xx	xx	xx	xx

Byte 0...3: Position value (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:*

<i>Node ID: 1</i>	<i>COB-ID Emergency: 81h (Default value)</i>
	<i>COB-ID Emergency: 87h (Changed by user)</i>
<i>Node ID: 3</i>	<i>COB-ID Emergency: 89h (Adapted automatic)</i>

---

### 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
Manufacturer-specific error	-	-	Communication error	Temperature error			Generic error

#### 8.4.1 Manufacturer-specific error

This error is indicated when a manufacture specific error occurs. A manufacturer-specific error is an error which doesn't have a dedicated error Bit in object 1001h. E.g. a temperature error does set bit 3 and 0. A battery monitoring error has no dedicated error bit an sets therefore bit 7 and bit 0.

#### 8.4.2 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.

#### 8.4.3 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.

#### 8.4.4 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

**Fehler! Verweisquelle konnte nicht gefunden werden.** and **Fehler! Verweisquelle konnte nicht gefunden werden.** 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 9.3.

### 9.1 Non-redundant encoder

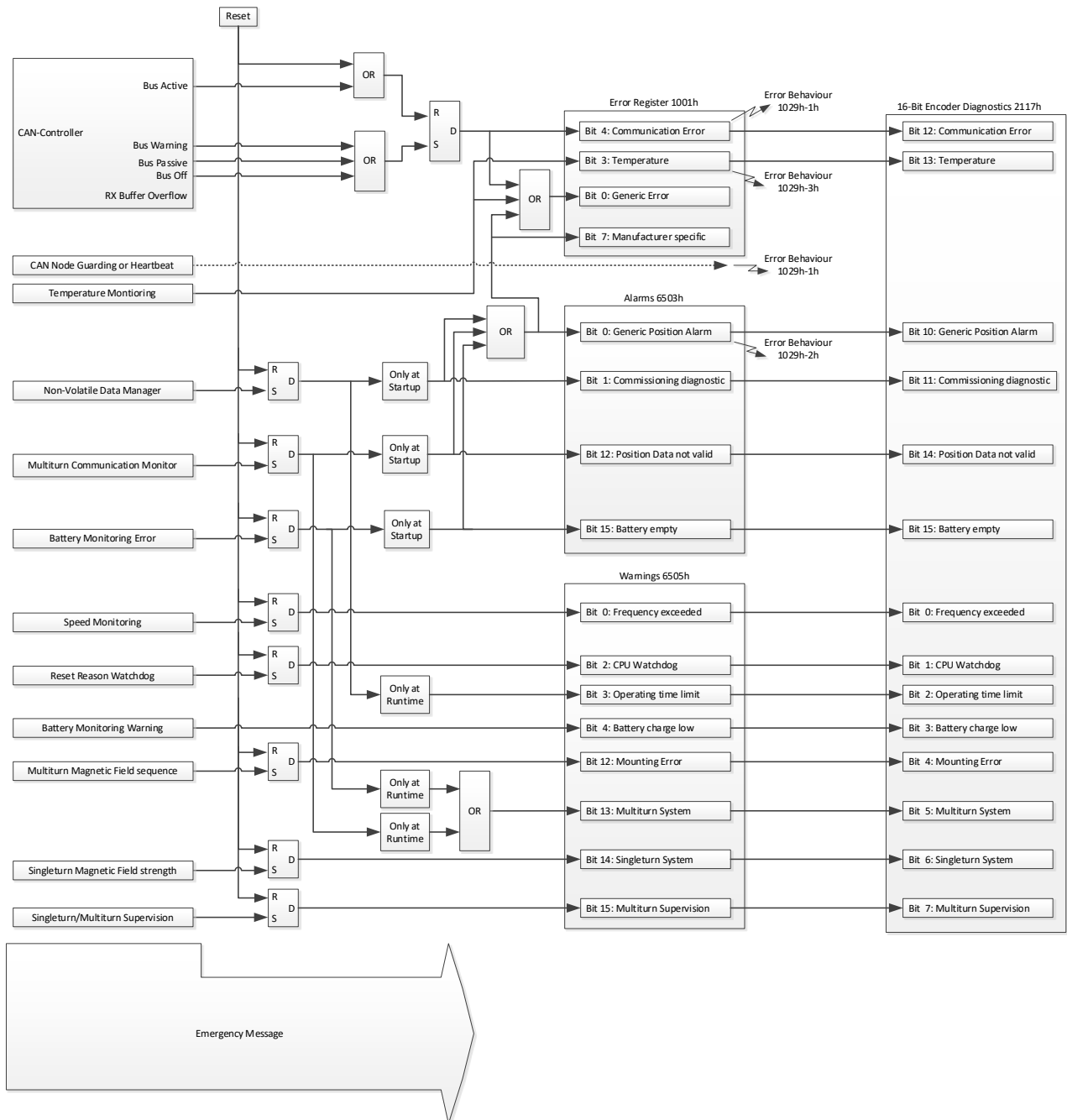


Figure 6: Dataflow of Error, Alarm, Warning, Diagnostic and Emergency messages

## 9.2 Redundant encoder

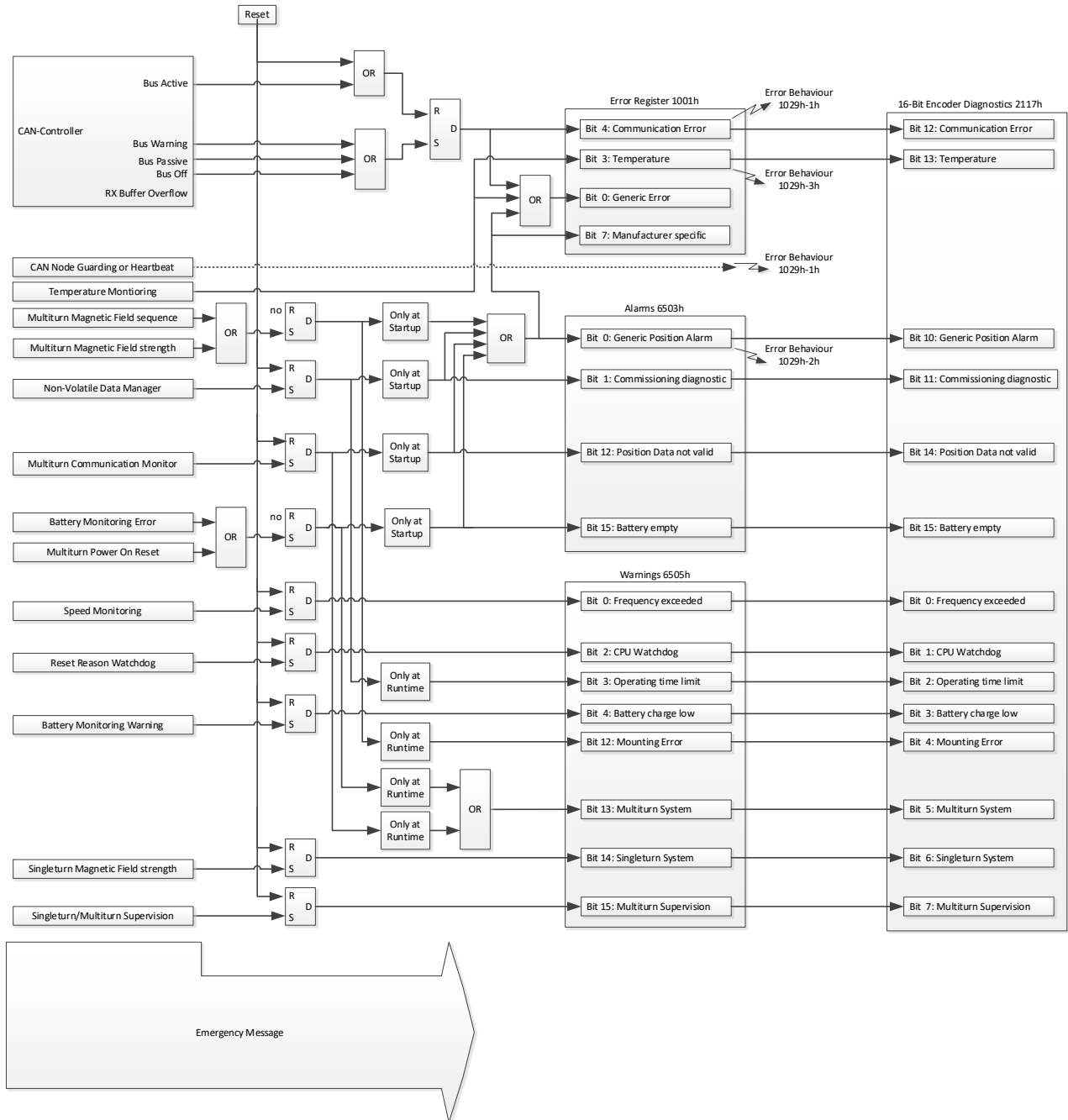


Figure 7: Dataflow of Error, Alarm, Warning, Diagnostic and Emergency messages (each node)

### 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.

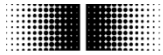
#### **0x2116-1 Diagnostic Injection**

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.

<b>Source</b>	Diagnostic Source
<b>Description</b>	Additional Information
<b>Emergency Error Code</b>	Error Code transmitted within the emergency message
<b>Signaling</b>	Object and bit number where the diagnostic source gets visible
<b>Appearance</b>	Describes when the signaling may occur
<b>Reset Behavior</b>	Describes when the signaling of a diagnostic source gets reset
<b>Error Injection Code</b>	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 Layer setting services / LSS producer

### 11.1 General

The device baud rate and node-ID can be configured by LSS (according to CiA 305). Another possibility to change the baud rate and node-ID is to access the objects 2100h and 2101h (see object directory).

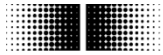
The LSS service is available in NMT stopped mode only.

### 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 producer
- LSS identify non-configured remote producer
- LSS identify non-configured producer
- LSS fast scan

### 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.

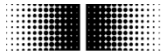
<b>Object</b>	Object number in Hex
<b>Name</b>	Object name
<b>Format</b>	U/I = Unsigned/Integer, No. = no of bits, ARR = Array, REC = Record, STR = String
<b>Access</b>	ro = read only, wo = write only, rw = read write, m = mappable
<b>Default</b>	Default value on first init
<b>Save</b>	X = can be stored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

### 12.1 Communication parameters

Object	Sub-Index	Name	Format	Access	Default	Save	Description
1000h		Device type	U32	ro			Device type and functionality 0001'0196h = singleturn encoder 0002'0196h = multiturn encoder
1001h		Error register	U8	ro	0h		Bit0 = Generic error Bit3 = Temperature error Bit4 = Communication error Bit7 = Manufacturer specific error
1003h		Pre-defined error field	ARR				Errors that occurred on the device and are signaled via EMCY object and listed in error field
	00h	Number of errors	U8	rw	0h		Number of stored messages (0...8)
	01h	Newest error entry	U32	ro			Newest error code
	...	...	...	...	...	..	...
	08h	Oldest error entry	U32	ro			Oldest error code
1005h		COB-ID SYNC message	U32	rw	80h	X	Configured COB-ID of SYNC object
1008h		Manufacturer device name	STR	ro			Device name as given by manufacturer in ASCII "EAMxxx MT" = absolute multiturn encoder "EAMxxx ST" = absolute singleturn encoder
1009h		Manufacturer hardware version	STR	ro			Hardware version in ASCII
100Ah		Manufacturer software version	STR	ro			Software version in ASCII
100Ch		Guard time	U16	rw	0h	X	Guard time in [ms] Life time factor multiplied with guard time gives life time for life guarding protocol.
100Dh		Life time factor	U8	rw	0h	X	Life time factor
1010h		Store parameters	ARR				Control for saving parameters to non-volatile memory
	00h	Highest sub-index supported	U8	ro	4h		
	01h	Store all parameters	U32	rw	1h		="evas" (6576'6173h) to store
	02h	Store communication parameters	U32	rw	1h		="evas" (6576'6173h) to store
	03h	Store application parameters	U32	rw	1h		="evas" (6576'6173h) to store
	04h	Store manufacturer defined parameters	U32	rw	1h		="evas" (6576'6173h) to store
1011h		Restore default parameters	ARR				Control for restoring parameters from non-volatile memory
	00h	Highest sub-index supported	U8	ro	4h		
	01h	Restore all default parameters	U32	rw	1h		="daol" (6461'6F6Ch) to restore
	02h	Restore communication default parameters	U32	rw	1h		="daol" (6461'6F6Ch) to restore
	03h	Restore application default parameters	U32	rw	1h		="daol" (6461'6F6Ch) to restore
	04h	Restore manufacturer defined default parameters	U32	rw	1h		="daol" (6461'6F6Ch) to restore
1014h		COB-ID EMCY	U32	rw	80h + Node-ID	X	Configured COB-ID of EMCY write service
1017h		Producer heartbeat time	U16	rw	0h	X	Producer heartbeat time in [ms] (0 = disabled)
1018h		Identity object	REC	ro			General identification information of device
	00h	Highest sub-index supported	U8	ro	4h		
	01h	Vendor-ID	U32	ro	5Fh		Vendor-ID
	02h	Product code	U32	ro			Product code: 70h = EAMxxx MT Multiturn Encoder 71h = EAMxxx MT Singleturn Encoder
	03h	Revision number	U32	ro			Product revision number
	04h	Serial number	U32	ro			Product serial number
1029h		Error behavior object	ARR				CANopen device is configurable to enter alternatively the NMT state Stopped or Pre-operational, or remain in the current NMT state (in case of failure detected in NMT operational state)
	00h	Highest sub-index supported	U8	ro	3h		
	01h	Communication error	U8	rw	1h	X	0h = Change to pre-operational mode
	02h	Generic error	U8	rw	1h	X	1h = No state change
	03h	Temperature error	U8	rw	1h	X	2h = Change to stopped mode

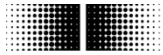


Object	Sub-Index	Name	Format	Access	Default	Save	Description
1800h		TPDO1 communication parameter	REC			X	Transmit PDO1 communication parameters
	00h	Highest sub-index supported	U8	ro	5h	X	
	01h	COB-ID used by TPDO	U32	rw	180h+node-ID	X	COB-ID for TPDO1
	02h	PDO transmission type	U8	rw	FEh	X	TPDO transmission type FEh = event-driven, time-triggered
	05h	Event time	U16	rw	100dec	X	Event time in [ms] (0 = disabled). Maximum interval for PDO transmission if type is set to event driven. Internally linked to object 6200h
1801h		TPDO2 communication parameter	REC			X	Transmit PDO2 communication parameters
	00h	Highest sub-index supported	U8	ro	5h	X	
	01h	COB-ID used by TPDO	U32	rw	280h+node-ID	X	COB-ID for TPDO2
	02h	PDO transmission type	U8	rw	2h	X	Transmission type synchronous (cyclic every 2nd SYNC)
	05h	Event time	U16	rw	0h	X	Event time in [ms] (0 = disabled). Maximum interval for PDO transmission if type is set to event driven.
1802h		TPDO3 communication parameter	REC			X	Transmit PDO 3 communication parameters
	00h	Highest sub-index supported	U8	ro	5h	X	
	01h	COB-ID used by TPDO	U32	rw	380h+node-ID	X	COB-ID for TPDO3
	02h	PDO transmission type	U8	rw	2h	X	Transmission type synchronous (cyclic every 2nd SYNC)
	05h	Event time	U16	rw	0h	X	Event time in [ms] (0 = disabled). Maximum interval for PDO transmission if type is set to event driven.
1A00h		TPDO1 mapping parameter	ARR			X	Mapping parameters for TPDO1
	00h	Highest sub-index supported	U8	rw	1h	X	Maximum value is 4
	01h	1st application object	U32	rw	6004'0020h	X	Position value (6004h)
	02h	2nd application object	U32	rw	-		
	03h	3rd application object	U32	rw	-		
1A01h		TPDO2 mapping parameter	ARR			X	Mapping parameters for TPDO2
	00h	Highest sub-index supported	U8	rw	1h	X	Maximum value is 4
	01h	1st application object	U32	rw	6004'0020h	X	Position value (6004h)
	02h	2nd application object	U32	rw	-		
	03h	3rd application object	U32	rw	-		
1A02h		TPDO3 mapping parameter	ARR			X	Mapping parameters for TPDO3
	00h	Highest sub-index supported	U8	rw	1h	X	Maximum value is 4
	01h	1st application object	U32	rw	6004'0020h	X	Position value (6004h)
	02h	2nd application object	U32	rw	-		
	03h	3rd application object	U32	rw	-		
1F80h		NMT startup	U32	rw	0	X	0h = NMT producer needs to be started by NMT consumer 8h = NMT producer autonomously enters NMT state operational (self-starting)

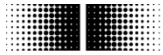


## 12.2 Manufacturer specific parameters

Object	Sub-Index	Name	Format	Access	Default	Save	Description
2001h		Electronic gear	ARR				Configuration of electronic gear function
	00h	Highest sub-index supported	U8	ro	3h		
	01h	Enable / disable	U8	rw	1h	X	Enable / disable electronic gear 1 = electronic gear disabled 2 = electronic gear enabled  NOTE: Object functionality depends on feature control (2110h) settings, for gear legacy mode "off": 0 = electronic gear disabled (default) 1 = electronic gear enabled
	02h	Gear value1	U16	rw	1h	X	Numerator of gear factor, range 1...32767  NOTE: Data type depend on feature control (2110h) settings, for gear legacy mode "off": Data type U32
	03h	Gear value2	U16	rw	1h	X	Denominator of gear factor, Range 1...32767  NOTE: Data type depend on feature control (2110h) settings, for gear legacy mode "off": Data type U32
2100h		Baud rate	U8	rw	2h	X	Device baud rate 0=10 kbits/s (not supported anymore) 1=20 kbits/s (not supported anymore) 2=50 kbits/s 3=100 kbits/s 4=125 kbits/s 5=250 kbits/s 6=500 kbits/s 7=800 kbits/s 8=1000 kbits/s The baud rate is activated after a reset or power-on (if parameter is stored to non-volatile memory) NOTE: Object 2100h table deviates from CiA standard bit timing table for LSS
2101h		Node-ID	U8	rw	1h	X	Device node-ID (range 1...127 is possible) New node-ID is activated after reset or power-on (if parameter is stored to non-volatile memory)
2110h		Feature control	U16	rw	8h	X	Bit 0: Speed sign legacy mode (Ignore DIR flag) 0 = Speed sign legacy mode "off" 1 = Speed sign legacy mode "on" (Ignore DIR flag of 6000h for speed value (6031h-01h), behavior like EAM V01.07.01 and earlier)  Bit 3: CAN bus-off behavior 0 = Encoder behaves according to object 1029h 1 = Automatic CANopen restart  Bit 4: Auto save behavior 0 = Auto save disabled 1 = Auto save enabled, auto save is triggered after preset  Bit 5: Speed and acceleration legacy mode 0 = Speed and acceleration legacy mode "on" (data type of object 6030h-01h: I32) 1 = Speed and acceleration legacy mode "off" (data type of object 6030h-01h: I16), behavior like EAM580S & EB360  Bit 6: Electronic gear legacy mode 0 = Electronic gear legacy mode "on" (2001h-01h Enable / disable: 2/1, gear values 2001h-02h/03h data type U16, 1 = Electronic gear legacy mode "off" (2001h-01h Enable / disable: 1/0, gear values 2001h-02h/03h data type U32), behavior like EAM580S & EB360  NOTE: For the most similar behavior as EAM580S and EB360 use the value 68h. Bit 6 and bit 5 have influence on object data types and EDS file.
2114h		Manufacturer reserved	U32	rw	0h		
2116h		Error injection	ARR				Simulation of encoder errors for test purpose
	00h	Highest sub-index supported	U8	ro	2h		
	01h	Trigger diagnostic error injection	U32	rw	0h		An error injection code, written on this object simulates a diagnostic source and activates the corresponding signaling according to chapter 9.5



Object	Sub-Index	Name	Format	Access	Default	Save	Description
	02h	Position offset error injection	U32	rw	0h		A temporary position offset could be injected to test a position cross-check in a PLC for example.  Allows a position offset error injection. The entered position offset value will be added to the actual position value (6004h).
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 value	I16	ro, m			Speed value of encoder in [rpm]
2120h		Time stamp	U16	ro, m			Time stamp of output position / value in [us]
2122h		Safety word	U16	ro, m			Safety word for mapping in TPDO1...TPDO3.  NOTE: Use in PDOs with 64-bit data only. Safety word must be placed in bit position 48...63.
2124h		Speed configuration					
	00h	Highest sub-index supported	U8	ro	3h		
	01h	Direction information	U8	ro, m	-		Sign of object 6030h-01h 1: positive speed 0: negative speed
	02h	Empty dummy	U8	ro, m	0h		Constant 00h for mapping in TPDO1...TPDO3.
	03h	Speed options	U8	rw	0h	X	Bit0 = Use absolute value for speed value (2118h) Bit1 = Invert direction information 2124h-01h
2300h		Customer EEPROM	ARR				Customer EEPROM to save any data
	00h	Highest sub-index supported	U8	ro	4h		
	01h	Customer EEPROM [0]	U32	rw	0h	X	
	02h	Customer EEPROM [1]	U32	rw	0h	X	
	03h	Customer EEPROM [2]	U32	rw	0h	X	
	04h	Customer EEPROM [3]	U32	rw	0h	X	
2800h		Baumer device info					
	00h	Highest sub-index supported	U8	ro	6h		
	01h	Serial number	STR	ro	-		String version of 1018h-04h, resp. 650Bh
	02h	SAP number	U32	ro	-		SAP number
	03h	Order number	U32	ro	-		Fixed to 0 / not available on the encoder
	04h	Product key	STR	ro	-		Internally linked to 1008h
	05h	Product name	STR	ro	-		e.g. EAM580R-SC0.7NC6.14180.A
	06h	Manufacturer date	STR	ro	-		In format "DD.MM.YYYY hh:mm:ss"
4001h		Speed sampling interval	U16	rw	32h	X	Speed sampling interval for calculation of output speed value in [ms]. Range 1...500 ms. Internally linked to 6031h-02h



### 12.3 Device profile specific parameters (rotary encoders, CiA DSP406)

Object	Sub-Index	Name	Format	Access	Default	Save	Description
6000h		Operating parameters	U16	rw	4h	X	Configuration of encoder operating parameters  Bit0: Code sequence 0 = Rising values on CW Rotation 1 = Rising values on CCW Rotation  Bit2: Scaling function control 0 = Scaling disabled 1 = Scaling enabled  If scaling is disabled the position value (6004h) will be calculated with the default values of the measuring units per revolution (6001h) and total measuring range (6002h) instead of the user settings.  NOTE: When changing operating parameters, the output position will change and the encoder has to be referenced (see preset value, 6003h)
6001h		Measuring units per revolution	U32	rw	4000h	X	Number of steps per revolution in [steps/rev]. Allowed range is 0 or 2...65'536 steps/rev  NOTE: Writing this object will adjust object 6502h. 6502h = 6002h / 6001h (rounded down to integer)
6002h		Total measuring range in measuring units	U32	rw	0h	X	Number of distinguishable steps over total measuring range in [steps]. Allowed range 0 or 1...2 <sup>32</sup> -1 steps (value 0h means 2 <sup>32</sup> steps, i.e. 4'294'967'296dec or 1'0000'0000h steps) For singleturn encoder, the range is 2...value of 6001h  Depending on values of 6001h and 6002h, encoder automatically operates in endless mode (please refer to chapter 4.4.1).  NOTE: Writing to this object will adjust object 6502h. 6502h = 6002h / 6001h (rounded down to integer)
6003h		Preset value	U32	rw	0h	X	Preset value for position value (object 6004h) in [steps] Internally linked to object 6010h-01h
6004h		Position value	U32	ro, m			Position value in [steps] Internally linked to object 6020h-01h
6008h		High resolution position value	U64	ro, m	-		High resolution position value of high resolution encoders. Unscaled position + an optional preset (6009h), optionally inverted by 6000h-00h Multiturn encoders: 16-bit singleturn + 30-bit multiturn Singleturn encoders: 16-bit singleturn
6009h		High resolution preset value	U64	rw	0h		Preset value for high resolution position value (object 6008h) of high resolution encoders. Allowed range: Multiturn encoders 0...2 <sup>16+30</sup> -1 Singleturn encoders: 0...2 <sup>16</sup> -1
600Ch		Position raw value	U32	ro	-		Output position value (raw value without scaling or inversion) Multiturn encoders: 16-bit singleturn + 16-bit multiturn Singleturn encoders: 16-bit singleturn
6010h		Preset values for multi-sensor devices	Array		-		Preset value for output position value of multi-sensor device.  NOTE: Only channel 1 supported.
	00h	Highest sub-index supported	U08	ro	1h		
	01h	Preset value channel 1	U32	rw	0h		Preset value for channel 1 in steps Internally linked to object 6003h
6020h		Position values for multi-sensor devices	Array		-		Output position value for multi-sensor device  NOTE: Only channel 1 is supported.
	00h	Highest sub-index supported	U8	ro	1h		
	01h	Position value channel 1	U32	ro, m	-		Output position value Internally linked to object 6004h
6030h		Speed value	Array		-		Output speed value
	00h	Highest sub-index supported	U08	ro	1h		
	01h	Speed value for channel 1	I32	ro, m			Output speed value for channel 1 in [steps/s]  NOTE: Object functionality and data type depend on feature control (2110h) settings, for speed and acceleration legacy mode "off": Data type I16





Object	Sub-index	Name	Format	Access	Default	Save	Description
6031h		Speed parameters	Array				
	00h	Highest sub-index supported	U8	ro	4h		
	01h	Speed source selector	U8	rw	1h		Selects position object from where speed value is derived. 1 = Object 6004h (position value) is used 2 = Object 600Ch (position raw value) is used
	02h	Speed integration time	U16	rw	50dec		Integration time of speed filter [ms] Range 1...500 ms Internally linked to object 4001h.
	03h	Multiplier value	U16	rw	1h		Output value multiplier
	04h	Divider value	U16	rw	1h		Output value divider
6040h		Acceleration value					Output acceleration value
	00h	Highest sub-index supported	U08	ro	1h		
	01h	Acceleration value channel 1	I16	ro, m			Acceleration value in [steps/s <sup>2</sup> ] scaled with settings of object 6041h
6041h		Acceleration parameters					
	00h	Highest sub-index supported	U08	ro	4h		
	01h	Acceleration source selector	U08	rw	2h	X	Selects position object from where acceleration value is derived. 1 = Object 6004h (position value) is used 2 = Object 600Ch (position raw value) is used
	02h	Acceleration integration time	U16	rw	200dec	X	Integration time of acceleration filter in [ms] Range 1...500 ms
	03h	Multiplier value	U16	rw	1h	X	Output value multiplier
	04h	Divider value	U16	rw	1092dec	X	Output value divider
6200h		Cyclic timer PDO1	U16	rw	100dec		Transmission period for TPDO1 in [ms] Internally linked to object 1800h-05h
6500h		Operating status	U16	ro	4h  Bit 2 = 1		Configuration of encoder operating parameters Internally linked to 6000h read-only  Bit0: Code sequence 0 = Rising values on CW Rotation 1 = Rising values on CCW Rotation  Bit2: Scaling function 0 = Disable scaling 1 = Enable scaling
6501h		Used single turn resolution [steps/rev]	U32	ro	4000h		Internally linked to 6001h read-only
6502h		Number of distinguishable revolutions	U32	ro	40000h		Multiturn: 6002h / 6001h (rounded down to integer) Singleturn: 1
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	9003h		The following alarms are supported: Bit0 = Generic position alarm Bit1 = Commissioning diagnostics 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	F01Dh		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. 4.1 = 0401h Byte 2: Software minor version Byte 3: Software major version
6508h		Operating time	U32	ro	0h		Total operating time in steps of 6 minutes
6509h		Offset value	I32	ro	0h		Offset value in [steps] (calculated by preset function, shifts position value with calculated value, internally linked to object 650Ch-01h)



Object	Sub-index	Name	Format	Access	Default	Save	Description
650Ah		Module identification	Array				
	00h	Highest sub-index supported	U08	ro	1h		
	01h	Manufacturer offset	I32	ro	0h		
650Bh		Serial number	U32	ro			Internally linked to object 1018h-04h
650Ch		Offset values for multi-sensor devices	Array				
	00h	Highest sub-index supported	U08	ro	1h		
	01h	Offset encoder	I32	ro	0h	X	Offset value channel 1 in [steps] Internally linked to object 6509h

## 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 store 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 stored 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 Appendix

### 14.1 Deviations from 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.
0x1029	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
2100h	0	Baud rate	Direct rw access via SDO not in line with CiA standard
2101h	0	Node ID	Direct rw access via SDO not in line with CiA standard

## 14.2 Electronic gear function

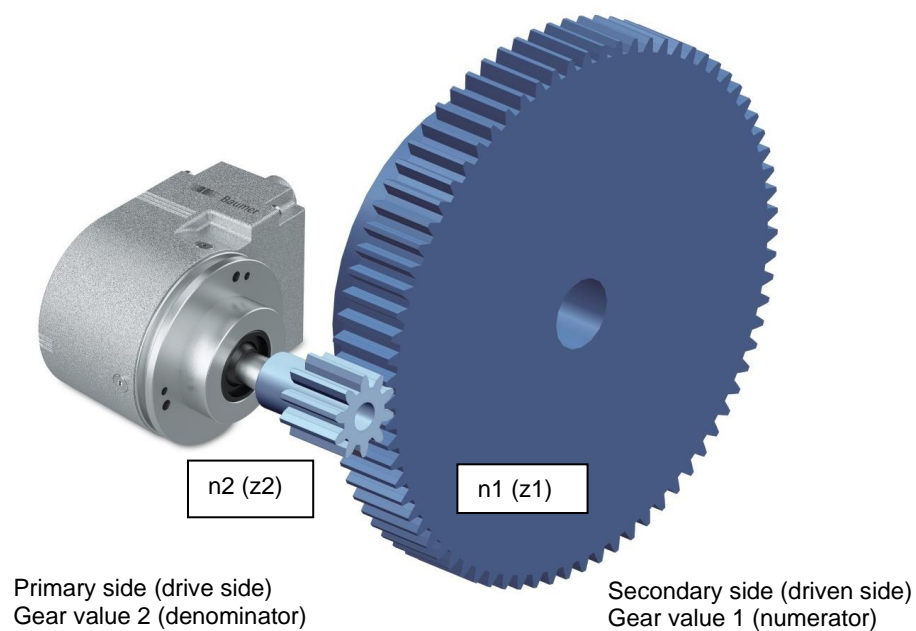
The electronic gear function (2001h) divides the encoder position value by the gear factor. Therefore it transforms the encoder position value into the view of the application:

$$\text{Application position} = \frac{\text{Encoder position}}{i}$$

The electronic gear function is also called numerator/denominator scaling or round axis function.

With electronic gear function enabled, the encoder can be mechanically mounted on the primary / input side (drive side) of a gearbox, while it outputs position data as if it was mounted on the secondary / output side (driven side) of the gearbox.

The parameter „total measuring range“ (6002h) always defines the number of requested steps for one revolution on the secondary side of the gear box. The parameter "measuring units per revolution" (6001h) is not taken into account when electronic gear function is enabled.



**Figure 8: Electronic gear function (2001h)**

The gear ratio or gear factor  $i$  is defined as:

$$\text{Gear factor } i = \frac{\text{Gear value 1}}{\text{Gear value 2}} = \frac{\text{Numerator}}{\text{Denominator}} = \frac{\text{Speed at drive side (n2)}}{\text{Speed at driven side (n1)}} = \frac{\text{Number of teeth at driven side (z1)}}{\text{Number of teeth at drive side (z2)}}$$

Gear value 1 (numerator, 2001h-02h) and gear value 2 (denominator, 2001h-03h) of the gear factor  $i$  directly result from the number of teeth / gear ratio in the application. In the above example, the number of teeth at the driven side is 75. At the drive side, the number of teeth is 10.

### Example

The gear factor shall be 75:10 (means  $i = 7,5$ ).

The resolution on the secondary side of the gearbox shall be "1 revolution = 10000 steps".

The numerator is 75 and the denominator is 10.

Only integer values are admissible for numerator and denominator. The total measuring range is 10000.

**Electronic gear enable / disable (2001h-01h)**

Set object 2001h-01h to value 1h to enable the electronic gear function, while value 0h disables it (further details see table **Fehler! Verweisquelle konnte nicht gefunden werden. Fehler! Verweisquelle konnte nicht gefunden werden.**).

NOTE: A change of object 2001h-01h Electronic gear enable / disable clears internal position offsets (if any). In this case, the current absolute multiturn position reference is lost and the encoder has to be referenced (see preset value, 6003h).

**Gear value 1 (2001h-02h)**

This object defines the numerator of the gear factor.

The range of this integer value is 1...32'767.

**Gear value 2 (2001h-03h)**

This object defines the denominator of the gear factor.

The range of this integer value is 1...32'767.

NOTE: After setting and storing the electronic gear function setting, the encoder has to be restarted to activate the electronic gear function.

**Limitations**

A useful gear factor is greater than 0.125, while a gear ratio smaller than 1 may result in higher signal noise.

Valid combinations of numerator, denominator and total measuring range fulfill following condition:

$$\text{total measuring range (6002h)} * \frac{\text{denominator (2001h - 03h)}}{\text{numerator (2001h - 02h)}} \leq 65536$$

The maximum encoder revolutions when the encoder is unpowered or power on time is shorter than 5 minutes must be smaller than  $2^{29}$  (536'870'912) turns. If this number of revolutions is exceeded, the encoder has to be referenced (see preset value, 6003h) after every power-up.

The electronic gear function is useful for multiturn encoders. In case of singleturn encoders, the position value gets lost after a power cycle.

### 14.3 Pin Assignments

#### Assignment cable (connection - L or - U)

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, - B or - A)

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-

