

## SMRIL bearingless encoder + MRI ring



- Magnetic modular encoder with incremental output
- Suitable for rings with non-integer pole pitch size
- To be paired with MRI/... magnetic rings
- IP67 protection rate (standard); IP69K on request
- Cable and M12 connector output

#### Suitable for the following models:

- SMRIL... + MRI/...

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The logo for Lika Electronic s.r.l. consists of the word "lika" in a bold, lowercase, sans-serif font. The letter 'i' has a dot, and the 'a' has a tail that extends to the right.

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# Typographic and iconographic conventions

In this guide, to make it easier to understand and read the text the following typographic and iconographic conventions are used:

- parameters are coloured in **GREEN**;
- alarms are coloured in **RED**;
- states are coloured in **FUCSIA**.

When scrolling through the text some icons can be found on the side of the page: they are expressly designed to highlight the parts of the text which are of great interest and significance for the user. Sometimes they are used to warn against dangers or potential sources of danger arising from the use of the device. You are advised to follow strictly the instructions given in this guide in order to guarantee the safety of the user and ensure the performance of the device. In this guide the following symbols are used:

	This icon, followed by the word <b>WARNING</b> , is meant to highlight the parts of the text where information of great significance for the user can be found: user must pay the greatest attention to them! Instructions must be followed strictly in order to guarantee the safety of the user and a correct use of the device. Failure to heed a warning or comply with instructions could lead to personal injury and/or damage to the unit or other equipment.
	This icon, followed by the word <b>NOTE</b> , is meant to highlight the parts of the text where important notes needful for a correct and reliable use of the device can be found. User must pay attention to them! Failure to comply with instructions could cause the equipment to be set wrongly: hence a faulty and improper working of the device could be the consequence.
	This icon is meant to highlight the parts of the text where suggestions useful for making it easier to set the device and optimize performance and reliability can be found. Sometimes this symbol is followed by the word <b>EXAMPLE</b> when instructions for setting parameters are accompanied by examples to clarify the explanation.

# Preliminary information

This guide is designed to provide the most complete and exhaustive information the operator needs to correctly and safely install and operate the **SMRIL incremental magnetic modular encoder + MRI magnetic ring**.

SMRIL modular encoder is designed to measure linear or angular displacements on industrial machines and automation systems. The measurement system includes a magnetic ring, conversion electronics and a magnetic sensor. It is designed to read pole pitches whose size is not an integer value. For example: the pole pitch of the MRI/102-128-3-75 ring is about 2.5 mm wide; the pole pitch of the MRI/203-180-3-190 ring is about 3.5 mm wide.

The readhead must be paired with the appropriate magnetic ring; see also the "3.2 Sensor and ring combination" section on page 10.

The ring has alternating magnetic north/south poles that are magnetized at a fixed distance called the pole pitch (see Figure 10). The conversion electronics inside the sensor translates the magnetic fields of the ring into electrical signals equivalent to those of an incremental encoder or a linear scale.

The measuring system can include specific sensor and ring with additional magnetic track for the transmission of a Reference signal.

Please note that:

- encoders having order code SMRIL-xx-x-xxx-**R**-... are equipped with Reference sensor;
- rings having order code MRI/xxx**Z**-... have the Reference track;
- encoders having order code SMRIL-xx-x-xxx-**N**-... are not equipped with Reference sensor;
- rings having order code MRI/xxx-... have not the Reference track.

# 1 Safety summary



## 1.1 Safety

- Always adhere to the professional safety and accident prevention regulations applicable to your country during device installation and operation;
- installation and maintenance operations have to be carried out by qualified personnel only, with power supply disconnected and stationary mechanical parts;
- device must be used only for the purpose appropriate to its design: use for purposes other than those for which it has been designed could result in serious personal and/or the environment damage;
- high current, voltage and moving mechanical parts can cause serious or fatal injury;
- warning ! Do not use in explosive or flammable areas;
- failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the equipment;
- Lika Electronic assumes no liability for the customer's failure to comply with these requirements.



## 1.2 Electrical safety

- Turn OFF the power supply before connecting the device;
- connect according to the explanation in the "Electrical connection" section on page 18;
- the wires of unused output signals must be cut at different lengths and insulated singularly;
- in compliance with 2014/30/EU norm on electromagnetic compatibility, the following precautions must be taken:
  - before handling and installing the equipment, discharge electrical charge from your body and tools which may come in touch with the device;
  - power supply must be stabilized without noise; install EMC filters on device power supply if needed;
  - always use shielded cables (twisted pair cables whenever possible);
  - avoid cables runs longer than necessary;
  - avoid running the signal cable near high voltage power cables;
  - mount the device as far as possible from any capacitive or inductive noise source; shield the device from noise source if needed;
  - to guarantee a correct working of the device, avoid using strong magnets on or near by the unit;



- minimize noise by connecting the cable shield (or the connector housing) and the frame to ground. Make sure that ground is not affected by noise. The connection point to ground can be situated both on the device side and on user's side. The best solution to minimize the interference must be carried out by the user;
- do not stretch the cable; do not pull or carry by cable; do not use the cable as a handle.



### 1.3 Mechanical safety

- Install the device following strictly the information in the "Mechanical installation" section on page 9;
- mechanical installation must be carried out with stationary mechanical parts;
- do not disassemble the unit;
- do not tool the unit;
- delicate electronic equipment: handle with care; do not subject the device to knocks or shocks;
- protect the unit against acid solutions or chemicals that may damage it;
- respect the environmental characteristics of the product;
- we suggest installing the unit providing protection means against waste, especially swarf as turnings, chips, or fillings; should this not be possible, please make sure that adequate cleaning measures (as for instance jets of compressed air) are in place in order to prevent the sensor and the magnetic ring from jamming.



#### CAUTION

Keep magnets away from the ring, it could be damaged by strong magnetic fields.

## 2 Identification

Device can be identified through the **order code** and the **serial number** printed on the label applied to its enclosure. Information is listed in the delivery document too. Please always quote the order code and the serial number when reaching Lika Electronic for purchasing spare parts or needing assistance. For any information on the technical characteristics of the product refer to the technical catalogue.



**Warning:** encoders having order code ending with "/Sxxx" may have mechanical and electrical characteristics different from standard and be supplied with additional documentation for special connections (Technical Info).



### 3 Mechanical installation



**WARNING**

Installation must be carried out by qualified personnel only, with power supply disconnected and mechanical parts compulsorily in stop.

**3.1 Overall dimensions**

(values are expressed in mm)

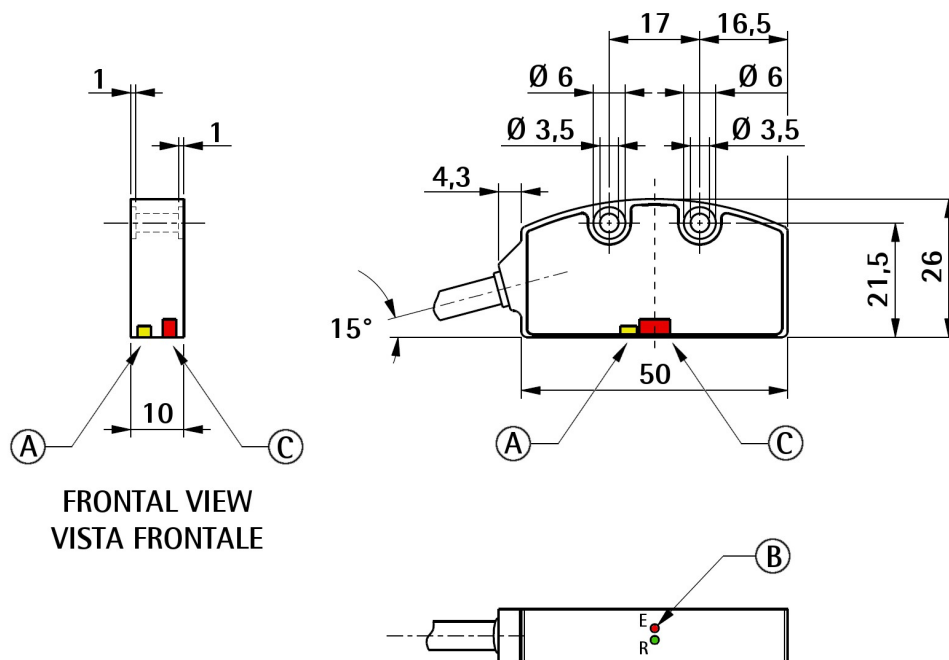


Figure 1 - Encumbrance sizes

A	Reference sensor (page 24)	B	Diagnostic LEDs (page 24)
C	Incremental sensor		

### 3.2 Sensor and ring combination

The sensor has to be compulsorily paired with its specific type of magnetic ring as indicated in order code of the bearingless encoder and in the table below.

Sensor	MRI ring
SMRIL-...-E...	MRI/72-...
SMRIL-...-G...	MRI/102-...
SMRIL-...-P...	MRI/203-...

### 3.3 Mounting instructions

Protect the device against knocks, frictions, solvents as well as under and over temperatures. Please never stretch the cable. Do not pull or carry by cable. Do not use the cable as a handle. We suggest installing the unit providing protection means against waste, especially swarf as turnings, chips, or filings; should this not be possible, please make sure that adequate cleaning measures (as for instance jets of compressed air) are in place in order to prevent the sensor and the magnetic ring from jamming.

SMRIL encoder must be compulsorily paired with the suitable ring as stated in the previous section.

Make sure that the mechanical installation always complies with the system requirements for distance, planarity and parallelism between the readhead and the ring indicated in Figure 7, Figure 8 and Figure 9. Avoid any contact between the readhead and the ring.

If the Reference "R" signals are not provided (encoders having order code SMRIL-xx-x-xxx-**N**-... and rings having order code MRI/xxx-...) the readhead can be mounted over the ring as desired (both directions are allowed). If required, please only be careful that the sensor is properly aligned on the correct side of the ring (see Figure 8).

If the Reference "R" signals are provided (encoders having order code SMRIL-xx-x-xxx-**R**-... and rings having order code MRI/xxx**Z**-...) the readhead and the ring must be compulsorily installed as shown in Figure 7. For further information please refer to the "3.5 Mounting the sensor" section on page 14.

The arrow in Figure 7 indicates the **standard counting direction** (the rising edge of A signal leads the rising edge of B signal) when the ring turns in the direction indicated by the arrow; further information in the "4.7 Counting direction" section on page 23.

### 3.4 Mounting the magnetic ring

Several types of MRI magnetic rings featuring different mechanical characteristics and mounting options are available. The rings can be fixed to the motor shaft by means of grub screws (Figure 2) or screws (Figure 3). For technical features and dimensions of the rings please see below or refer to the product datasheet.

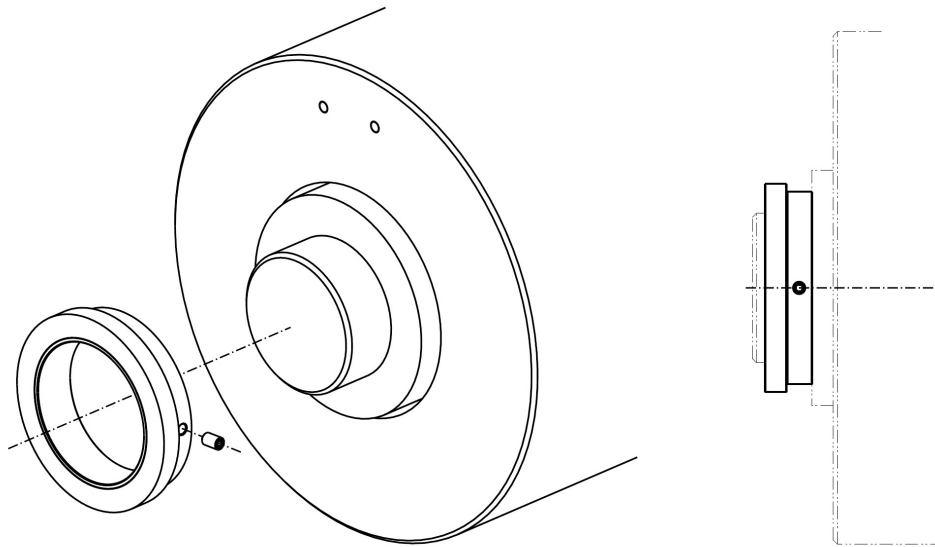


Figure 2 - Mounting MRI rings with grub screws

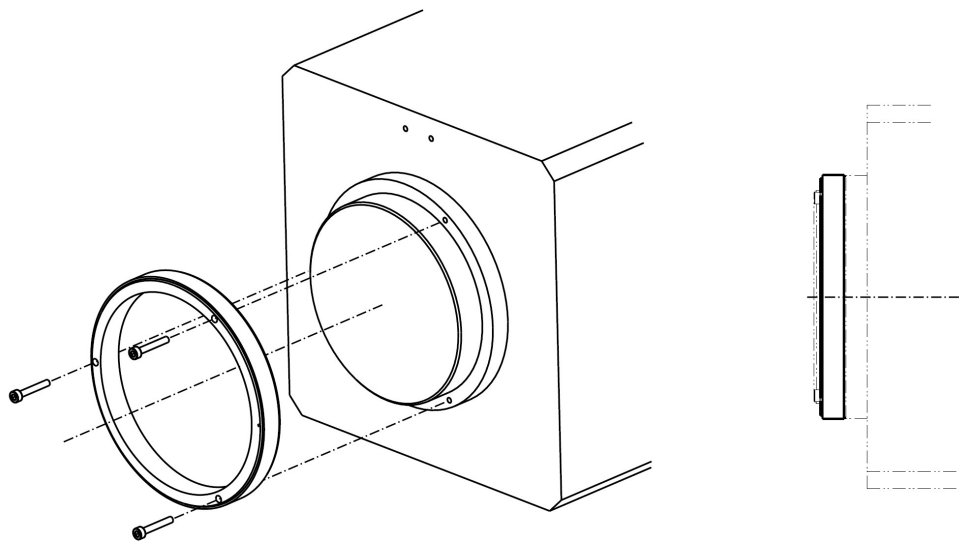


Figure 3 - Mounting MRI rings with screws

The mark punched in the frame of the ring (see Figure 7) shows the side where the Reference track is coded. It further indicates the point when the Reference signal is transmitted. Please note that the punch mark may be provided also in the rings that do not have the Reference track.



**CAUTION**

Keep magnets away from the ring, it could be damaged by strong magnetic fields.

**3.4.1 MRI/72 ring**

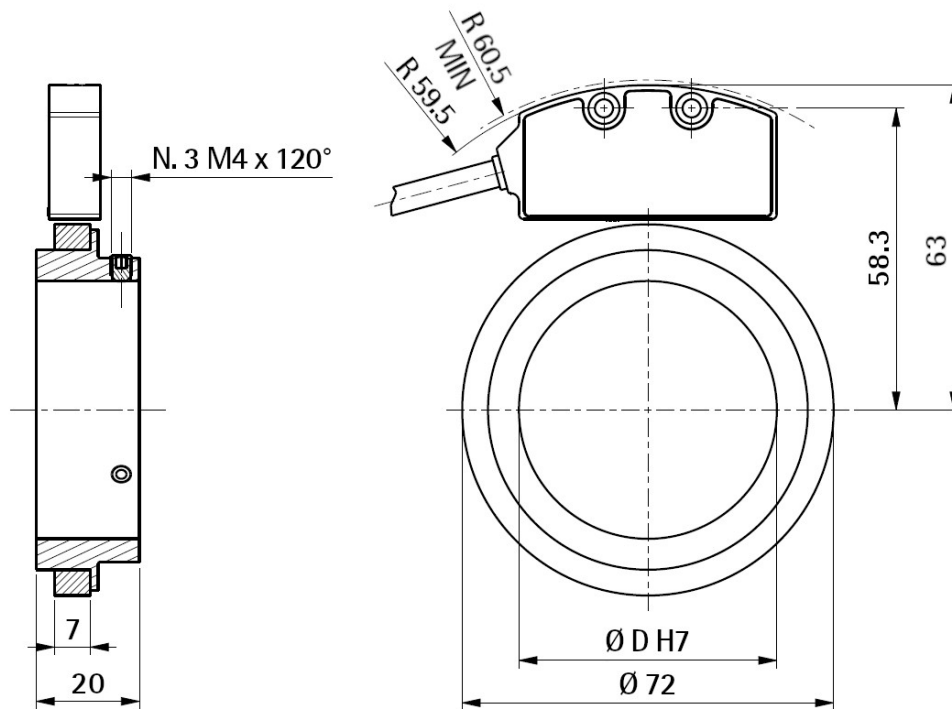


Figure 4 - MRI/72 ring technical features

3.4.2 MRI/102 ring

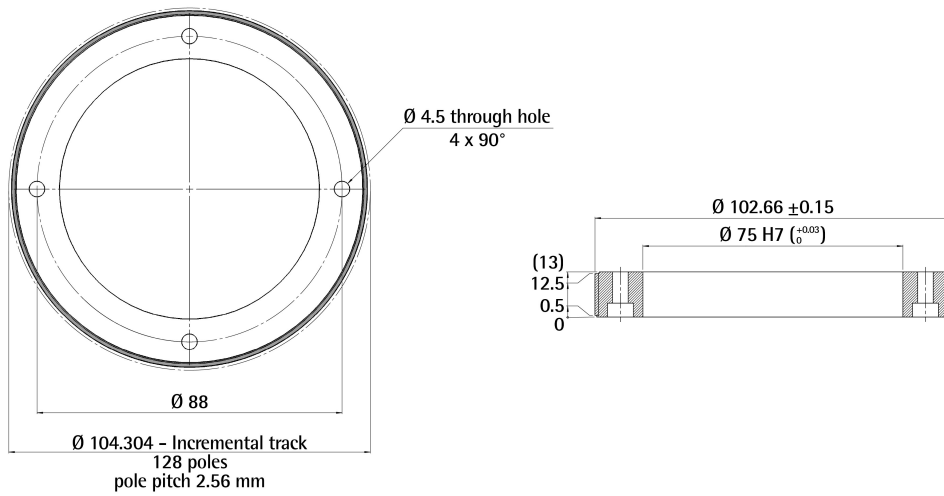


Figure 5 - MRI/102 ring technical features

3.4.3 MRI/203 ring

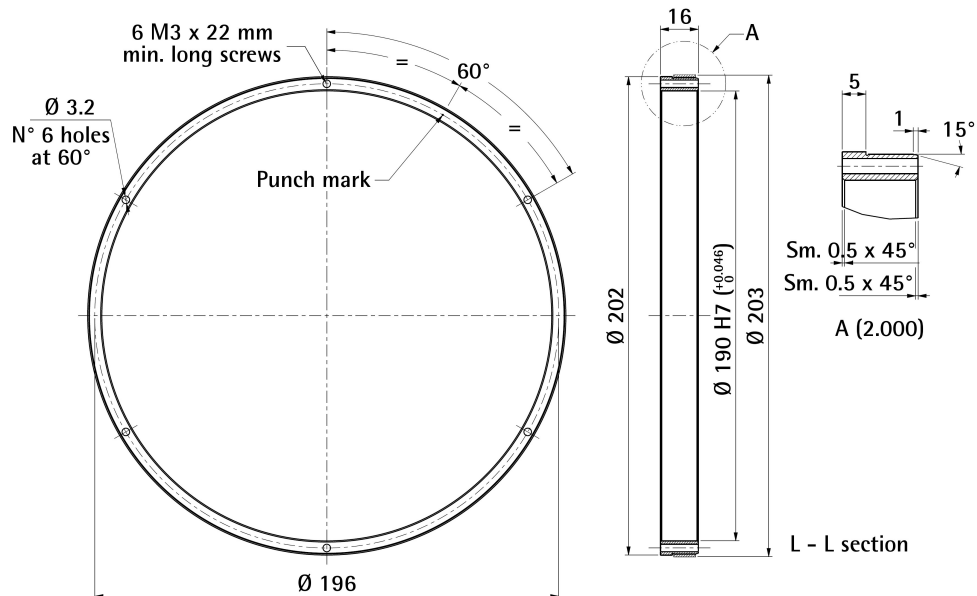
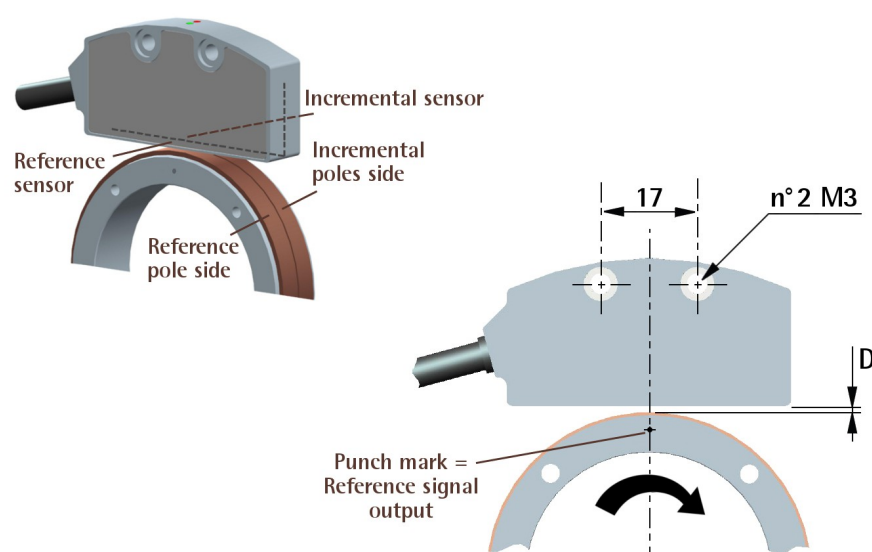


Figure 6 - MRI/203 ring technical features

**CAUTION**

Keep magnets away from the ring, it could be damaged by strong magnetic fields.

**3.5 Mounting the sensor**

**Figure 7 - Mounting the encoder / ring**

Make sure that the mechanical installation complies with the system requirements concerning distance, planarity and parallelism between the sensor and the ring as indicated in the "3.6 Mounting tolerances" section on page 16. Avoid any contact between the readhead and the ring.

Fix the sensor by means of **two M3 15 mm / 0.6" min. long cylinder head screws** inserted in the provided holes.

The recommended tightening torque is **1.1 Nm**.

The recommended **minimum bend radius** of the cable is:  **$R \geq 42$  mm**.

Install the sensor and the magnetic ring as shown in the Figure. As previously stated, the arrow is intended to indicate the standard counting direction (the rising edge of A signal leads the rising edge of B signal).

The distance D (see Figure 7) between the bottom of the readhead and the MRI magnetic ring must be as follows:

Sensor	Distance D between sensor / ring	
	without Reference	with Reference
SMRIL + MRI/72	0.1 mm ÷ 1.5 mm 0.004" ÷ 0.059"	-
SMRIL + MRI/102	0.1 mm ÷ 1.0 mm 0.004" ÷ 0.039"	0.1 mm ÷ 0.7 mm 0.004" ÷ 0.027"
SMRIL + MRI/203	0.1 mm ÷ 1.5 mm 0.004" ÷ 0.059"	0.1 mm ÷ 1.0 mm 0.004" ÷ 0.039"

For better operation we suggest the following distance D:

Sensor	Recommended distance D between sensor and ring
SMRIL + MRI/72	1.0 mm / 0.039"
SMRIL + MRI/102	0.5 mm / 0.019"
SMRIL + MRI/203	0.7 mm / 0.027"



**WARNING**

When the "R" Reference signal is available (encoders having order code SMRIL-xx-x-xxx-R-... and rings having order code MRI/xxxZ-...) please pay attention to the mounting side of the magnetic ring: there is the incremental track on one side and the Reference track on the other side. The mark punched in the frame of the ring shows the side where the Reference track is coded. It further indicates the point when the Reference signal is transmitted. See Figure 7.



**WARNING**

When the sensor is installed on magnetic rings having a 10 mm / 0.4" wide magnetic surface, line up both the sensor and the ring on the central axis; as previously stated, if the Reference track is provided pay attention to the mounting direction of the sensor and the ring.  
When magnetic rings having a 5-7 mm / 0.197"-0.275" wide magnetic surface are used, line up the sensor and the ring as shown in Figure 8; please consider

that the incremental sensor is located laterally in the sensing head (see Figure 1). With 5-7 mm / 0.197"-0.275" rings the mounting direction of the ring makes no difference (but be sure that the sensor is properly aligned on the correct side!).

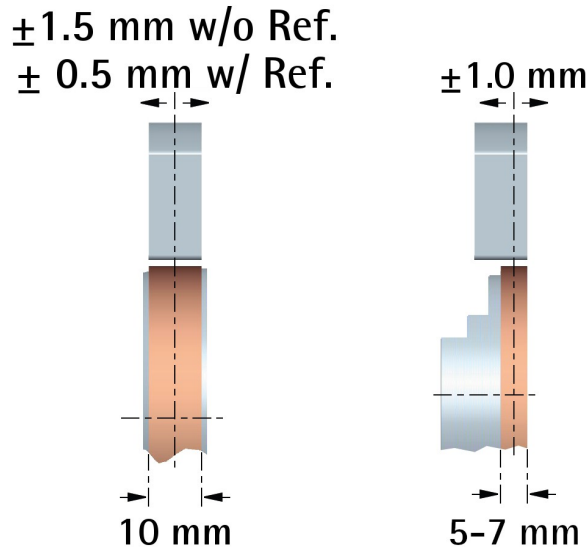


Figure 8 - Alignment of the readhead / ring

### 3.6 Mounting tolerances

Always comply with the mounting tolerances indicated in Figure 7, Figure 8 and Figure 9. Make sure that the mechanical installation complies with the system requirements concerning distance, planarity and parallelism between the sensor and the ring.

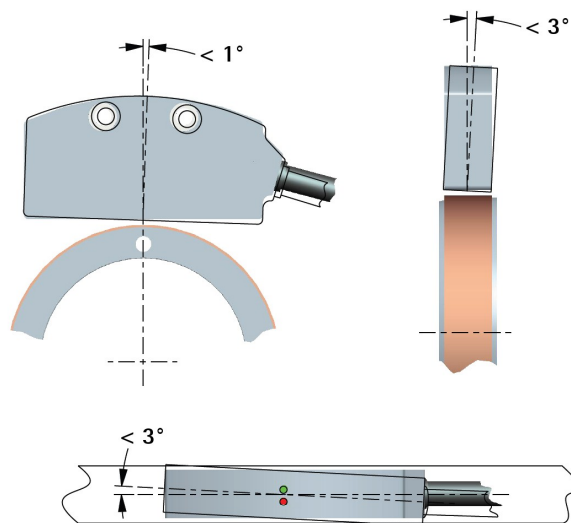


Figure 9 - Mounting tolerances of the readhead / ring



### 3.7 Standard counting direction

The positive counting direction (the rising edge of A signal leads the rising edge of B signal) is achieved when the ring turns according to the arrow shown in Figure 7. For further information see the "4.7 Counting direction" section on page 23.

## 4 Electrical connection



**WARNING**

Electrical connection must be carried out by qualified personnel only, with power supply disconnected and mechanical parts compulsorily in stop.



**WARNING**

If wires of unused signals come in contact, irreparable damage could be caused to the device. Thus they must be cut at different lengths and insulated singularly.

### 4.1 Cable and connector connections

Function	M8 cable	M12 8-pin
0Vdc	Black	1
+Vdc <sup>1</sup>	Red	2
A	Yellow	3
/A	Blue	4
B	Green	5
/B	Orange	6
0 <sup>2</sup>	White	7
/0 <sup>2</sup>	Grey	8
Shield	Shield	Case

1 See the order code for power supply voltage level



**EXAMPLE**

SMRIL-L-1-... +Vdc = +5Vdc ± 5%

SMRIL-YC-2-... +Vdc = +10Vdc +30Vdc

2 Reference signals (see the "4.8 Reference "R"" section on page 24) are only available with encoders having order code SMRIL-xx-x-xxx-**R**-... and rings having order code MRI/xxx**Z**-... . With encoders having order code SMRIL-xx-x-xxx-**N**-... and rings having order code MRI/xxx-... the signals are not provided.



**NOTE**

All sensors can provide inverted signals.

A = A signal;

/A = inverted A signal (or complementary signal).

You are advised to always connect the inverted signals if the receiving device will accept them. Otherwise each output should be insulated singularly.

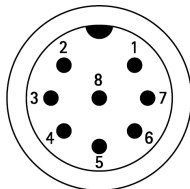
**4.2 M8 cable specifications**

Model:	LIKA HI-FLEX sensor cable type M8
Cross section:	2 x 0.22 mm <sup>2</sup> + 6 x 0.14 mm <sup>2</sup> (24/26 AWG)
Jacket:	Matt Polyurethane (TPU) halogen free, oil, hydrolysis, abrasion resistant
Shield:	Tinned copper braid, coverage > 85%
Outer diameter:	5.3 ÷ 5.6 mm (0.209" ÷ 0.220")
Min. bending radius:	outer diameter x 7.5
Work temperature:	dynamic -40°C +90°C (-40°F +194°F) / fixed -50°C +90°C (-58°F +194°F)
Conductor resistance:	<90 Ω/Km (0.22 mm <sup>2</sup> ), <148 Ω/Km (0.14 mm <sup>2</sup> )

The total length of the cable that connects the sensor and the receiving device should not exceed the values stated in the "Cable lengths" section of the rotary encoders' catalogue; they are specific for each type of output circuit. If you need to reach greater distances please contact Lika Electronic Technical Dept.

Do not bend the cable excessively; the **min. bending radius is Ø x 7.5** at a minimum distance of 10 mm from the sensor head.

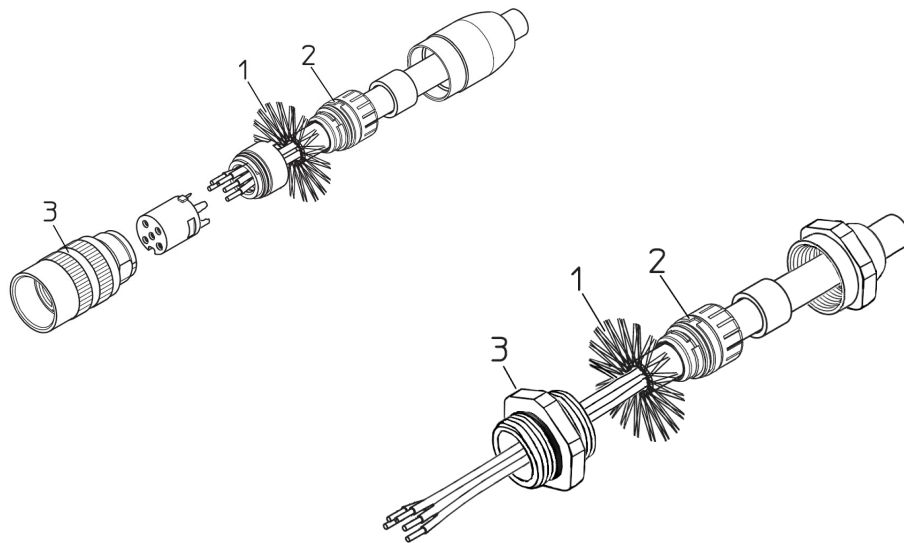
**4.3 M12 8-pin connector specifications**



Male  
Frontal side  
A coding

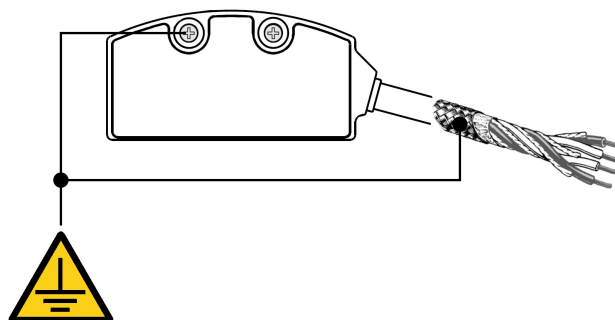
#### 4.4 Connection of the shield

For signals transmission always use shielded cables. The cable shielding must be connected properly to the metal ring nut **3** of the connector in order to ensure a good earthing through the frame of the device. To do this disentangle and shorten the shielding **1** and then bend it over the part **2**; finally place the ring nut **3** of the connector. Be sure that the shielding **1** is in tight contact with the ring nut **3**.



#### 4.5 Ground connection

Minimize noise by connecting the cable shield (or the connector housing) and the sensor to ground. Make sure that ground is not affected by noise. The connection point to ground can be situated both on the device side and on the user's side. The best solution to minimize the interference must be carried out by the user. You are advised to provide the ground connection as close as possible to the encoder.



4.6 ABO, /ABO output channels

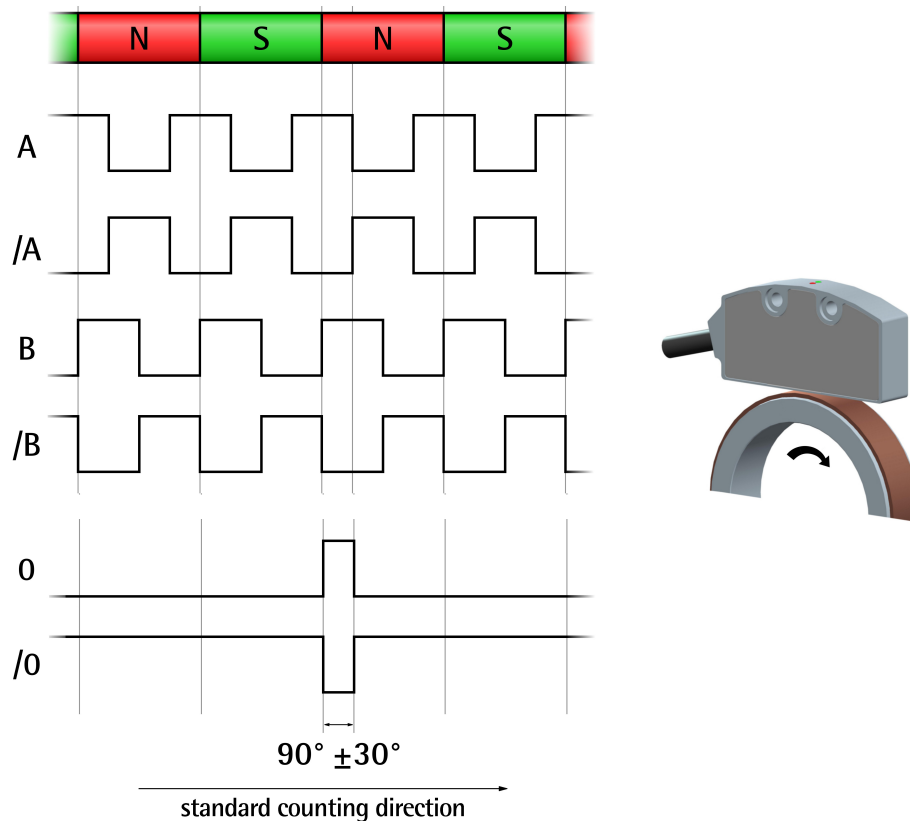


Figure 10 - Example with interpolation factor x4

The conversion electronics inside the sensor translates the magnetic fields of the ring into electrical signals equivalent to those of an incremental encoder or similar incremental optical devices.

The frequency of the output signal is proportional to the measuring speed and the rotational speed of the ring.

Please note that the "R" Reference signal (0, /0) is provided once per revolution of the magnetic ring (see the "4.8 Reference "R"" section on page 24).

In the order code of the encoder you can find information about the interpolation factor.



**EXAMPLE**

SMRIL-L-2-16-N-...: interpolation factor = 16.

The interpolation factor is useful to calculate the number of encoder PPRs (pulses per revolution).

You need to know also the number of poles of the magnetic ring, the information can be found in the order code of the magnetic ring.



**EXAMPLE**

MRI/203-**180**-3-190: number of poles = 180.

The number of encoder PPRs results from the following calculation:

$$\text{interpolation factor} * \text{number of ring poles}$$



**EXAMPLE**

We are using the SMRIL-L-2-**16**-N-... encoder paired with the MRI/203-**180**-3-190 magnetic ring where 180 is the number of ring poles. As you can see in the order code, the interpolation factor is x16. We have to calculate the number of edges per revolution (intended after multiplying by 4) first.

The number of edges per revolution results from:

$$\text{interpolation factor} * \text{number of ring poles}$$

So, in our example we will get:

$$16 * 180 = 2,880 \text{ edges per revolution}$$

Encoder PPRs result from the following calculation:

$$\text{Encoder PPRs} = \frac{\text{Edges/revolution}}{4} = \frac{2,880}{4} = 720 \text{ PPR}$$



**WARNING**

The position value issued by the sensor is expressed in pulses; to convert the pulses into a metric measuring unit (useful, for instance, for knowing the position of a linear axis controlled through the encoder) you must multiply the number of detected pulses by the linear resolution expressed in millimetres or micrometres.

We know the interpolation factor of the encoder, so we can calculate the linear resolution expressed in millimetres or micrometres.

It results from the following formula:

$$\text{pitch of the ring pole} / \text{interpolation factor}$$

The pole pitch is 3.5 mm for SMRIL-L-2-16-N... + MRI/203...-3-....

The pole pitch can be calculated as follows:

$$\frac{\text{circumference of the ring}}{\text{number of poles}}$$

$$\text{Pole pitch} = \frac{\text{circumference of the ring}}{\text{number of poles}} = \frac{637.743}{180} = 3.543 \text{ mm}$$

In our example the linear resolution will be as follows:

$$3.5 / 16 = 0.221... \text{ mm} = 221... \mu\text{m}$$



**EXAMPLE**

SMRIL-L-2-**16**-N-... encoder

MRI/203-**180**-3-190 magnetic ring

resolution = 221... μm = 0.221... mm

detected pulses = 2,866

position value = 2,866 \* 221... μm = 634,643 μm = 634.643 mm

**4.7 Counting direction**

The phase relationship between A and B channels is so that the rising edge of A channel leads the rising edge of B channel when the ring turns in the direction shown by the arrow in Figure 7. See also the previous "4.6 ABO, /ABO output channels" section on page 21. Thus the counter in the subsequent electronics will get a count up. The counting direction cannot be changed.

#### 4.8 Reference "R"

Reference signals (0, /0) are available in the encoders having order code SMRIL-xx-x-xxx-**R**-... and rings having order code MRI/xxx**Z**-... . In the encoders having order code SMRIL-xx-x-xxx-**N**-... and rings having order code MRI/xxx-... the Reference signals are not available.

They provide a univocal position information once per revolution of the magnetic ring for use at power-on or following a loss of power. In the measuring systems equipped with Reference sensor the "R" LED (see the "4.9 Diagnostic LEDs (Figure 11)" section) lights up when the Reference South pole is detected. Please note that this does not mean that the Reference pulse is output in the same time: the Reference pulse is synchronized with A and B channels within the South pole and has a duration of one measuring step (90 electrical degrees  $\pm 30^\circ$ ). Thus, it may be either not output yet or already output while the LED is lit. The Reference signal has an amplitude according to the power supply voltage level.



**NOTE**

The Reference track can be available only in the magnetic rings having a 10 mm / 0.4" wide magnetic surface. Magnetic rings having a 5-7 mm / 0.197"-0.275" wide magnetic surface cannot have the Reference track.

#### 4.9 Diagnostic LEDs (Figure 11)

Two LEDs located in the upper face of the encoder enclosure are intended to show visually the work status of the device as explained in the following table.



Figure 11 - Diagnostic LEDs and optional cleaning wipers

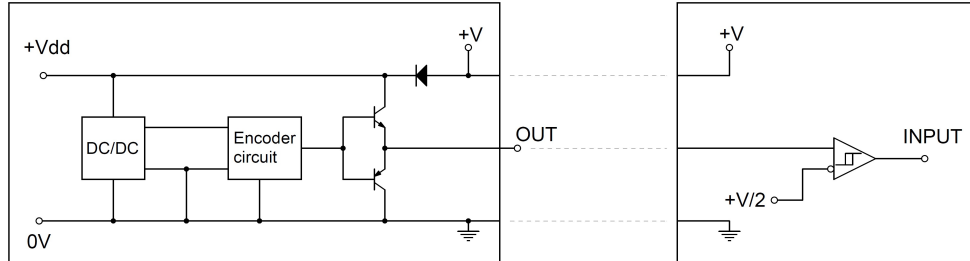


E RED LED (error status)	Description
ON Red	It warns about the presence of an error. <ul style="list-style-type: none"> <li>Distance error: the specified mounting tolerances between the sensor and the ring are not met; please refer to the "Mechanical installation" section on page 9.</li> <li>Speed / frequency error: overspeed detected, the rotational speed of the ring is too high.</li> </ul>
OFF	No error is active currently.

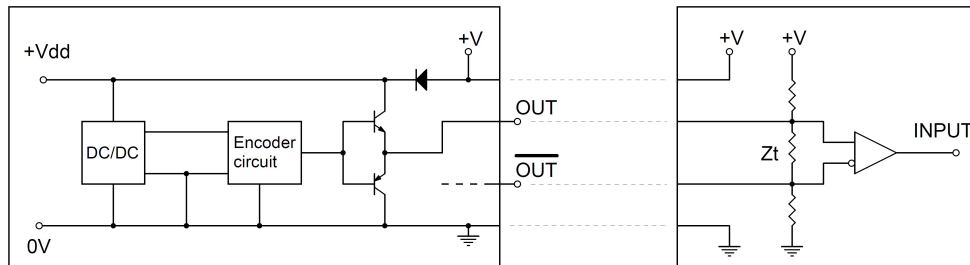
R GREEN LED (Reference)	Description
ON Green	<ul style="list-style-type: none"> <li>Sensors with Reference ("-R-" order code): Reference south pole detected, zero signal. It is on as long as the Reference South pole is detected. Refer to the "4.8 Reference "R"" section on page 24.</li> <li>Sensors without Reference ("-N-" order code): the encoder is supplied.</li> </ul>
OFF	<ul style="list-style-type: none"> <li>Sensors with Reference ("-R-" order code): no Reference signal.</li> <li>Sensors without Reference ("-N-" order code): the encoder is not supplied.</li> </ul>

### 4.10 Recommended circuit

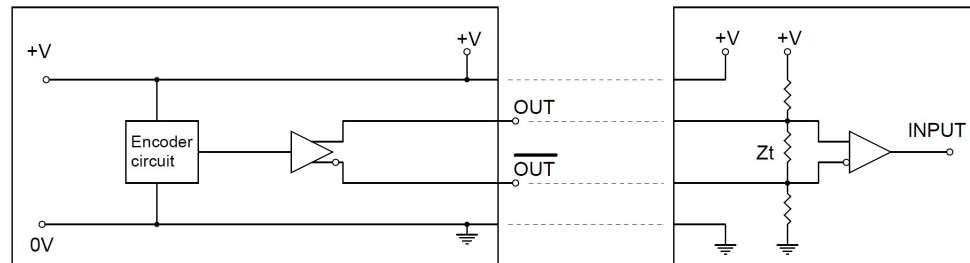
Push-Pull (Y order code)



Push-Pull (YC order code)



Line Driver (L order code)



## 5 Maintenance and troubleshooting

The magnetic measurement system does not need any particular maintenance; please always consider it is a delicate electronic equipment and therefore it must be handled with care. From time to time we recommend the following operations:

- Check the mounting tolerances between the sensor and the magnetic ring are always met. Wear of the machine may increase the tolerances.
- The surface of the magnetic ring should be cleaned periodically using a soft cloth to remove dust, chips, moisture etc.

The following list shows some typical faults and errors that may occur during installation and operation of the magnetic measurement system. Refer also to the "4.9 Diagnostic LEDs (Figure 11)" section on page 24.

**Fault:**

The system does not work (no pulse output).

**Possible cause:**

- The ring or the sensor has been mounted incorrectly.
- A magnetic piece or an inappropriate strip is in between the sensor and the ring. Only non-magnetic materials are allowed between the sensor and the ring.
- The sensor touches the ring: the mounting tolerances are not met. Check if the active side of the sensor is damaged.
- The sensor has been damaged by a short circuit or a wrong connection.

**Fault:**

The measured values are inaccurate.

**Possible cause:**

- The mounting tolerances between the sensor and the ring are not always met.
- The connection cable runs near to high voltage cable or shield is not connected correctly. See the "4 -Electrical connection" section on page 18.
- The presence of external noise may cause malfunctioning or a decrease in the quality of the signals.
- The max. counting frequency of your receiving device is too low.
- A section of the magnetic ring has been damaged mechanically or magnetically.

- The measuring error is caused by torsion of the machine structure. Check parallelism and symmetry of machine movement.

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Document release	Release date	Description	HW	SW	Interface
1.0	03.02.2021	First issue	-	-	-



Dispose separately

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