AksIM-4™

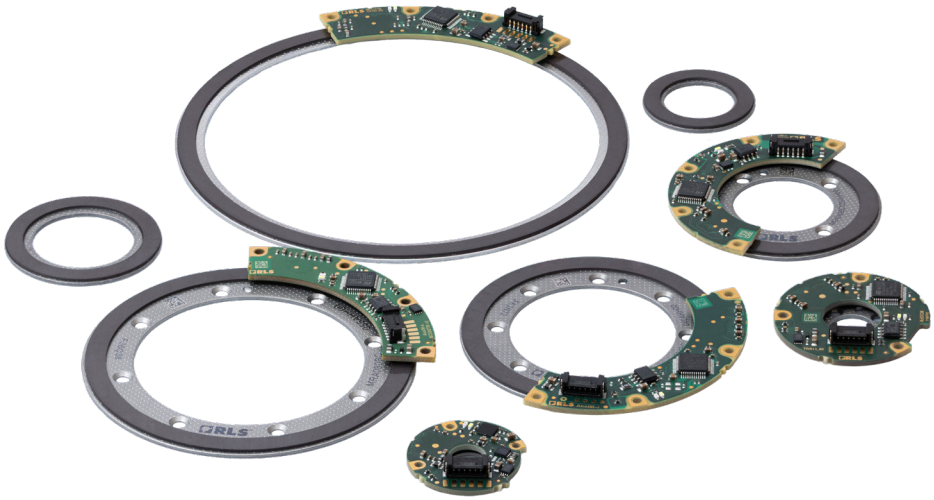
Off-Axis Rotary Absolute Magnetic Encoder

HIGH ACCURACY

HIGH REPEATABILITY

SIMPLE INTEGRATION

The AksIM-4 is a non-contact, high performance off-axis absolute rotary encoder designed for integration into applications with limited space. A hollow ring, true absolute functionality and high-speed operation make this encoder suitable for many applications.
The AksIM-4 encoder system consists of an axially magnetised ring and a readhead. The encoders are equipped with BiSS, SSI or SPI communication interfaces and offer a range of binary resolutions up to 22 bits per revolution.



Features and benefits

- True absolute system
- Custom magnetic sensor ASIC
- Self-calibration option
- No hysteresis
- Resolution up to 22 bits
- Multiturn counter option
- High speed operation
- Low profile, non-contact
- Integrated status LED
- High repeatability

COLLABORATIVE & INDUSTRIAL ROBOTS | SURGICAL ROBOTS | GIMBALS | HUMANOID ROBOTS | MOTOR FEEDBACK

General information

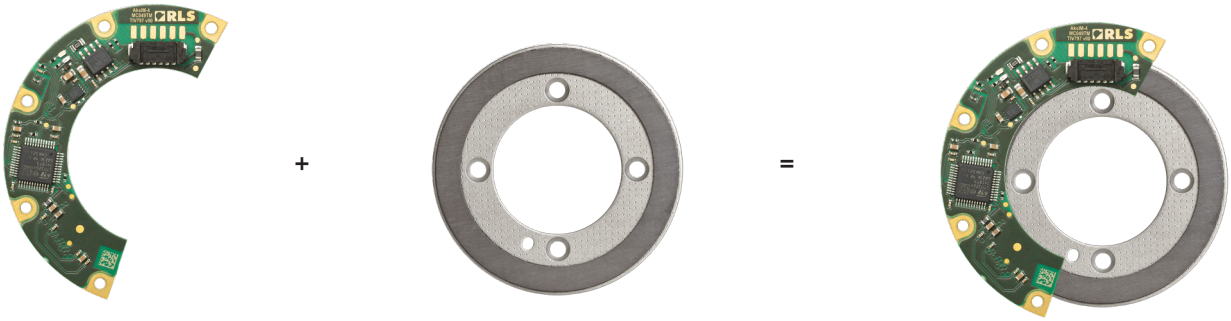
The AksIM-4 encoder family is based on advanced magnetic sensing and proprietary signal processing. It delivers precise, reliable absolute position feedback in a compact, integration-ready form. Its non-contact architecture—combining a readhead and an axially magnetised ring—enables space-efficient designs and simplifies integration.

AksIM encoders are true absolute systems. Position data is available immediately at power-up, without referencing. Integrated self-monitoring continuously evaluates internal conditions, ensuring stable operation and early detection of anomalies.

The family supports industry-standard interfaces, including BiSS-C, SSI, and SPI. Flexible configuration options—such as self-calibration, multiturn capability, and programmable parameters—allow adaptation to specific application requirements.

Designed for demanding environments, AksIM encoders offer high immunity to external magnetic fields and strong resistance to shock, vibration, and temperature extremes. This ensures reliable performance in industrial, robotic, medical, and precision motion systems. A typical application is a robotic arm joint with a cable feed through the ring, or a precision gearbox where the ring is mounted on the main transmission shaft. A custom design service for OEM integration is also available.

AksIM-4 is available in **multiple variants**. This datasheet describes the standard variant.



MC readhead + MRA axial magnetic ring = AksIM-4 system

Selection guide

	Magnetic ring					Readhead					
Part number	**Inner diameter**	**Circle for fasteners**	**Outer diameter**	**Thickness**	**Inertia (kg × mm²)**	**Inner diameter**	**Circle for fasteners**	**Outer diameter**	**Arc length**	**System thickness (Typ.)**	**Mass (g)**
For MC011 Assembly contact RLS.											
MC022 Assembly											
MC022						8.5	24	28.5	360°		2.7
MRA022BG010DHN00	10	none	21.5	2.0	0.36					8	3.0
MC029 Assembly											
MC029						14	33.3	38	360°		4.5
MRA029BC010DHH00	10	15	29	2.0	0.75					8	6.0
MRA029BG018DHN00	18	none	29	2.0	1.0					8	4.0
MC039 Assembly											
MC039						21.1	49	54	196°		4.8
MRA039BC020DHH00	20	25	39	2.0	2.3					8	9.0
MRA039BG025DHN00	25	none	39	2.0	2.1					8	8.0
MC049 Assembly											
MC049						34	54	59	190°		4.5
MRA049BC025AHH00	25	31	49	2.0	5.1					8	13
MRA049BG034AHN00	34	none	49	2.0	4.4					8	10
MC053 Assembly											
MC053						36	66	74	130°		5.3
MRA053BC030AHH00	30	36	53	2.0	6.6					8	14
MRA053BG040AHN00	40	none	53	2.0	5.3					8	9
MC064 Assembly											
MC064						48	69	74	140°		6.9
MRA064BC040AHH00	40	46	64	2.0	13.2					8	18
MRA064BG051AHN00	51	none	64	2.0	9.9					8	12
MC080 Assembly											
MC080						64.4	85	90	97°		4.0
MRA080BC055AHH00	55	61.5	80	2.0	29.5					8	25
MRA080BG064AHN00	64	none	80	2.0	23.4					8	18
MC115 Assembly											
MC115						96	120	125	65°		5.0
MRA115BC090AHH00	90	97	115	2.0	103					8	39
MRA115BG100AHN00	100	none	115	2.0	72.5					8	25
MC150 Assembly											
MC150						134	158	163	50°		5.0
MRA150JF125AGH00	125	132	150	5.8	990					12	207

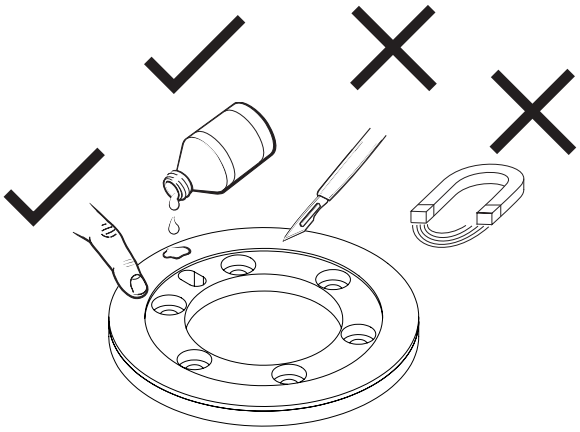
Storage and handling

Operating and storage temperature

With connector: –40 °C to +105 °C
With solder pads: –40 °C to +125 °C

Humidity

Up to 70 % non-condensing



HANDLE WITH CARE. This encoder system is a high performance metrology product and should be treated with the same care as any other precision instrument. Use of heavy duty industrial tools or exposure to strong magnets, such as a magnetic base, is unacceptable and risks of irreparable damage to the product.

The magnetic ring should not be exposed to magnetic field densities higher than 50 mT on its surface, as this can damage the ring.

For more information, refer to the chapter **Chemical resistance** or **contact RLS**.



Readhead is ESD sensitive - handle with care.
Do not touch electronic circuit, wires or sensor area without proper ESD protection or outside of ESD controlled environment.

Technical specifications

System data

Reading type		Axial reading	
Maximum speed	MC022 to MC080	10,000 rpm	For higher speeds **contact RLS**.
	MC115	7,350 rpm	
	MC150	4,750 rpm	
Hysteresis		Less than unit of resolution	
Repeatability		Less than unit of resolution	
Update rate		9 kHz bandwidth, 18 kHz sampling rate, up to 50 kHz refresh rate Refer to the relevant communication interface chapter for details.	
Latency		Refer to the relevant communication interface chapter for details.	
Thermal drift		None (accuracy does not change with temperature)	

Resolution / Size		**MC022**	**MC029**	**MC039**	**MC049**	**MC053**	**MC064**	**MC080**	**MC115**	**MC150**
Singleturn	**High***	19 bit	19 bit	20 bit	21 bit	22 bit	22 bit	22 bit	22 bit	22 bit
	Standard	17 bit	17 bit	18 bit	18 bit	19 bit	19 bit	20 bit	20 bit	20 bit
Multiturn		Singleturn resolution + 16 bits multiturn counter (for all sizes).								

* At standard resolution, hysteresis and repeatability are below one LSB, giving a stable output. High resolution options suit smoother control loops or averaging to obtain fine position, but the lowest bits may fluctuate due to noise, which increases with ride height. A tight ride height is recommended for best results.

Accuracy / Size	**MC022**	**MC029**	**MC039**	**MC049**	**MC053**	**MC064**	**MC080**	**MC115**	**MC150**
System accuracy*	±0.020° (±72.0″)	±0.014° (±50.4″)	±0.012° (±43.2″)	±0.007° (±25.2″)	±0.006° (±21.6″)	±0.004° (±14.4″)	±0.004° (±14.4″)	±0.004° (±14.4″)	±0.004° (±14.4″)
Typical installed accuracy - Calibrated	±0.030° (±108.0″)	±0.023° (±82.8″)	±0.016° (±57.6″)	±0.015° (±54.0″)	±0.012° (±43.2″)	±0.010° (±36.0″)	±0.009° (±32.4″)	±0.009° (±32.4″)	±0.009° (±32.4″)
Typical installed accuracy - Uncalibrated	±0.100° (±360.0″)	±0.070° (±252.0″)	±0.048° (±172.8″)	±0.045° (±162.0″)	±0.040° (±144.0″)	±0.032° (±115.2″)	±0.029° (±104.4″)	±0.029° (±104.4″)	±0.029° (±104.4″)

Total installed accuracy without calibration depends on mounting precision. Minimising the eccentricity of the ring assembly (using a gauge) and using a drive shaft with precision bearings is the key to good overall accuracy.

* Installed accuracy can achieve the specified system accuracy when two readheads are mounted 180° apart, or in optimal conditions after self-calibration. Refer to the chapter **Self-calibration after installation**.

Electrical data

Supply voltage (V_{DD})	4.5 V to 5.5 V at the connector. Rise time ≤ 20 ms.
Set-up time	200 ms (first data ready after supply voltage is in range), typ. 100 ms
Current consumption	Typ. 130 mA, max. 150 mA (without load on the outputs)
Connection	6-pin low-profile locking connector (Molex MicroLock P/N: 5055670671) or soldering pads
Connector locking mechanism	Retention force 20 N (2 kg)
Output load	RS422: ±40 mA
	SPI: 5 mA (LVTTL logic level)
ESD protection	HBM, Class 2, ±2 kV (valid only on RS422 signals on connector; do not touch other components)

Mechanical data

Ring material type	EN 1.4016 / AISI430 with glued rubber filled with ferrite particles MRA150: EN 1.4057 / AISI431 with glued rubber filled with ferrite particles

Environmental and operational conditions

Environmental data

Operating and storage temperature	With connector: −40 °C to +105 °C With solder pads: −40 °C to +125 °C
Humidity	Up to 70 % non-condensing (for higher with conformal coating **contact RLS**)
Shock	100 g (6 ms, half-sine, EN 60068-2-27:2009)
Vibration	80 g (55–2000 Hz, EN 60068-2-6:2008)
Environmental compliance	RoHS, REACH

Chemical resistance

RLS products are commonly used in industrial applications and are exposed to chemicals that can affect their internal and external components. Although our products are designed to withstand many harsh chemicals and environments, long-term resistance depends on exposure, temperature and concentration. Most of the chemicals to which our products are exposed are not in constant contact. Therefore, a material that is not resistant when immersed in a chemical may be durable indefinitely if wiped with the same chemical once a day.

External magnetic field

Magnetic encoders operate by detecting changes in the magnetic field of a magnetised ring. In typical applications, nearby magnetic sources such as motors do not affect performance when the encoder is properly integrated. For optimal performance, the encoder should be mounted in the following arrangement:

Motor → Ring → Readhead.

In this configuration, the ring naturally acts as a shield between the motor and the readhead, reducing the influence of stray magnetic fields. In most applications, no additional shielding is required. If unusually strong magnetic fields are present, simple shielding – such as a thin ferromagnetic plate – can be placed between the source and the readhead.

During handling and storage, avoid placing strong magnetic objects near the ring, as they may affect its magnetic properties. Magnetic fields above 50 mT can permanently damage the ring.

Operation in high-pressure applications

The encoder can be configured to operate at ambient pressures of up to 600 bar. Typical applications include ROV submarines where the entire system is submerged in oil.

Lifetime impact for variants with max. temperature above +105 °C (variants with solder pads)

While the device remains fully functional within the specified operating conditions, microcontroller manufacturer characterization data and the implemented wear-leveling algorithm indicate that exceeding approximately 175,000 power cycles, over entire device temperature range (−40 °C to 125 °C) may reduce the expected lifetime to below 10 years if average ambient temperature is around 125 °C. Actual lifetime may vary depending on application, usage patterns, and environmental conditions.

Operation in ultra-high-vacuum applications

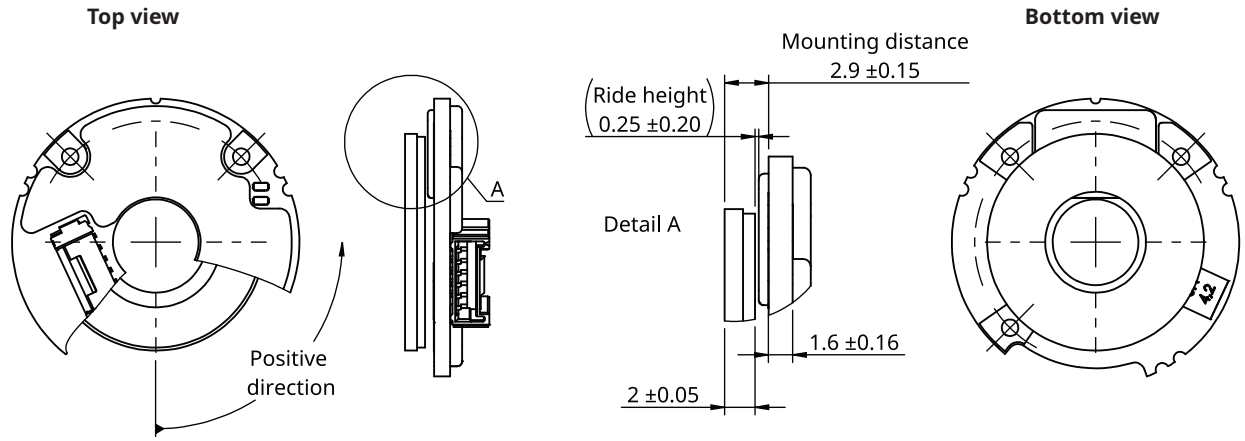
AksIM encoders are suitable for operation in ultra-high-vacuum environments. For more information **contact RLS**.

For additional details, please **contact RLS.**

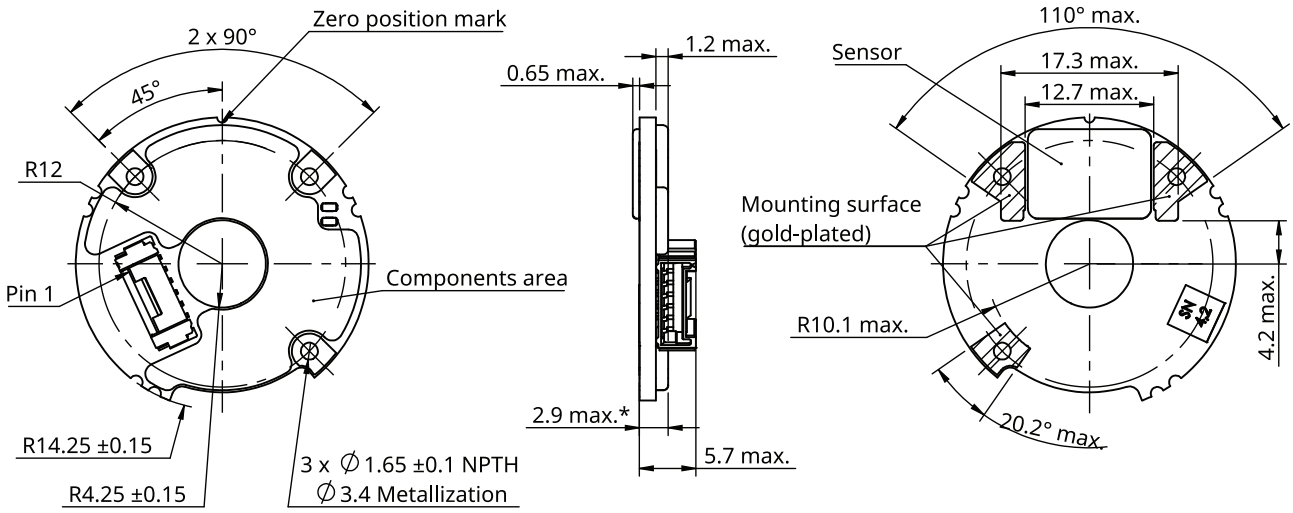
Dimension and installation drawings

Dimensions and tolerances are in mm. Dimensions without tolerance values are in accordance with ISO 2768-m.

Encoder assembly MC022 readhead with MRA022BG010DHN00 magnetic ring

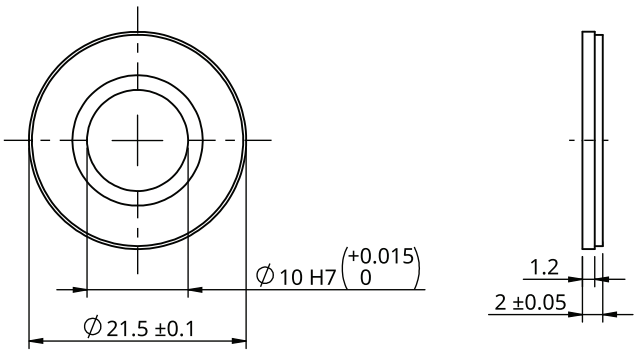


MC022 readhead



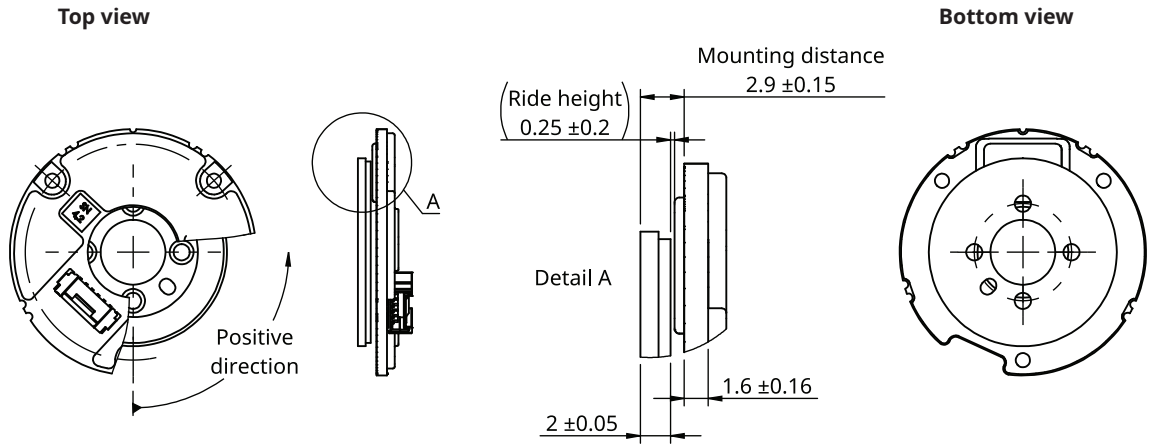
* Total thickness with solder pads option.

MRA022BG010DHN00 magnetic ring

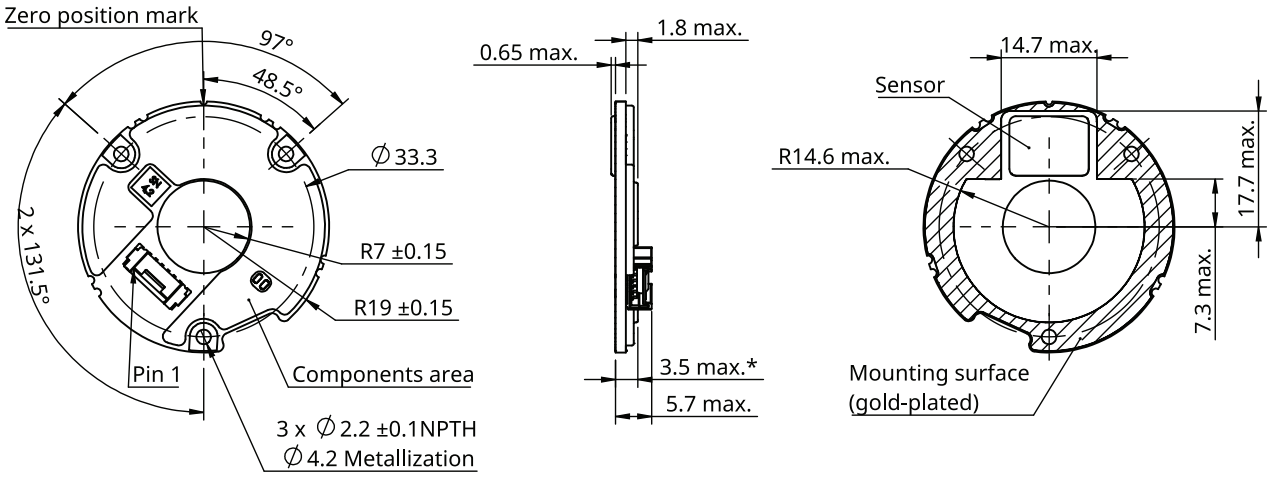


Dimensions and installation drawings continued

Encoder assembly MC029 readhead with MRA029BC010DHH00 magnetic ring

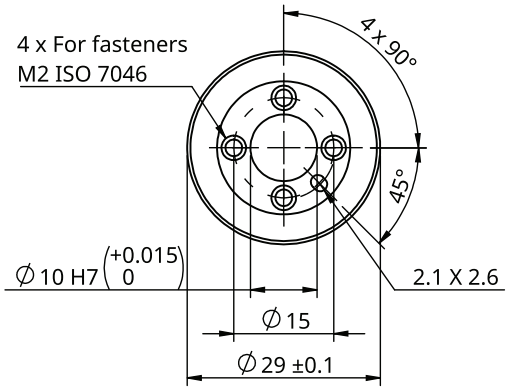


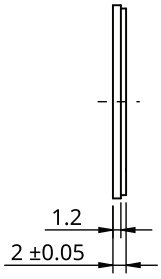
MC029 readhead



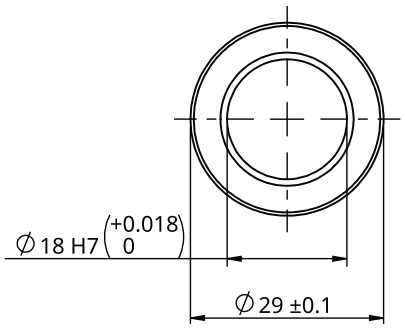
* Total thickness with solder pads option.

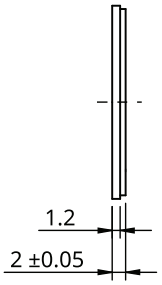
MRA029BC010DHH00 magnetic ring





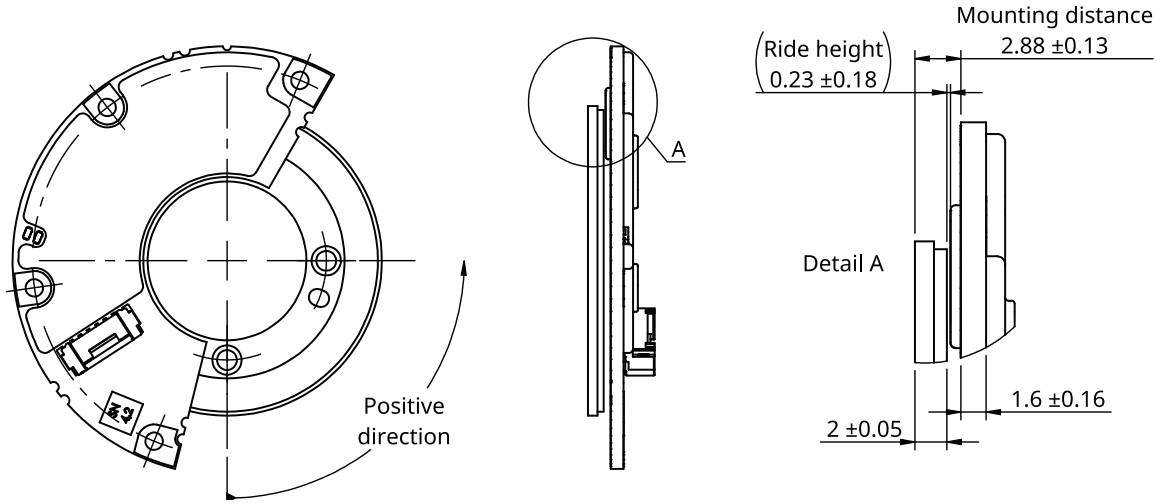
MRA029BG018DHN00 magnetic ring



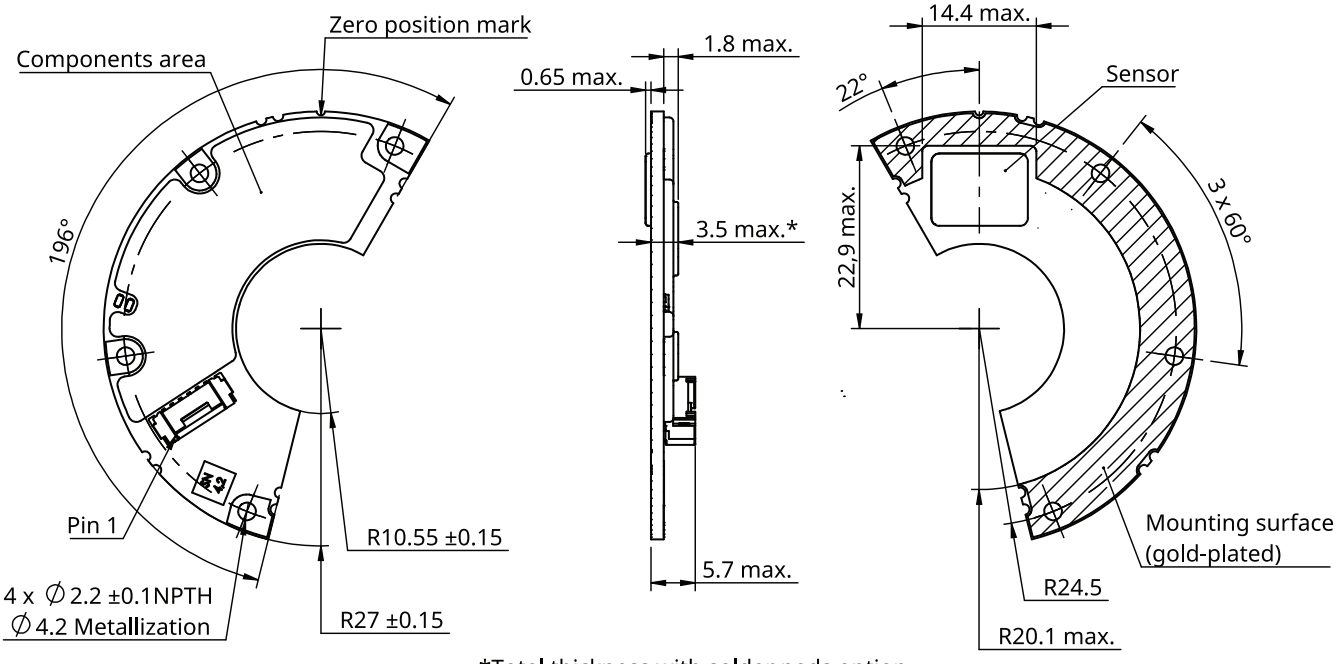


Dimensions and installation drawings continued

Encoder assembly MC039 readhead with MRA039BC020DHH00 magnetic ring

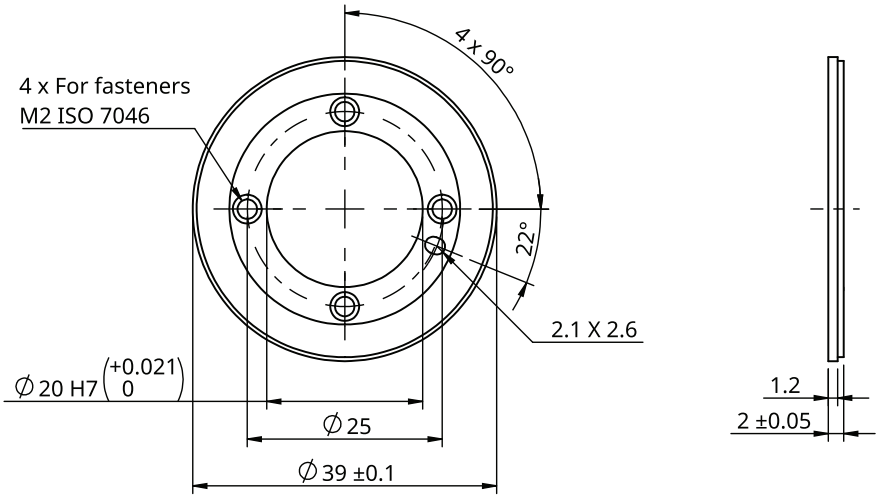


MC039 readhead

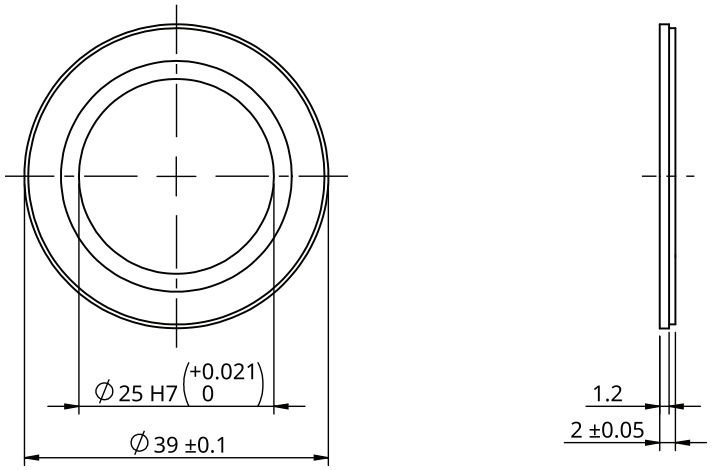


*Total thickness with solder pads option.

MRA039BC020DHH00 magnetic ring

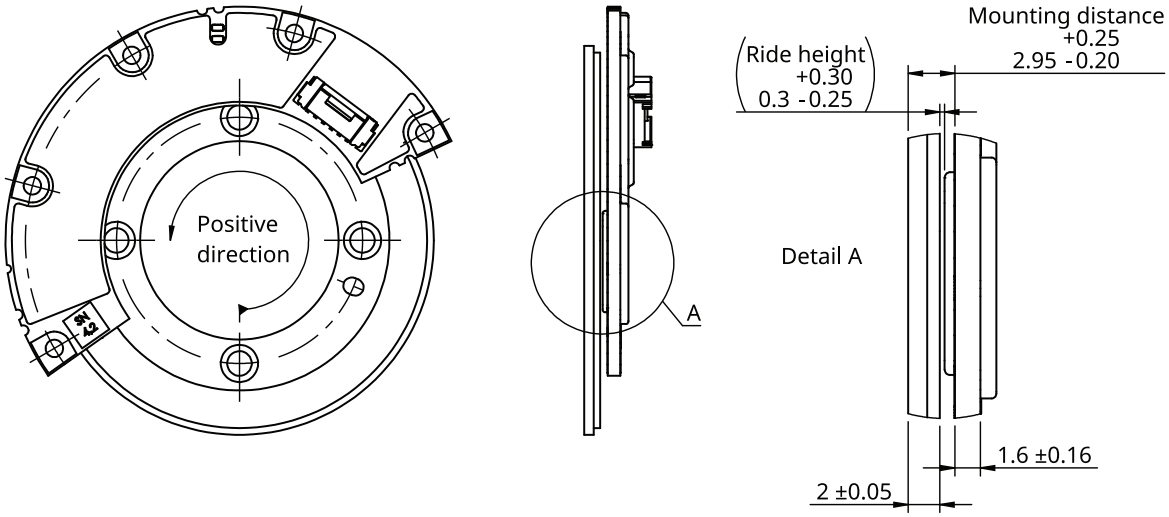


MRA039BG025DHN00 magnetic ring

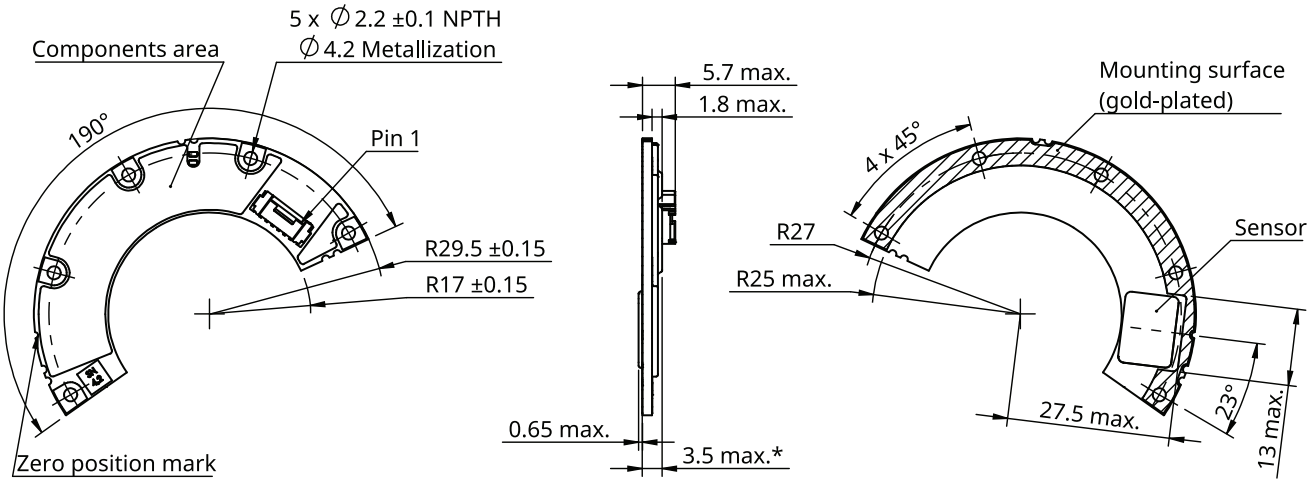


Dimensions and installation drawings continued

Encoder assembly MC049 readhead with MRA049BC025AHH00 magnetic ring

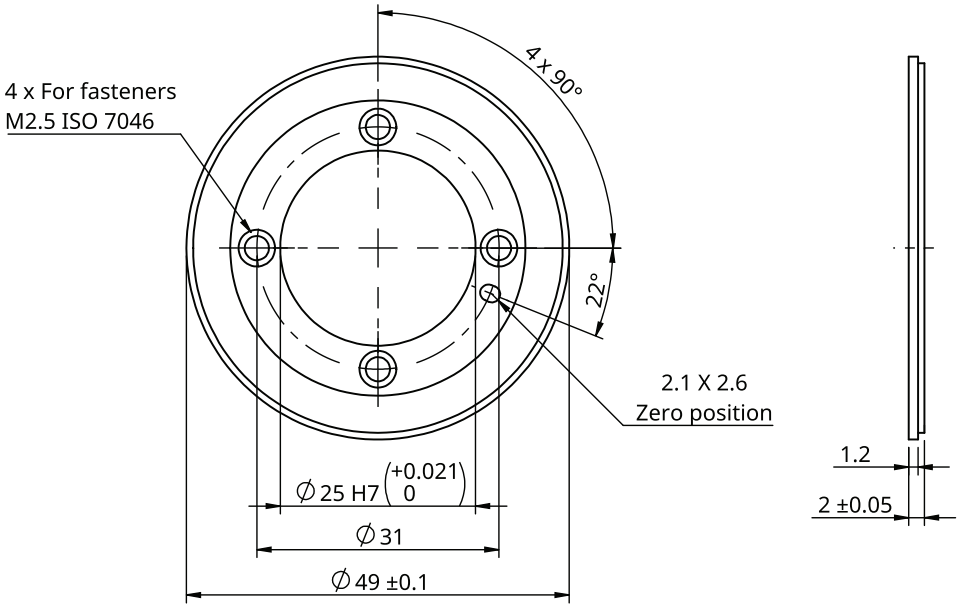


MC049 readhead

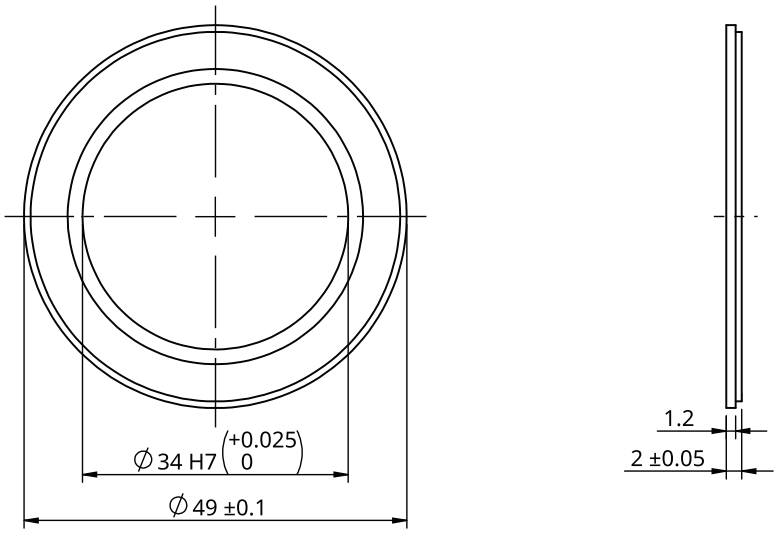


* Total thickness with solder pads option.

MRA049BC025AHH00 magnetic ring

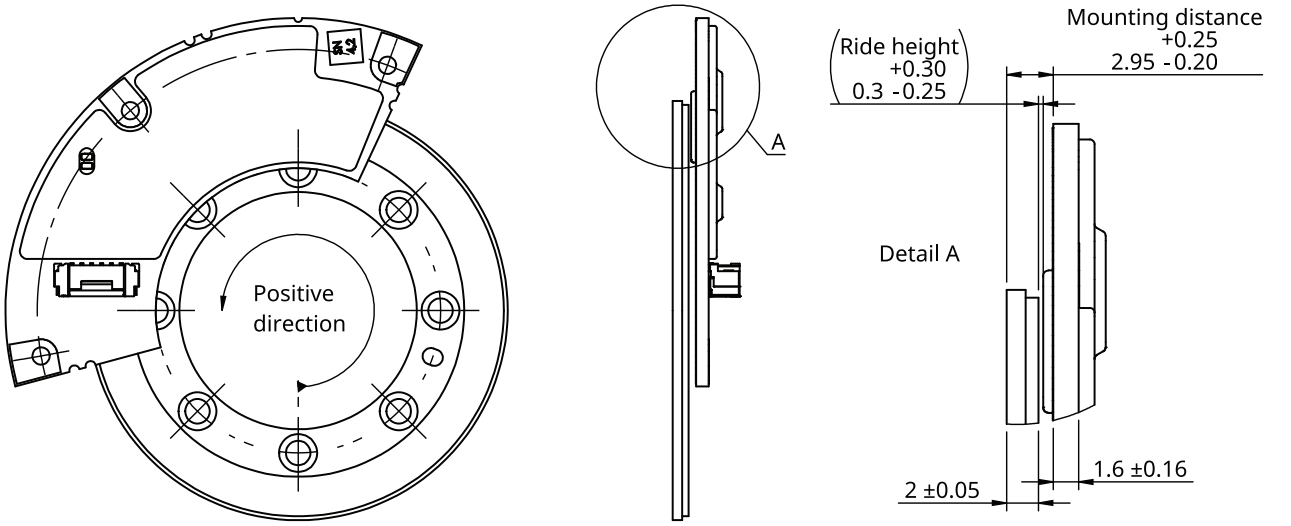


MRA049BG034AHN00 magnetic ring

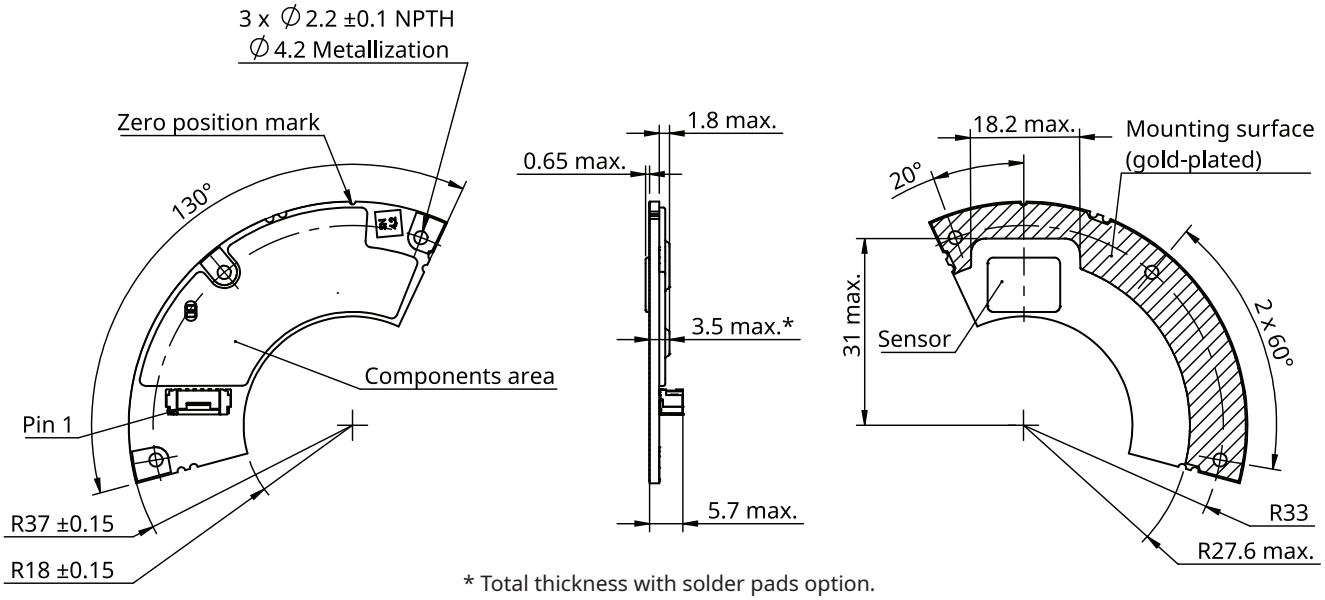


Dimensions and installation drawings continued

Encoder assembly MC053 readhead with MRA053BC030AHH00 magnetic ring

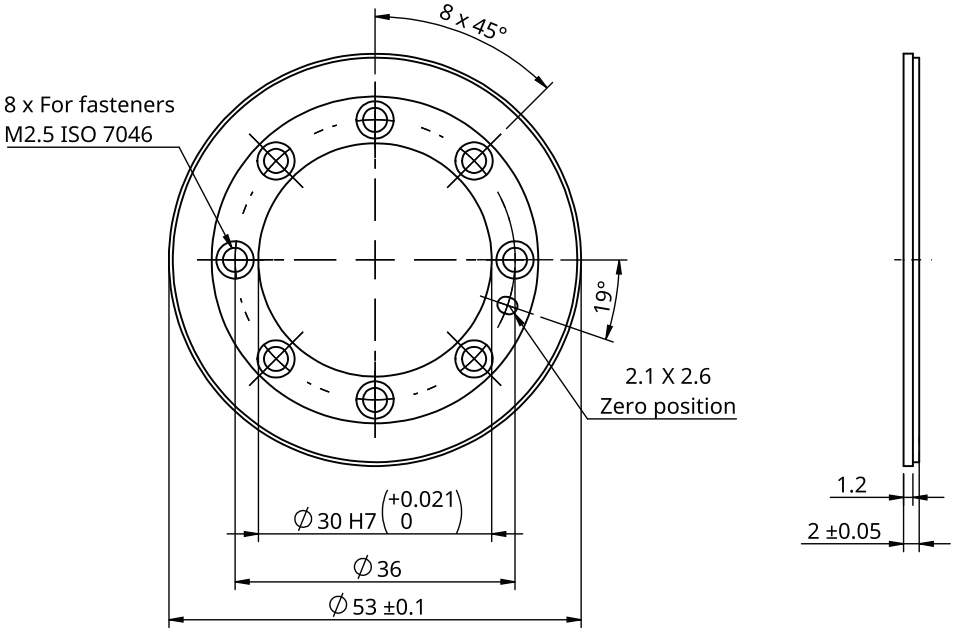


MC053 readhead

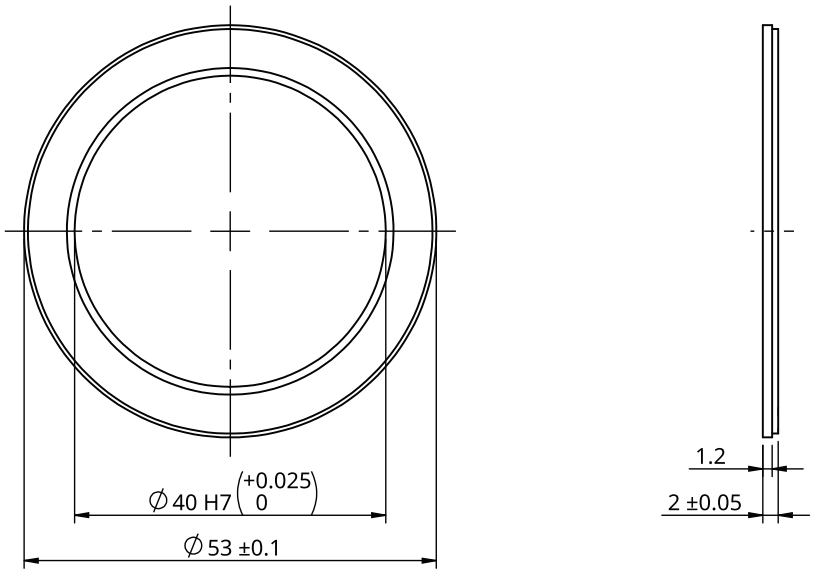


* Total thickness with solder pads option.

MRA053BC030AHH00 magnetic ring

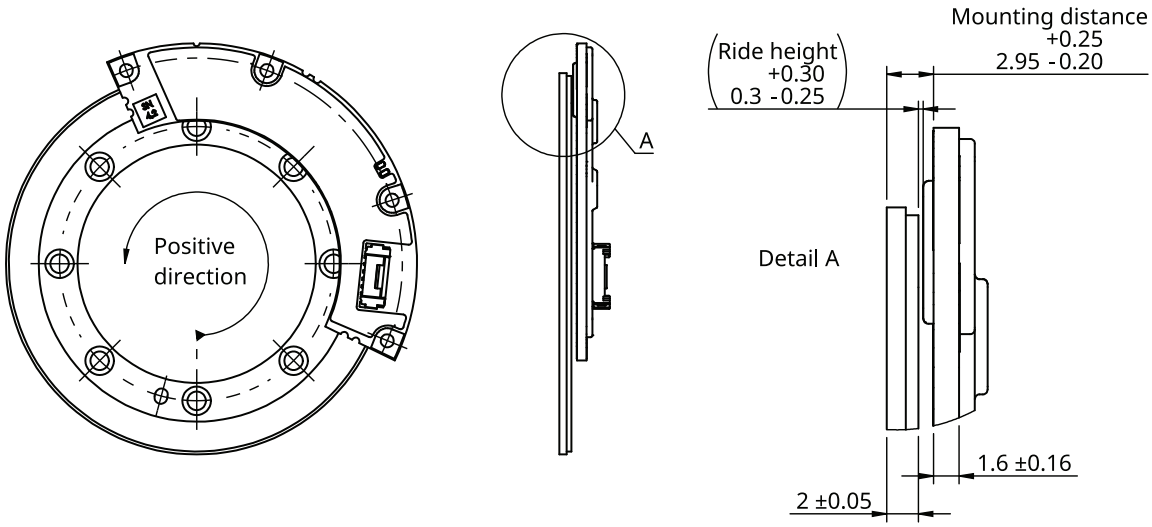


MRA053BG040AHN00 magnetic ring

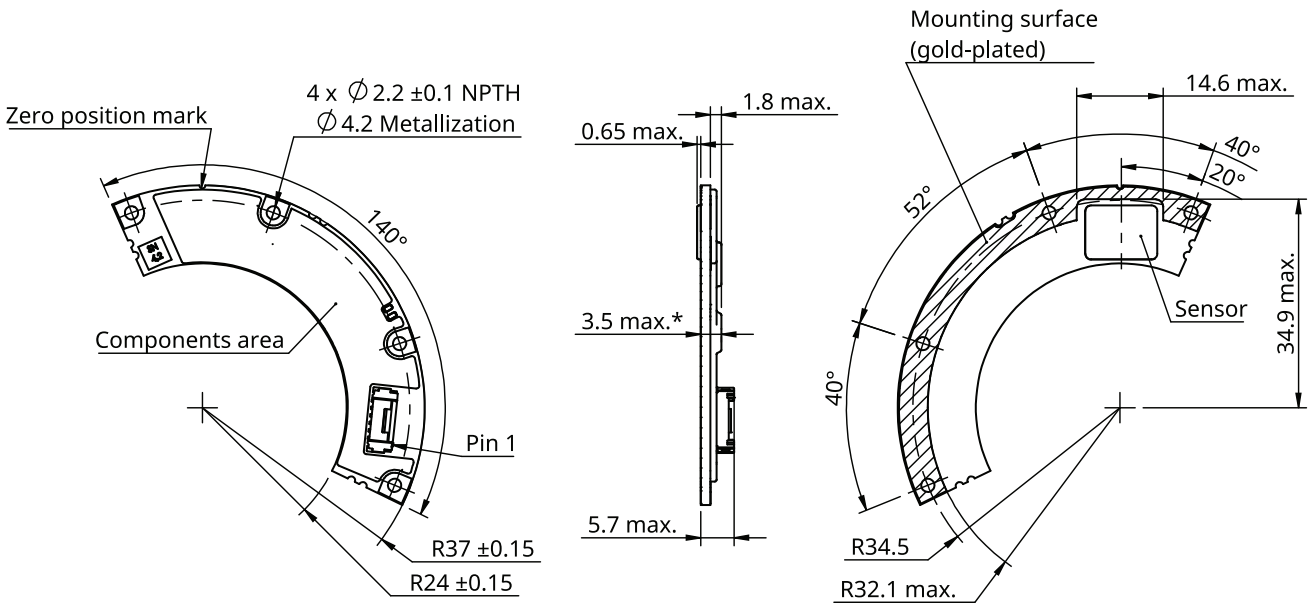


Dimensions and installation drawings continued

Encoder assembly MC064 readhead with MRA064BC040AHH00 magnetic ring

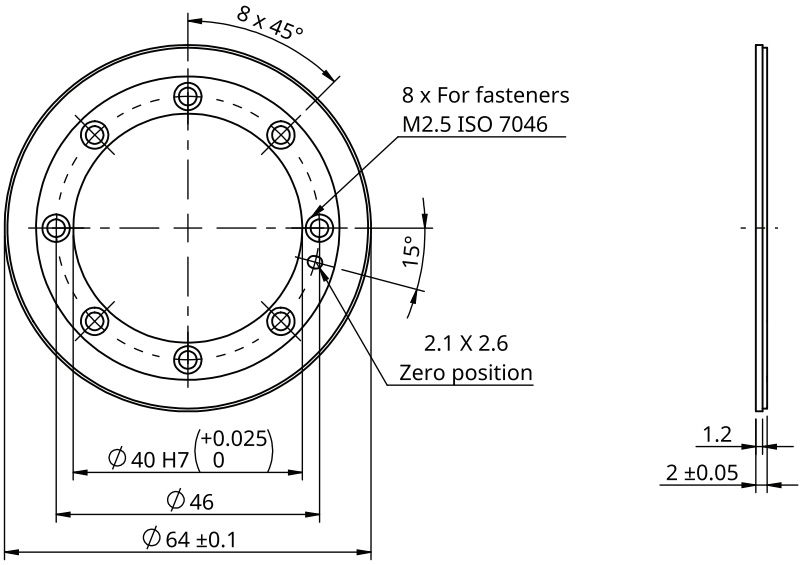


MC064 readhead

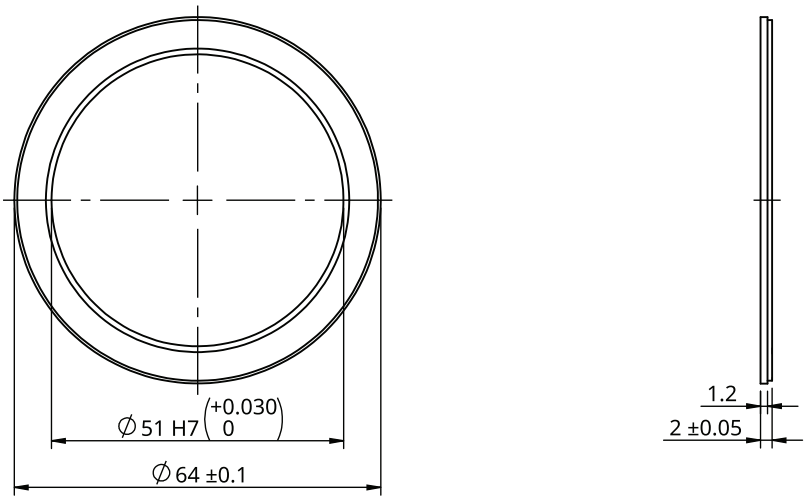


* Total thickness with solder pads option.

MRA064BC040AHH00 magnetic ring

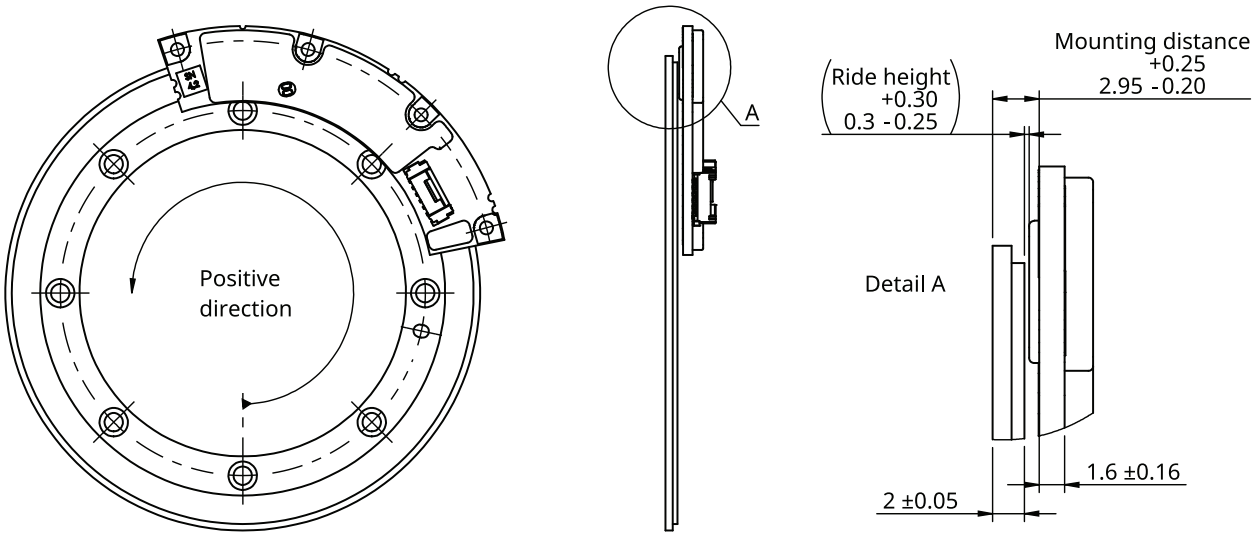


MRA064BG051AHN00 magnetic ring

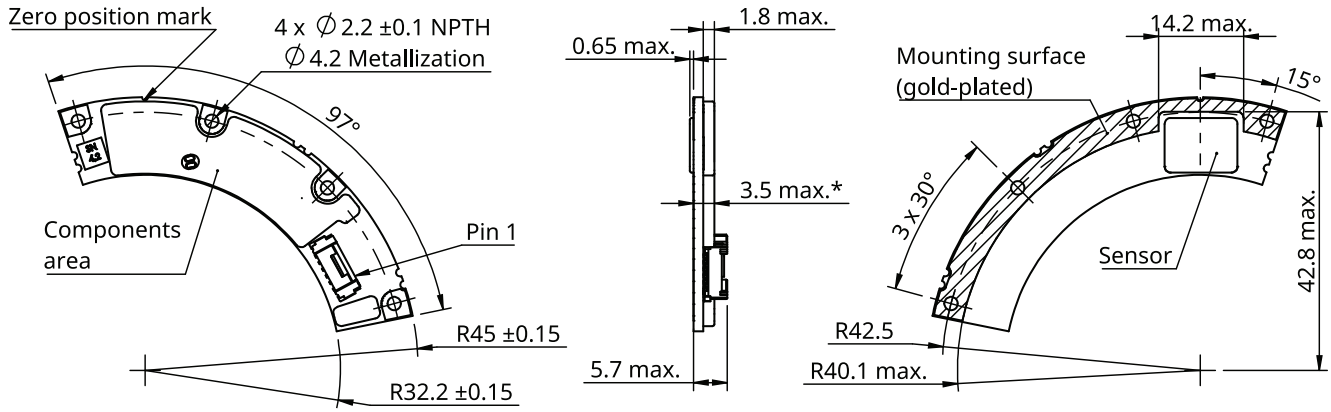


Dimensions and installation drawings continued

Encoder assembly MC080 readhead with MRA080BC055AHH00 magnetic ring

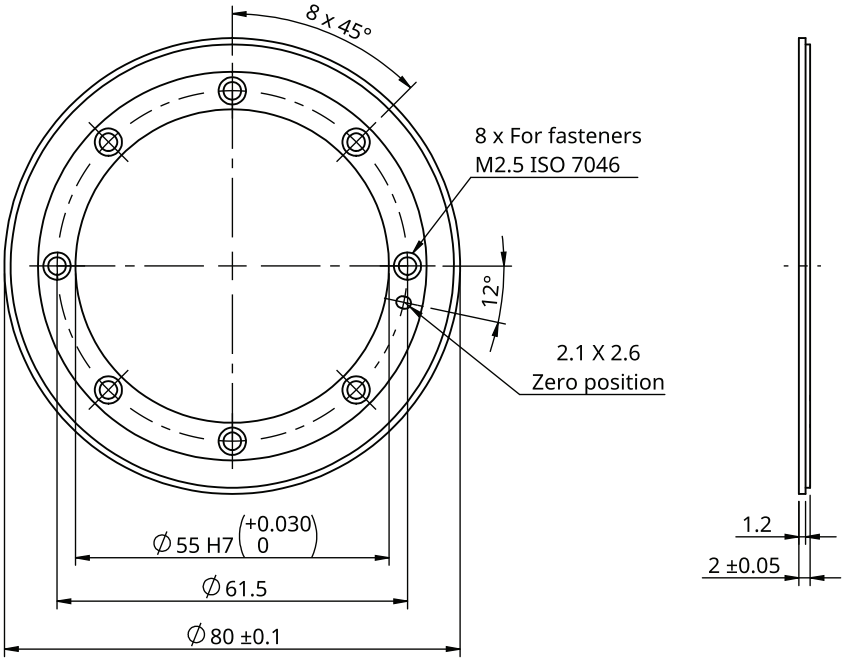


MC080 readhead

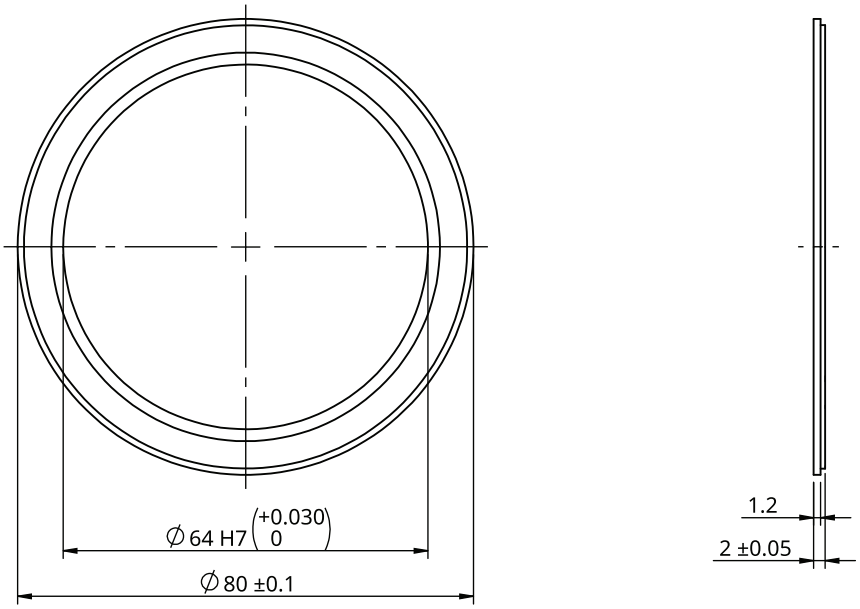


* Total thickness with solder pads option.

MRA080BC055AHH00 magnetic ring

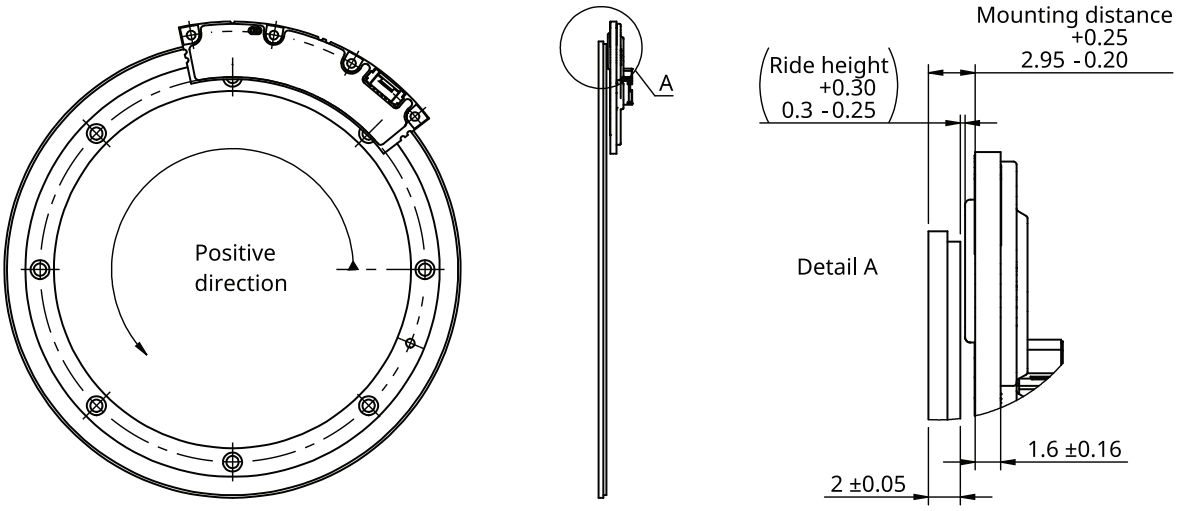


MRA080BG064AHN00 magnetic ring

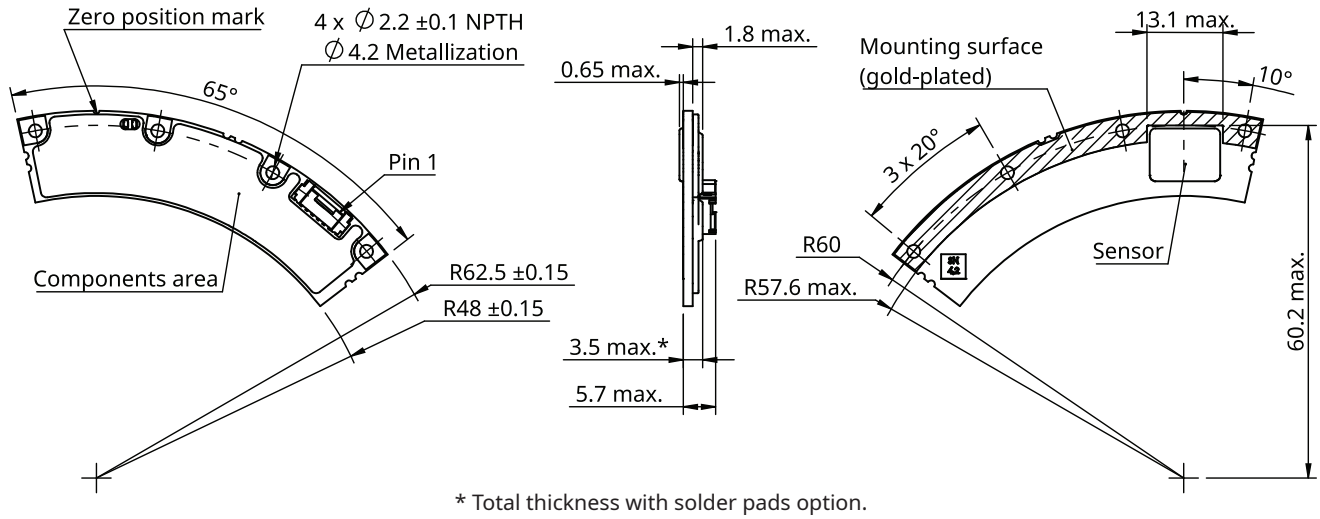


Dimensions and installation drawings continued

Encoder assembly MC115 readhead with MRA115BC090AHH00 magnetic ring

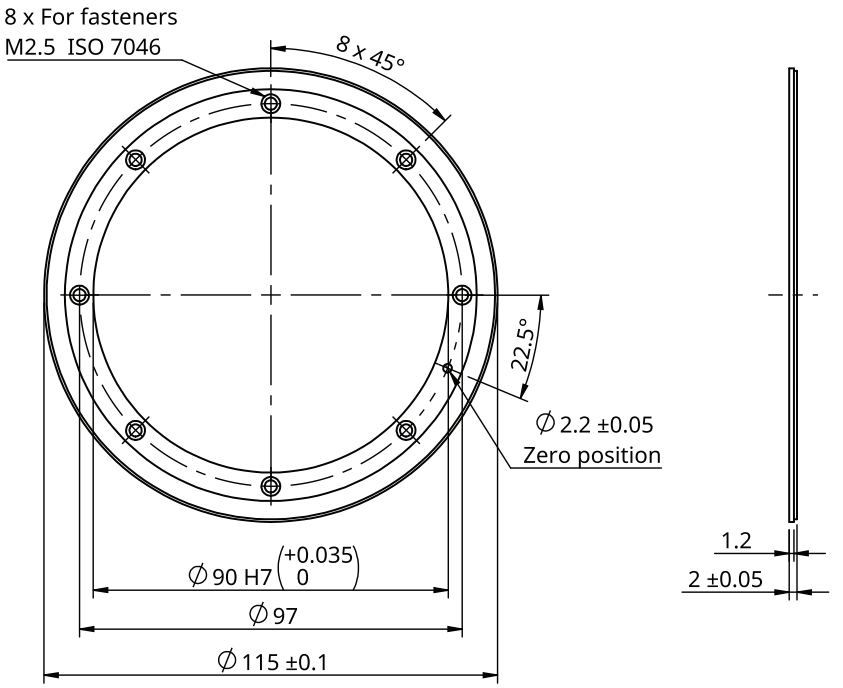


MC115 readhead

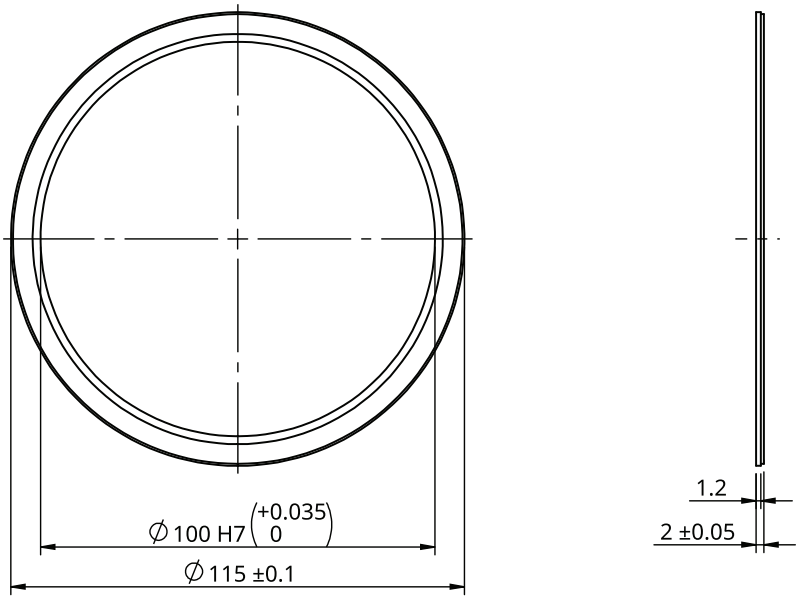


* Total thickness with solder pads option.

MRA115BC090AHH00 magnetic ring

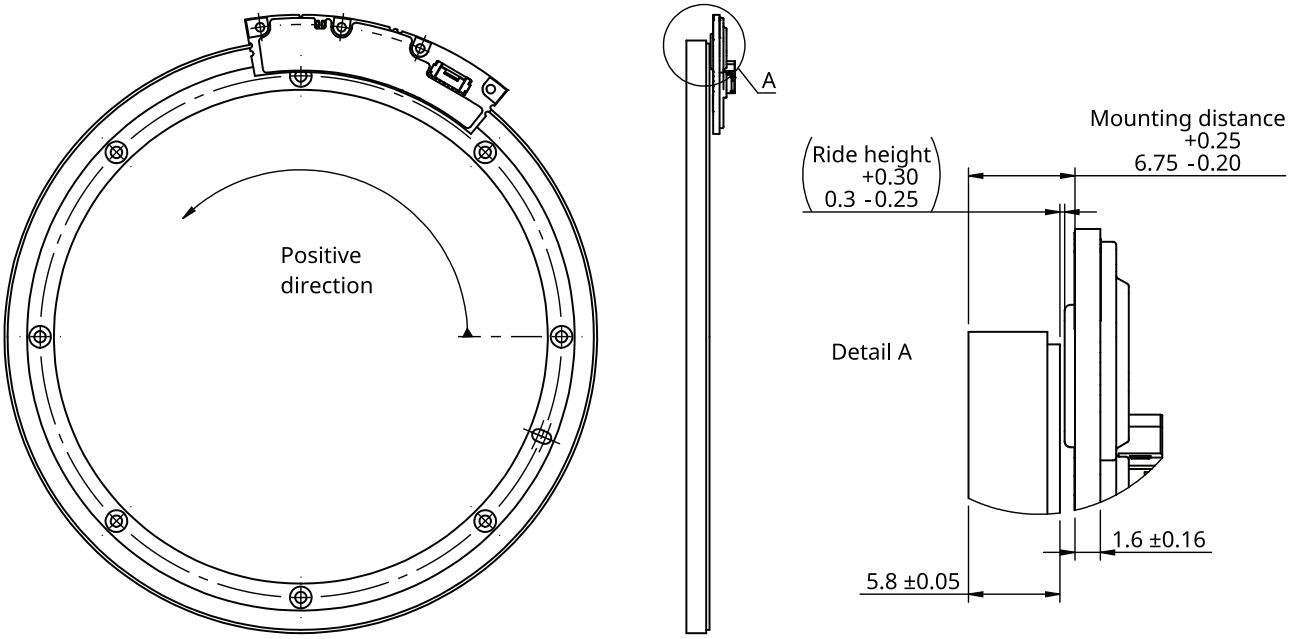


MRA115BG100AHN00 magnetic ring

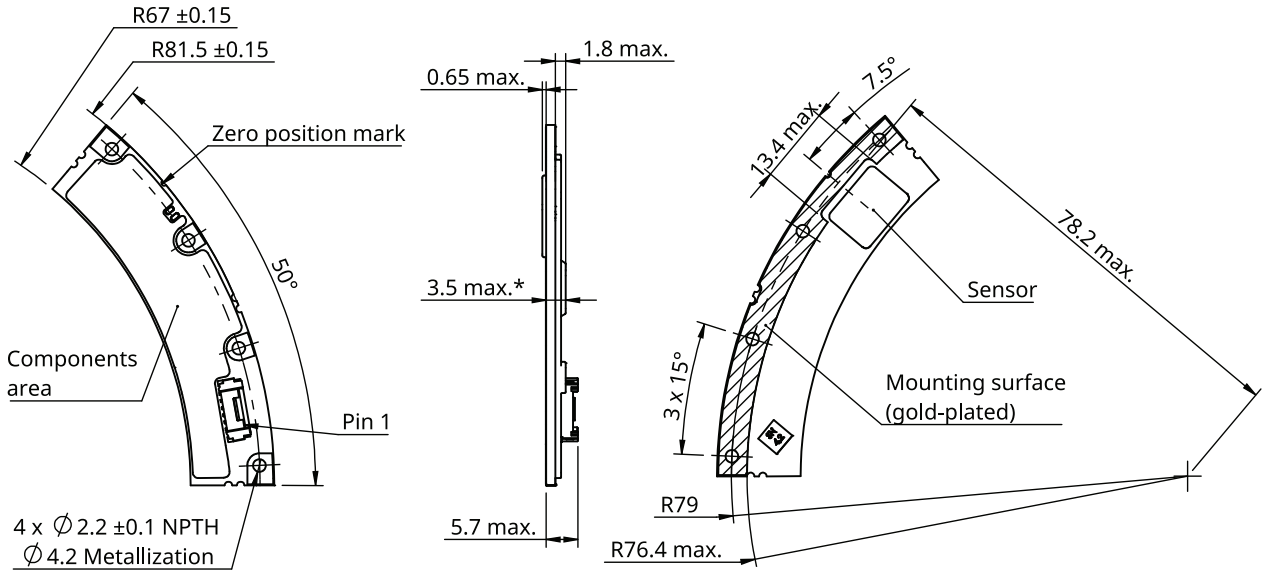


Dimensions and installation drawings continued

Encoder assembly MC150 readhead with MRA150JF125AGH00 magnetic ring

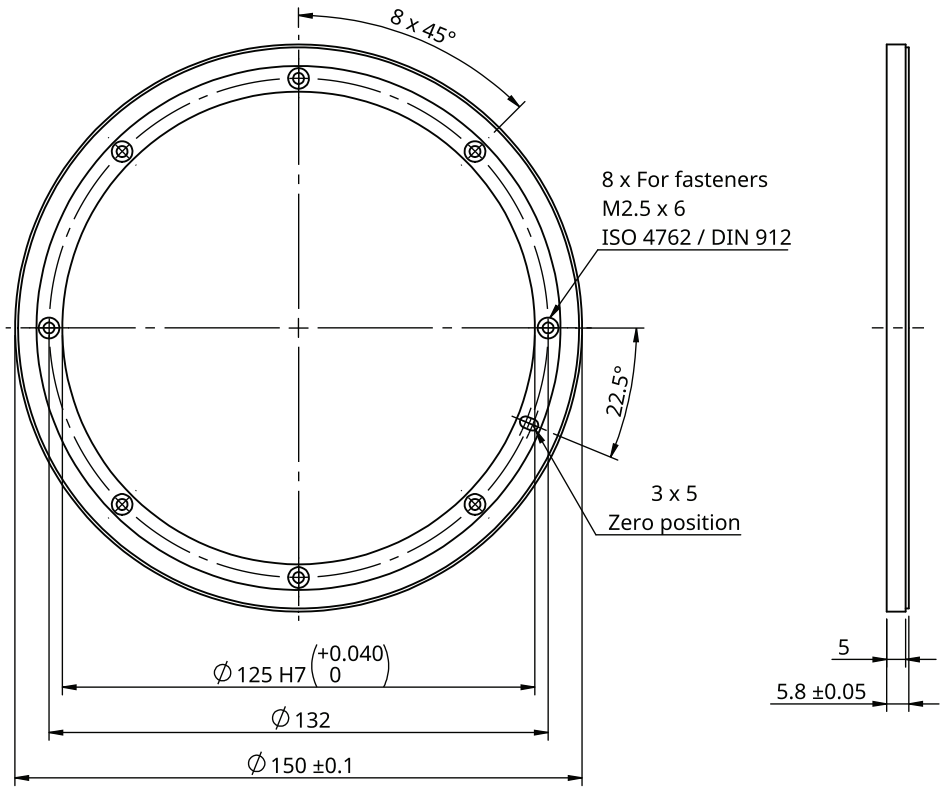


MC150 readhead

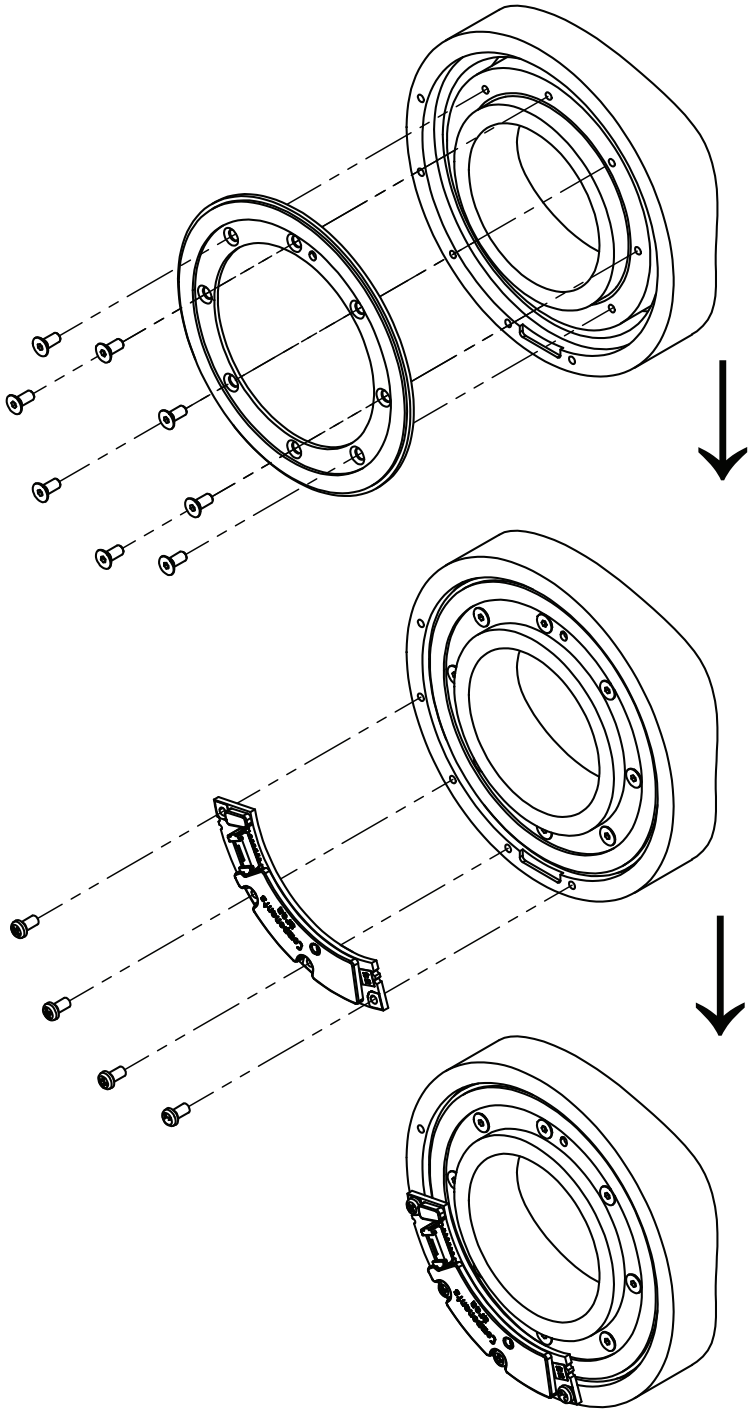


* Total thickness with solder pads option.

MRA150JF125AGH00 magnetic ring

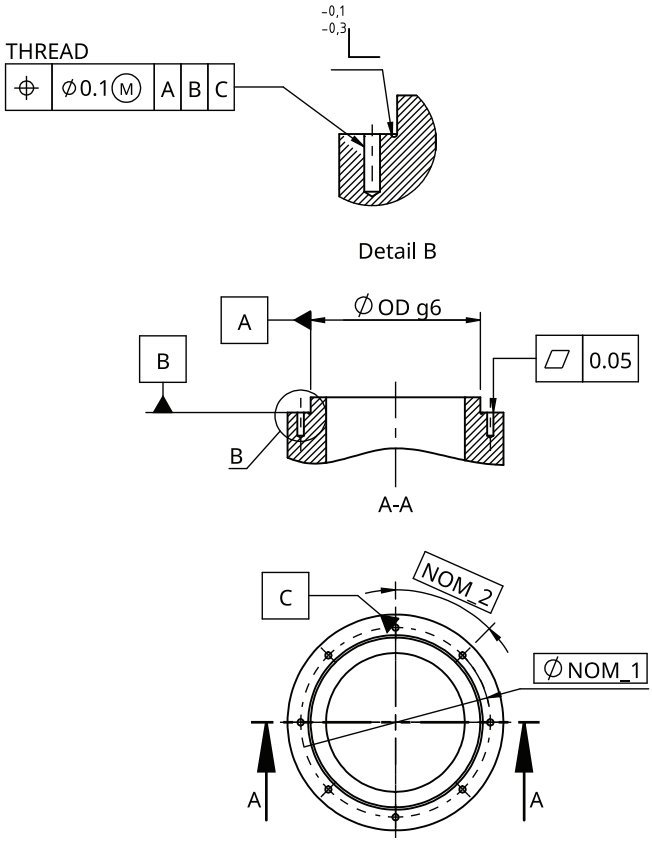


Installation instructions



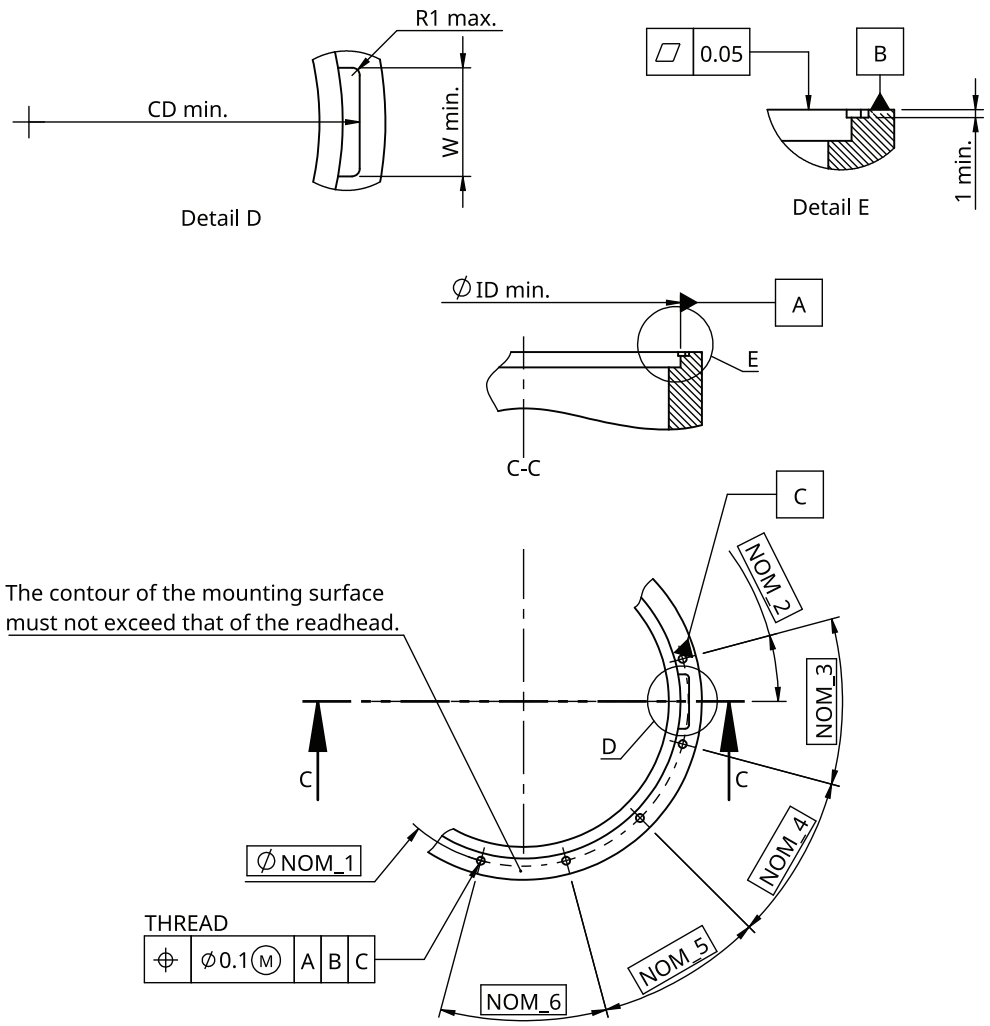
Alternative mounting methods
Refer to the **MRAD01** data sheet for detailed guidance on all alternative mounting options, including press-fit and adhesive bonding.

Shaft design recommendations



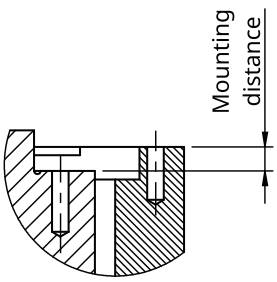
Ring type	**OD (shaft)** [mm]	**Thread** [min]	**Nom_1** [mm]	**Nom_2** [°]
MRA022BG010DHN00	10	-	-	-
MRA029BC010DHH00	10	4 × M2 ↧ 6	15	4 × 90
MRA029BG018DHN00	18	-	-	-
MRA039BC020DHH00	20	4 × M2 ↧ 6	25	4 × 90
MRA039BG025DHN00	25	-	-	-
MRA049BC025AHH00	25	4 × M2.5 ↧ 7	31	4 × 90
MRA049BG034AHN00	34	-	-	-
MRA053BC030AHH00	30	8 × M2.5 ↧ 7	36	8 × 45
MRA053BG040AHN00	40	-	-	-
MRA064BC040AHH00	40	8 × M2.5 ↧ 7	46	8 × 45
MRA064BG051AHN00	51	-	-	-
MRA080BC055AHH00	55	8 × M2.5 ↧ 7	61.5	8 × 45
MRA080BG064AHN00	64	-	-	-
MRA115BC090AHH00	90	8 × M2.5 ↧ 7	97	8 × 45
MRA115BG100AHN00	100	-	-	-
MRA150JF125AGH00	125	8 × M2.5 ↧ 7	132	8 × 45

Readhead mounting surface design recommendations



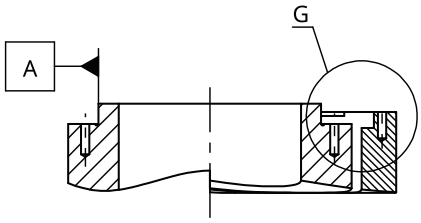
Readhead	Thread [min]	Nom_1 [mm]	Nom_2 [°]	Nom_3 [°]	Nom_4 [°]	Nom_5 [°]	Nom_6 [°]	ID [mm]	CD [mm]	W [mm]
MC022	3 x M1.6 ↧ 4.2	24	45	90	90	-	-	22	14.5	12.5
MC029	3 x M2 ↧ 5.5	33.3	48.5	97	131.5	-	-	29.5	17.7	14.5
MC039	4 x M2 ↧ 5.5	49	22	60	60	60	-	40	23	13.8
MC049	5 x M2 ↧ 5.5	54	23	45	45	45	45	50	27.5	13
MC053	3 x M2 ↧ 5.5	66	20	60	60	-	-	56	31	18
MC064	4 x M2 ↧ 5.5	69	20	40	52	40	-	64.5	34.8	14.5
MC080	4 x M2 ↧ 5.5	85	15	30	30	30	-	80.5	42.7	14
MC115	4 x M2 ↧ 5.5	120	10	20	20	20	-	115.5	60	13
MC150	4 x M2 ↧ 5.5	158	7.5	15	15	15	-	153	78	13.3

Mounting distance

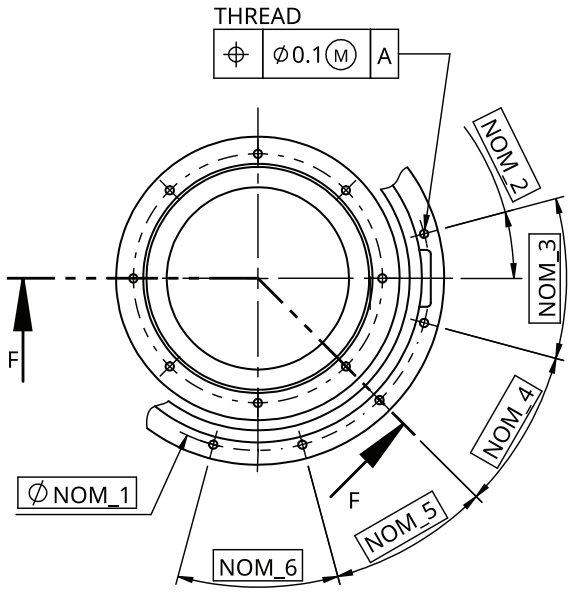


Detail G

Ring type	Mounting distance [mm]
Ring OD ≤ 29	2.9 ±0.15
Ring OD 39	2.88 ±0.13
Ring OD ≥ 49	$2.95\ ^{+0.25}_{-0.20}$
Ring OD 150	$6.75\ ^{+0.25}_{-0.20}$



F-F



Axial position adjustment (ride height)

The distance between the sensor and the ring should be as shown on the dimension drawings of encoder assemblies. Using the gold-plated surface on the bottom as a reference surface for mounting the readhead is recommended. If the top side of the readhead is used as a reference surface, note that the thickness tolerance of the readhead must be taken into account. Also make sure that the signal traces and components are not in contact with mechanical assembly. Optionally, you may also use **shims** for height adjustment of the readheads.

The integrated LED can be used as an indicator. If the ride height is within the installation tolerances, the indicator LED will be green and will not change when the ring rotates. The center of the ring and the center of the readhead arc must be coaxial. The permissible installation tolerances are given in the table below. Precise centering of the ring is essential, as the eccentricity of the ring mounting plays a major role in the overall accuracy.

Installation tolerances (readhead to ring)

Axial displacement / ride height	See detail A on **dimension drawings** of encoder assemblies. Tight ride height (tight mounting distance) is recommended. **Increasing the ride height exponentially increases encoder noise even if it is within installation tolerances.**	
Tangential displacement of the readhead	From MC022 to MC039: ±0.3 mm From MC049 to MC150: ±0.5 mm	
Radial displacement of the readhead	MC022: ±0.1 mm MC029: ±0.3 mm MC039: ±0.4 mm From MC049 to MC150: ±0.5 mm	
Non-parallel mounting	Tilt angle <0.2°	

For additional information about installation types and ring properties, refer to the MRAD01 data sheet, available at **RLS Media center**.

AksIM-4 installation video

Measuring ride height between the ring and the readhead

For a ready-to-use ride height (air gap) measurement, connect the encoder to a PC via the E201 interface and view the value directly using the RLS software. For more information, refer to the chapter **Accessories**.

The signal level information read out via communication interface can be used to calculate the ride height (distance between rubber on the ring and sensor on the readhead).

The value is proportional to the distance between the sensor and the ring. To calculate the real distance use the following formula:

Ride height = K × Ln (SignalLevel) + N

Ln stands for natural logarithm.
K and N are depending on the encoder size and can be read from the register access*
SignalLevel value can be read from the register access*
Calculated ride height has tolerance of ±20 µm.
* Refer to the **APP13** (BiSS C) and **APP14** (SPI EncoLink), available at **RLS Media center**.

Self-calibration after installation

The self-calibration function eliminates the error caused by eccentricity, which is a dominant contributor to the accuracy of the encoder and is caused by the eccentric mounting of the ring. It cannot compensate for the magnetisation error between different rings. The Subdivisional Error (SDE) is negligible with AksIM. This function removes the error from one sine wave per revolution.

The self-calibration function can be initiated by the user either:

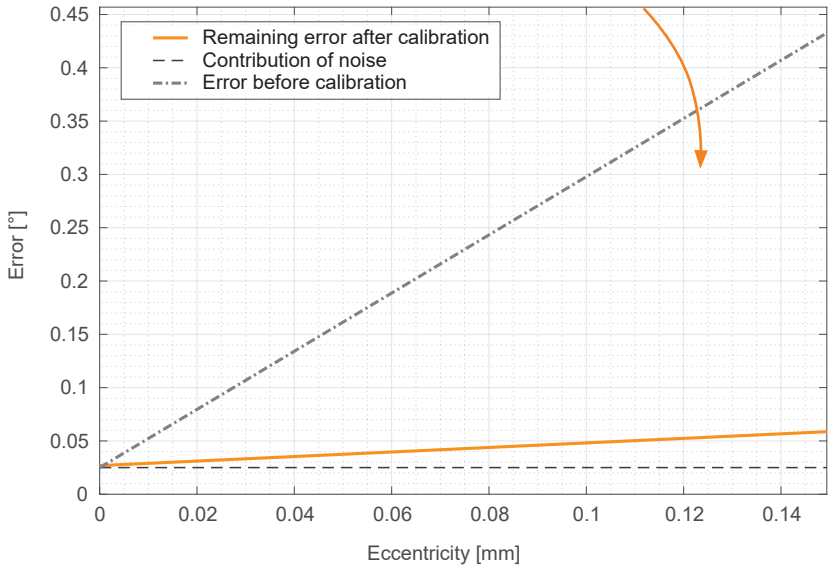
- via a supported communication interface (refer to the **APP13** for BiSS C and **APP14** for SPI EncoLink), or
- using the appropriate **RLS USB encoder interface.**

Not available with SSI outputs. Refer to the description of the selected communication interface for details. Requirements:

- Free mechanical rotation of 360°
- Good signal over the entire calibration angle (no warnings or errors).
- Default time available is 10 seconds. Desired time (up to 40 seconds) can be set via the communication interface.
- Variation of direction and speed are not important. Minimum speed is 6 RPM.
- Suitable communication interface or adapter that enables the function to be triggered.

The graph below shows how much the accuracy of the encoder can be improved with the self-calibration function.
The remaining minimum accuracy is influenced by magnetisation variations and noise of the readhead.

For typical accuracy values after self-calibration, refer to the chapter **Technical specifications.**



When the self-calibration process is complete, fast-flashing LED indicates whether the process was successful.

LED		Self-calibration status
🟢🟢🟢🟢🟢	Green flashing fast	Self-calibration successfully performed.
🟠🟠🟠🟠🟠	Orange flashing fast	Ring positioning is already perfect - correction was not performed. Status bit 0x20 is set.
🔴🔴🔴🔴🔴	Red flashing fast	Input parameter out of range. Status bit 0x10 is set. Eccentricity or radial offset is very high. Status bit 0x08 is set. Timeout. Ring is rotating too slowly (<6 RPM). Status bit 0x04 is set.

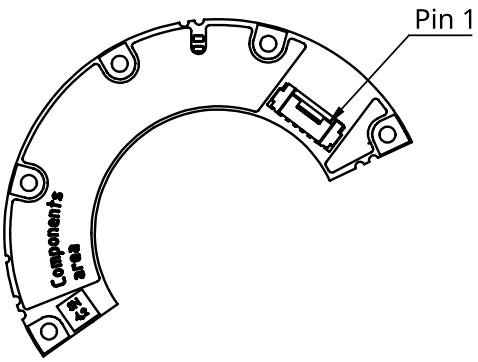
Explainer video: AksIM-4 self-calibration feature

Electrical connections

Pinout

Refer to the chapter **Dimension and installation drawings** for Pin 1 location. Images represent the size 080 encoder example.

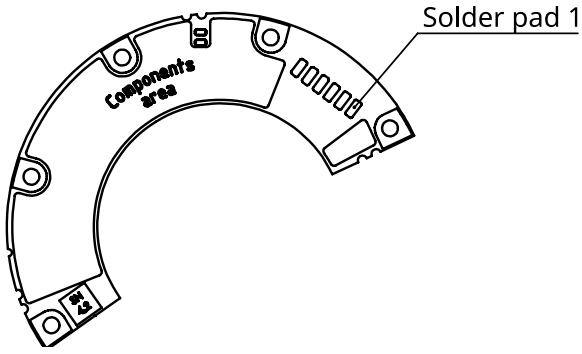
Connector pin / Soldering pads	BiSS C	SPI	SSI
1	5 V supply	5 V supply	5 V supply
2	0 V (GND)	0 V (GND)	0 V (GND)
3	MA+	SCK	Clock+
4	MA–	NCS	Clock–
5	SLO+	MISO	Data+
6	SLO–	MOSI	Data–



6-pin low profile locking connector
Molex MicroLock (P/N: 5055670671) - horizontal

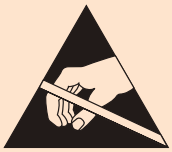
Counterpart mating connector:
Molex MicroLock (P/N: 5055650601)

Connector locking features
Make sure to use original parts that comply with these features.



Soldering pads
Dimensions: 2.54 mm x 1.14 mm
Pitch : between 1.7 mm and 2 mm

Soldering of the wires to the encoder must comply with IPC-A-610 Class 2 or 3 (or similar). Improper soldering will void the warranty.



Readhead is ESD sensitive - handle with care.
Do not touch electronic circuit, wires or sensor area without proper ESD protection or outside of ESD controlled environment.

Status indicator LED

The LED provides visual feedback on signal strength, error status, and is used for setup and diagnostics.
Flashing LED indicates that power is being supplied to the encoder, but communication has not been established.
When communication is running at a rate of at least 5 readings per second, LED will be constantly lit.
On encoder startup the LED briefly flashes red or orange. This is intended function for testing the LED.

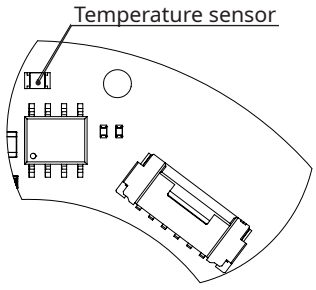
LED signal		Status
●	Green	Normal operation; position data is valid.
●	Orange	Warning; position is valid, but the resolution and/or accuracy might be out of specification. Some operating conditions are outside limits.
●	Red	Error; position data is not valid.
● ● ● ● ● ●	Slow flashing	Communication has not been established. Position was not requested within last 200 ms. Color of flashing - see above.
○	No light	No power supply.
● ● ● ● ●	Continuously fast flashing red	System error during start-up or operation.
● ● ● 3 s ● ● ● 3 s ● ● ● 3 s	3 sec. fast flashing	Self-calibration result - refer to the chapter **Self calibration after installation.**

The LED signal statuses listed in the table above do not indicate non-optimal installation of the readhead, e. g. an accuracy outside the specified range. To ensure optimal installation, it is recommended to verify the ride height with the diagnostic tool (E201)

Integrated temperature sensor

Encoders have integrated temperature sensor which can be accessed via register access. For more information, refer to the **APP13** (BiSS C) and **APP14** (SPI EncoLink) available at **RLS Media center**.

It provides temperature monitoring in applications such as electric motors, gearboxes, etc. where precise monitoring is required in the vicinity of the encoder.



The image does not represent all the variants.

Communication protocols

The following data is common to all communication protocols; each protocol is described separately in the subsequent chapters.

Detailed status

Bit	Status	Description
b15	Reserved	
b14	Warning	Temperature out of range. The readhead temperature is out of specified range (T_{min}, T_{max}).
b13	Warning	Signal amplitude low. The distance between the readhead and the ring is too large.
b12	Warning	Signal amplitude high. The readhead is too close to the ring.
b11	Warning	Signal decoding below certain threshold - position decoding might be inaccurate or fail.
b10	Warning	Overspeed. Ring rotation speed is too high.
b9	Error	Multiturn counter error (value always 0 when singleturn option is selected).
b8	Error	Acceleration error. The position data changed unexpectedly. A stray magnetic field is present or metal particles are present between the readhead and the ring.
b7	Error	Magnetic pattern error. A stray magnetic field is present or metal particles are present between the readhead and the ring or radial positioning between the readhead and the ring is out of tolerances.
b6	Error	Signal lost. The readhead is out of alignment with the ring or the ring is damaged.
b5	Error	Signal amplitude too high. External magnetic field is present.
b4	Error	System error. Malfunction inside the circuitry. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b3	Error	Internal power supply error
b2	Error	System error. Inconsistent calibration data is detected. To reset the System error bit try to cycle the power supply while the rise time is shorter than 20 ms.
b1	Reserved	
b0	Reserved	

Encoder programming

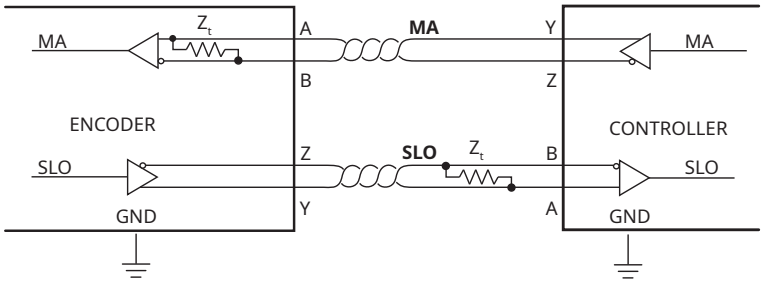
For certain communications encoder supports register access which allows setting zero position, running self-calibration function, configuring the encoder, reading signal level indicator, temperature and detailed status bits. For more information refer to the **APP13** (BiSS C) and **APP14** (SPI EncoLink) available at RLS Media center or **contact RLS.**

BiSS C interface

Encoder position in up to 22 bit natural binary code and encoder status are available via the BiSS C protocol. The position data is followed by two status bits (active low) followed by CRC (inverted).

BiSS is implemented for point-to-point operation, multiple slaves are not supported. Communication is bidirectional, the readhead is user programmable. Additional data can be read from the readhead.

Electrical connection

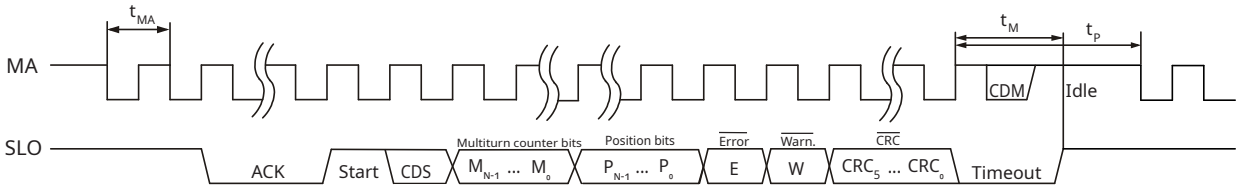


The signal MA is Master Clock with a maximum frequency of 5 MHz and SLO is Slave Out, whose data is transmitted on the rising edges on the line MA. The MA and SLO lines are 5 V RS422 compatible differential pairs. The RC termination on the MA line is built into in the encoder. If the total cable length exceeds 5 m, termination on the controller is required. The nominal impedance of the cable should be 120 Ω.

Output protection

Excessive output current and power dissipation caused by faults or bus conflicts are prevented by two mechanisms. A foldback current limit at the output stage provides immediate protection against short circuits. In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state, if the chip temperature becomes too high.

BiSS C timing diagram



Data package description

Data	Length (N)	Description
M_{N-1} - M_0	16 bits	Multiturn counter value (length 0 when single turn option is selected)
P_{N-1} - P_0	17 bits to 22 bits	Absolute position inside one revolution
E	1 bit	Error status bit; inverted
W	1 bit	Warning status bit; inverted
CRC_5 - CRC_0	6 bits	Cyclic redundancy check; polynomial 0x43; inverted

Communication parameters

Parameter	Symbol	Min	Typ	Max
MA period	t_{MA}	200 ns		2.5 µs
MA frequency	$f_{MA} = 1/t_{MA}$	400 kHz		5 MHz
ACK length	ACK		13 bits	
Transfer timeout	t_M		13 µs	
Pause time	t_P	$t_M + 1$ µs		
Latency			2 µs	5 µs
Mechanical bandwidth*				12.5 kHz
Mechanical sample rate				25 kHz
Maximum request rate				44 kHz (singleturn)

* AksIM samples at 25 kHz, so mechanical changes faster than 12.5 kHz cannot be detected at the output (Nyquist theorem). If the position request comes faster than the sampling frequency, the encoder recalculates the position at the time of the request based on the current ring velocity.

If number of clocks from master is less than specified, SLO within timeout is not necessarily in low state.

First valid frame is expected after encoder set-up time.

The request cycle starts with MA in idle state (MA is high). Its first falling edge initiates communication. The encoder responds by setting SLO to low on the second rising edge on the MA line and generating the ACK signal (Acknowledge). When the encoder is ready for the next request cycle, it indicates this to the master by setting SLO to high. The absolute position and the CRC data are available in binary format and are initially transmitted in MSB format.

Encoder data packet structure

For singleturn

Bit	Status	Description
b28 : b8	Encoder position	MSB first (for 21 bit resolution)
b7	Error	If low, the position data is not valid.
b6	Warning	If low, the position data is valid, but some operating conditions are close to limits.
b5 : b0		Inverted CRC, calculated by using 0x43 polynomial

When error is active (error bit is low) singleturn position data (b28 : b8) is replaced (b23 : b8) by detailed status bits. Refer to the chapter **Detailed status**. In case of active warning, position data is valid.

For multiturn

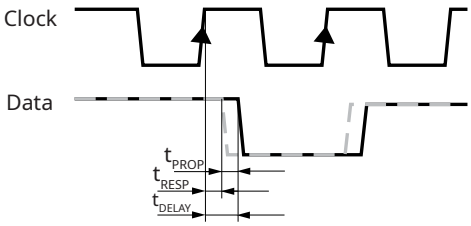
Bit	Status	Description
b44 : b29	Multiturn counter	
b28 : b8	Encoder position	MSB first (for 21 bit resolution)
b7	Error	If low, the position data is not valid.
b6	Warning	If low, the position data is valid, but some operating conditions are close to limits.
b5 : b0		Inverted CRC, calculated by using 0x43 polynomial

Cable length compensation

The readhead needs 60 ns to respond to incoming clocks (t_{RESP}). The change on the Data signal is delayed by 60 ns after the rising edge on the Clock line. An additional delay is caused by the time the signal takes to propagate through the cable to the readhead and back (t_{PROP}). This delay is typically 14 ns per 1 meter cable. The total cable length from the encoder to the receiver must be considered.

The total delay (t_{DELAY}) is calculated as in the formula below.

A proper implementation of BiSS Master should automatically measure t_{DELAY} and adjust the internal timing to compensate for it. BiSS Master without compensation for cable delay will work even with short wiring (up to 1 meter at 5 MHz clock frequency).

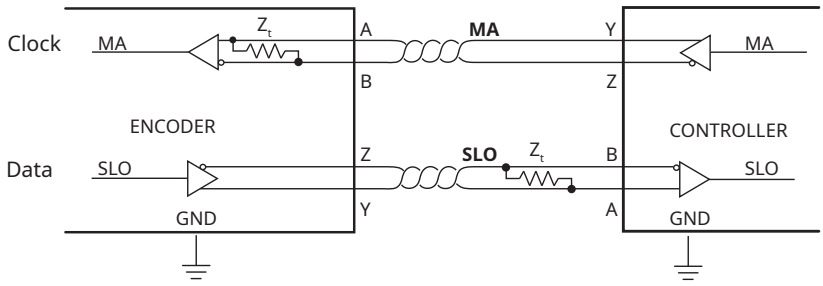


$$t_{DELAY} = t_{RESP} + t_{PROP} \times \text{cable length}$$

SSI - Synchronous serial interface

The encoder position in natural binary code and the encoder status are available via the SSI protocol. The SSI interface is not recommended for closed-loop applications and motor feedback because of the low update speed and the noticeable latency.

Electrical connection

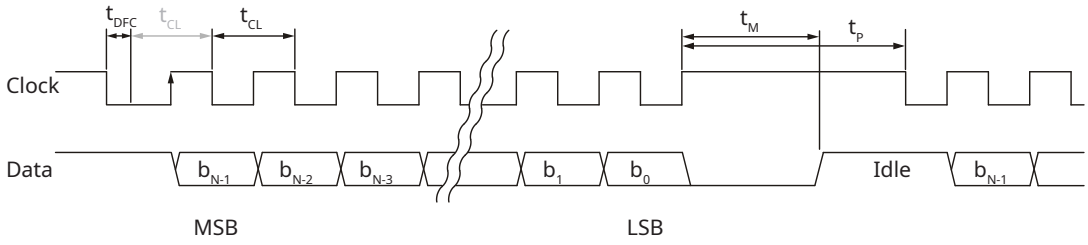


The Clock and Data signals are 5 V RS422-compatible differential pairs with RC termination within the readhead. If the total cable length is more than 5 m, termination on the controller is required. The nominal impedance of the cable should be 120 Ω.

Output protection

An excessive output current and power dissipation caused by errors or bus conflicts are prevented by two mechanisms. A foldback current limit on the output stage provides immediate protection against short circuits. In addition, a thermal shutdown circuit forces the driver outputs into a high-impedance state, if the chip temperature becomes too high.

SSI timing diagram

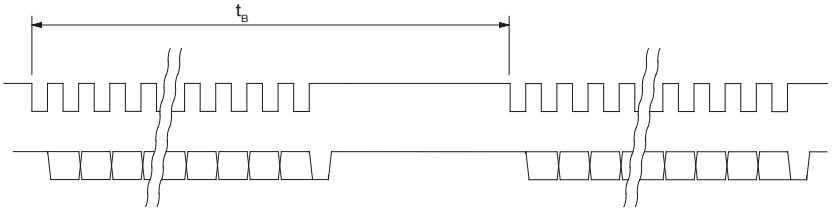


The controller requests the position and status data of the encoder by sending a pulse train to the Clock input. The Clock signal always starts from high. The first falling edge of the Clock latches the last position data available and on the first rising edge of the Clock the most significant bit (MSB) of the position is transmitted to the Data output. The Data output should then be read on the following falling or rising edge. On subsequent rising edges of the Clock signal the next bits are transmitted.

After the transmission of the last bit the Data output goes to low. When the t_M time expires, the Data output goes high. The Clock signal must remain high for at least t_P before the next reading can take place.

While reading the data, the half of a Clock period t_{CL} must always be less than t_M. However, reading the encoder position can be terminated at any time by setting the Clock signal to high for the duration of t_M.

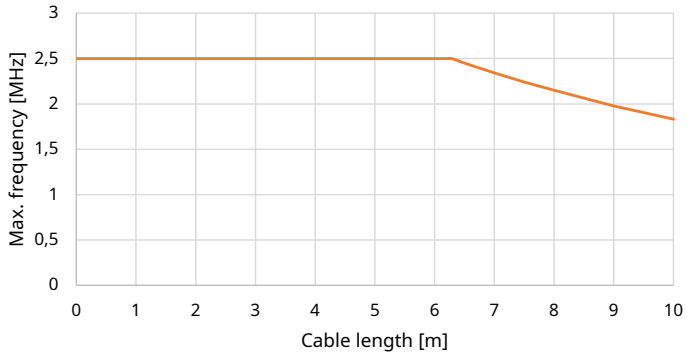
To allow updating of the position data at least t_B should pass between two subsequent readings. If the reading request arrives earlier than t_B after the previous reading, the encoder position will not be updated.

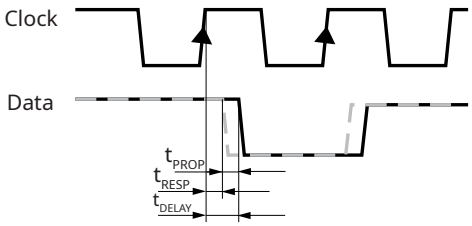


The power supply must be applied at least 100 ms before the clock sequence is being sent to the encoder.

Maximum frequency

The readhead takes 60 ns to respond to incoming clocks (t_{RESP}). Change on Data signal is delayed for 60 ns after the rising edge on Clock line. An additional delay is caused by the time the signal takes to propagate through cable to the readhead and back (t_{PROP}). This delay is typically 14 ns per 1 meter cable. The clock frequency must be reduced with a longer cable. The total cable length from the encoder to the receiver must be considered.





$t_{DELAY} = t_{RESP} + t_{PROP}$ x cable length

Listed cable propagation delay is valid for ACC091 and ACC093.

If the cable length is longer than 6 m, max frequency must be adjusted to the graph above.

Communication parameters

Parameter	Symbol	Min	Typ	Max
Delay first clock	t_{DFC}	1 µs		10 µs
Clock period	t_{CL}	2 µs		20 µs
Clock frequency	f_{CL}	80 kHz		500 kHz (2.5 MHz*)
Timeout (monoflop time)	t_M		20 µs	
Pause time	t_P		t_M + 2 µs	
Readhead response delay	t_{RESP}		60 ns	
Latency				32 µs

* With *Delay First Clock* function on the controller.

Encoder data packet structure

For singleturn

Bit	Status	Description
b37 : b18	Encoder position	MSB first (this is a 20 bit encoder example).
b17	Error	If set, the position data is not valid.
b16	Warning	If set, the position data is valid, but some operating conditions are close to limits.
b15 : b0	Detailed status	

When error is active (error bit is set) then singleturn position data is replaced by detailed status bits. Refer to the chapter **Detailed status**. In case of active warning, position data is valid.

For multiturn

Bit	Status	Description
b53 : b38	Multiturn counter	MSB first (this is for a 20 bit encoder example).
b37 : b18	Encoder position	MSB first (this is a 20 bit encoder example).
b17	Error	If set, the position data is not valid.
b16	Warning	If set, the position data is valid, but some operating conditions are close to limits.
b15 : b0	Detailed status	

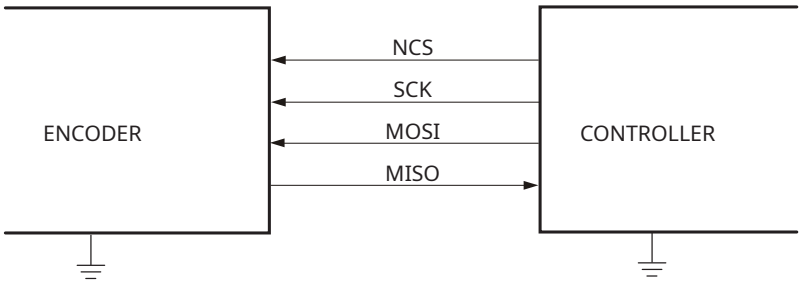
SPI EncoLink interface

The Serial Peripheral Interface (SPI) bus is a four-wire bidirectional synchronous serial communication interface, typically used for short distance communication. It operates in full duplex mode, where master (controller) selects the slave with NCS line, generates clock signal on SCK line, sends command over MOSI line and receives data over MISO line.

All data signals are 3.3 V LVTTL. Inputs are 5 V tolerant. The maximum current sourced or sunk from signal lines should not exceed 5 mA. Single-ended signals should be as short as possible, especially when high frequencies are used.

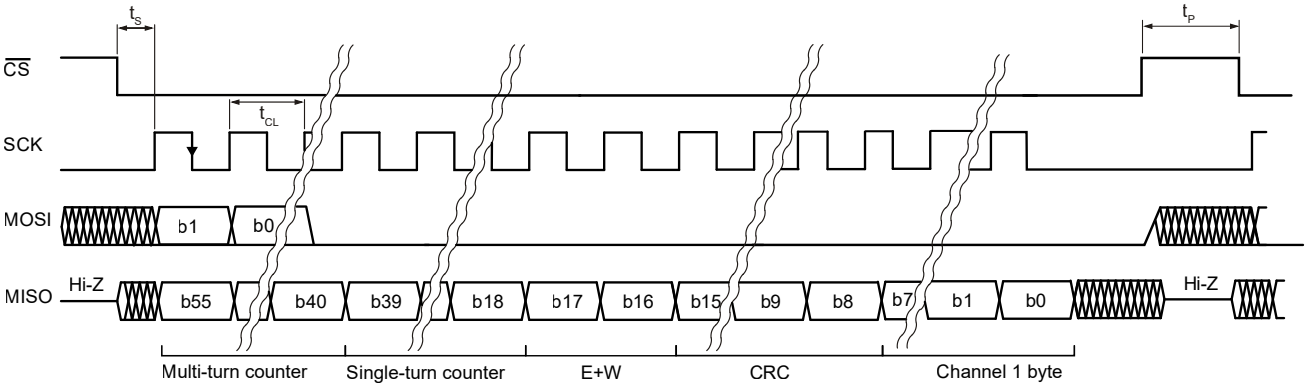
Signal termination: 100 Ω resistors are added in series with all SPI signals.

Electrical connection



Signal	Description
NCS	Active low. NCS line is used for synchronisation between master and slave devices. During communication it must be held low. Idle is high. When NCS is high, MISO line is in high-Z mode. This allows connection of multiple slaves in parallel, sharing all lines except NCS.
SCK	Serial clock. Shifts out the data on rising edge. Data is stable and valid on falling edge.
MOSI	Master output ⟶ Slave input. Command from the controller to encoder.
MISO	Master input ⟵ Slave output. Data is output on rising edge on SCK after NCS low. When NCS is high, MISO line is in high-Z mode.

SPI timing diagram



The controller starts the communication by setting the NCS signal low. A delay of t_S is required to allow the encoder to prepare the data which is then shifted to MISO output on rising edges of clock signal SCK.
Encoder Position and General Status (active low) data is transmitted, followed by CRC (inverted) of the entire data packet.

Communication parameters

Parameter	Symbol	Min	Typ	Max
NCS to SCK delay	t_S	2 µs		
Clock frequency	f_{SCK}			6 MHz*
Pause time (NCS high)	t_P	2 µs		
Sampling rate				50 kHz
Latency			2 µs	5 µs
SPI settings	CPOL= 0 (clock idle is low)			
	CPHA = 1 (data is output on clock rising edge and sampled on clock falling edge)			

* With 500 mm cable or less.

SPI data structure

Data sent by the master on the MOSI line (b15:b0):

Byte	B1	B2
Bits	b15..b8	b7..b0
Data length	8 bits	8 bits
Contents	Command 0x00*	Data

Command and Data values should be always 0x00 if EncoLink register access is not in use.

* Special commands:
  0xAA Reset EncoLink channels
  0xBB Request Version information from encoder

Command 0x00 (Singleturn variant of the encoder)

Data received over the MISO line contain:

Bytes	Bits	Data length	Contents
B1, B2, B3	b39..b18	Singleturn resolution*	Encoder position / Detailed status (If b17 (General Error) is 0 (active) then position data is replaced by **Detailed status**.)
	b17	1 bit	Error (active low)
	b16	1 bit	Warning (active low)
B4	b15..b8	8 bits	CRC (inverted)
B5	b7..b0	8 bits	EncoLink register access (If EncoLink register access is not used, the last byte can be ignored and the SPI transaction ended after B4.)

* Encoder position is binary, left aligned, MSB first. Remaining bits are set to zero

Command 0x00 (Multiturn variant of the encoder)

Data received over the MISO line contain:

Bytes	Bits	Data length	Contents
B1, B2	b55..b40	16 bits	Multiturn
B3, B4, B5	b39..b18	Singleturn resolution*	Encoder position / Detailed status (If b17 (General Error) is 0 (active) then position data is replaced by Detailed status.)
	b17	1 bit	Error (active low)
	b16	1 bit	Warning (active low)
B6	b15..b8	8 bits	CRC (inverted)
B7	b7..b0	8 bits	EncoLink register access (If EncoLink register access is not used, the last byte can be ignored and the SPI transaction ended after B6.)

* Encoder position is binary, left aligned, MSB first. Remaining bits are set to zero

General status (next to Encoder position)

Bit	Status	Description
b17	Error	If bit is reset, position is not valid. Red LED.
b16	Warning	If bit is reset, encoder is near operation limits. Position is valid. Resolution and/or accuracy might be lower than specified. Orange LED.

Detailed status

Refer to the chapter **Communication protocols**.

Error behavior and internal encoder speed measurement

Each time the Error bit is reset, the internal speed is invalidated and is set to 0.

Three consecutive encoder cycles after the error condition has been cleared (Error bit set), the calculated speed is valid again.

CRC check

Length: 8 bits
Polynomial: 0x97
Value is inverted.

CRC calculation example is in application note CRCD01, available for download at **RLS media center.**

Command 0xBB (Encoder identification request)

Request Version information from encoder: Encoder returns 19 bytes, presented in the table below.

Byte	Description	Value
B1	Protocol version	4 = Encolink v4
B2	Number of bytes in communication frame	5/7 bytes in communication frame (see command 0x00)
B3..B18	Part number	Refer to **Part numbering**
B19	CRC	Inverted

EncoLink Register access

Encoder supports running self-calibration function, reading signal level value, temperature, detailed status bits, identification information and other diagnostic values. Additional functions are available with use of EncoLink libraries. **Contact RLS** for details.
To access EncoLink registers it is recommended to use **EncoLink library** provided by RLS.
The self-calibration function and the description of the other registers can be found in APP14 application note, available for download at **RLS media center.**

> Make sure that you only execute commands that store parameters in non-volatile memory if the ambient temperature is below 105 °C.

Persistent detailed status

The EncoLink register 0x000A accumulates all status bits that were active during encoder operation in each internal encoder cycle, even if communication is not active. The format of the data is the same as standard Detailed status register.

Clearing the Persistent status register is performed by writing value 0x62 into Command register 0x00BD.

Part numbering

Readhead

MC 049 DC B 21B T M D 00

Series

MC - AksIM-4 board-level readhead

MRA ring compatibility

022 - For use with MRA022 ring
029 - For use with MRA029 ring
039 - For use with MRA039 ring
049 - For use with MRA049 ring
053 - For use with MRA053 ring
064 - For use with MRA064 ring
080 - For use with MRA080 ring
115 - For use with MRA115 ring
150 - For use with MRA150 ring

Communication protocol

DC - BiSS C, RS422
SC - Synchronous serial interface (SSI), RS422
SP - SPI (Serial peripheral interface), LVTTL

Communication protocol variant

For **DC**: **B** - BiSS-C, bidirectional, 13 ACK bits, with register access
For **SC**: **B** - First bit and idle line: logic 1 (high)
For **SP**: **M** - SPI, EncoLink, with register access

Resolution

Singleturn counter options

17B - 17 bits per revolution
18B - 18 bits per revolution
19B - 19 bits per revolution
20B - 20 bits per revolution
21B - 21 bits per revolution
22B - 22 bits per revolution

Multiturn counter options

17M - 17 bits per revolution + 16 bits multiturn counter
18M - 18 bits per revolution + 16 bits multiturn counter
19M - 19 bits per revolution + 16 bits multiturn counter
20M - 20 bits per revolution + 16 bits multiturn counter
21M - 21 bits per revolution + 16 bits multiturn counter
22M - 22 bits per revolution + 16 bits multiturn counter

PCB shape, mounting and connector orientation

E - Partial arc, tangential connector exit, ring OD < 049
F - Full circle, radial connector exit
T - Partial arc, radial connector exit, ring OD ≥ 049
U - Partial arc, tangential connector exit

Connector option

M - Molex MicroLock Plus 1x6 Right Angle connector (MFG P/N: 5055670671)
P - Soldering pads

Option

D - –40 °C to +105 °C, ultra high vacuum and high pressure (up to 600 bar), revision 1A
F - –40 °C to +125 °C, ultra high vacuum and high pressure (up to 600 bar), revision 1A

Special requirements

00 - No special requirements (standard)
11 - Conformal coating - **contact RLS** for availability

Not all part number combinations are valid. Refer to the table of available combinations on the next page.

Table of available combinations

Series	Ring compatibility	Communication interface	Communication interface variant	Resolution	Shape & connector orientation	Connector option	Option	Special requirements
MC	022	DC	B	17B / 17M / 19B / 19M	F	M / P	D / F*	00
		SC						
		SP	M					
	029	DC	B					
		SC						
		SP	M					
	039	DC	B	18B / 18M / 20B / 20M	E			
		SC						
		SP	M					
	049	DC	B	18B / 18M / 21B / 21M	T			
		SC						
		SP	M					
	053	DC	B	19B / 19M / 22B / 22M	U			
		SC						
		SP	M					
	064	DC	B		T			
		SC						
		SP	M					
	080	DC	B	20B / 20M / 22B / 22M				
		SC						
		SP	M					
	115	DC	B					
		SC						
		SP	M					
	150	DC	B					
		SC						
		SP	M					

* For connector option "P" only.

Magnetic ring

MRA **049** **B** **C** **025** **A** **H** **H** **00**

Series

MRA - AksIM magnetic ring

Outer diameter and readhead compatibility

022 - 22 mm
029 - 29 mm
039 - 39 mm
049 - 49 mm
053 - 53 mm
064 - 64 mm
080 - 80 mm
115 - 115 mm
150 - 150 mm

Thickness

B - 2.0 mm
J - 5.8 mm

Installation type

C - Countersunk holes (use flat-head fasteners DIN 965 / 7046)
F - Flat-bottom counterbored holes (use socket head fasteners DIN 912)
G - Installation by adhesive bonding or press fit, as specified for each ring part number; for details refer to the MRAD01 data sheet, available at **RLS Media Center**.

Inner diameter

010 - 10 mm
018 - 18 mm
020 - 20 mm
025 - 25 mm
030 - 30 mm
034 - 34 mm
040 - 40 mm
051 - 51 mm
055 - 55 mm
064 - 64 mm
090 - 90 mm
100 - 100 mm
125 - 125 mm

Magnetization type

A - Magnetization type 1, ring OD ≥ 049
D - Magnetization type 2, ring OD < 049

Material

H - Stamped metal plate with glued HNBR rubber
G - Machined stainless steel hub with glued HNBR rubber

Zero marking

H - Hole
N - None

Special requirements

00 - No special requirements (standard)

Not all part number combinations are valid. Refer to the table of available combinations on the next page.

Table of available combinations

Series	Outer diameter and readhead compatibility	Thickness	Installation type	Inner diameter	Magnetization type	Material	Zero marking	Special requirements
MRA	022	B	G	010	D	H	N	00
	029		C	010			H	
			G	018			N	
	039		C	020			H	
			G	025			N	
	049		C	025	A		H	
			G	034			N	
	053		C	030			H	
			G	040			N	
	064		C	040			H	
			G	051			N	
	080		C	055			H	
			G	064			N	
	115		C	090			H	
			G	100			N	
	150	J	F	125		G	H	

Accessories



Cable assembly, 1 m
ACC093



Cable assembly, 1 m
ACC091



USB interface (for BiSS C communication interface)
E201-9B



Magnet viewer
MM0001



USB interface (for SPI EncoLink communication interface)
E201-9P



Shims for height adjustment of the readheads
MC-ACC

For technical details about cable assemblies and pinout, refer to the chapter **Cable assemblies.**

Packaging

There are two packaging options. Less than 20 products are packed individually in an antistatic box. If more than 20 systems are ordered, the parts are packed in antistatic plastic trays. Magnetic rings and readheads are packed separately.

Bulk packaging:

Readheads		
Part	**Tray size**	**Box size**
MC022	34 units per tray	12 trays per box
MC029	24 units per tray	11 trays per box
MC039	16 units per tray	
MC049	18 units per tray	
MC053	18 units per tray	
MC064	18 units per tray	
MC080	20 units per tray	
MC115	20 units per tray	
MC150	22 units per tray	12 trays per box

Magnetic rings		
Part	**Tray size**	**Box size**
MRA022	45 units per tray	10 trays per box
MRA029, MRA039	10 units per tray	12 trays per box
MRA049BC	10 units per tray	15 trays per box
MRA049BG	14 units per tray	11 trays per box
MRA053BC	10 units per tray	15 trays per box
MRA053BG	10 units per tray	7 trays per box
MRA064BC, MRA064BG	5 units per tray	15 trays per box
MRA080BC	5 units per tray	15 trays per box
MRA080BG	5 units per tray	14 trays per box
MRA115	2 units per tray	7 trays per box
MRA150	NA	1 tray per box

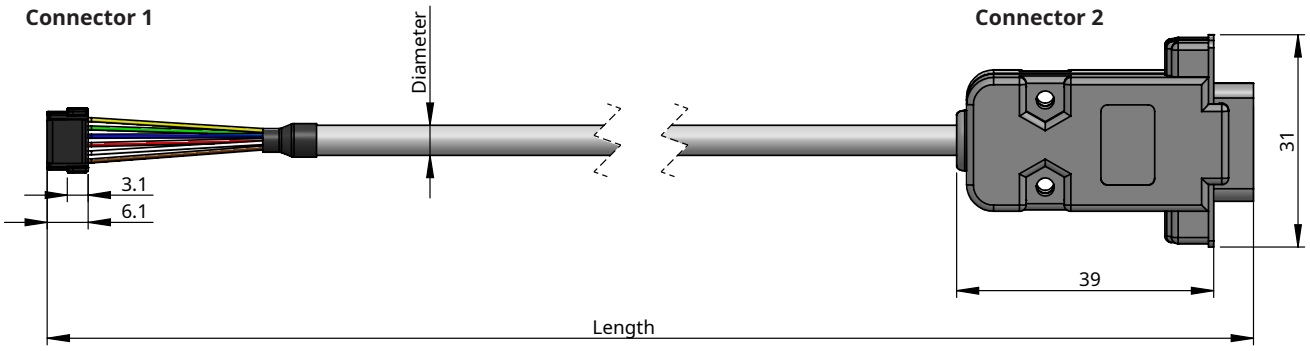
Cable assemblies

Cable specifications

Part numbers		ACC091 (cable length: 1.0 m), ACC093 (cable length: 1.0 m)
Compatible readhead		Every readhead with connector option "M"
Cable type		LiYCY (twisted pairs, shielded, up to +75 °C)
Connector 1		Molex MicroLock (P/N: 5055650601)
Connector 2		Flying leads (ACC091) DSUB-9 M (ACC093)
Configuration		4 × 2 × 0.14 mm² (twisted pairs, shielded, up to +75 °C)
Diameter		6.2 mm
Rated voltage		350 V
Temperature	**Operating**	–40 °C to +75 °C (fixed) –5 °C to +70 °C (bending)
	Storage	–40 °C to +80 °C
Environmental compliance		RoHS and REACH compliant Flame-retardant according IEC 60332-1-2 Approvals based on VDE 0812 Classification ETIM 5.0 Class-ID: EC000104

Dimensions

Dimensions and tolerances in mm.



Pinout

Connector 1 Molex MicroLock	Connector 2 DSUB-9 M				
Pin number		**Wire color**	**BiSS C**	**SPI**	**SSI**
	1	Shield			
1	5	Brown		5 V supply	
2	9	White		0 V (GND)	
3	2	Red	MA+	SCK	Clock+
4	3	Blue	MA–	NCS	Clock–
5	6	Green	SLO+	MISO	Data+
6	7	Yellow	SLO–	MOSI	Data–

ACC093 can be used for direct connection to E201-9B USB encoder interface.

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Document issues

Issue	Date	Page	Description
1	19. 11. 2026	-	New document

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