Baumer

Passion for Sensors

Manual

Absolute encoder
Absolute encoder redundant
CANopen

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Contents

Appendix

1 Safety and operating instructions

1.1 Supplementary information

- This manual is intended as a supplement to already existing documentation (catalogues, data sheets and assembly instructions).
- The manual must be read without fail before initial commissioning of the equipment.

1.2 Intended purpose of the equipment

- The encoder is a precision measuring device. It is explicitly designed for registration of angular positions and revolutions as well as evaluation and supply of measuring values as electric output signals for the subsequently connected device. The encoder must not be used for any other purpose.

1.3 Commissioning

- Installation and assembly of the encoder only by electrically skilled and qualified personnel.
- Consider also the operation manual of the machine manufacturer..

1.4 Safety remarks

- Prior to commissioning the equipment, check all electrical connections.
- If installation, electrical connection or any other work performed at the encoder or at the equipment is not correctly executed, this can result in a malfunction or failure of the encoder.
- Steps must be taken to exclude any risk of personal injury, damage to the plant or to the operating equipment as a result of encoder failure or malfunction by providing suitable safety precautions.
- Encoders must not be operated outside the specified limited values (see detailed product documentation).

Failure to comply with the safety remarks can result in malfunctions, personal injury or damage to property.

1.5 Transport and storage

- Only ever transport or store encoders in their original packaging.
- Never drop encoders or expose them to major vibrations.

1.6 Assembly

- Avoid impacts or shocks on the housing and shaft / hollow shaft.
- Avoid any twist or torsion on the housing.
- Do not open the encoder or make any mechanical changes to it.

The shaft, ball bearings, glass pane or electronic components can be damaged. In this case, safe and reliable operation cannot be guaranteed.

1.7 Electrical commissioning

- Do not modify the encoder electrically and remove power supply while connecting the encoder electrically.
- The electrical connection must not be attached or removed under power supply.
- Only use shielded cables. The cable shield must be attached over a large area with as less impedance as possible. EMC-compatible connectors and cable bushings must be used for connecting the encoder to a control system.
- Ensure that the entire plant is installed in line with EMC requirements. The installation environment and wiring affect the electromagnetic compatibility of the encoder. Install the encoder and supply cables separately or at a long distance from cables with high interference emissions (frequency converters, contactors etc.)
- Where working with consumers which have high interference emissions, make available a separate power supply for the encoder.
- The encoder housing must be grounded via the encoder flange, if the mechanical structure is electrically isolated an additional grounding must be provided.
- The protective earth (PE) should be attached to both sides, the mechanical structure and the control system in a way to avoid impedance. In order to prevent currents in the cable shielding, a potential equalization should be implemented.
- When a potential ground loop can't be avoided, only one side must be grounded.
- Unused outputs must not be connected.

Failure to observe these instructions can result in malfunctions, material damage or personal injury.

2 Product Assignment

2.1 Absolute encoder

Product	Product-Code	Device Name	EDS-file
Absolute encoder singleturn redundant (MAGRES)	0x0037	BMSx Redundant	BMSx_0x0037.eds
Absolute encoder multiturn redundant (MAGRES)	0x0036	BMMx Redundant	BMMx_0x0036.eds
Absolute encoder singleturn without bearings	0x001B	MHAD	MHAD_0x001B.eds

3 System Overview

3.1 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 encoders are galvanically isolated (non-isolated on request).

3.2 Supported Profiles

Following CANopen profiles are supported:

- CiA 301 / Version 4.1 (Communication)
- CiA 305 / Version 1.0 (LSS)
- CiA 406 / Version 3.2 (Encoder Profile)
    - Absolute rotary encoder redundant: Multi-sensor encoder interface / Absolute rotary encoder

3.3 Supported CANopen Services

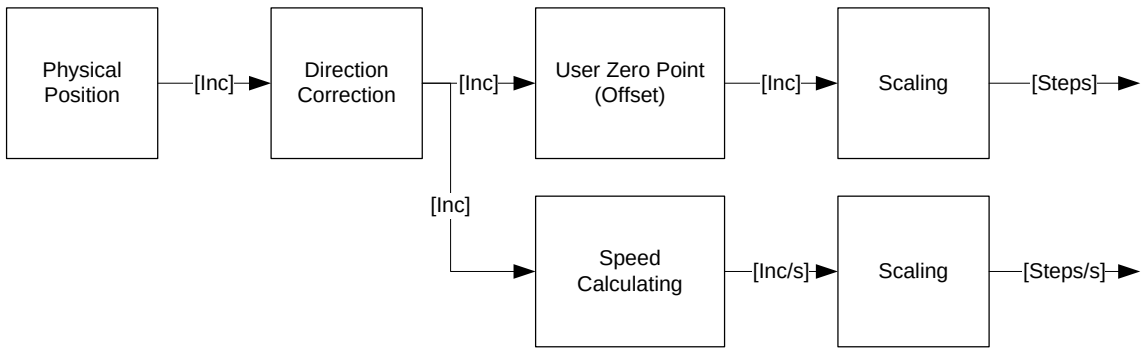
Following CANopen services are supported:

- 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 LSS Client (according to CiA 305)

3.4 Function Principle

3.4.1 Overview

Figure 1: Function principle overview



3.4.2 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)*

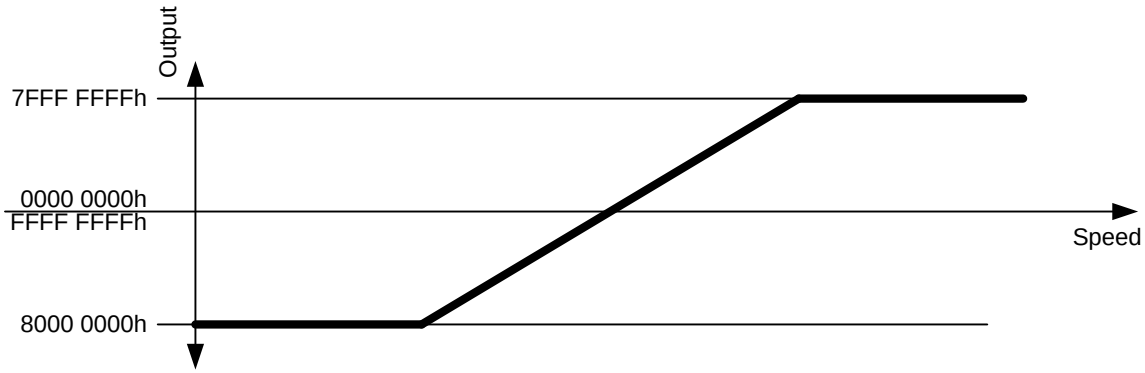
3.4.3 Position Range

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.

3.4.4 Speed range

The range for object 6030h-1 Speed encoder A and object 6030h-2 Speed encoder B is -8000'0000h…7FFF'FFFFh.
If the scaled speed value exceeds this range, the output is -8000'0000h or 7FFF'FFFFh (Saturated Logic).

Figure 3: Speed range



4 NMT Service

4.1 Supported commands

Following NMT commands are supported:

- NMT Start
- NMT Preoperational
- NMT Stop
- NMT Reset
- NMT Communication Reset

There is no difference between NMT Reset and NMT Communication Reset

4.2 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

5 SDO service

5.1 General

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

5.2 Save/load parameters

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

5.2.1 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 immediately. (Parameter saving is performed after answering the SDO request.)

5.2.2 Load

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

5.2.3 Safe non-volatile operation

To ensure safe non-volatile operation, the time between access object 1010h-x or 1011h-x and a reset or power-on has to be at least 1000ms.

5.2.4 Side effect

Save/Load operations interrupt the updating of position and speed.

6 PDO Service

6.1 General

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

6.2 PDO transmission types

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

- Synchronous transmission (1-240)
- Asynchronous transmission (255)
- Manufacturer transmission (254)

Both PDOs support all transmission types.

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.

6.3 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)*

6.4 PDO mapping

The encoder supports dynamic mapping.

6.4.1 Mappable objects

The following objects are mappable:

Mapping content	Mapping entry	Description
Position encoder A	0x60040020	Object 6004h Subindex 00h, data length 32 Bit
Position encoder A	0x60200120	Object 6020h Subindex 01h, data length 32 Bit
Position encoder B	0x60200220	Object 6020h Subindex 02h, data length 32 Bit
Speed encoder A	0x60300120	Object 6030h Subindex 01h, data length 32 Bit
Speed encoder B	0x60300220	Object 6030h Subindex 02h, data length 32 Bit
Alarms	0x65030010	Object 6503h Subindex 00h, data length 16 Bit
Warnings	0x65050010	Object 6505h Subindex 00h, data length 16 Bit

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

6.4.2 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)

6.4.3 Default mapping of absolute encoder redundant

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	Byte 4	Byte 5	Byte 6	Byte 7
181h/281h	8	xx	xx	xx	xx	yy	yy	yy	yy

Byte 0..3: Position A (Object 6020h-1)
Byte 4..7: Position B (Object 6020h-2)

6.5 Timing

The minimal cycle time for TPDOs is 1 ms.

6.6 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:

- Non-volatile operations
- Changing the scaling parameters

7 Emergency Service

7.1 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.

7.2 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)

7.3 Emergency message

The format of the emergency messages is according to CiA 301. Additionally our 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

7.4 Error register

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

7.4.1 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.

7.4.2 Generic error

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

7.5 Error codes

The following error codes are generated by the device:

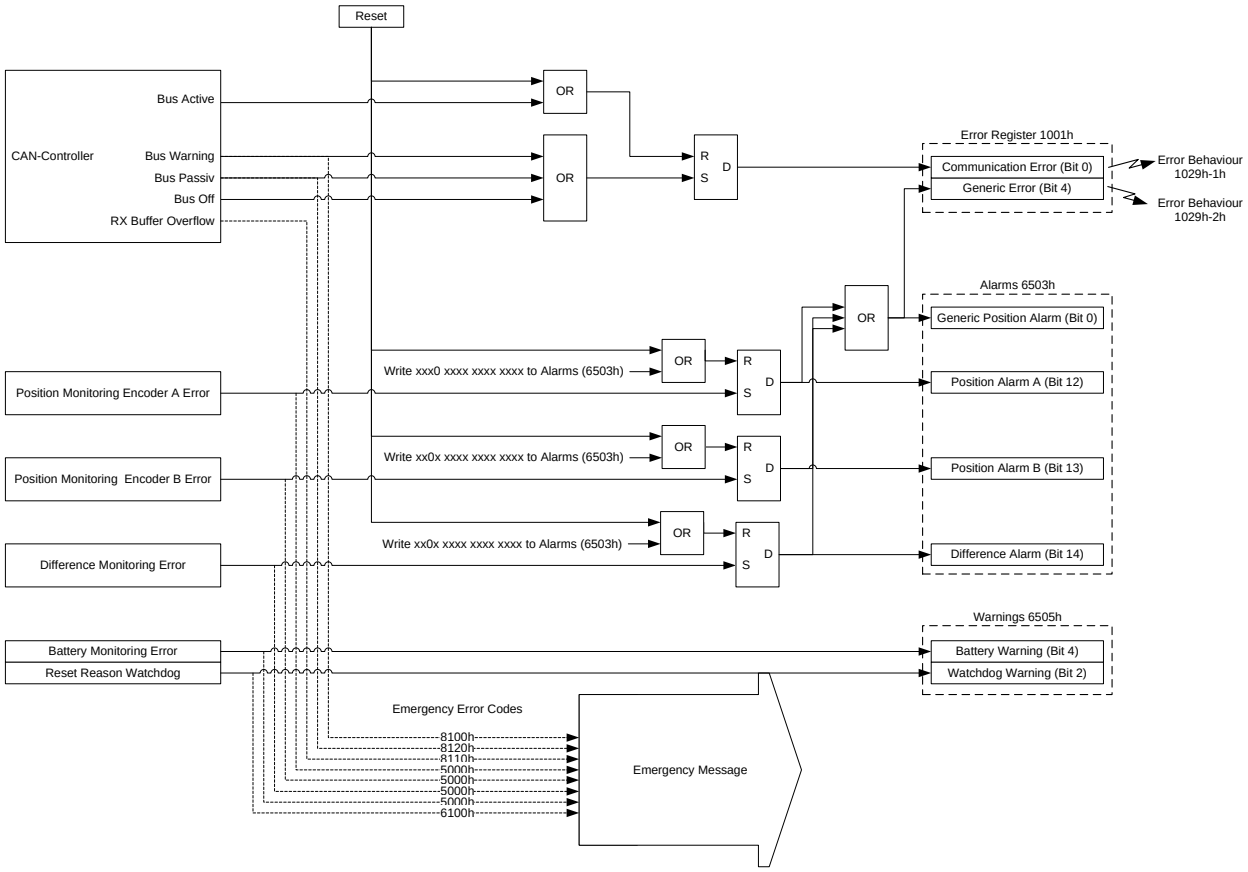
Error Code (hex)	Meaning
0000	Error reset or no error
5000	Hardware fault (position error)
6100	Software fault (watchdog)
8100	Communication error (bus warning)
8110	CAN RX overflow
8120	CAN in error passive mode

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

Figures 4, 5 and 6 show the surveillance mechanisms. If one of them fails, an alarm or warning will be indicated. The behaviour upon an error can be defined and is described in chapter 8.3.

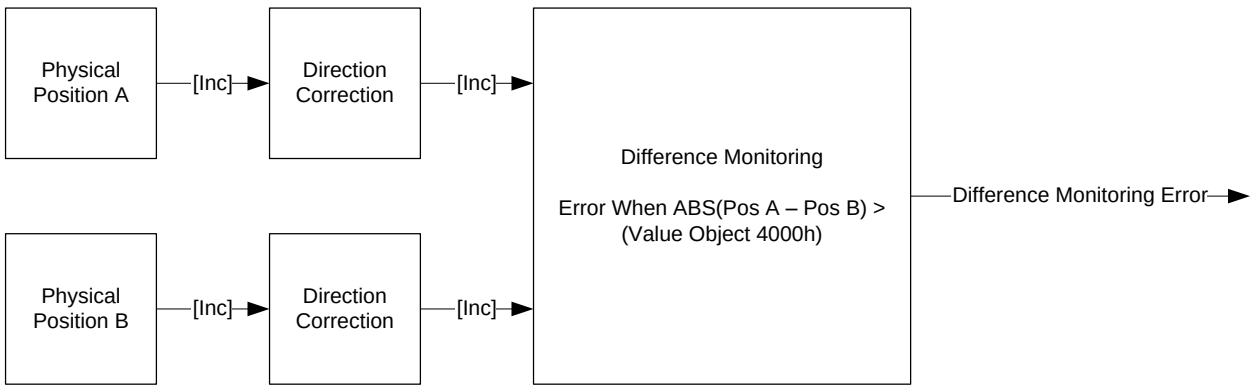
8.1 Absolute encoder redundant

Figure 4: Block diagram redundant encoder



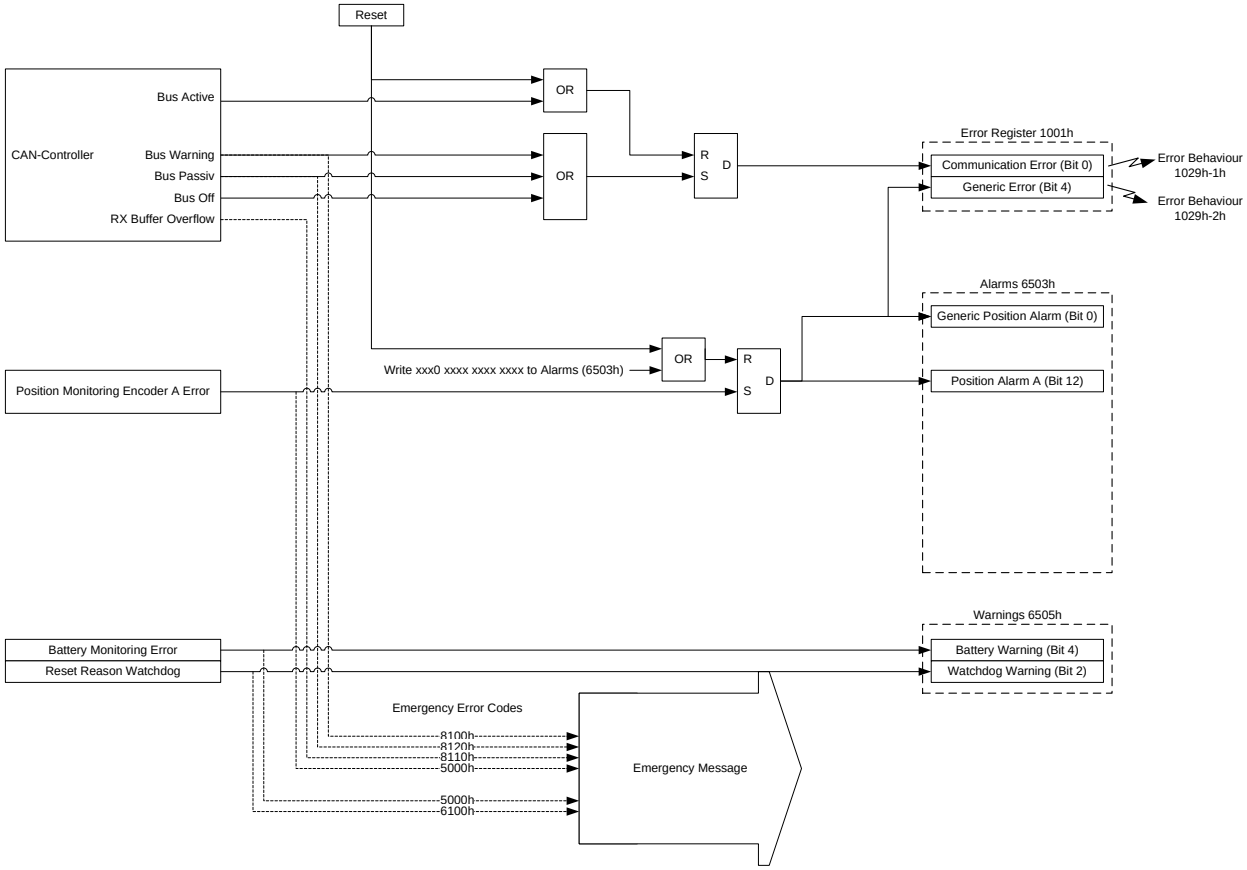
8.1.1 Difference monitoring

Figure 5: Block diagram difference monitoring



8.2 Absolute encoder

Figure 6: Block diagram encoder



8.3 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 Heartbeat Service

9.1 General

The device supports a heartbeat producer according CiA 301.

9.2 COB-ID

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

9.3 Timing

The minimal cycle time for heartbeat messages is 1 ms.

10 LSS slave

10.1 General

The 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 to the objects 2100h and 2101h (see object directory).
The LSS service is only available in NMT Stopped Mode.

10.2 Supported commands

- Switch state global
- Switch state selective
- Configure node ID protocol
- Configure bit timing parameters
- Store configuration
- Inquire identity vendor-ID
- Inquire identity product code
- Inquire identity revision number
- Inquire identity serial number
- Inquire identity node ID

10.3 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.

11 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

Objects extensions for *Absolute encoder redundant* compared to *Absolute encoders* are marked with grey background.

11.1 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 Redundant Devices: 000A'0196h
1001h		Error Register	U8	ro	0h		Bit0 = Generic 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 = "BMMx" "BMMx Redundant" "BMSx" "BMSx Redundant" "MHAD"
1009h		Hardware Version	STR	ro			Hardware version in ASCII
100Ah		Software Version	STR	ro			Software version in ASCII
1010h		Store parameters	ARR				
	00h	Largest Subindex	U8	ro	4h		No. of save possibilities 4
	01h	Save all parameters	U32	rw			="evas " (0x65766173) to save
	02h	Communication parameters	U32	rw			="evas " (0x65766173) to save
	03h	Application parameters	U32	rw			="evas " (0x65766173) to save
	04h	Manuf. specific parameters	U32	rw			="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			="daol" (0x64616F6C) to load
	02h	Communication parameters	U32	rw			="daol" (0x64616F6C) to load
	03h	Application parameters	U32	rw			="daol" (0x64616F6C) to load
	04h	Manufacturer specific parameters	U32	rw			="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
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: 37h = MAGRES Absolute rotary encoder single turn redundant 17h = MAGRES Absolute rotary encoder single turn 36h = MAGRES Absolute rotary encoder multi turn redundant 16h = MAGRES Absolute rotary encoder multi turn 1Bh = MHAD Absolute rotary encoder singleturn without bearings
	03h	Revision number	U32	ro			Product revision No.
	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 = hange to stopped mode
	02h	Generic 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	FFh	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	1h	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/ 2	X	Maximum value is 8
	01h	1st mapping parameter	U32	rw	6004'0020h 6020'0120h	X	Position encoder A
	02h	2nd mapping parameter	U32	rw	6020'0220h	X	Position encoder B
1A01h		Transmit PDO2 mapping	ARR			X	
	00h	Largest Subindex	U8	rw	1 / 2	X	Maximum Value is 8
	01h	1st mapping parameter	U32	rw	6004'0020h 6020'0120h	X	Position encoder A
	02h	2nd mapping parameter	U32	rw	6020'0220h	X	Position encoder B

11.2 Manufacturer Specific Profile Area

Object	Sub-Index	Name	Format	Access	Default	Save	Description
2100h		Baud rate	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 3: 1 = Encoder reset on CAN Bus Off 0 = No encoder reset on CAN Bus Off
4000h		Max Increment Difference [Inc]	U32	rw	100h	X	Max allowed difference between encoder 1 and encoder 2 in encoder increments. If the difference reaches this level the alarm bit 14 in the object 6504h will be set to 1. To deactivate the monitoring of the increment difference, this value has to be 0.
4001h		Speed sampling interval in ms	U16	rw	10	x	The speed sampling interval sets up the sampling interval of the speed calculation Changing this parameter to a value higher than 4'000 can cause problems (internatl overflows) with the speed object (6030h-x)

11.3 Standardized Device Profile Area

Object	Sub-Index	Name	Format	Access	Default	Save	Beschreibung
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	1000h		Measuring units per revolution. This value has to be less or equal than 1'0000'0000h divided by object 6502h (Value 0 means 1'0000'0000h)
6002h		Total measuring range [Step]	U32	rw			Total measuring range. This value has to be a multiple of object 6502h (Value 0 means 1'0000'0000h)
6003h		Preset value encoder A [Step]	U32	rw	0h		Preset in steps for encoder A → Offset (Internally linked to object 6020h-1)
6004h		Position encoder A [Step]	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 / 2		
	01h	Preset for encoder A [Step]	U32	rw	0		Preset in steps for encoder A
	02h	Preset for encoder B [Step]	U32	rw	0		Preset in steps for encoder B
6020h		Position Values	Array				
	00h	Largest Subindex	U08	ro	1 / 2		
	01h	Position encoder A [Step]	U32	ro,m			Position in steps for encoder A
	02h	Position encoder B [Step]	U32	ro,m			Position in steps for encoder B
6030h		Speed Values	Array				
	00h	Largest Subindex	U08	ro	1 / 2		
	01h	Speed encoder A [Step/s]	U32	ro,m			Speed in steps/second for encoder A
	02h	Speed encoder B [Step/s]	U32	ro,m			Speed in steps/second for encoder B
6200h		Cyclic timer PDO1 [ms]	U16	rw	100		internally linked to object 1800h-2
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	1000		
6502h		Number of distinguishable revolutions	U32[1]	ro	Singleturn: 1 Multiturn: 4'0000h		
6503h		Alarms	U16	rw[2],m	0h		The following alarms are evaluated: Bit0 = Position error Bit12 = Data valid encoder A Bit13 = Data valid encoder B Bit14 = Difference monitoring
6504h		Supported alarms	U16	ro	Standard: 1001h Redundant: 7001h		The following alarms are supported: Bit0 = Position error Bit12 = Data valid encoder A Bit13 = Data valid encoder B Bit14 = Difference monitoring
6505h		Warnings	U16	ro,m	0h		The following warnings are evaluated: Bit2 = CPU watchdog status reset generated Bit4 = Battery charge too low
6506h		Supported warnings	U16	ro	14h		The following warnings are supported: Bit2 = CPU Watchdog Status Bit4 = Battery Charge
6507h		Profile & software version	U32	ro			Byte 0..1: Profile-Version =3.02 = 0302h Byte 2: Software minor version Byte 3: Software major version
6508h		Operating time	U32	ro	0h		Always FFFF'FFFFh
6509h		Offset encoder A [step]	I32	ro	0h		Offset encoder A (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 / 2		
	01h	Offset encoder A [step]	I32	ro	0h	X	Offset encoder A
	02h	Offset encoder B [step]	I32	ro	0h	X	Offset encoder B

[1] Object 6502h according to profile 406 V3.02 is U16
[2] Object 6503h according to profile 406 V3.02 is read only

Appendix

A. Pin Assignments

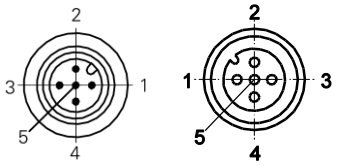
Default Pin Assignments for galvanically isolated encoders are listed below (non-isolated on request).

A.1 Assignment cable (connection - 5)

Cable color	signal	description
yellow	CAN_L	CAN bus signal (dominant LOW)
grey	CAN_GND	CAN bus ground
white	0 V	Supply voltage
green	CAN_H	CAN bus Signal (dominant HIGH)
brown	+Vs	Supply voltage

A.2 Pin assignment connector 2 x M12 (connection – M)

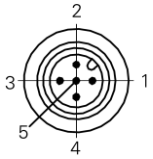
Pin no.	Signal	Description
1	CAN_GND	CAN bus ground
2	+Vs	Supply voltage
3	0 V	Supply voltage
4	CAN_H	CAN bus signal (dominant High)
5	CAN_L	CAN bus signal (dominant Low)



View to encoder

A.3 Pin assignment connector 1 x M12 (connection – N)

Pin no.	Signal	Description
1	CAN_GND	CAN bus ground
2	+Vs	Supply voltage
3	0 V	Supply voltage
4	CAN_H	CAN bus signal (dominant High)
5	CAN_L	CAN bus signal (dominant Low)



View to encoder

B. LED functional display (MHAD only)

LED	Description / possible causes
Green * **	▪ Voltage supply is present ▪ Encoder is in the OPERATIONAL state
Red	▪ Rotor not present, not correctly mounted or damaged ▪ Mounting tolerances not respected ▪ Internal error
Green single flash **	▪ The device is in the STOPPED state
Green blinking **	▪ The device is in the PREOPERATIONAL state
Off	▪ Sensor is not present ▪ Voltage supply not available or too low ▪ Internal error

* While the whole rotation the LED must emit green light.
** CAN RUN LED according to CiA DR-303-3.