MULTI-TURN ABSOLUTE ENCODERS

MEM40 Bus
MEM41 Bus

CANopen®

With CANopen Fieldbus

Instruction Manual

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Absolute Encoder with CANopen protocol, Class C2

1. CAN bus & CANopen protocol

1.1 CAN bus

The CAN bus (CAN: Controller Area Network) was originally developed by Bosch and Intel as a means of fast, low-cost data transmission in automotive applications. The CAN bus is used today also in industrial automation applications.
The CAN bus is a field bus (the standards are defined by CiA, the CAN in Automation Association) through which devices, actuators and sensors from different manufacturers can communicate with each other.
Elap encoder complies with standards **CiA DS 301** "Application Layer and Communication Profile" and **DS 406** "Device Profile for Encoders."

1.2 CAN bus Characteristics

- Data rate of 1 MBaud with network expansion up to 40
- Network connected on both sides
- The bus medium is a twisted-pair cable
- 'Real-Time' operation: a max wait time is set for high priority messages
- Theoretically 127 users at one bus, but physically only 32 are possible (due to the driver).
- Ensures data consistency across the network. Damaged messages are notified as faulty for all network nodes
- Message-oriented communication: the message is identified by a message identifier. All network nodes use the identifier to test whether the message is of relevance for them.
- Broadcasting, multicasting: All network nodes receive each message simultaneously. Synchronization is therefore possible.
- Multimaster capability: Each user in the field bus is able to independently transmit and receive data without being dependent upon the priority of the master. Each user is able to start its message when the bus is not occupied. When messages are sent simultaneously, the user with the highest priority prevails.
- Prioritization of messages: The identifier defines the priority of the message. This ensures that important messages are transmitted quickly via the bus
- Residual error probability: Safety procedures in the network reduce the probability of an undiscovered faulty data transmission to below 10 -11. In practical terms, it is possible to ensure a 100% reliable transmission.
- Function monitoring: Localization of faulty or failed stations. The CAN protocol encompasses a network node monitoring function. The function of network nodes which are faulty is restricted, or they are completely uncoupled from the network.
- Data transmission with short error recovery time: By using several error detection mechanisms, falsified messages are detected to a high degree of probability. If an error is detected, the message transmission is automatically repeated.
- In the CAN Bus, several network users are connected by means of a bus cable. Each network user is able to transmit and receive messages. The data between network users is serially transmitted.

Examples of network users for CAN bus devices are:

- Automation devices such as PLCs
- PCs
- Input and output modules
- Drive control systems
- Analysis devices, such as a CAN monitor
- Control and input devices as Human Machine Interfaces (HMI)
- Sensors and actuators

1.3 CANopen

Under the technical management of the Steinbeis Transfer Centre for Automation, the CANopen profile was developed on the basis of the Layer 7 specification CAL (CAN Application Layer). In comparison with CAL, CANopen only contains the functions suitable for this application. CANopen thus represents only a partial function of CAL optimized for the application in hand, so permitting a simplified system structure and the use of simplified devices. CANopen is optimized for fast data exchange in real time systems.
The organization CAN in Automation (CiA) is responsible for the applicable standards of the relevant profiles.

CANopen permits:

• Simplified access to all device and communication parameters
• Synchronization of several devices
• Automatic configuration of the network
• Cyclical and event-controlled process data communication

CANopen comprises four communication objects (COB) with different characteristics:
• Process data objects for real time data (PDO)
• Service data objects for parameter and program transmission (SDO)
• Network management (NMT, Heartbeat)
• Pre-defined objects (for synchronization, emergency message)

All device and communication parameters are subdivided into an object directory. An object directory encompasses the name of the object, data type, number of subindexes, structure of the parameters and the address. According to CiA, this object directory is subdivided into three different parts. Communication profile, device profile and a manufacturer-specific profile.

1.4 Communication Profile

Communication between the network users and the Master (PC / Control) takes place by means of object directories and objects. The objects are addressed via a 16 bit index. The CANopen communication profile DS 301 standardizes the various communication objects.

They are accordingly divided into several groups:
• Process data objects PDO for real time transmission of process data
• Service data objects SDO for read/write access to the object directory
• Objects for synchronization and error display of CAN users:
  - SYNC object (synchronization object) for synchronization of network users
  - EMCY object (emergency object) for error display of a device or its peripherals
• Network management NMT for initialization and network control
• Layer Setting Services LSS for configuration by means of serial numbers, revision numbers etc. in the middle of an existing network

1.5 CANopen Message Structure

The first part of a message is the COB ID (Identifier).
Structure of the 11-bit COB ID :

Function code (4 bit)				Node ID (7 bit)						

The function code provides information on the type of message and priority.
The lower the COB ID, the higher the priority of the message
Broadcast messages:

Function code	COB ID
NMT	0
SYNC	80H

Other messages:

Function code	COB ID
Emergency	80H + Node ID
PDO1 (tx)	180H + Node ID
PDO2 (tx)	280H + Node ID
SDO (tx)	580H + Node ID
SDO (rx)	600H + Node ID
Heartbeat	700H + Node ID
LSS (tx)	7E4H
LSS (rx)	7E5H

(tx) and (rx) from the viewpoint of the encoder

The node ID can be freely selected by means of the CANopen bus between 1 and 127. The encoders are supplied with the Node ID 1.
This can be changed with the service data object 2101h or using LSS.

A CAN message is made up of the COB ID and up to 8 bytes of data:

COB ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
Xxx	x	xx	xx	xx	xx	xx	xx	xx	xx

The message details are described at a later point.

1.6 Service Data Communication

The service data objects correspond to the standards of the CiA. It is possible to access an object via index and subindex.

The data can be requested or where applicable written into the object.

Structure of an **SDO telegram**:

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

An SDO-**COB ID** is composed as follows:
Master → Encoder : 600H + Node ID

Encoder → Master : 580H + Node ID

DLC (data length code) 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 encoder
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 5 – 8

COB ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
580H+Node	08H	80H	Object L	Object H	Subindex	Err.0	Err.1	Err.2	Err.3

Byte 8..5 results in the SDO abort message (byte 5 → LSB, .., 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
- 06070010H Inconsistent data type

Some SDO examples follow.

SDO examples

Request of a value by the master to the encoder (position value, object 6004H).

COB ID	DLC	Command	Object L	Object H	Subindex	Data 0	Data 1	Data 2	Data 3
600H+Node	08H	40H	04H	60H	00H	xx	xx	xx	xx

Response by the encoder **to the request** for a value (the position value is composed by 4 byte).

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data 0	Data 1	Data 2	Data 3
580H+Node	08H	43H	04H	60H	00H	FAH	59H	00H	00H

The encoder position is 000059FAH.

Writing of a value by the master into the encoder (Position setting can be performed with preset, object 6003H, at 300H).

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data 0	Data 1	Data 2	Data 3
600H+Node	08H	22H	03H	60H	00H	00H	03H	00H	00H

Encoder response to the writing of a value.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data 0	Data 1	Data 2	Data 3
580H+Node	08H	60H	03H	60H	00H	00H	00H	00H	00H

1.7 Process data communication

Process data objects are used for real time data exchange for process data, for example position or operating status. PDOs can be transmitted synchronously or cyclically (asynchronously). The encoder supports the PDO1 and the PDO2. Both PDOs supply the current position of the encoder and are defined in the objects 1800H, 1801H, 1A00H, 1A01H and 6200H.

Synchronous PDO

In order to transmit the process data synchronously, a value between 1 and F0h (=240) must be written into the object 1800h / 1801h Subindex 2. If the value is 3, the PDO is transmitted on every third sync telegram (if the value 1 is entered, transmission takes place on every SYNC telegram).

In synchronous operation, the PDO is requested by the master via the Sync telegram.

COB ID	DLC
80H	00H

Cyclical PDO (asynchronous)

If you wish the PDOs to be transmitted cyclically, the value FEh must be written into the object 1800h / 1801h Subindex 2. In addition, the cycle time in milliseconds must be entered in the same object subindex 5. If the value is stored for 0 ms, the PDOs are not transmitted.

PDO1 Telegram structure

COB ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4
180H+Node	04H	Xx	xx	xx	xx

PDO2 Telegram structure

COB ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4
280H+Node	04H	Xx	xx	xx	xx

1.8 Emergency service

Internal device error or bus problems initiate an emergency message:

COB ID	DLC	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8
80H+Node	08H	Err.Code L	Err.Code H	Register					

Byte 1 and 2 contain the error code.

Code	Meaning
0000H	Error reset/ no error
1000H	Generic error
6010H	Software reset (watchdog)
7320H	Position error
8110H	CAN communication error (Overrun)
8120H	CAN communication error (Transmission / Reception)
8140H	Recovered Bus-Off
FF00H	Battery low (3.2 Volts)
FF01H	Data loss

Byte 3 contains the error register (object 1001H).

Bit	Meaning
0	Generic error
4	Communication error
7	Manufacturer specific

Byte 4 to 8: not used

1.9 Network Management (NMT)

Network management can be divided into two groups.
Using the NMT services for **device monitoring**, bus users can be initialized, started and stopped.
In addition, NMT services exist for **connection monitoring**.

Description of the NMT command

The commands are transmitted as unconfirmed objects and are structured as follows:

COB ID	DLC	Byte 1	Byte 2
00H	02H	Command	Node

Command byte

Command byte	Description	State
01H	Start remote node	Operational
02H	Stop remote node	Stop
80H	Enter pre-operational mode	Pre-operational
81H, 82H	Reset remote node	Boot-up

The **node number** corresponds to the node ID of the required users. With node number = 0, all users are addressed.

Following initialization, the encoder is in the pre-operational mode. In this status, SDO parameters can be read and written. In order to request PDO parameters, the encoder must first be moved to the operational mode status by the command *Start*.

NMT states

Initialization

Following initialization, the encoder logs on to the CAN bus with a BootUp message. The encoder then goes automatically to the pre-operational mode status.

The COB ID of the BootUp message is made up of 700H and the node ID.

COB ID	DLC	Byte 1
700H + Node	01H	00H

Pre-operational mode
In the pre-operational mode, SDOs can be read and written.

Operational mode
In the operational mode, the encoder transmits the requested PDOs. In addition, SDOs can be read and written

Stopped mode

In the stopped mode, only NMT and LSS communication is possible. No SDO parameters can be read or written.

Status change

Start command

With the start command, the encoder is switched to the operational mode status.

COB ID	DLC	Command	Node
00H	02H	01H	00H, …, 7FH

Stop command

With the stop command, the encoder is switched to the stopped mode status.

COB ID	DLC	Command	Node
00H	02H	02H	00H, …, 7FH

Pre-operational mode command

The encoder switches to the pre-operational mode status

COB ID	DLC	Command	Node
00H	02H	80H	00H, …, 7FH

Application reset command

With the reset command the encoder is re-initialized and switches to the pre-operational mode status.

COB ID	DLC	Command	Node
00H	02H	81H	00H, …, 7FH

Communication reset

The encoder re-initializes the communication and switches to the pre-operational mode status.

COB ID	DLC	Command	Node
00H	02H	82H	00H, …, 7FH

***Heartbeat* Protocol**

The encoder (Heartbeat producer) transmits the Heartbeat message cyclically with the frequency defined in the object 1017H.

One or more Heartbeat Consumer may receive the indication. The relationship between producer and consumer is configurable via Object Dictionary entries.

The heartbeat messages consist of the COB ID and one byte. In this byte, the NMT status is supplied.

COB ID	DLC	Byte 1
700H+Node	01H	7FH

- 00H Boot-up
- 04H Stopped state
- 05H Operational state
- 7FH Pre-operational state

In the above example the encoder is in the pre-operational state (7FH).

1.10 Layer Setting Services (LSS)

The encoder is provided with default values for node number (1) and *baud rate* (50 kBaud). Since several encoders can be connected to the same CAN network with the same node number, the LSS protocol allows to address each individual encoder. In other words different encoders with the same node number can be connected to the system to be initialized via LSS protocol.
Both the node number and the baud rate can be modified (see *Layer Setting Services and Protocol,* CiA Draft Standard Proposal 305). LSS commands can only be executed with the encoder in the stopped or pre-operational mode state.

Message structure

COB ID:

Master → Slave: 7E5H

Slave → Master: 7E4H

The COB ID is followed by the LSS command specifier and seven data bytes.

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7

Global Switch mode

With this command the master sets all the LSS slave in the network to the waiting status (0) or configuring mode (1). No response follows.

COB ID	DLC	Command	Mode	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	04H	00H / 01H	Reserved					

Selective Switch Mode

With this command the master sets the LSS addressed node to the configuring mode. The response if the addressed device follows.

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	40H	Vendor ID				reserved		
7E5H→	08H	41H	Product code				reserved		
7E5H→	08H	42H	Revision number				reserved		

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	44H	Reserved						

Vendor ID ELAP: 000002B4H

Product code: Encoder inside code (see label)

Revision number: Current encoder revision (see label)

Setting the node ID

After setting the encoder in the configuration mode, it is possible to modify the node ID.

Accepted node numbers: 1 to 127.

The response telegram by the slave with result in byte 1 follows (0 → ok, 1 →Node ID outside range).

COB ID	DLC	Command	Node	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	11H	01H,…,7FH	Reserved					

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	11H	Result	Reserved					

Setting the baud rate

After setting the encoder in the configuration mode it is possible to modify the baud rate.

The response telegram by the slave with result in byte 1 follows (0 → ok, 1 baud rate outside range).

COB ID	DLC	Command	Sel,Table	Sel.Baud	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	13H	00H o 80H	xx	Reserved				

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	13H	Result	Reserved					

Table selection : 00H Standard CiA table

80H Vendor specific table

Standard CiA table (Sel.Table = 00H)

Baud Rate	Index
1000 kBaud	0
800 kBaud	1
500 kBaud	2
250 kBaud	3
125 kBaud	4
-	5 (reserved)
50 kBaud	6
20 kBaud	7
10 kBaud	8

Elap Table (Sel.Table = 80H)

Baud Rate	Index
10 kBaud	0
20 kBaud	1
50 kBaud	2
125 kBaud	3
250 kBaud	4
500 kBaud	5
800 kBaud	6
1000 kBaud	7

Configuration saving command

With this command the master requires to save the modified data (node identification and baud rate).

The response telegram by the slave with result in byte 1 follows (0 → ok, 1 → saving not supported, 2 → access error).

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	17H	Reserved						
COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	17H	Result	Reserved					

Activating the new baud rate

The new baud rate set with the relevant LSS command is activated by this command. Bytes 1 and 2 contain a delay in ms. No response follows by the slave.

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	15H	Delay time (ms)		Reserved				

The encoder waits the set time before re-initializing the baud rate records. Then it still waits the same time span before sending the messages with the new baud rate to the network.

Requesting the Vendor ID

With this message the master requests the selected slave (that is in the configuration state) the vendor ID code. The slave response with the requested data in bytes 1 to 4 follows.

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	5AH	Reserved						

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	5AH	B4H	02H	00H	00H	Reserved		

ELAP Vendor ID code is 000002B4H.

Requesting the product code

With this message the master requests the selected slave (that is in the configuration state) the product code. The slave response with the requested data in bytes 1 to 4 follows.

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	5BH	Reserved						

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	5BH	32 bit product code				Reserved		

Requesting the revision number

With this message the master requests the selected slave (that is in the configuration state) the vendor ID code. The slave response with the requested data in bytes 1 to 4 follows.

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	5CH	Reserved						

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	5CH	32 bit revision number				Reserved		

Searching for a device

The encoder can be searched for in the network. The master sends the following telegrams in sequence.

The response of the relevant slave follows.

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E5H→	08H	46H	Vendor ID					Reserved	
7E5H→	08H	47H	Product code					Reserved	
7E5H→	08H	48H	Revision number (low)					Reserved	
7E5H→	08H	49H	Revision number (high)					Reserved	

COB ID	DLC	Command	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
7E4H←	08H	4FH	Reserved						

2. Encoder communication profile

2.1 Overview of encoder objects

According to CiA (CAN in Automation), objects are subdivided into three groups:

- • **Standard objects** (see DS 301, Application Layer and Communication Profile)**:**
  - 1000H, 1001H, 1018H
- • **Manufacturer-specific objects** (see DS 301)**:**
  - 2000H - 5FFFH
- • **Device-specific objects**(see DS 406, Device Profile for encoders)**:**
  - All other objects from 1000H - 1FFFH, 6000H - FFFFH

The following table provides a summary of all SDO objects supported by the encoder.

Object Object number in Hex
Name ===
Type U/I = Unsigned/Integer, No. = number of bits, ARR = Array, REC = structure
Attr access attributes: ro = read only, wo = write only, rw = read write
Default Default value on first init

Object	Name	Type	Attr	Default	Info
1000H	Device type	U32	ro	00020196H 00010196H	Byte 0-1: Profile 0196H = 406 Byte 2-3: Encoder type=2(absolute, multiturn) Encoder type=1 (absolute single turn)
1001H	Error register	U8	ro	00H	Bit0 → generic error Bit4 → communication error Bit7 → battery voltage low
1003H 00H 01H … 04H	Predefined error field Biggest Subindex Latest error … Oldest error	ARR U8 U32 … U32	 rw ro … ro		Contains the last 4 errors/warnings Number of stored errors (0 – 4) Error or warning: 1000H Generic error 6010H Watchdog 7320H Position Error 8110H CAN Error (overrun) 8120H CAN Error (tx / rx) 8140H Recovered Bus-Off FF00H Buffer battery (< 3.2V) FF01H Lost Data
1005H	COB ID SYNC message	U32	rw	00000080H	COB ID of the SYNC object
1008H	Device name	U32	ro	“MEMC”	
1009H	Hardware Version	U32	ro	“n.nn”	Hardware Version in ASCII
100AH	Software Version	U32	ro	“n.nn”	Software Version in ASCII
1010H 00H 01H	Store parameters Max sub-index Save all parameters	ARR U8 U32	 ro rw	01H	Single turn encoder only Save possibility (1) “save” (0x73617665) to save
1010H 00H 01H	Restore default parameters Max sub-index Restore default values	ARR U8 U32	 ro rw	01H	Single turn encoder only Restore possibility (1) “load” (0x6C6F6164) to restore
1014H	COB ID emergency	U32	ro	80H+Node	COB ID of the Emergency object
1017H	Heartbeat time	U16	rw	07D0H	Heartbeat cycle time in ms

Object	Name	Type	Attr	Default	Info
1018H	Identity Object	ARR			
00H	Biggest Subindex	U8	ro	03H	
01H	*Vendor ID*	U32	ro	000002B4H	Manufacturer Id (by CiA)
02H	Product code	U32	ro		0AH → multiturn, 0BH → single turn
03H	Revision No.	U32	ro		Current revision
1029H	Error behavior	ARR			Object present from 1.10 version
00H	Biggest Subindex	U8	ro	01H	(see 100AH, software version)
01H	Communication error	U8	rw	00H	00H → change to pre-operational 01H → no change of NMT state 02H → change to Stop mode
1800H	Transm. PDO1 parameters	REC			
00H	Biggest Subindex	U8	ro	05H	
01H	COB ID	U32	rw	180H+node	PDO ID = 180H + node
02H	PDO type	U8	rw	FEH	Cyclic PDO
05H	Event timer	U16	rw	0064H	Cycle time in ms
1801H	Transm. PDO2 parameters	REC			
00H	Biggest Subindex	U8	ro	05H	
01H	COB ID	U32	rw	280H+node	PDO ID = 280H + node
02H	PDO Type	U8	rw	01H	Synchronous PDO
05H	Event timer	U16	rw	01F4H	Cycle time in ms
1A00H	PDO1 Mapping	ARR			
00H	Biggest Subindex	U8	ro	01H	
01H	Content of PDO1	U32	ro	60040020H	ro, although for CiA it is rw Byte 0-1: 0020H = 32 bit Byte 2-3: 6004H = object index (position)
1A01H	PDO2 Mapping	ARR			
00H	Biggest Subindex	U8	ro	01H	
01H	Content of PDO2	U32	ro	60040020H	ro, although for CiA it is rw Byte 0-1: 0020H = 32 bit Byte 2-3: 6004H = object index (position)
2100H	Baud rate	U8	rw	02H	Init is required after setting a value: 00H → 10 kBit/s 01H → 20 kBit/s 02H → 50 kBit/s 03H → 125 kBit/s 04H → 250 kBit/s 05H → 500 kBit/s 06H → 800 kBit/s 07H → 1000 kBit/s
2101H	Node ID	U8	rw	01H	Accepted values: 01H to 7FH. Init is required after setting a value
2110H	Options	U16	rw	08H	Bit0 → rotation direction (see object 6000H, Bit0) Bit1 → not used Bit2 → scaling function (see object 6000H, Bit2) Bit3 → Bus-Off automatic recovery 0 disabled 1 enabled

Object	Name	Type	Attr	Default	Info
6000H	Operational parameters	U16	rw	0000H	Bit0 → rotation direction 0 clockwise rotation 1 anti-clockwise rotation Bit2 → scaling function 0 disabled 1 enabled
6001H	Resolution – single turn	U32	rw	00002000H	13 bit resolution; accepted values: 01H to 2000H.
6002H	Overall measuring range	U32	rw	20000000H	20000000H → 29 bit (multiturn) 00002000H → 13 bit (singleturn)
6003H	Preset value	U32	rw	00000000H	Preset in increments
6004H	Encoder position	U32	ro		Encoder position, inclluding offset by the preset value
6200H	Cycle time for PDO1	U16	rw	0064H	In ms, identical to object 1800H, subindex 05H.
6500H	Operational state	U16	ro	0000H	Bit0 → rotation direction Bit2 → scaling function
6501H	Max Single turn resolution	U32	ro	2000H	13 bit resolution
6502H	Revolutions number	U16	ro		Absolute number of performed rotations
6503H	Alarms	U16	ro	0000H	The following alarms are evaluated: Bit0 → Position error
6504H	Supported alarms	U16	ro	0001H	The following alarms are supported: Bit0 → Position error
6505H	Warnings	U16	ro	0000H	The following warnings are evaluated Bit2 → Watchdog (single turn) Bit4 → Battery charge (multiturn)
6506H	Supported warnings	U16	ro	0004H 0010H	The following warnings are supported Bit2 → Watchdog (single turn) Bit4 → Battery charge (multiturn)
6507H	Profile & software version	U32	ro	01000302H	Byte 0-1: Profile version 0302H → 3.02 Byte 2-3: *Software* Version = 0100H → 1.00
6508H	Operating time	U32	ro	00000000H	Time in 1/10 hours since last reset
6509H	Offset	U32	ro	00000000H	Offset calculated from preset (object 6003H)
650BH	Serial number	U32	ro	FFFFFFFFH	Not used

2.2 Parameters saving

The objects below are saved via object 1010H. In order to prevent unintentional saving, the message "save" must be written in subindex 1. The saving operation is necessary to store modifications performed in the objects below.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	23H	10H	10H	01H	73H ‘s’	61H ‘a’	76H ‘v’	65H ‘e’

Saved objects

Object	Sub-index	Description	Default values
1005H	00H	COB ID SYNC message	80H
1017H	00H	H*eartbeat time*	07D0H (2000 ms)
1029H	01H	Behavior in case of communication error	00H (change to pre-operational)
1800H	01H	COB ID PDO1	180H + node
1800H	02H	Type PDO1	FEH (PDO cyclical asynchronous)
1800H	05H	Timing PDO1	0064H (100 ms)
1801H	01H	COB ID PDO2	280H + node

Object	Sub-index	Description	Default values
1801H	02H	Type PDO2	01H (PDO synchronous))
1801H	05H	Timing PDO2	01F4H (500 ms)
2100H	00H	*Baud rate* index	02H (50 kbps)
2101H	00H	Node identification	01H
2110H	00H	Manufacturer options	08H
6000H	00H	Operating parameters	00H
6001H	00H	Single turn resolution	2000H (13 bit)
6002H	00H	Total measuring range	2000H
6003H	00H	Preset value	0000H
6200H	00H	PDO1 cycle time	0064H (100 ms)
6509H	00h	Offset value	0000H

The default values of the save parameters can be restored via object 1011H. In order to prevent unintentional restoring, the message "load" must be written in subindex 1. Default values will be used by the slave after resetting.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	23H	10H	10H	01H	6CH 'l'	6FH 'o'	61H 'a'	64H 'd'

3. Diagnosis and useful information

3.1 Error diagnosis field bus communication

- If the encoder cannot be addressed via the CANopen bus, first of all check the terminals. If the terminals are not in order, field bus operation should be tested next. For this purpose, a CAN monitor is required which records CANopen communication and shows the telegrams.

- The encoder should now place a BootUp message when switching the power supply off and on again. Should no BootUp message appear, check whether the baud rates of the encoder, the CAN monitor and the bus system are in agreement.

- If you have difficulty in establishing the connection to the user, check the node number and baud rate. The baud rate must be set the same throughout. The node number (node ID, node address) must be between 1 and 127. Each bus user must be unambiguously assigned a node ID, i.e. it is strictly prohibited to assign the same node ID more than once.

The node ID and baud rate can also be set conveniently using the LSS service.

3.2 Error diagnosis via field bus

The encoder has at its disposal several objects and messages which transcribe the status or error status of the encoder.

- Object 1001H: This object is an error register for the device error status.
- Object 1003H: In this object, the last four error codes and warnings are stored.
- Object Emergency (80H + Node): High-priority error message of a user with error code and error register.
- SDO: If SDO communication does not run correctly, the SDO response contains an error code. A list of the possible errors follows:
    - 05040001H Command byte is not supported
    - 06010000H Incorrect access to an object
    - 06010001H Read access to write only object
    - 06010002H Write access to read only object
    - 06020000H Object is not supported
    - 06060000H FLASH memory writing/reading error (single turn only)
    - 06090011H Subindex is not supported
    - 06090030H Value outside limits
    - 06070010H Inconsistent data type
    - 08000020H Incorrect "save"/"load" code

3.3 Further useful information

Modifying the node number:

1. The node can be set in Elap specific object 2101H
2. The new node number is saved into RAM buffer.
3. On next initialization, the sensor logs on with the new node ID.

Modifying the baud rate:

1. The baud rate can be set in Elap specific object 2100H
2. The new baud rate is saved into RAM buffer.
3. On next initialization the encoder logs on with the new baud rate.
4. PAY ATTENTION: the MASTER must also be set with the same baud rate.

3.4 Signaling LEDs

The encoder is provided with a green LED *(DATA),* indicating the encoder state within the CANopen network, a red LED *(ERROR),* indicating the error state, and a green LED *(POWER)* indicating the supply state. The three signaling LEDs are shown in the picture 5.1.

DATA LED (green)

- It flashes with a frequency of about 10 Hz (50 ma light, 50 ms off): the encoder is in the LSS setup state (the red LED also flashes with the same frequency in this case).
- It flashes with a frequency of about 2.5 Hz: the encoder is in the pre-operative state
- It flashes every one second: the encoder is stopped.
- Fixed light: the encoder is in the operative state.

ERROR LED (red)

- Light off: the encoder is running correctly.
- It flashes with a frequency of about 10 Hz (50 ma light, 50 ms off): the encoder is in the LSS setup state (the green LED also flashes with the same frequency in this case).
- It flashes every one second: there are errors in the CAN communication (*frame errors, overrun, …*)
- Fixed light: the CAN controller is in the *bus off* state.

POWER LED (green)

- Fixed light: the power supply is on.

4. Applications

4.1 Reading and setting objects

In order to overwrite an object (SDO) or to read it, two telegrams always have to be transmitted: one request from the master and one confirmation by the slave.

Example: setting an object

Setting the *Heartbeat* time (object 1017H, default = 2000 ms) 1500 ms (= 05DCH).

Master command telegram:

- Command: 2BH, 2 byte writing request
- Object address node: low byte first, then high byte
- Object sub-index: 0
- Value to be set: low byte first, then high byte

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	2BH	17H	10H	00H	DCH	05H	xx	xx

The slave confirmation telegram follows:

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	60H	17H	10H	00H	xx	xx	xx	xx

Example: reading an object

Reading the encoder position (object 6004H).

Master command message:

- Command: 40H, request for reading
- Object address node: low byte first, then high byte
- Object sub-index: 0

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	40H	04H	60H	00H	xx	xx	xx	xx

The slave response telegram follows:

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	43H	04H	60H	00H	04H	03H	02H	01H

The encoder value starts from the less significant byte, therefore in this case it is 01020304H (= 16909060).

When the encoder is entered into the network, it starts with the *BootUp* message. The encoder must be adjusted and configured for the environment it works in.

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 vendor ID, product code, and revision no. (object 1018H)

Changing the node ID (node no.)

The node ID can be changed in object 2101H between 1 and 127. On the next initialization, the encoder logs on with the new node ID.

Example: node no. Modification from 01H to 02H (writing 1 byte, value 02H)

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
601H	08H	2FH	01H	21H	00H	02H	xx	xx	xx

The encoder confirmation telegram follows.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
581H	08H	60H	01H	21H	00H	xx	xx	xx	xx

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. On next initialization, the encoder logs on to the new baud rate. The baud rate of the master must also be changed accordingly.

Baud rate

Index	Baud rate
0	10 kBaud
1	20 kBaud
2	50 kBaud
3	125 kBaud
4	250 kBaud
5	500 kBaud
6	800 kBaud
7	1000 kBaud

Example: baud rate modification from 02H (50 kBaud) to 03H (125 kBaud): writing 1 byte, value 03H

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
601H	08H	2FH	00H	21H	00H	03H	xx	xx	xx

The encoder confirmation telegram follows.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
581H	08H	60H	00H	21H	00H	xx	xx	xx	xx

4.2 Configuration

Setting the preset value

Command message: writing 4 byte, value 0400H.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	23H	03H	60H	00H	00H	04H	00H	00H

The encoder confirmation telegram follows.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	60H	03H	60H	00H	xx	xx	xx	xx

Changing the sense of rotation and scaling

The sense of rotation can be set to CW (clockwise) or CCW (counterclockwise). In addition, the scaling can be switched on or off in the same object (6000H). With the scaling switched on, the set resolutions are used. If the scaling is switched off, the encoder works with the maximum resolution settings (objects 6501H and 6502H).

Object 6000H:

Bit0: 0 → CW (clockwise)

1 → CCW (counterclockwise)

Bit2: 0 → Scaling on

1 → Scaling off

Command message: writing 2 byte Counterclockwise rotation and scaling on (value = 0005H)

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	2BH	00H	60H	00H	05H	00H	xx	xx

The encoder confirmation telegram follows.

Confirmation:

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	60H	00H	60H	00H	xx	xx	xx	xx

Changing singleturn resolution

In object 6001H, the singleturn resolution can be configured. For example 1024 (10bit) steps per revolution (1024 = 400h):

Command message: writing 4 byte, value = 0400H.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	23H	01H	60H	00H	00H	04H	00H	00H

The encoder confirmation telegram follows.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	60H	01H	60H	00H	xx	xx	xx	xx

Modifying the measuring range

The measuring range can be set in the object 6002H. The measuring range and the single turn resolution result in the number of revolutions. For instance, if the single turn resolution is 10 bit (that is 1024 steps) and the measuring range is 22 bit (4194304 steps), the result is 4096 revolutions (12 bit), each by 1024 steps (10 bits).

Command message: writing 4 byte, measuring range = 4194304 (= 00400000H).

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	23H	02H	60H	00H	00H	00H	40H	00H

The encoder confirmation telegram follows.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	60H	02H	60H	00H	xx	xx	xx	xx

4.3 Operation

NMT statuses

Once the encoder has been initialized, it is then in the **Pre-operational mode**. In this mode, SDO can be read and written.

In order to start PDO communication, you must transmit an **NMT start**. The encoder is then in the **Operational mode**. Any required PDOs are then transmitted. SDOs can also be read and written.

If the encoder is stopped with an **NMT stop**, the encoder is then in the **stopped mode**. In this mode, only

NMT communication is the possible, i.e. also heartbeat.

By means of an **NMT reset** the encoder is re-initialized and is then once again in the **pre-operational mode**.

Reading the position

Request telegram:

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	40H	04H	60H	00H	00H	00H	40H	00H

Encoder response: value ‘dcba’.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	43H	04H	60H	00H	a	b	c	d

Configuring PDOs

The PDOs can be configured in accordance with the following table:

1800H		**Description**
Sub-ind.2	**Sub-ind.5**	
FEH	500 ms	Cyclical transmission every 500 ms
FEH	10 ms	Cyclical transmission every 10 ms
FEH	0 ms	PDO transmission switched off
01H	xx	PDO transmission for each SYNC message received
03H	xx	PDO transmission for each third SYNC message received

Defining Heartbeat time

In order to monitor communication capability, the heartbeat time must be defined in object 1017H with the heartbeat time. The encoder cyclically transmits the Heartbeat message containing the indication of its NMT state. The time is set in ms; if the set time is 0 the Heartbeat message will not be transmitted.

Command message: writing 2 byte, Heartbeat time = 100 ms (0064H).

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
600H+node	08H	2BH	17H	10H	00H	64H	00H	xx	xx

The slave confirmation follows.

COB ID	DLC	Command	ObjectL	ObjectH	Sub-ind	Data0	Data1	Data2	Data3
580H+node	08H	60H	17H	10H	00H	xx	xx	xx	xx

The *Heartbeat* message is composed by the COB ID and by one byte containing the encoder NMT state.

COB ID	DLC	Byte 1
700H+node	01H	7FH

Byte 1: 00H → *BootUp*
04H → stop
05H → operational
7FH → pre-operational

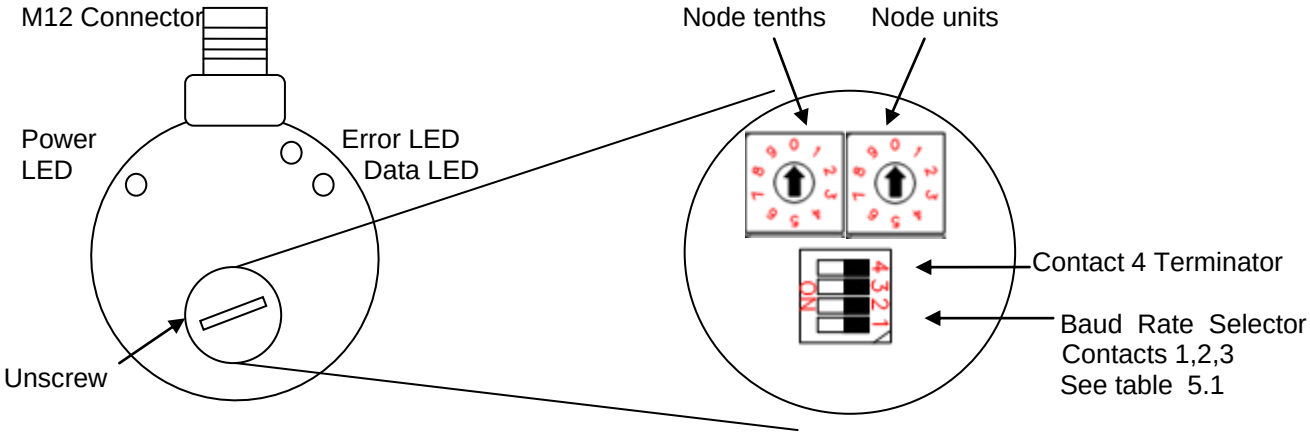
5. Hardware configuration

5. Hardware Configuration

The encoder rear cap must be removed to gain access to two rotary switches, one 4-pin DIP switch and one 8-pin tap connector (Picture 5.1).

The 8-pin tap connector can be disconnected and is supplied inserted in the corresponding plug connector.

Picture 5.1

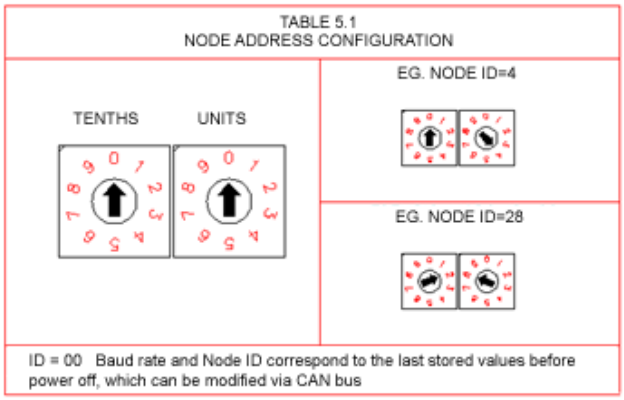


Setting the user address (Node ID)
As mentioned previously, the node ID (user address) is defined/modified in object 2101H . In addition, it is possible to set the user address using two rotary switches of the encoder (see TABLE 5.1). The max. set is 99.

If the switches are set at 0, at power on the encoder keeps as node number the one stored in object 2101H; otherwise it keeps the one set with the rotating switches.

The default set of the two switches is 00.

TABLE 5.1
NODE ADDRESS CONFIGURATION



ID = 00 Baud rate and Node ID correspond to the last stored values before power off, which can be modified via CAN bus

Setting the baud rate

As mentioned previously, the baud rate is defined/modified in object 2100H . In addition, it is possible to set the baud rate by means of contacts 1, 2 and 3 of the encoder DIP switch (see TABLE 5.2).

If the switches relating to the baud rate are set at 0, at power on the encoder keeps as baud rate the one stored in object 2100H; otherwise it keeps the one set with the DIP switch.

The default set of the DIP swicht contacts 1, 2 and 3 is: OFF ON OFF.

Terminating resistor

If the connected encoder is the last device in the bus line, the bus must be terminated with a resistor. The resistor can be connected by the contact 4 of the encoder DIP switch (see TABLE 5.2).

The default set of the DIP swicht contact4 is: OFF.

TABLE 5.2
DIP SWITCH SET (Baud rate/Termination)

Baud Rate	Switch 1	Switch 2	Switch 3
10Kbit/s	OFF	OFF	OFF
20Kbit/s	OFF	OFF	ON
50Kbit/s	OFF	ON	OFF
125Kbit/s	OFF	ON	ON
250Kbit/s	ON	OFF	OFF
500Kbit/s	ON	OFF	ON
800Kbit/s	ON	ON	OFF
1Mbit/s	ON	ON	ON

Switch 4 = ON : Termination inserted
Switch 4 = OFF : Ternination diserted

6. Connections

Cable gland PG9 version

The bus and supply cables must be connected to the M12 connector as shown in the Picture 6.2 and in the TABLE 6.2.

The encoder should always be connected with shielded conductors. The cable shield should be in placed at both ends of the cable. Connectors must be selected to permit a 360 degree contact of the shield . Ensure that no equalizing currents are discharged via the shield. As the encoder is not always connected to a defined earth potential depending on its mounting position, the encoder flange should always be additionally linked to earth potential.

M12 male connector – sight from the insertion side

Picture 6.2

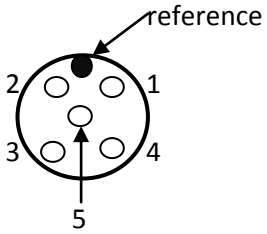


Table 6.2

Pin number	Name	Description
1	**Shield**	**Shield connection**
2	**+V**	**Supply positive pole 10-30 Vdc**
3	**0V**	**Supply 0 V pole 10-30dVcc**
4	**Can-H**	**Can Bus high signal**
5	**Can-L**	**Can Bus low signal**

7. Technical Specifications

Mechanical & Environmental Specifications

Type	MEM40B/	MEM41B
• Materials: case shaft	Aluminium Stainless steel	
• Weight	100 g ca	
• Shaft/hollow shaft Ø	10 mm	10 mm
• Revolutions/minute	6000	
• Starting torque	≤0,2 Ncm	
• Intertia	≤5 g cm^2	
• Max load	Magnetic	
• Vibrations resistance (10÷2000 Hz)	8192 steps/rev – 13 bit	
• Shock (11 ms)	65536/16 bit	
• Protection degree	< 1 s	IP65
• Operating temperature	>21 years power off	
• Stocking temperature	-20 ÷ 80°C	

Electrical & Operating Specifications

• Operating principle	Magnetic
• Resolution/revoltution	8192 steps/rev – 13 bit
• Revolutions no. (multiturn)	65536/16 bit
• Initializing time	< 1 s
• Data memory	>30 years power off
• Fieldbus	CANopen
• Supply	10 ÷ 30 Vdc Protection against polarity reversal
• Power consumption	2 W
• Accuracy	± 0.2°
• Connection	M12 5 5 pin radial connector
• Interference immunity	EN 61000-6-2
• Emitted interference	EN61000-6-4

Ordering Information

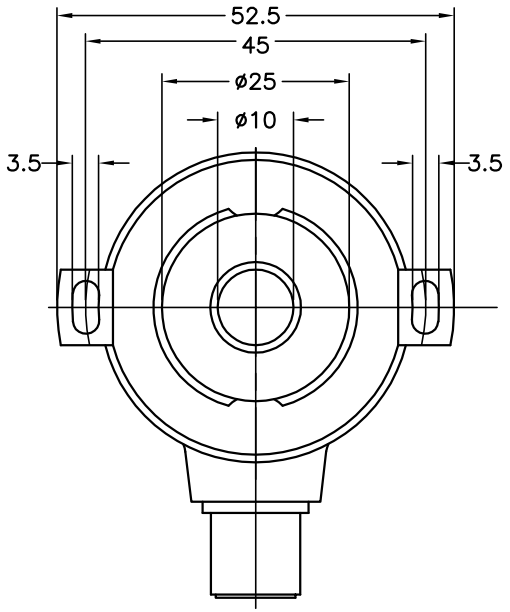
MEM40B | **CAN** | **M** | **10**

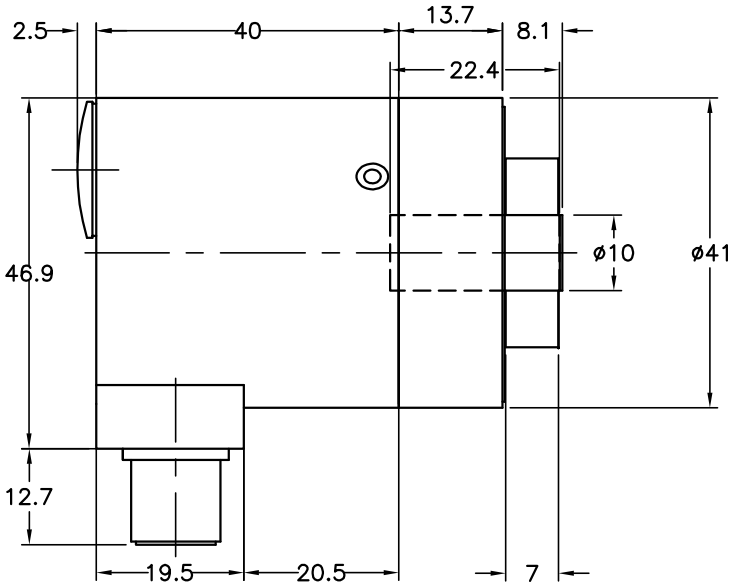
TYPE
***MEM40-Bus** = Round flange, servo coupling*
***MEM41-Bus** = Hollow shaft, elastic support*

FIELDBUS INTERFACE
***CAN**= CANopen*

REVOLUTIONS NO
***M** = Multiturn*

SHAFT /HOLLOW SHAF DIAMETER
***10** mm*





DISEGNO N.	CODICE	SCALA	FOGLIO	SOSTITUITO DA	DATA	FIRMA	DISEGNATO	DATA	SOFTWARE
M2116		1:1	1 di 1				T.R.	18.9.19	

DENOMINAZIONE	TOLL.	MATER.	SOSTITUISCE	DATA	FIRMA	VISTA	FILE
MEM41B Dimensioni ingombro encoder MEM41B albero cavo	V.note	Vari					M2116.DWG

MODIFICHE	DESCRIZIONE	DATA	FIRMA

NOTE

Tolleranza gen. ISO 2768 – m

CLIENTE

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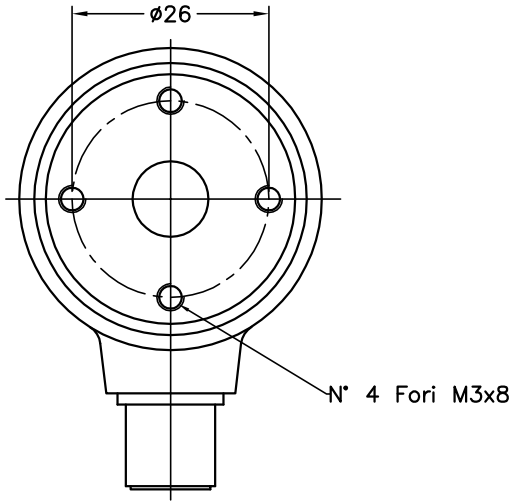

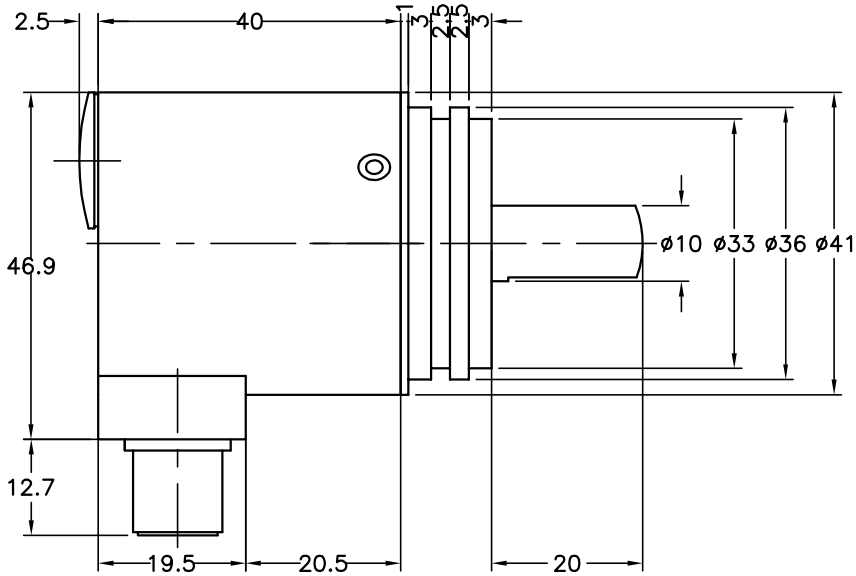

DISEGNO N.	CODICE	SCALA	FOGLIO	SOSTITUITO DA	DATA	FIRMA	DISEGNATO	DATA	SOFTWARE
M2081		1:1	1 di 1				T.R.	27.7.18	

DENOMINAZIONE	TOLL.	MATER.	SOSTITUISCE	DATA	FIRMA	VISTA	FILE
MEM40B Dimensioni ingombro encoder MEM40B	V.note	Vari					M2081.DWG

MODIFICHE	DESCRIZIONE	DATA	FIRMA

NOTE

Tolleranza gen. ISO 2768 – m

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can be downloaded at:

https://www.elap.it/absolute-encoders/encoder-mem40-canopen/

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