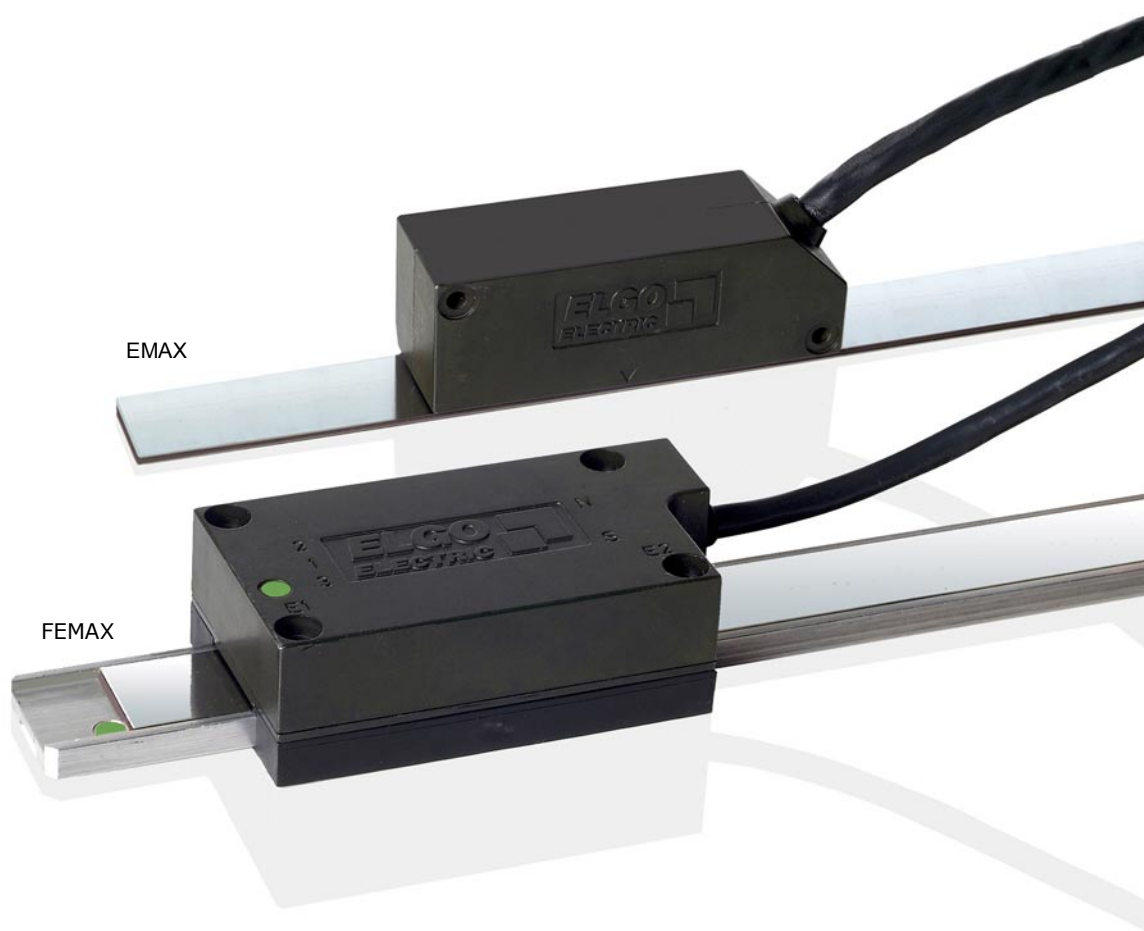*Preliminary variant*

EMAX & FEMAX series
INSTALLATION MANUAL
Magnetic Linear Encoders with 0.01 mm Resolution

EMAX

FEMAX

Only functional with an absolute coded ELGO Magnetic Tape, Type AB20-50

1. Introduction

The series EMAX is an absolute magnetic length measuring system. Sensor technology and translator are both placed in a zinc die cast housing. The magnetic tape of the series EMAB is stuck on a plane base with the provided sticky tape. The EMAX can be installed up to a maximum distance of 0.8 mm.

- As interface is a RS422 available integrated in the sensor housing.
- The absolute measuring system offers decisive advantages:
- no reference necessary
- direct measurement
- contactless, the gap between sensor and measuring tape can vary between 0.1 and 0.8 mm
- measuring length up to 10 m
- resolution of 0.01 mm
- repeating accuracy of +/- increment
- abrasion resistant
- very robust against dust, dirt and water (as sealed IP 67 option)

Typical applications are handling systems, conveyor and storage technology, hydraulic presses, stamping machines, casting machines, linear slides, linear drives and pick and place systems.

For position data transmission are different interfaces are available:
RS422, RS232, SSI or CANopen

The guided FEMAX are complete guided with an Aluminium-Rail for the magnetic tape and a slide carriage in which the sensor circuit is placed.

2. Safety

Note

Before first commissioning read this installation manual carefully and observe absolutely the installation instructions.
The measuring system is only dedicated for recording lengths. The type label is intended for exact identification of the measuring system. The label is situated on the measuring system. It informs about the exact type designation (see chapter 0, order description on page 10), the delivery date and the production number. When contacting the company ELGO Electric GmbH please use these terms.

Attention

The company ELGO Electric GmbH is not liable for possible damages to machines and or to persons, which can result from defective material at the measuring system and the following circuit. The machine manufacturer is responsible for taking and realizing the necessary safety precautions.

3. Function principle

A Hall sensor line and a magneto-resistive resistor measuring bridge element are moved over a magnetic tape written with two tracks. The tracks are a fine interpolation track and an absolute track. The absolute track provides together with the sensor line an absolute value and the fine interpolation track together with the interpolation circuit the high resolution of the measuring system.
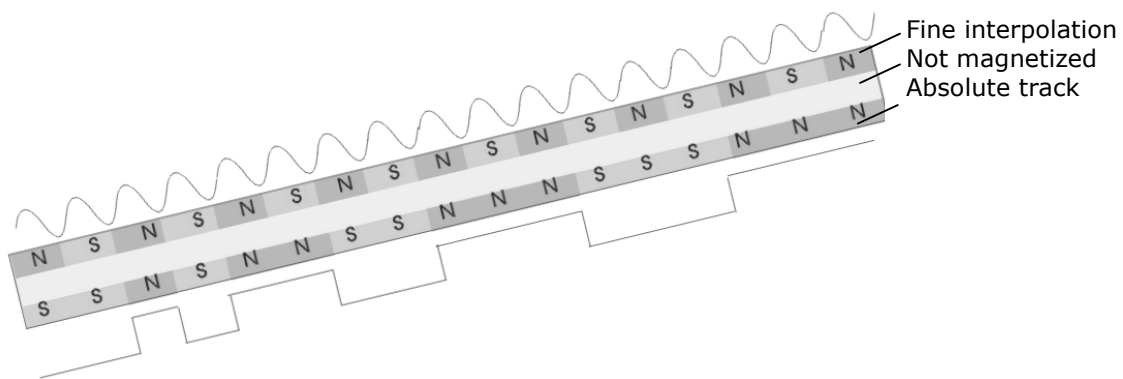
Picture 1: Functional principal EMAX

Picture 2 shows the two magnetic tracks with north and south pole magnetization. On the fine interpolation track the north and south poles alternate with a distance of 5 mm. The poles are sampled with resistor measuring bridges and provide a resolution of 0.01 mm. The sensor line with 16 single Hall sensors, which sample the code sequence of the north and south poles provides the absolute value. The absolute value on the magnetic tape repeats all 10 m.


Picture 2: Coding

4. Technical Specifications

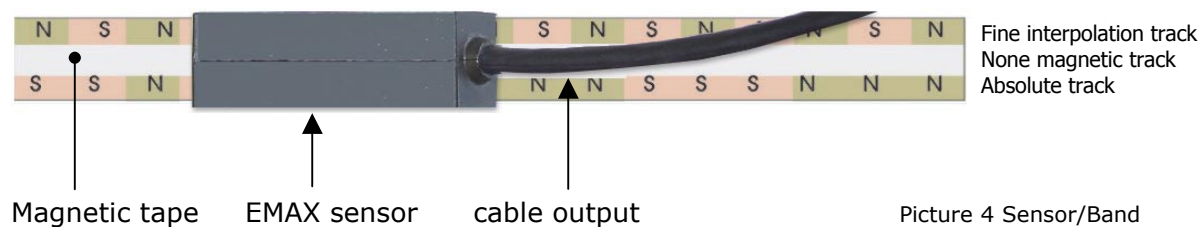|	
Power supply	10-30 VDC / ripple < 5 %
Consumption	max. 150 mA
Signal level	5 V TTL / RS422 (standard Interface)
Resolution	0.01 mm
Repeat accuracy	+/- 1 Increment
max. operating speed	4 m/s
Interfaces: (Data and protocols see in chapter 6. on page 7)	RS422 (standard) RS422 addressable (Option A22) SSI (Option SSI) CAN open (Option CAO)
Incremental output (option)	Channels **A** / **B** (Option I): HTL (10... 30 VDC - Push/Pull), single ended
Measuring length *	max. 10 m
Mounting distance sensor 7 tape	max. 0.8 mm
System accuracy in µm at 20 °C	+/- 150 + 20 x L (L = measuring length in meters)
Working temperature	0... + 60 ° C
Service temperature	- 20... + 70 ° C
Stock temperature	- 40... + 85 ° C
Humidity	max. 80 %, not condensing
Operation height	max. 2000 m above sea level
Protection class	IP 54 (Standard) IP 67 (Option V)
Mechanical data of the sensor	EMAX: 78 x 24 x 33 mm (L x W x H) Zinc die cast, black FEMAX: 90 x 48 x 28 mm (L x W x H) Zinc die cast, black - with slideable plastic guides
Dimensions of guidance rail	Length* (as ordered) x W = 25 x H = 6 mm Available rail lengths: 1 m, 1,5 m oder 2 m. It is possible to arrange e.g. four 4 m rails, to reach the measuring length of 8 meters. The complete 8 m magnetic tape will be stick into the arranged rails then.
Signal cable	Dragchain suitable, max. length = 30,0 m Weight: app. 58,0 g/m, Wires: 2 x 0.75 mm^2 and 6 x 0.14 mm^2 Bending radius: min. 60 mm
Magnetic tape AB20-50-20-2-R-11	Extension coefficient $\alpha = 16 \times 10^{-6} K^{-1}$ Linear extension $\Delta L = L \times \alpha \times \Delta\vartheta$ Measurements : 20 mm x ca. 1.8 mm (B x H) min. bending radius 150 mm

5. Initiation

5.1 Sensor head installation

When installing the sensor head use two M3 screws.
Tolerances for distance and angle must be observed (see picture 3).

Justified in parallel:
Center sensor = Center tape
0.0 +/- 0.5mm

B

C

A

A, B , C = 0° +/- 0.5°
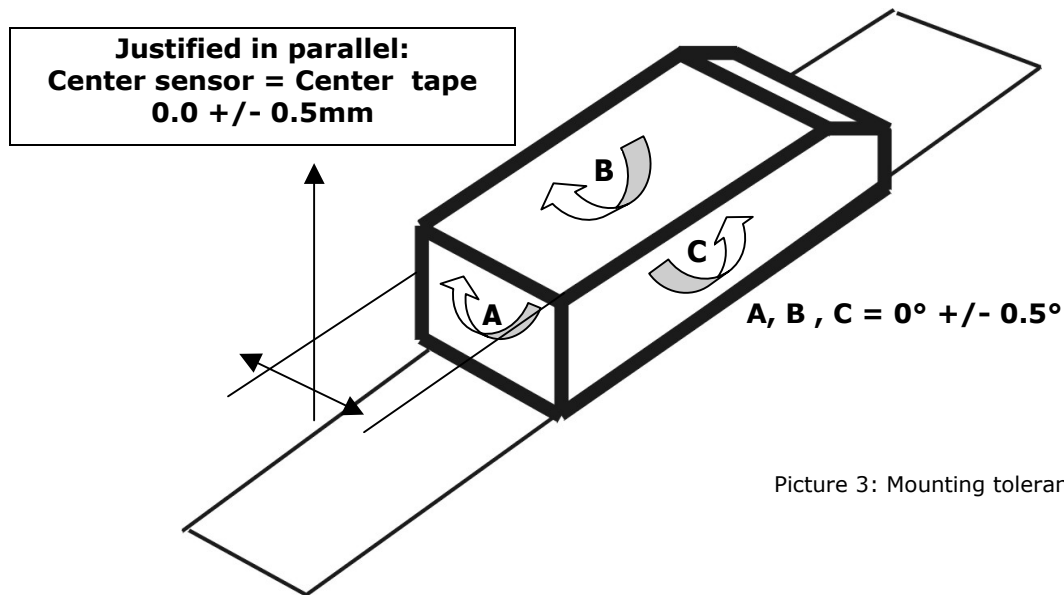
Picture 3: Mounting tolerances

Installation direction of the sensor to the magnetic tape:

The provided pole searcher film allows to determine the respective pole separations when lying on the tape. From that the following installation direction results:

| N | S | N | | | | S | N | S | N | N | S | N | Fine interpolation track |

None magnetic track

| S | S | N | | | | N | N | S | S | S | N | N | N | Absolute track |

Magnetic tape   EMAX sensor   cable output   Picture 4 Sensor/Band

Markers on tape and sensor are additionally indicators for the counting direction.
With FEMAX, the markers are placed on sensor and guide rail.

5.2 Connections

Signal cable	Function RS422	Option RS232	Option SSI	Option CAN open
white	0 V	0 V	0 V	0 V (GND)
brown	+ 24 V	+ 24 V	+ 24 V	+ 24 VDC
orange	TX -	TX	SSI / TX Data inv.	CAN low
yellow	TX	RX	SSI / TX Data	CAN high
violet	RX -	-	SSI / CLK Clock inv.	-
green	RX	-	SSI / CLK Clock	-
shielding	- ⏚	- ⏚	*reserved for tests*	-
white	-	-	*reserved for tests*	-
brown	PE* ⏚	PE* ⏚	PE* ⏚	PE* ⏚

*) Please connect the screen only to the machine side!

6. Interfaces

6.1 RS-422 Standard & RS232 (Option 232)

The measuring system EMAX is provided with an interface in the format RS422.
The data transmission has the following format:

**9600 Baud / 1 Start Bit / 8 Data Bits / 1 Stop Bit / No Parity**

Data protocol: The actual value is transferred in the following format with 9600 bit/s, 8 data bits, 1 stop bit and no parity bit:

```
02h STX
xxh ABS data  MSB
xxh ABS data
xxh ABS data  LSB
03h ETX
00h
0Dh
```

The measured absolute position is shown with 0.01 mm resolution binary in the 3 ABS data bytes. Between two transmissions of the actual value (seven bytes ever) is an intermission of approx. 4.8 ms duration.

| Standard	9600 baud, 8 data bits, 1 stop bit, no parity 7 bytes, 02 MSB MSB-1 LSB 03 00 0D binary position value STX ETX
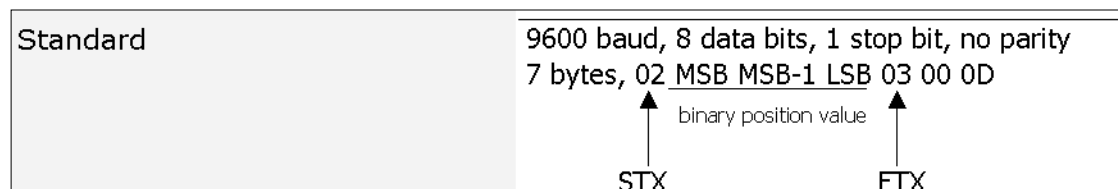
Other protocols on request.

RS422: Addressable variants are optionally available (see next pages).

6.2 RS-422 Addressable Version (Option A22)

Protocol an addressable EMAX Version 1.4

The device address can be adjusted by a BCD-switch which is located behind a protector film on the top of the sensor housing (range: 0B... 1A):
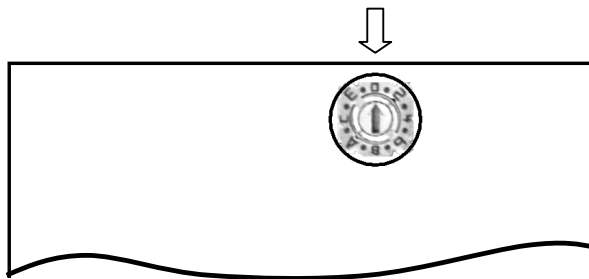
Position	Adress
0	0B
1	0C
2	0D
3	0E
4	0F
5	10
6	11
7	12
8	13
9	14
A	15
B	16
C	17
D	18
E	19
F	1A

```
Principle format of messages to EMAX:
0x02     Byte1     Byte2     Byte3        0x03
STX                          check        ETX
```

0x02 (STX) starts a message
0x03 (ETX) ends a message
Byte3 (check) is the arithmetic sum of **0x02** (STX), Byte1 and Byte2
ETX is **not** included in the checksum

```
 Principle format of messages from EMAX:
0x02     Byte1       Byte2     Byte3     Byte4
STX
```

```
Request for Position of EMAX with address i :
Message to EMAX
0x0     20x04   i   check     0x03
STX                 check     ETX
```

0x04 characterizes the message as position-request
i is the address of the requested EMAX (i = 0x0b… 0x7f)

```
Answer of requested EMAX
0x02    PosHigh      PosMid    PosLow    EMAX- Address
```

The positions-value consist of 3 Bytes:
PosLow (bit 0… bit 7), PosMid (bit 8… bit15) , PosHigh (bit16..bit23). Bit 0 has the value10 µm. Position-values are always lower than 0xffff00

Please note: The last Byte is no ETX like in all the other messages, but the EMAX-address.

Interrogation of the address of a EMAX:
Connect always only a single EMAX to be interrogated via RS422/RS232-converter to COM-Port of a PC.

```
Message to EMAX
0x02       0x05                0x05       0x0c       0x03
STX        Address request  check       ETX
```

```
Answer of EMAX
0x02     0xff     0xff   i                    0x03
STX                      EMAX Address         ETX
```

Note: Due to the combination 0xff 0xff does not appear in normal mode (sending of positions). It is a sign for a special message (in this case with 0x0b <= i <=0x7f it is the answer to the interrogation of the address).
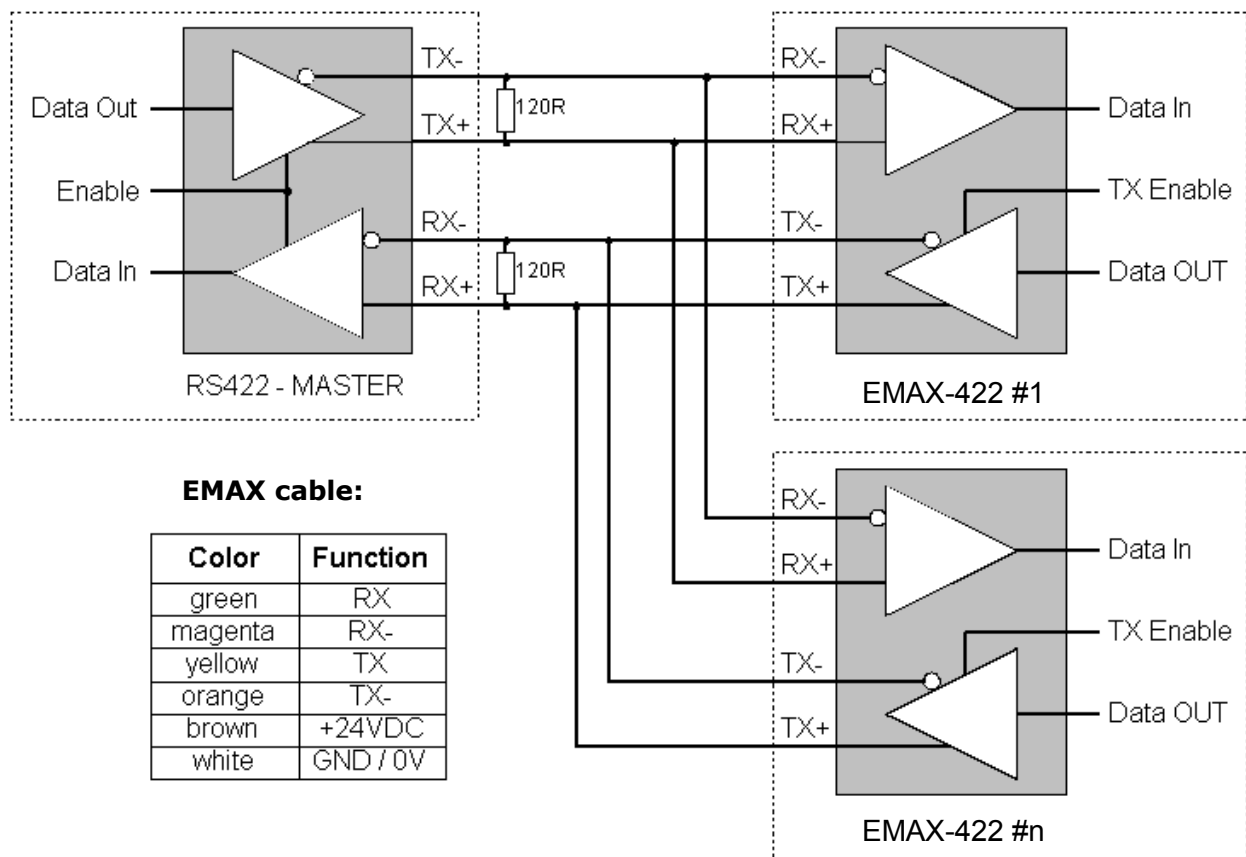

Negative answer: If one of the described operations failed for some reasons, EMAX gives a negative answer with a concerning Err-code.

```
EMAX answers
0x02          0xff          0xff          Err          0x03
STX           0xff          0xff          Error-Code    ETX
with Err = 0x04... 0x0a
```

Error-Code meanings of an addressable EMAX:

Code	Meaning
0x04	**Wrong succession of bytes** sent to EMAX, for example if 4. Byte after STX is no ETX or the Byte after STX is not 0x04, 0x05 or 0x06.
0x05	**Receive Error:** Error concerning the interface (for example if there has been sent a message with a wrong baud rate etc.)
0x06	**Invalid EMAX-address** – appears after trying to assign an address smaller 0x0b or bigger 0x7f to EMAX
0x07	**EMAX has forgotten its address -** check of internal redundant stored address of EMAX failed, this error-message is sent at power up immediately if an error in reading EEPROM is detected or if the internal redundant stored address does not fit.
0x08	**Internal store error** of address in EEPROM.
0x09	**Error in calculation of position** (No tape, tape damaged or to big distance)
0x0a	**Check-Sum-Error** - Check-Sum of a message sent to EMAX is wrong

6.2.1 Connection to a RS422 Master:

EMAX cable:

| Color	Function
green	RX
magenta	RX-
yellow	TX
orange	TX-
brown	+24VDC
white	GND / 0V

6.3 SSI - (Option SSI)

Principle of the function:
If the clock is not interrupted for the time **Tm-T/2** (output of further 25 periods), the shift register clocks once again the same data value (error recognition in evaluation).

Some encoders contains a Power Failure Bit (PFB):

> **With EMAX the PFB is always LOW!**

Read out of the datas (2 times with 25 clocks):

PFB = Power Failure Bit
T = time of the period
Tm = Monoflop time > 15 us
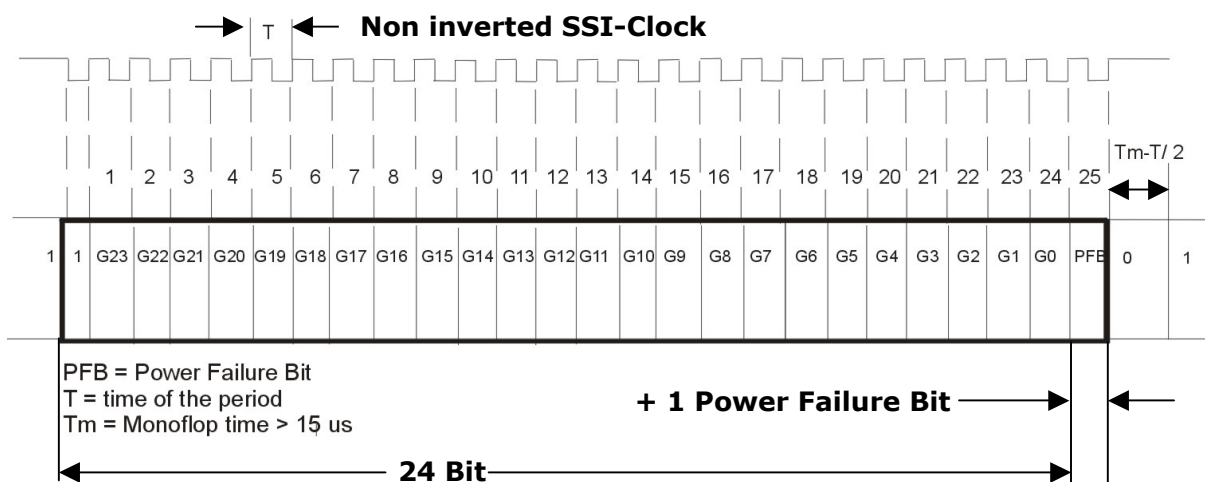
By using the BCD-switch which is located behind a protector film on the top of the sensor, the data format of the SSI interface can be changed over from Binary to Gray-Code.

Position	Adress
F	Binary
0	Gray
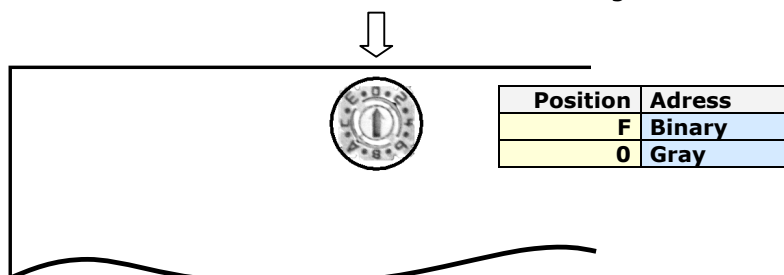
6.4 CANopen - (Option CAO)

Interface and protocol:
As standard the EMAX linear encoder is equipped with a CANopen standard interface.
The following identifier is given:
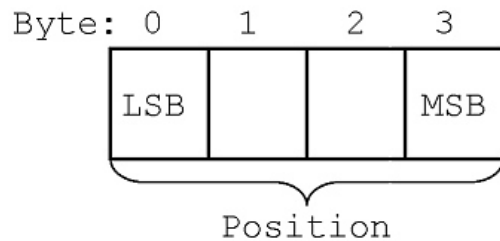
```
CAN - Identifier
(4 Byte telegram)
180 (16)  = Identifier
First 4 Bytes = position in mm (resolution 0.01 mm),
Next 2 Bytes = speed in mm/s
Bit rate 250 KB/s
```
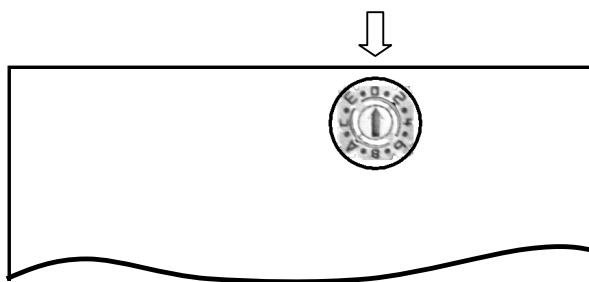

The CAN-Identifier can be adjusted by a BCD-switch which is located behind a protector film on the top of the sensor housing.
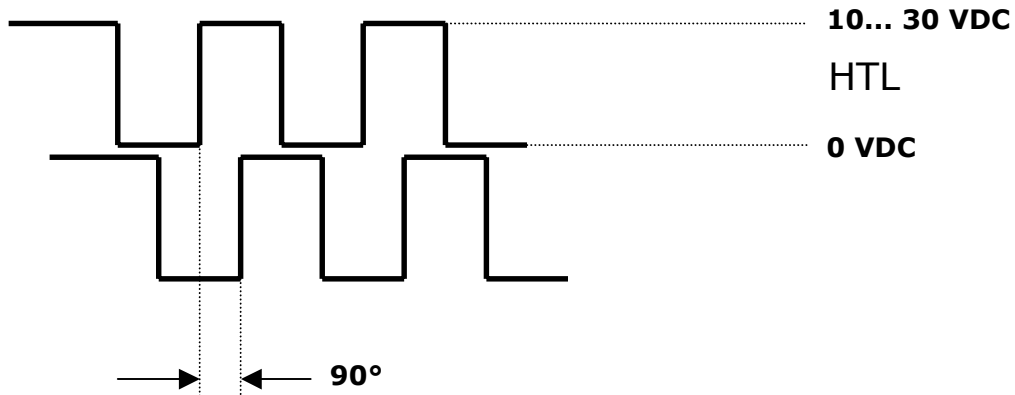Adjustable range: 1A0 (16) up to 1B5 (16)

Position	CAN Identifier
0	1fe
1	181
2	182
3	183
4	184
5	185
6	186
7	187
8	-
9	-
A	-
B	-
C	-
D	-
E	-
F	-

6.5 A/B – Incremental output (Option I)

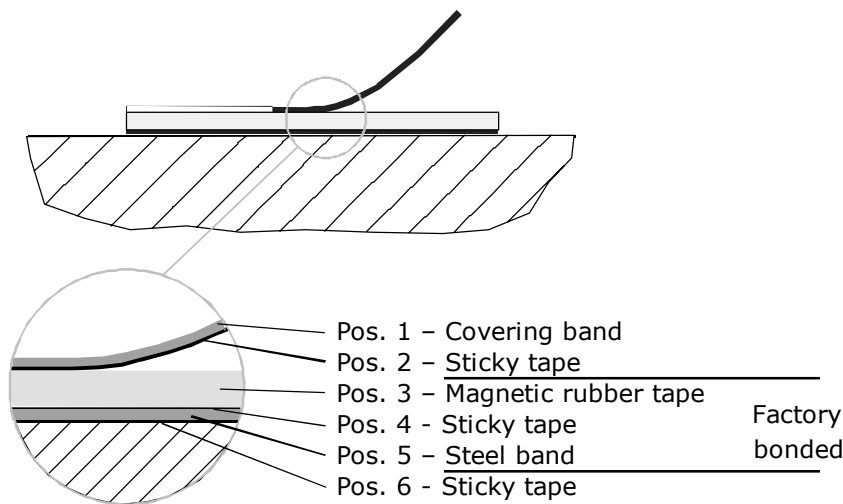Optionally two 90° phase shifted square wave channels are available (HTL – push/pull).

The EMAX resolution (at 4 edge triggering) amounts to $\dfrac{5\ \text{mm}}{4096} = 1.22\ \mu\text{m}$

10... 30 VDC

HTL

0 VDC

90°

7. Magnetic tape

The magnetic tape consists of 3 components (see picture 5)
- a magnetized flexible rubber tape (pos. 3), which is connected factory made with a
- steel band (pos. 5) and a
- covering band (pos. 1) , which is intended for the protection of the rubber tape.
- For mechanical protection of the magnetic tape the covering band must be stuck on. Additionally it protects the magnetic tape from extreme external magnetic influences.
  To reach a complete adhesion between the several materials a special sticky tape is
  used (pos. 2, pos. 4, pos. 6).

Pos. 1 – Covering band
Pos. 2 – Sticky tape
Pos. 3 – Magnetic rubber tape
Pos. 4 - Sticky tape   Factory
Pos. 5 – Steel band   bonded
Pos. 6 - Sticky tape

Picture 5: Components of the magnetic tape

7.1.1 Handling

To avoid tension in the magnetic tape, don't tuck or twist it. Avoid also to store or to handle it with the magnetic rubber tape to the inside (min. bend radius 150 mm).

Magnetized
synthetic tape

Steel band
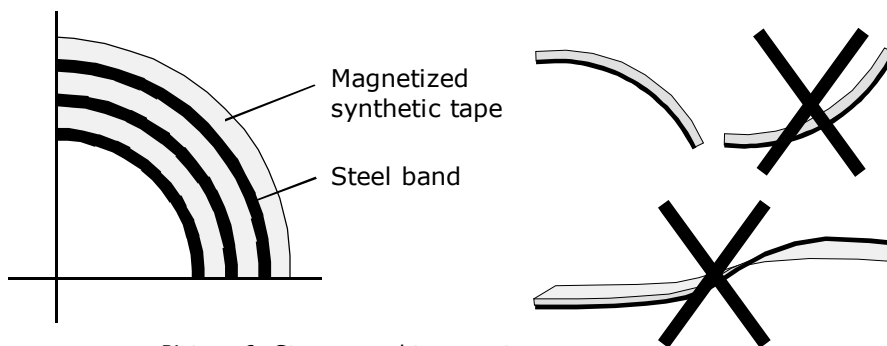
Picture 6: Storage and transport

7.1.2 Processing note for sticking

The provided sticky tapes stick well on clean, dry and plain surfaces. The more pollution exists the more proper the surface has to be. A surface roughness of $R_a <= 3,2$ ($R_z <= 25 / N8$) is recommendable. Typical solvent for cleaning surfaces are a 50/50 - isopropyl-alcohol / water mixture or heptane. The surfaces of materials as copper, brass etc. should be sealed to avoid an oxidation. The stability of the adhesion is directly depending on the contact, which the adhesive develops to the stuck surfaces. A high pressure results in a good surface contact.

The optimal sticking temperature is between + 21°C and 38°C.

Avoid colder sticking surfaces than + 10 °C, because in this case the adhesive becomes to hard and perhaps a sufficient immediate adhesion is hardly to achieve. After proper sticking the stability of the connection is ensured also when the temperature is below zero. The final tackiness of a sticking is from experience reached after approximately 72 hours (at + 21 °C). For sticking use only the provided sticky tape.

7.1.3 Resistance to chemicals of the magnetic tape

The magnetic tape shows no or only small effects when contacting permanently the following materials after 2 to 5 years: formic acid, glycerol 93°C, linseed oil, soy beans oil, cotton seed oil, N-hexane, lactic acid, formaldehyde 40%, isooctane, petroleum.
Poor to medium effects result when contacting permanently the following materials after approximately 1 year: acetone, gasoline, acetic acid 30%, olein acid, acetylene, steam, acetic acid, pure acetic acid, sea water, ammonia, acetic acid 20%, isopropyl ether, stearic acid 70°C anhydrous, kerosene.
Strong effects result when contacting permanently the following materials after 1 to 5 months: benzene, nitric acid 70%, turpentine, toluene, lacquer solvent, nitric acid red and vitriolic, carbon tetrachloride, trichloroethane, nitrobenzene, hydrochloric acid 37% and 93°C, tetrahydrofuran, xylene.

7.1.4 Sticking and cutting

Attention!

When sticking the magnetic tape pay attention to the marks on the magnetic tape and on the sensor head. A faulty installation delivers incorrect values. An already stuck magnetic tape is ruined after removing and can't be used again. Observe also the counting direction of the measuring system.

The magnetic tape and the covering band must be cut to the exact length before sticking:
Magnetic tape length = measuring length + 0.15 m
Preferably the magnetic tape should be stuck into a nut or aligned to an edge.
Procedure for sticking: The magnetic tape is already factory bonded with the steel band, in between is a double sided sticky tape. Stick the provided sticky tape onto the carrier side
(= steel band). Now adjust the magnetic tape and stick it onto the surface. The best way to stick the magnetic tape is to do it in two steps. Remove the first half of the adhesive film from the sticky tape and stick it, then do the rest length.
Then stick the sticky tape onto the covering band. It is not important on which side of the covering band the sticky tape is stuck on. Stick the covering band onto the visible brown magnetic rubber tape.

8. Offset

After installation of magnetic tape and measuring system (sensor head), a value is transferred by the interface. Because these value does not agree with the machine zero point, an offset should to be deposited at the controller side.

> **Please note:**
> **An Offset is necessary in each case of a replacement**
> **of the EMAX encoder (sensor head) or magnetic tape.**

9. Fault clearance

> The shielding of the signal cable should be connected only on one side with the further connected unit (e.g. PC or PLC). The signal output cable must principally be wired separately from heavy duty current wires and keep a distance of at least 0.5 m to inductive and capacitive interference sources as contactors, relays, engines, switch power packs, clocked controllers, etc.

If there arise interferences in spite of observing all above described points,
proceed as follows:

- Add RC elements over contactor reels of AC contactors (e.g. 0.1 µF / 100 Ω).

- Add recovery diodes over DC inductances.

- Add RC elements over each engine phase and over the engine brake
  (in the terminal box of the engine).

- Do not connect PE (potential earth) to GND (Ground)

10. Dimensions of EMAX

BCD switch
behind the protector film

24

3,4
4,8

26
22
14,3
4

4

71
75
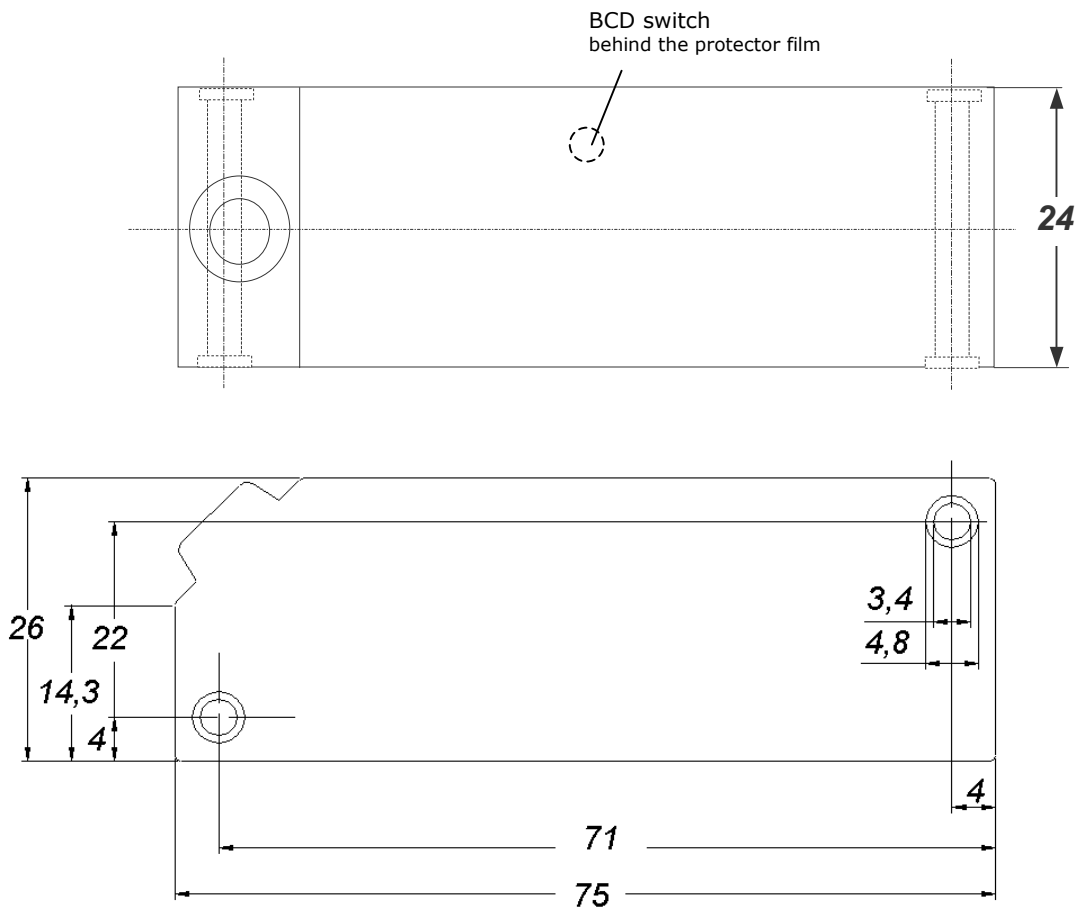
10.2 Dimensions of FEMAX with guide-rail
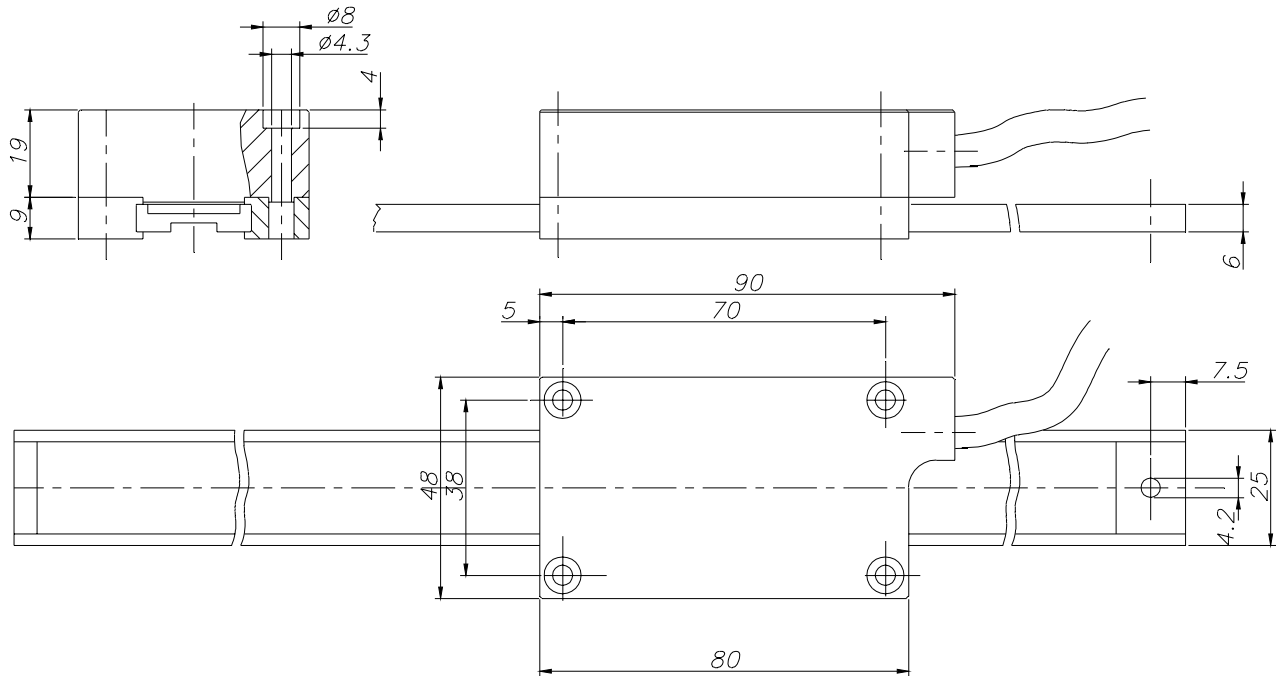
11. Type designation

Sensor head

$$\boxed{(\text{F})\text{EMAX} - \text{XXX} - \text{XX.X} - \text{X} - \text{XXX} - \text{X} - \text{X}}$$

Type
EMAX (unguided) / **FEMAX** (guided)

Version
000 = standard
001 = 1. special version

Signal cable length
01,5 = 1,5 m (standard)
deviating lengths on request

Resolution
2

Interface
422 = Standard - RS-422
A22 = *Optional - addressable RS-422*
232 = *Optional - RS-232*
SSI = *Optional - SSI*
CAO = *Optional - CANopen standard*

Baud rate (RS 232 and RS422)	
0 = 9600 Baud	**standard**
1 = 19200 Baud	optional (on request)
2 = 34800 Baud	optional (on request)
Bitrate (CAN open)	
0 = 10 KBit/s	optional (on request)
1 = 20 KBit/s	optional (on request)
2 = 50 KBit/s	optional (on request)
3 = 125 KBit/s	optional (on request)
4 = 250 KBit/s	**standard**
5 = 500 KBit/s	optional (on request)
6 = 800 KBit/s	optional (on request)
7 = 1 MBit/s	optional (on request)
Number of Bits (SSI)	
0 = 25 bit	**standard**
1 = 32 bit	optional (on request)

Further options
V = sealed version IP67
I = additional incremental output **A/B**

Accessories:

EMAX and FEMAX → Magnetic tape AB20-50-20-2-R-11:
Pleas order the tape in the desired length, The cover band is included in the delivery.

Attention! Magnetic Tape Length = effective Measuring Length + 0.15 m
Example for 1 m of measuring length: *AB20-50-20-2-R-11 / 1.15 m*

FEMAX-Rail → FS-1000 (1 m) / FS1500 (1,5 m) / FS-2000 (2 m):
In case of ordering length's > 2 m, please assemble the rail pieces corresponding to the desired measuring length (up to 8 m) an indicate it with the order. The complete magnetic tape (whole length) will be stick into the arranged rails then.

12. Liability exclusion / Guarantee

We have checked the contents of this instruction manual carefully, to the best of our knowledge and belief for conformity with the described hardware and software. Nevertheless errors, mistakes or deviations can not be excluded, therefore we do not guarantee complete conformity. Necessary corrections will be included in the subsequent editions. We appreciate your ideas and improvement suggestions very much.

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The guarantee period is one calendar year from the date of delivery and includes the delivered unit with all components. ELGO Electric GmbH will at its option replace or repair without charge defects at the unit or the included parts, verifiable caused by faulty manufacturing and/or material in spite of proper handling and compliance to the instruction manual.

Damages verifiably not caused by ELGO Electric GmbH and due to improper handling are excluded from any guarantee e.g. by applying faulty voltage, diffusion of liquid into the interior of the engine, using force, scratching the surface, chemical influences etc.!