Data sheet
MBD01_02
Issue 2, 26th June 2019

AksIM-2 off-axis rotary absolute encoder

AksIM-2 is a non-contact high performance off-axis absolute rotary encoder designed for integration into space-constrained applications. A hollow ring, true absolute functionality and high speed operation make this encoder suitable for many applications.

The AksIM-2 encoder system consists of an axially magnetised ring and a readhead.

The encoders come with BiSS, asynchronous serial (UART), PWM or SSI communication interfaces and offer a range of binary resolutions to 20 bits per revolution.

The encoder operates from -40 °C to +105 °C with extended temperature range option and is resistant to shock and vibrations.

The AksIM-2 encoder has a built-in advanced self-monitoring function, continually checking several internal parameters. Error reporting, warnings and other status signals are available on all communication interfaces and are visualised with the on-board LED.

The AksIM-2 encoder system is suitable for use in industrial and medical applications.

A typical application is a robotic arm joint with a cable feed running through the ring or a precision gearbox where the ring is attached onto the main transmission shaft.

Custom design service for OEM integration is also available.

- True absolute system
- Custom magnetic sensor ASIC
- Self-calibration option
- No hysteresis
- Resolutions up to 20 bits
- Multiturn counter option
- High speed operation
- 9 kHz bandwidth, 44 kHz refresh rate
- Low profile, non-contact
- Built-in self-monitoring
- Integrated status LED
- BiSS, Asynchronous serial (UART), PWM or SSI
- Corrosion resistant magnetic ring
- Up to 600 bar pressure

AksIM-2 dimensions - encoder selection table

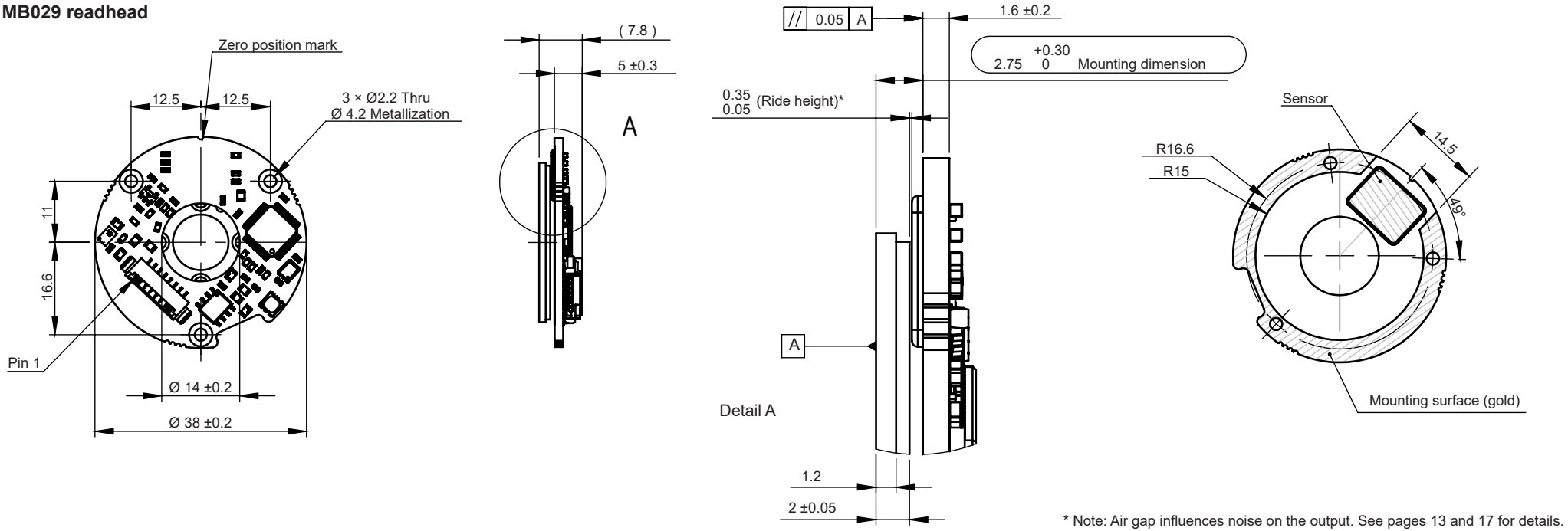
Dimensions in mm.

Part number	Ring					Readhead				Max resolution	System thickness	Mass (g)
	Inner diameter	Circle for fasteners	Outer diameter	Thickness	Inertia (kg × mm²)	Inner diameter	Circle for fasteners	Outer diameter	Arc length			
MRA029 rings and MB029 readhead												
MRA029BC010DSE00	10	15	29	2.0	0.75						7.8	5.9
MRA029GP013DMN00	12.7	none	29	7.0	1.0						12.8	9.0
MB029-F						14	35.4	38	360°	18 bit		4.5
MRA039 ring and MB039 readhead												
MRA039BC020DSE00	20	25	39	2.0	2.3						9.2	9.2
MB039-E						23	49	54	196°	19 bit		4.8
MRA049 rings and MB049 readheads												
MRA049BC025DSE00	25	31	49	2.0	5.5						7.8	15
MRA049AF025EMH00	25	31	49	3.9	13						9.7	32
MRA049BG034DSN00	34	none	49	2.0	4.8						7.8	11
MB049-D						34	54	59	190°	19 bit		4.5
MB049-E						26	54	59	138°	19 bit		4.2
MRA053 ring and MB053 readhead												
MRA053BC030DSE00	30	36	53	2.0	7.4						9.2	16
MB053-E						36	66	74	130°	20 bit		5.3
MRA064 ring and MB064 readheads												
MRA064BC040DSE00	40	46	64	2.0	15						9.2	20
MB064-D						48	69	74	140°	20 bit		6.9
MB064-E						46	80	89	130°	20 bit		6.8
MRA080 rings and MB080 readhead												
MRA080BC055DSE00	55	61.5	80	2.0	32						7.8	26
MRA080AF055EMH00	55	61.5	80	3.9	74						9.7	64
MRA080DF068DMH00	68	88	95	4.9	114						10.7	72
MB080-D						64.4	85	90	97°	20 bit		4.0

Dimensions and installation drawings

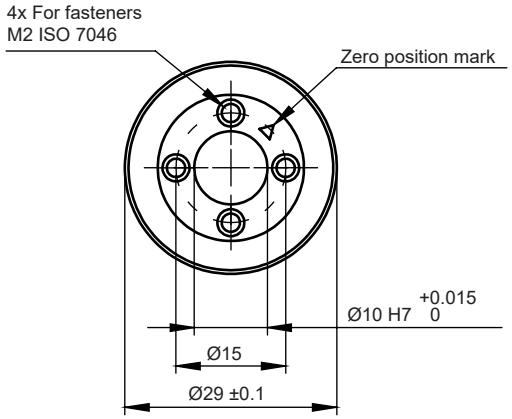
Dimensions and tolerances in mm.

MB029 readhead

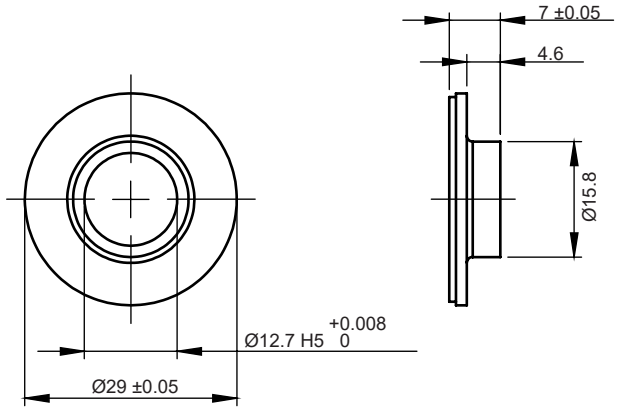


* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

MRA029BC010DSE00 ring



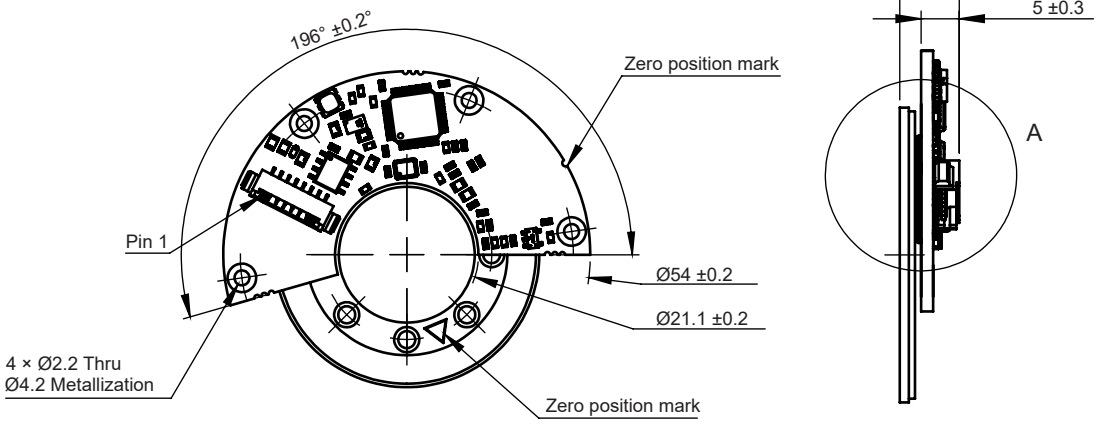
MRA029GP013DMN00 ring

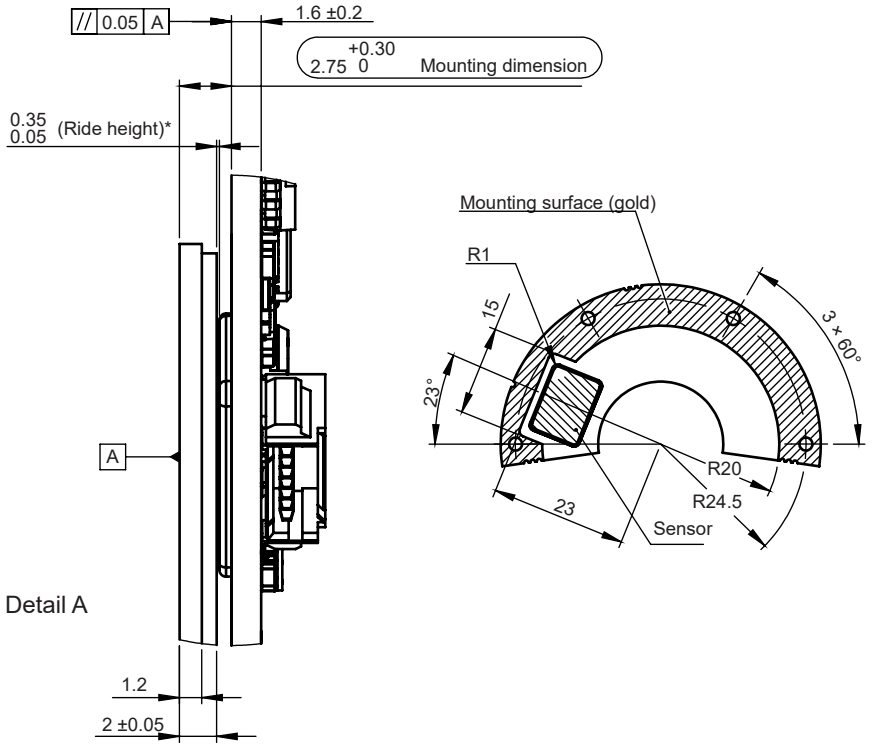


Dimensions and installation drawings continued

Dimensions and tolerances in mm.

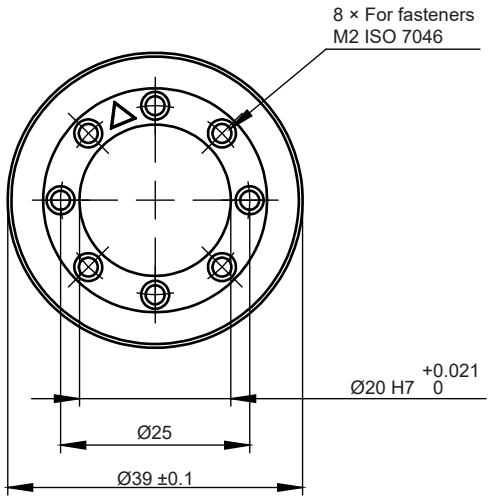
MB039 readhead





* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

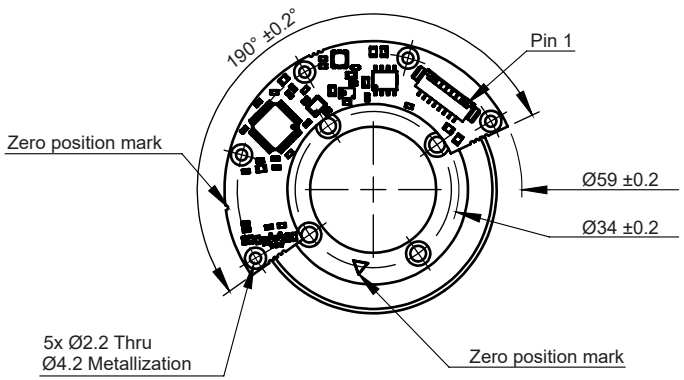
MRA039BC020DSE00 ring

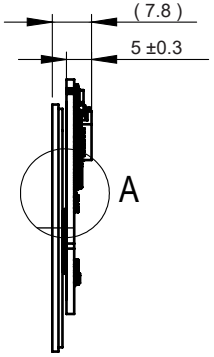


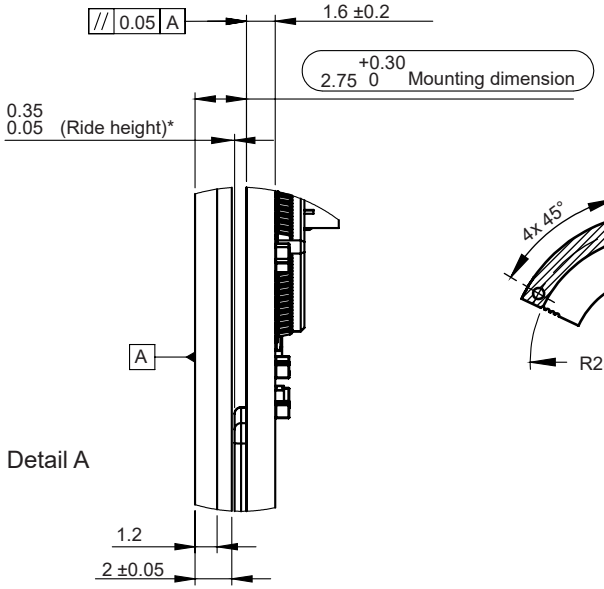
Dimensions and installation drawings continued

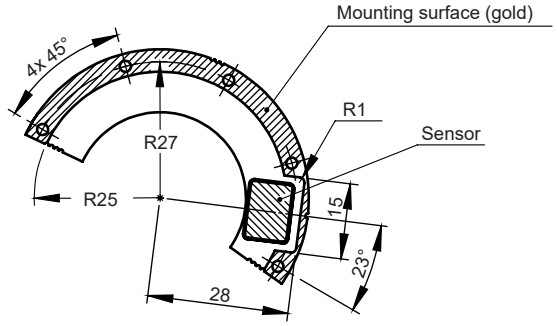
Dimensions and tolerances in mm.

MB049 readhead size D



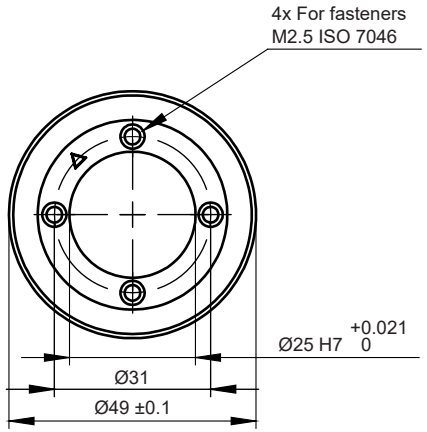




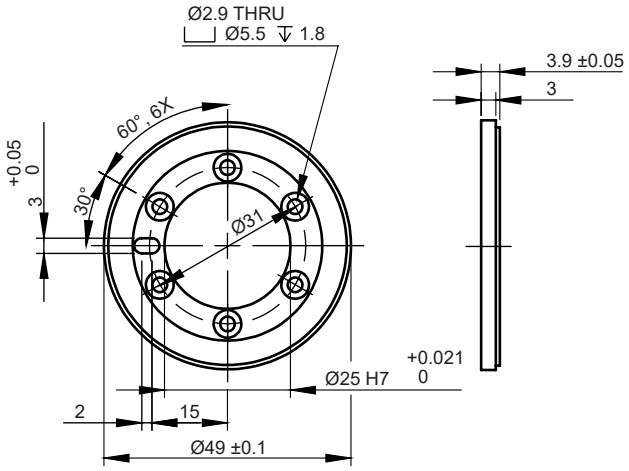


* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

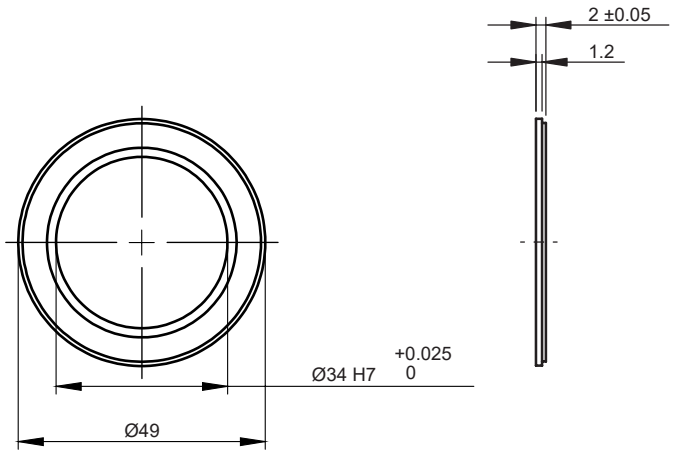
MRA049BC025DSE00 ring



MRA049AF025EMH00 ring



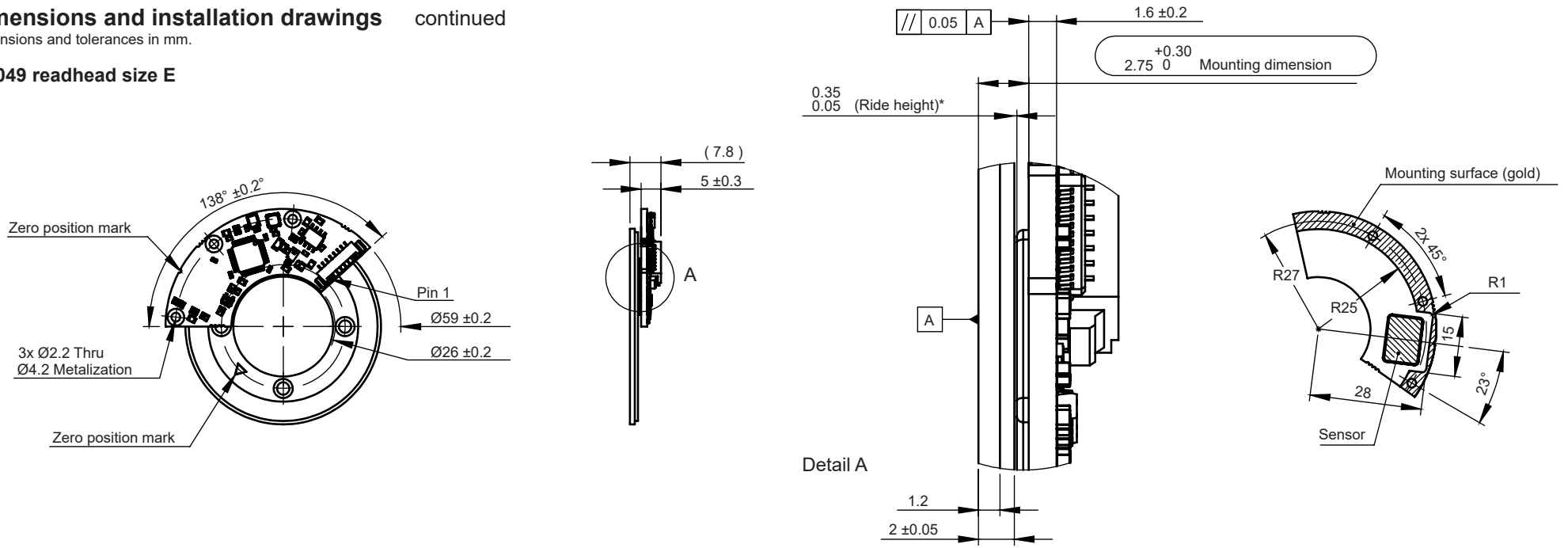
MRA049BG034DSN00 ring



Dimensions and installation drawings continued

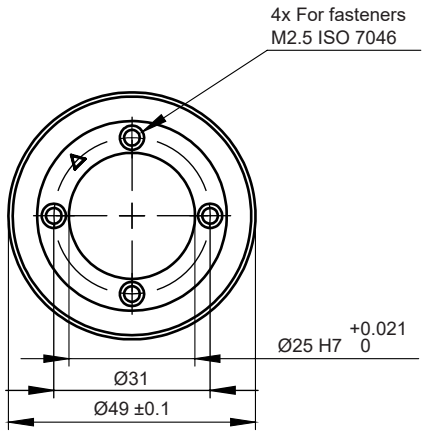
Dimensions and tolerances in mm.

MB049 readhead size E

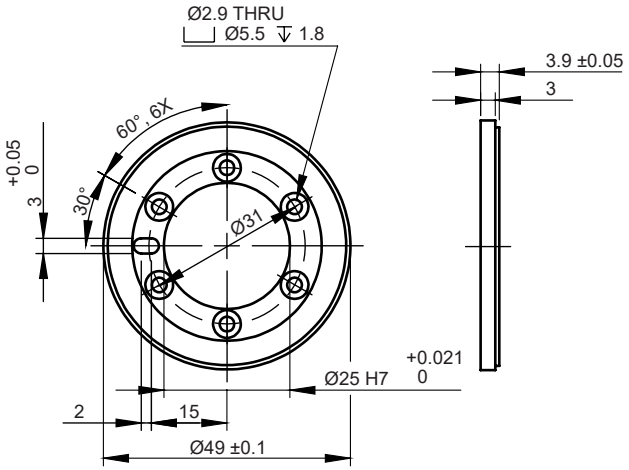


* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

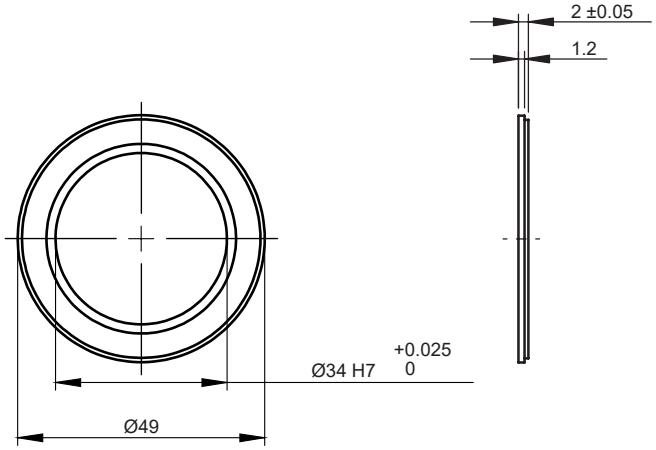
MRA049BC025DSE00 ring



MRA049AF025EMH00 ring



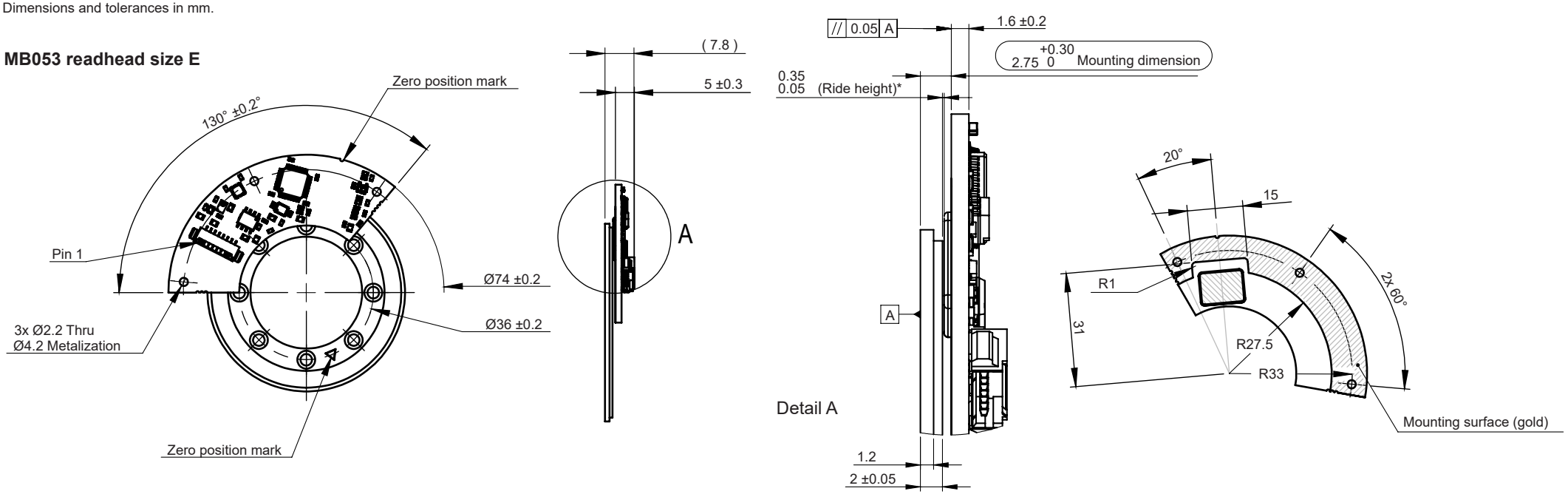
MRA049BG034DSN00 ring



Dimensions and installation drawings continued

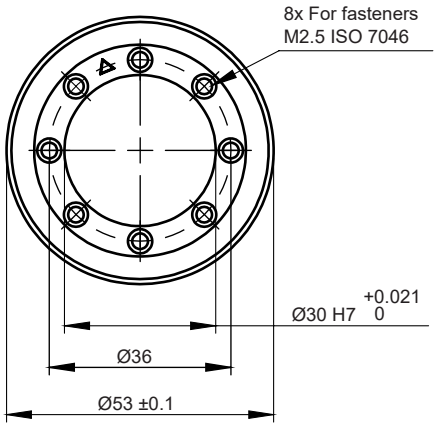
Dimensions and tolerances in mm.

MB053 readhead size E



* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

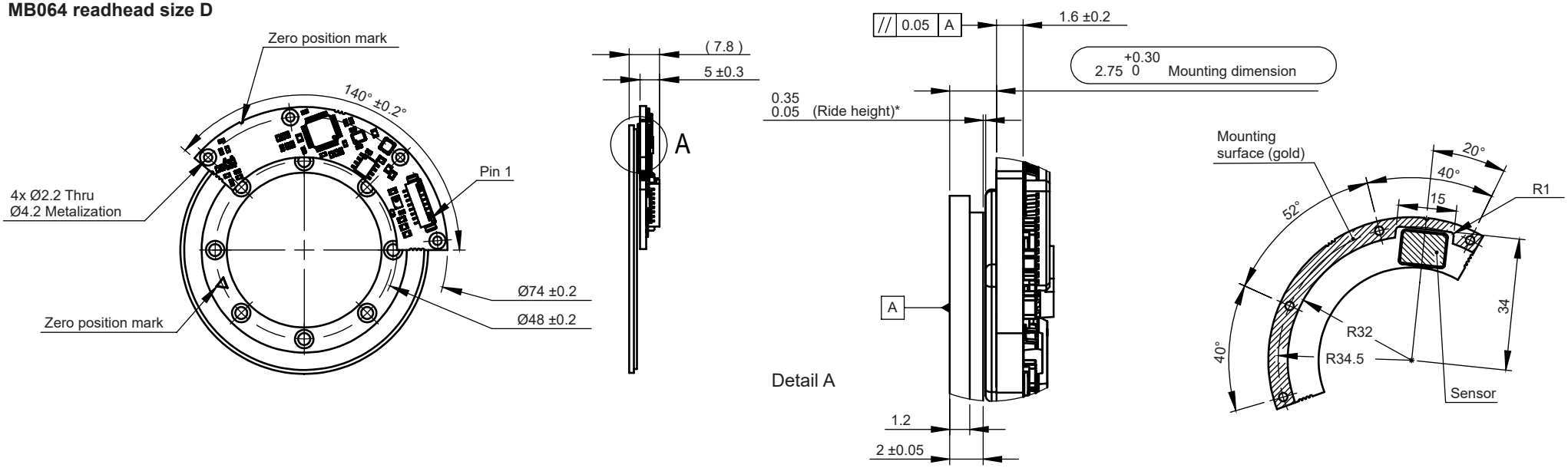
MRA053BC030DSE00 ring



Dimensions and installation drawings continued

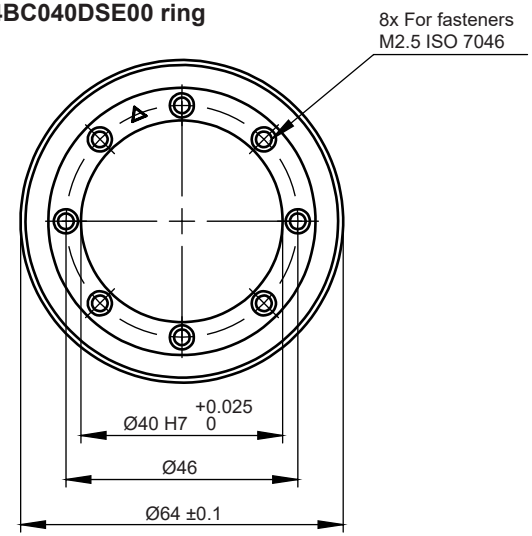
Dimensions and tolerances in mm.

MB064 readhead size D



* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

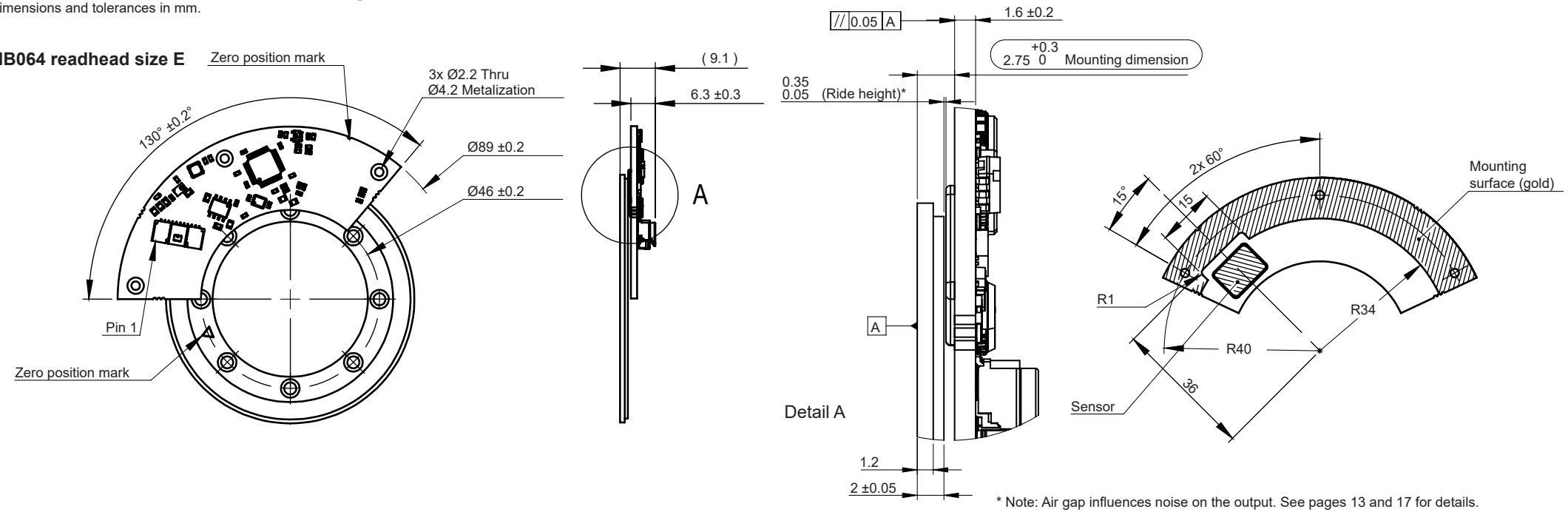
MRA064BC040DSE00 ring



Dimensions and installation drawings continued

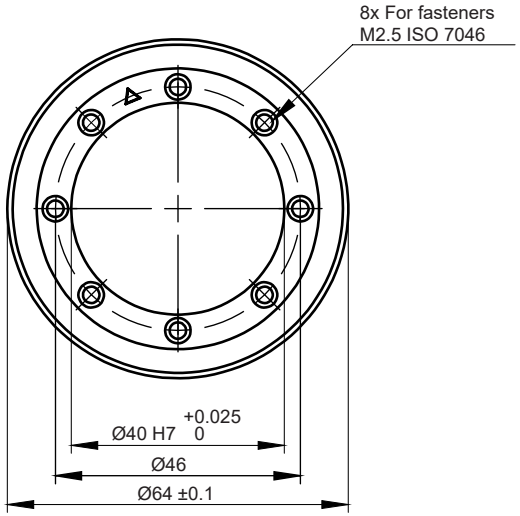
Dimensions and tolerances in mm.

MB064 readhead size E



* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

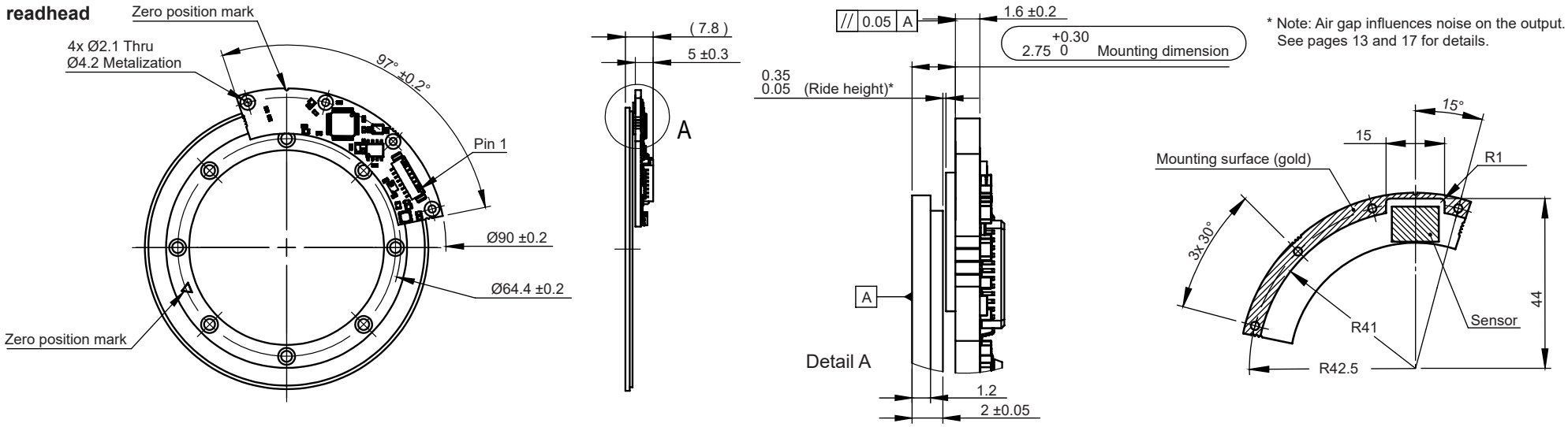
MRA064BC040DSE00 ring



Dimensions and installation drawings continued

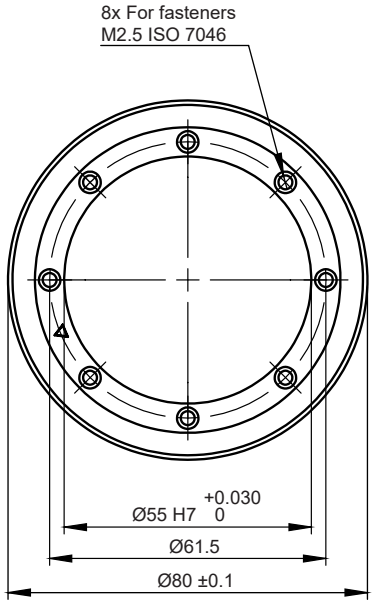
Dimensions and tolerances in mm.

MB080 readhead

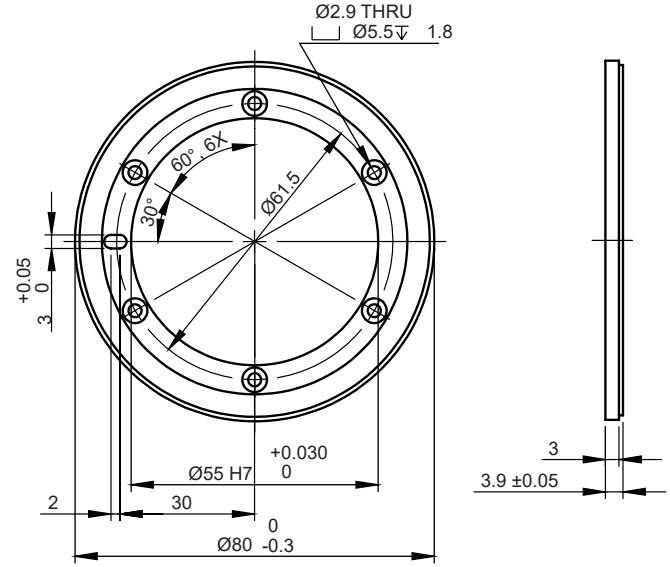


* Note: Air gap influences noise on the output. See pages 13 and 17 for details.

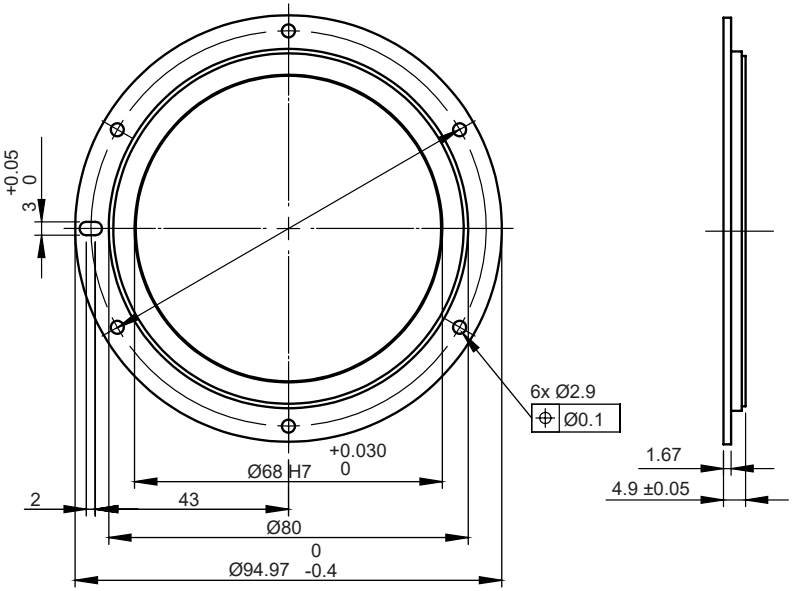
MRA080BC055DSE00 ring



MRA080AF055EMH00 ring



MRA080DF068DMH00 ring



Technical specifications

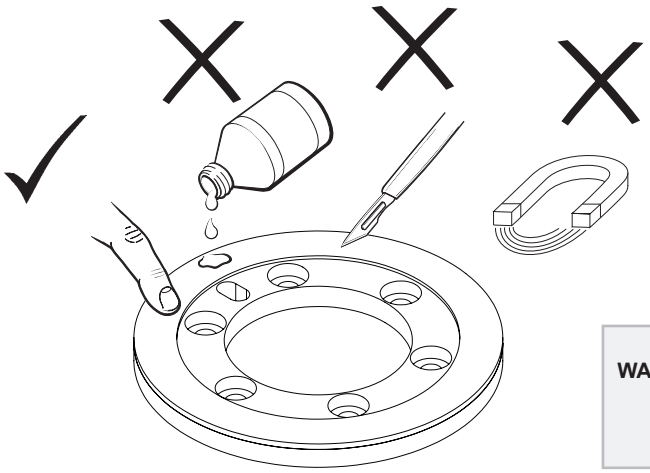
System data		
Reading type	Axial reading	
Resolution	From 17 bit to 20 bit and 16 bit multiturn counter option (see chapter Available resolutions on page 18)	
Maximum speed	10,000 RPM (for higher speeds contact RLS)	
Encoder accuracy	±0.05° / 180 arcsec (before installation - errors caused by mounting inaccuracy of the readhead, ring and drive shaft are not included)	
Final system accuracy	Typ. ±0.025° / 90 arcsec (after encoder self-calibration - see chapter Installation instructions on page 13). For accuracy up to ±0.005° / 18 arcsec contact RLS.	
Hysteresis	Less than unit of resolution	
Repeatability	Better than unit of resolution	
Encoder speed	9 kHz bandwidth, 18 kHz sampling rate, up to 44 kHz refresh rate	
Electrical data		
Supply voltage (V_{DD})	4.5 V to 5.5 V at the connector. Rise time should be shorter than 20 ms.	
Set-up time	100 ms (first data ready after supply voltage is in range), worst case: 200 ms	
Current consumption	Typ. 130 mA, max. 150 mA (without load on the outputs)	
Connection	11-pin locking connector, 8-pin low-profile connector or soldering pads	
Output load	RS422	±40 mA
	PWM	5 mA (LVTTL logic level)
ESD protection	HBM, Class 2, ±2 kV	
Mechanical data		
Available ring sizes (outer diameter)	29 mm, 39 mm, 49 mm, 53 mm, 64 mm, 80 mm	
Material type	2 mm thick rings	EN 1.4016 / AISI430 with glued CPE rubber filled with ferrite particles
	3.9 mm and 4.9 mm thick rings	EN 1.4005 / AISI416 or EN 1.4104 / AISI430F with glued CPE rubber filled with ferrite particles
Mass, inertia	see table on page 2	
Environmental data		
Operating and storage temperature	–40 °C to +105 °C (standard) –30 °C to +85 °C (obsolete, available only on request)	
Humidity	0 to 70 % non-condensing (for higher contact RLS)	
External magnetic field	±25 mT	
Pressure	Up to 600 bar with special option - contact RLS	

Status indicator LED

The LED provides visual feedback of signal strength, error condition and is used for set-up and diagnostics.
Flashing LED indicates the encoder is powered but communication has not been established. When communication is running at a rate of minimum 5 readings per second LED is constantly lit.

LED	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 sec. fast flashing	Self-calibration result - see table on page 15.

Storage and handling



WARNING: Magnetic rings should not be exposed to magnetic field densities higher than 50 mT on its surface.
Magnetic fields higher than 50 mT can damage the ring.

Chemical resistance

Chemical	Test performed with	Readhead	Ring with CPE rubber	Testing parameters
Hydraulic oil	Panolin Atlantis 15	-	✕	4 weeks at 60 °C (ISO175)
	ISO VG 46 (SAE MS1004)	✓	✕	4 weeks at 60 °C (ISO175) and 70 °C
	Catrol Hyspin AWS 32	-	✕ (✓ at 25°C)	65 °C ✕, 25 °C ✓
Insulating oil	Nytro 10 XN	-	✕	4 weeks at 60 °C (ISO175) and 70 °C
	MIDEL 7131	-	✕	70 °C
	Shell Diala S3 ZX-I	✓	✕	70 °C and 85 °C
Motor oil	SAE 15W-40	✓	✓	4 weeks at 25 °C (ISO175)
Cutting oil	Rezilol SCM BCL	✓	✓	4 weeks at 25 °C (ISO175)
Brake fluid	DOT-4	✓	✓	4 weeks at 25 °C (ISO175)
Coolant	Blasocut 2000 CF, 5%	-	✓	4 weeks at 25 °C (ISO175)
Antifreeze	Wolf VW G12 (100%)	✕	✓	70 °C and 85 °C
Lubricating grease	ISOFLEX TOPAS NB 52	✓	✓	4 weeks at 25 °C (ASTM D4289)
	HD Flexolub-A1 (pink)	✓	✕	Readheads 1 week at 80 °C (ASTM D4289), rings several weeks at 25 °C
	HD 4B No. 2 (yellow)	✓	✕	1 week at 80 °C (ASTM D4289)
	HD SK-2 (green)	✓	✕	1 week at 80 °C (ASTM D4289)
Sea water	Instant Ocean® sea salt, 3.5 %	✕**	✓	4 weeks at 25 °C (ISO175)
Ethanol	Technical, ≥ 95 %	-	✓	4 weeks at 25 °C (ISO175)
Isopropyl alcohol	Technical, ≥ 95 %	O*	(✓ short term cleaning)	12 hours at 25 °C
Acetone	Technical, ≥ 95 %	✕	✕	4 weeks at 25 °C (ISO175)

✓ Resistant
✕ Not resistant (elastoferrite swelling > 0.5 % / adhesive joint failure / reading head failure)
O Noticeable impact, but does not interfere with encoder operation
* Destroys conformal coating (if present). No impact on other components
** Open electronic circuit should not come in contact with conductive fluids
\- Not tested

Test samples were immersed in chemicals in accordance with ISO 175:2010(E) and ASTM D4289 – 13 (2014) standards. During testing, we closely monitored changes in CPE elastoferrite layer's mass and height as well as readhead's functionality. Metal hubs did not corrode.

Installation instructions

Axial position adjustment (ride height)
The nominal gap between the gold mounting areas on the PCB mounting side and the rubber band on the ring is 0.8 mm ±0.15 mm. We recommend using gold plated surfaces on the bottom of the PCB as a reference for mounting the readhead. If the top side of the readhead is used, user must adjust the ride height carefully due to wide PCB thickness tolerances.
Any nonmagnetic tool with 0.2 mm thickness can be used to mechanically check the ride height between the sensor and the ring.
The integrated LED can be used as an indicator. When the correct ride height is achieved, the LED glows green and does not change colour when the ring rotates.
Center point of the ring and center point of the readhead arc must be coaxial. Allowed tolerances are listed in the table below.

Installation tolerances (readhead to ring)

Axial displacement (ride height)	0.05 mm to 0.35 mm Smaller ride height is desired. Increasing the ride height exponentially increases encoder noise.
Installation height (nominal distance between readhead and ring mounting surfaces)	See installation drawings on pages 3 to 10.
Readhead to ring distance	0.8 mm ±0.15 mm
Tangential displacement	±0.3 mm
Radial displacement	MRA029: ±0.3 mm MRA039: ±0.4 mm MRA049, MRA053, MRA064, MRA080: ±0.5 mm
Non-paralell mounting	tilt angle < 0.2°

Visual process of the encoder installation can be seen in the Explainer video: AksIM-2 self-calibration feature.

Measuring ride height between ring and readhead

Signal level information read over communication interface can be used to calculate ride height.

Value is proportional to the distance between the sensor and ring. To calculate real distance use following formula:
AirGap = K × (N - Ln (Sqrt (SignalLevel)))

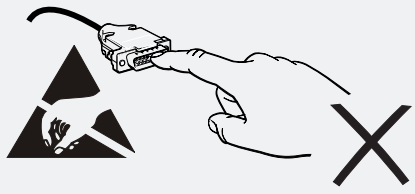
K and N are chosen depending on the encoder size.

Encoder size	K	N
029	188.42	8.37
039, 049	167.24	8.647
053, 064, 080	142.08	9.023

SignalLevel value is available in BiSS register at addresses 0x4E - 0x4F (see document MBD02) and on UART interface with command 'a' (see page 22).

Installation tolerances (ring to shaft)

Ring / shaft fit	Encoder accuracy					
	MRA029	**MRA039**	**MRA049**	**MRA053**	**MRA064**	**MRA080**
H7/g6 worst case	±0.15°	±0.15°	±0.11°	±0.11°	±0.10°	±0.09°
H7/g6 average	±0.08°	±0.07°	±0.06°	±0.06°	±0.05°	±0.05°
After self-calibration	±0.03°	±0.03°	±0.025°	±0.025°	±0.02°	±0.02°



WARNING!

ESD protection
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.

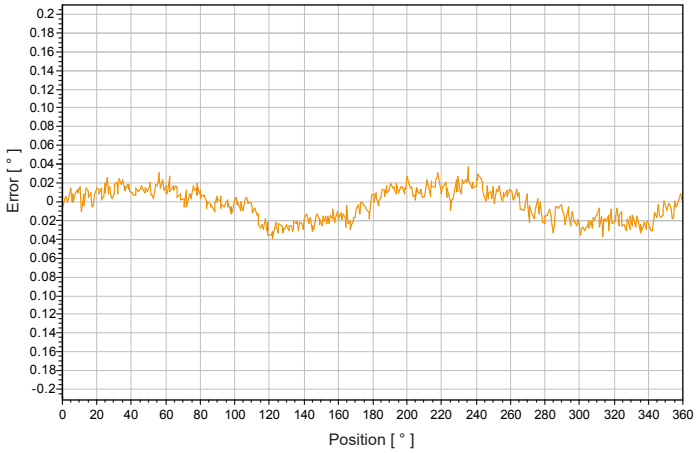
Accuracy of the encoder system

Precise centering of the ring is key to achieving good overall accuracy.

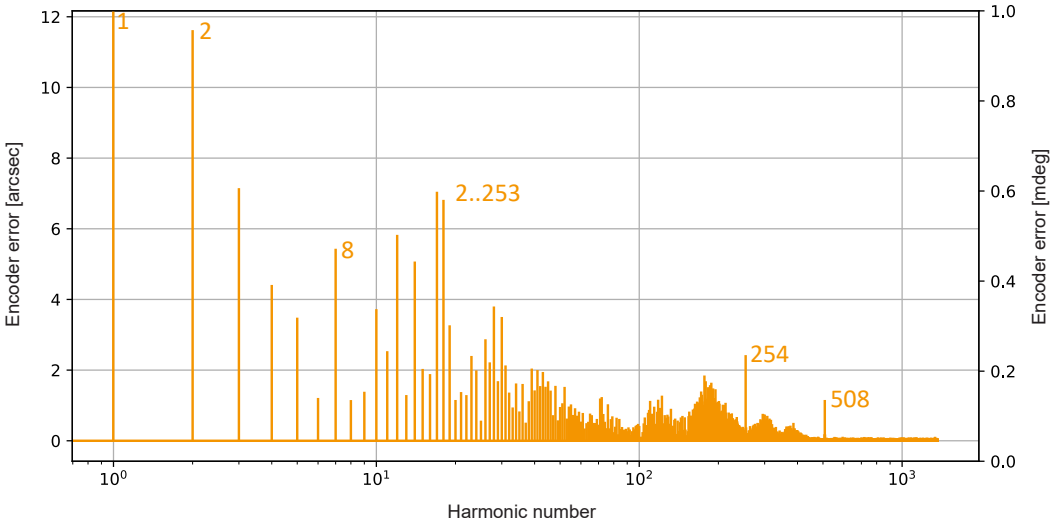
By minimising the eccentricity of the ring installation (using a gauge) and using a drive shaft with precision bearings, the error can typically be reduced to ±0.05° on MRA080 rings or ±0.06° on MRA049 rings.

A typical accuracy plot after good installation of MRA080 (without eccentricity) is shown in the graph below.

For improved accuracy after installation it is advised to run the self-calibration function.



Higher harmonic components of the encoder error plot



Typical encoder error has some definite higher harmonic components. Example is from the MRA080 + MB080 encoder.
Harmonic number:
1 – Eccentricity of the ring mounting
2 – Oval shape of the ring
8 – Number of mounting holes
2..253 – Absolute code influence
254 – SDE (offset)
508 – SDE (amplitude, phase)

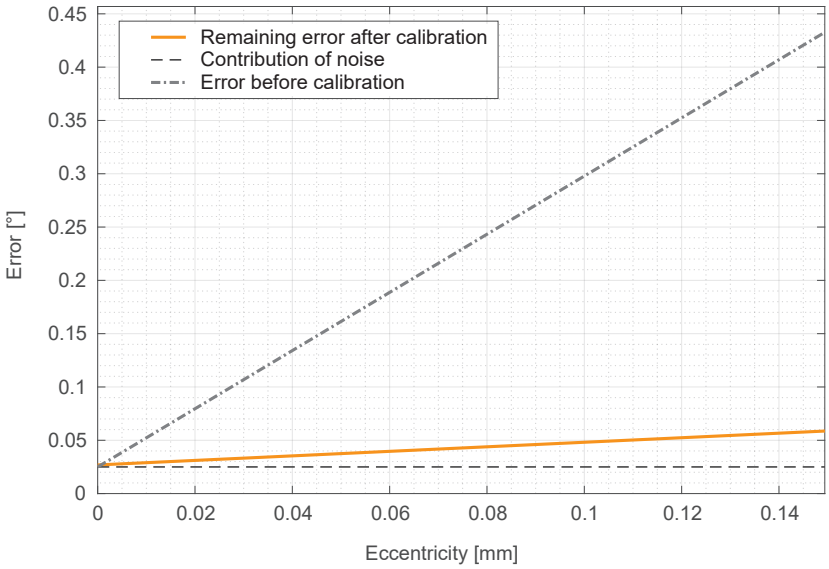
Self-calibration after installation

The self-calibration function eliminates eccentricity-caused error, which is a dominant part of the encoder accuracy and is caused by the eccentric mounting of the ring. It cannot compensate the magnetisation deviations between different rings. SDE error is neglectable on AksIM. This function removes the one sine wave per revolution error. The self-calibration function can be triggered by user over selected communication interfaces or by using the appropriate USB encoder interface. Not available with PWM and SSI encoder output. For details refer to the chosen communication interface description. If multiturn counter is being used in the encoder, it may have incorrect value after self-calibration, if rotational speed is higher than ±300 RPM. Multiturn error flag will be set in such case.

Requirements:

- Free mechanical rotation between 180° and 360° (desired angle can be selected over communication interface).
- Good signal throughout the calibration angle.
- Maximum time available is 10 seconds.
- Direction and speed are not important.
- Suitable communication interface or adaptor that allows triggering the function.

Graph below shows how much the encoder accuracy can be improved with the self-calibration function.
The remaining minimum accuracy of ±0.02° has contribution from magnetisation variation and readhead noise.



After completing the self-calibration procedure, fast-flashing LED reports if procedure was successful.

LED colour	Self-calibration status
Green fast flashing	Self-calibration performed succesfully
Orange fast flashing	Ring positioning is already perfect - correction was not performed. Status bit 0x20 is set.
Red fast flashing	- Input parameter out of range Status bit 0x10 is set. - Eccentricity or radial displacement is very high Status bit 0x08 is set. - Timeout. Ring is rotating too slow. Status bit 0x04 is set.

Video on self-calibration function is available here: Explainer video: AksIM-2 self-calibration feature.

External magnetic field

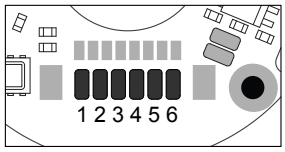
Principle of operation of any magnetic encoder is sensing changes in the magnetic field of the magnetised ring. External magnetic fields, generated by permanent magnets, electric motors, coils, magnetic brakes, etc. may influence the operation of the encoder. When homogeneous magnetic field is between 0 mT and 25 mT perpendicularly to the readhead it might affect accuracy. When bigger than 25 mT it temporarily causes the encoder to malfunction. Fields stronger than 50 mT can permanently damage the ring.

Unwanted magnetic fields must be blocked at the source. When this is not possible, encoder can be shielded with ferromagnetic metal plate. The ring can also be used for partial shielding. It is recommended to mount the bottom side of the ring towards the source of the leaking magnetic field with the readhead pointing away. Contact RLS for more information.

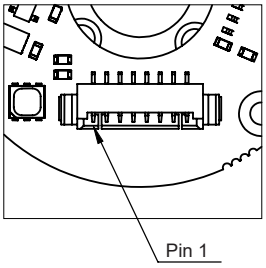
Electrical connections

11-pin connector	8-pin connector	Soldering pads	BiSS-C	Asynchronous serial	PWM	SSI
1			V_{DD}			
2	1	1				
3	2	2	GND			
4						
5	3		Temperature sensor pin 1			
6	4		Temperature sensor pin 2			
7	5	3	MA+	RX Command in+	Status out	Clock+
8	6	4	MA–	RX Command in–	-	Clock–
9			-			
10	7	5	SLO+	TX Data out+	PWM out	Data+
11	8	6	SLO–	TX Data out–	-	Data–

Pinout

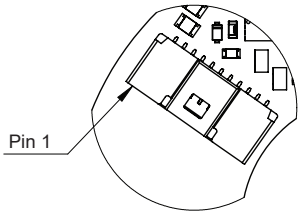


Soldering pads
Dimensions: 2.54 x 1.14 mm
with 1.875 mm pitch



8-pin low profile connector
FCI 10114830-11108LF

Counterpart mating connector:
FCI 10114826-00008LF
and 10114827-002LF

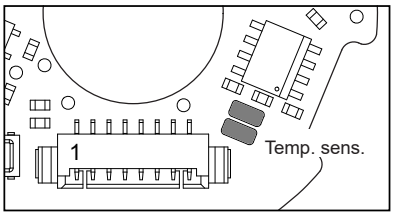


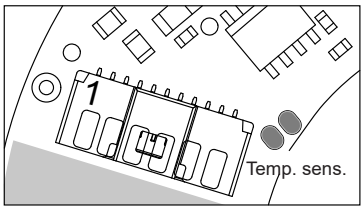
11-pin locking connector
Molex 501568-1107
Not recommended for new design.
Only available on sizes 039, 053 and 064.

Counterpart mating connector:
Molex 501330-1100 and 501334-0000

External isolated temperature sensor

Encoders provide two pass-through signals for connecting an external temperature sensor in an application. It can be Pt100, Pt1000, NTC, 1-wire or any other similar low-voltage analogue or digital sensor. Signals are isolated from the encoder circuit and are just routed from the "Temp. Sens." pins on the connector to the soldering pads, where external sensor in an application is to be connected.
Purpose of this is to add temperature monitoring to applications like electric motor, gearbox, etc. where precise monitoring is required close to the encoder. This solution simplifies cable management, as the existing encoder cable can be used to carry these two signals.
Voltage must be limited to ±30 V relatively to the other encoder signals and current to ±500 mA.
If measurement of readhead temperature is enough, Special option "05" in the readhead part numbering specifies Pt1000 sensor soldered directly on the readhead.





Communication interfaces

BiSS		
	Clock frequency	From 150 kHz to 5 MHz
	Maximum request rate	44 kHz (38 kHz multiturn counter option)
	Mechanical sample rate rate	18 kHz
	Bandwidth	9 kHz
	Resolution	See table on page 18
	Latency	<10 µs
	Timeout (monoflop time)	13.5 µs
Asynchronous serial RS422 (UART)		
	Baud rate	115.2 kbps, 128 kbps, 230.4 kbps, 256 kbps, 500 kbps, 1 Mbps (Configurable from 300 baud to 1 Mbaud)
	Data format	8 bits, no parity, 1 stop bit
	Request rate	On demand or continuous
	Mechanical sample rate	18 kHz
	Bandwidth	9 kHz
	Resolution	See table on page 18
	Latency	<10 µs
PWM *		
	Base frequency	122.07 Hz, 274.66 Hz, 366.21 Hz, 549.32 Hz, 1098,63 Hz (High Pressure encoder option changes these frequencies)
	Update rate	Same as Base frequency
	Resolution	16 bits
	Latency	55 to 110 µs
SSI * (Not recommended for new design)		
	Clock frequency	Minimum 80 kHZ Maximum 500 kHz with standard SSI 2.5 MHz with *Delay First Clock* function on the controller
	Mechanical sample rate	18 kHz
	Resolution	See table on page 18
	Latency	55 µs to 110 µs
	Timeout (monoflop time)	20 µs

* Note: Interfaces with big or variable latency are not suitable for high-speed closed control loops.
SSI interface is supported for legacy applications and is not recommended for new design.

Available resolutions

Resolution	Ring MRA029	Ring MRA039, MRA049	Ring MRA053, MRA064, MRA080
Binary	17 bits per revolution 18 bits per revolution *	17 bits per revolution 18 bits per revolution * 19 bits per revolution *	17 bits per revolution 18 bits per revolution 19 bits per revolution * 20 bits per revolution *

* High resolution options may contain noise on the output. These resolutions are suitable for smoother operation of the control loops or averaging to get fine position. Noise margin increases exponentially with increasing ride height between the ring and readhead.

Multiturn counter

Multi-turn counter is available on the following communication interfaces: BiSS, Asynchronous serial (UART) or SSI.
Multiturn option is chosen with Resolution in part number on page 29. Multi-turn counter is 16 bit (0 to 65535 counts). Counting is available only when the encoder is powered, but the counter state is stored in a non-volatile memory at power-down and is restored at power-up. Maximum permissible rotation during power-down is ±90°. If rotation is bigger, encoder will signal an error to indicate invalid multiturn counter value. To reset this condition it is required to apply a new multiturn counter value over the communication interface or cycle power to the encoder. If encoder is rotated for ±360° or multiple rotations, this movement is not registered and also multiturn error is not set. If any other error is set during a 90° rotation or more the multiturn counter value might become inconsistent with mechanical position.

User must implement multiturn counter validation method by either:
- Activating mechanical brake before encoder goes to power-down state and releasing after encoder is powered-up.
- Performing zeroing procedure after every encoder power-up.
- Other user-implemented multiturn counter validation methods.

Multiturn - shaft turn counter limitations

Counter may have invalid value in following circumstances:

Possible reasons for failure	Solution
If encoder is rotated for ±360° or multiple rotations during off state.	Use mechanical brake.
If Error flag (red LED) is present for 180° rotation or more.	Read and evaluate Error bit.
When encoder has moved for 180° or more or rotating at 300 RPM or more when encoder is performing blocking operation (saving information to non-volatile memory, factory reset, write protect, self-calibration).	Stop rotation before performing those operations.
If user changes single-turn position offset for 180° or more.	Set new multiturn counter value right after setting zero position offset.
If any function for saving information to non-volatile memory (save configuration, factory reset, write protect, self-calibration) is active when power-down happens.	Keep power supply stable when performing those operations.

Multiturn error flag

Error flag is set in one of the following conditions:
- Detected movement of >90° and <270° when powered off
- Detected speed of more than 300 RPM during blocking operation
- High, unexpected positional difference detected (acceleration error)

Multiturn error bit can be cleared by writting new value into the encoder or by power cycle. On SSI interface only power cycle is available.

Latency on BiSS and Asynchronous serial (UART) interface

BiSS and UART use an algorithm that recalculates new position at every request. This way request frequency can be higher than encoder's internal cycle frequency. Typically, request rate can be up to 44 kHz. Position is latched at the first falling edge on the MA (clock) line or first bit of the Command byte and new position value is calculated instantly, therefore latency is shorter than 10 µs.

Latency on other type interfaces (SSI, PWM)

All interfaces transmit the last valid data available from the last encoder's internal cycle. There is no additional recalculation.
Internal cycle of the encoder is 55 µs. This is the delay from the time when the mechanical position is latched by the sensor to when the data is ready to be transmitted over the interface.
If the request comes right after the data is ready, latency will be 55 µs.
If request comes just before the new data will be calculated, then latency is 110 µs.

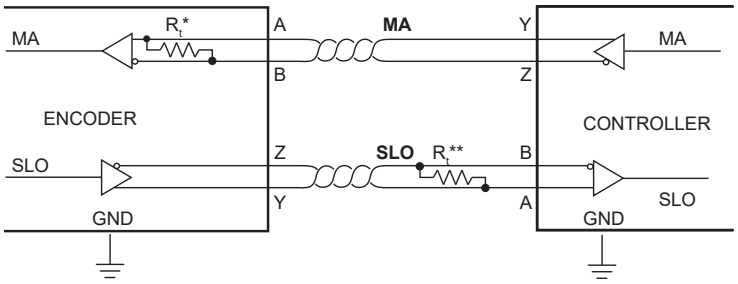
For example:
At t = 0 µs the physical position is latched but position data is not yet calculated. It will be available at 55 µs.
If the request comes at t = 1 µs – 54 µs, the last available data will be sent - the one from previous cycle when position was latched at t = –55 µs.

BiSS-C interface

The encoder position, in up to 20 bit natural binary code, and the encoder status are available through the BiSS-C protocol. The position data is left aligned. After the position data there are 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 and custom parameters can be stored into the readhead and additional data can be read from the readhead.

Electrical connection



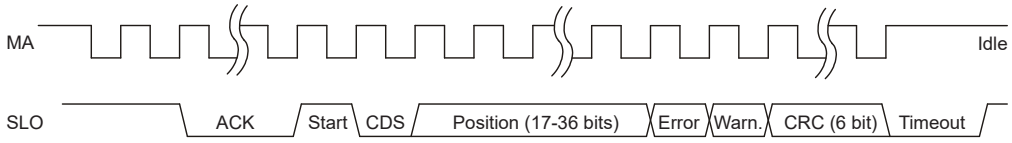
Signals	
MA	Master clock. Max clock frequency is 5 MHz.
SLO	Slave out. Data is output on rising edge on MA.

* The MA and SLO lines are 5 V RS422 compatible differential pairs. The termination resistor on the MA line is integrated inside the encoder.
** Termination at the controller is required, if total cable length is longer than 5 m. The nominal impedance of the cable is 120 Ω.

Output protection

Excessive output current and power dissipation caused by faults or by bus contention 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.

BiSS-C timing diagram



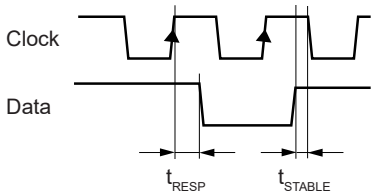
MA is idle high. Communication is initiated with first falling edge.
The encoder responds by setting SLO low on the second rising edge on MA. ACK length is 13 bits.
When the encoder is ready for the next request cycle it indicates this to the master by setting SLO high.
The absolute position and CRC data is in binary format and sent MSB first.

Cable length compensation

The readhead needs 170 ns to respond to incoming clocks (t_{RESP}). Change on Data signal is delayed for 170 ns after the rising edge on Clock line. Additional delay is caused by the time the signal needs to propagate through cable to the readhead and back (t_{PROP}). This delay is typically 14 ns per 1 meter of cable. Total cable length must be taken into account, from the encoder to the receiver.

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

The data signal must be stable before the value is latched. Therefore with a cable longer than 1 meter and a clock frequency higher than 2.5 MHz this delay must be compensated for in the receiver (controller) to which the encoder is connected.



Status bits

Type	Value 0	Value 1	Possible reason for failure
Error	Position data is invalid.	OK	Error bit is active low. If low, the position is not valid.
Warning	Position data is valid.	OK	Warning bit is active low. If low, the encoder operation is close to its limits. The position is still valid but the resolution and/or accuracy might be out of specification.

Communication parameters

Communication interface variant in the part number defines the functionality of the encoder.

Communication interface variant	Parameter	Value
C	MA frequency	Max. 5 MHz
	ACK length	13 bit
	Register access	Yes

Parameter	Value
Latency	<10 µs (recalculated on every transmission)
Bandwidth *	9 kHz
Mechanical sample rate	18 kHz
Maximum request rate	44 kHz (38 kHz Multiturn counter option)
Timeout	13.5 µs

* Bandwidth parameter is mechanical bandwidth. AksIM samples at 18 kHz therefore any mechanical changes that are appearing faster than 9 kHz are not detectable on the output (Nyquist theorem). If request for position comes faster than sampling frequency, AksIM encoder recalculates the position at the time of request based on current ring velocity. 9 kHz bandwidth is valid for high dynamic movements of 2 degrees or smaller.

Data packet description

Data packet length depends on the resolution and can be from 25 to 44 bits long. It consists of 16 bits for the multiturn counter (if selected) and 17 to 20 bits of Position selected by (resolution), followed by 2 Status bits and 6 CRC bits (see table below).

Resolution	Multiturn counter	Position	Status		CRC (inverted)
			Error	Warning	
17B	0 bits	17 bits	1 bit	1 bit	6 bits
18B		18 bits			
19B		19 bits			
20B		20 bits			
17M	16 bits	17 bits	1 bit	1 bit	6 bits
18M		18 bits			
19M		19 bits			
20M		20 bits			

Example: 18 bits of position + 2 status bits + 6 bits CRC = 26 bits long data packet.

Polynomial for CRC calculation of position, error and warning data is: $x^6 + x^1 + 1$. Represented also as 0x43.
It is inverted and transmitted MSB first.
Example of calculation routine for 6-bit CRC can be found in application note CRCD01.

For more information regarding BiSS protocol see **www.biss-interface.com**.

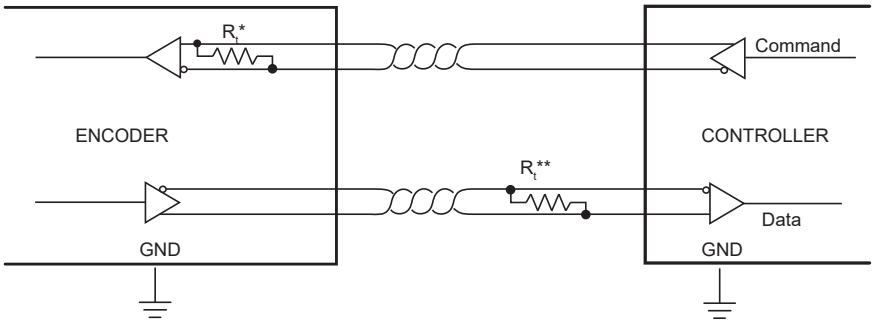
Encoder programming

Encoder supports register access which allows setting zero position, running self-calibration function, configuring the encoder, reading signal level indicator, temperature, detailed status bits and electronic datasheet. It also allows storing up to 4 kB of user data into the encoder (like motor parameters, assembly data or similar).
This additional information can be found in the "Application note: AksIM-2 BiSS-C register access", document number MBD02.

Asynchronous serial communication interface over RS422 (UART)

Encoder identification, position data and temperature are available with request-response type of communication over the asynchronous serial link. There are two unidirectional communication channels, forming a full-duplex bidirectional data link. Every channel consists of a two wire differential twisted-pair connection conforming to the RS422 signalling standard. Data is transmitted LSB first; big-endian order.

Electrical connection



* The Command and Data signals are 5 V RS422 compatible differential pairs with RC termination inside the readhead.
** Termination at the controller is required, if total cable length is longer than 5 m. The nominal impedance of the cable is 120 Ω.

Output protection

Excessive output current and power dissipation caused by faults or by bus contention 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.

Communication parameters

Character length	8 bits
Parity	None
Stop bits	1
Flow control	None
Request rate	Maximum achievable, depending on selected baud rate. Can be transmitted continuously without delays between packets.
Mechanical sample rate	18 kHz
Bandwidth *	9 kHz
Position latency	<10 µs (recalculated on every transmission)

* Bandwidth parameter is mechanical bandwidth. AksIM samples at 18 kHz therefore any mechanical changes that are appearing faster than 9 kHz are not detectable on the output (Nyquist theorem). If request for position comes faster than sampling frequency, AksIM encoder recalculates the position at the time of request based on current ring velocity. 9 kHz bandwidth is valid for high dynamic movements of 2 degrees or smaller.

Link speed is selectable by the *Communication interface variant* in the part number:

Communication interface variant	A	B	C	D	E	F
Link speed (baud rate)	115.2 kbps	128 kbps	230.4 kbps	256 kbps	500 kbps	1 Mbps

Link speed setting can be changed in the field by following the procedure described in the "Special commands" section.

It is not possible to revert to factory settings. New settings are permanent until encoder is reprogrammed again with different settings.

Encoder supports a range of commands to read position data and additional information. In case multiturn option is selected, number in brackets is to be used.

Command (ASCII)	Response
'1'	'1' + 3 (5) bytes (Position + E/W bits)
'3'	3 (5) bytes (Position + E/W bits)
'd'	'd' + 3 (5) bytes (Position + E/W bits) + 2 bytes (Detailed status)
's'	's' + 3 (5) bytes (Position + E/W bits) + 3 bytes (Speed in RPM)
't'	't' + 3 (5) bytes (Position + E/W bits) + 1 byte (Sensor temperature in °C)
'a'	'a' + 3 (5) bytes (Position + E/W bits) + 2 bytes (Signal level)
'i'	'i' + 1 byte (Self calibration status)
'v'	'v' + 58 bytes (Version info and serial number) (Changed in FW version 2.5)

Command '3' is used as a request for the shortest possible response. In this case, only 3 (or 5 bytes in multiturn variant) bytes of position with integrated general error and warning bits are replied.

In case of any other command, the header byte, which should be equal to the command itself, is replied first. Then, regardless of the command, 3 bytes (or 5 bytes if multiturn) of position with Error and Warning bits are sent. After that additional bytes are transmitted that carry requested information.
Returned header byte should be equal to the command and can be used to determine which data packet format is to be decoded. In case of incorrect command, only header byte is returned with no other data.

Position data packet structure

Position data consists of 3 bytes if singleturn variant is selected or 5 bytes if multiturn variant is selected. Encoder position is always left aligned and starts with multiturn data (if available). Error and warning bits are always right aligned (bit 1 and bit 0 respectively). Between LSB of position and error bit are padding bits with value 0. The structure of position data bytes for each encoder resolution is presented in table below.

Position data structure for singleturn variant			
Encoder resolution	**Position bits**	**Zero padding bits**	**Error bit, Warning bit**
17B	b23 – b7	b6 – b2	b1, b0 (both active low)
18B	b23 – b6	b5 – b2	b1, b0 (both active low)
19B	b23 – b5	b4 – b2	b1, b0 (both active low)
20B	b23 – b4	b3 – b2	b1, b0 (both active low)

Position data structure for multiturn variant			
Encoder resolution	**Position bits**	**Zero padding bits**	**Error bit, Warning bit**
17M	b39 – b7	b6 – b2	b1, b0 (both active low)
18M	b39 – b6	b5 – b2	b1, b0 (both active low)
19M	b39 – b5	b4 – b2	b1, b0 (both active low)
20M	b39 – b4	b3 – b2	b1, b0 (both active low)

Error and warning bits integrated into position data are always transmitted inverted (active low). Value '0' on error bit means that the position is not valid. Value '0' on warning bit means position is valid, but the encoder is near operational limits. In case of error, the last valid data is transmitted.

Commands and their respective responses for singleturn version. For multiturn add 2 bytes to the length of position data.

Command '1'	
Byte transmitted	**Contents**
B1	ASCII header '1'
B2 - B4	Position + E/W
Command '3'	
Byte transmitted	**Contents**
B1 - B3	Position + E/W
Command 'd'	
Byte transmitted	**Contents**
B1	ASCII header 'd'
B2 - B4	Position + E/W
B5 - B6	Detailed status (refer to table on next page)
Command 's'	
Byte transmitted	**Contents**
B1	ASCII header 's'
B2 - B4	Position + E/W
B5 - B7	(Signed binary) speed in number of counts per 1 µs multiplied by 65,536. Rotational speed in RPM.
Command 't'	
Byte transmitted	**Contents**
B1	ASCII header 't'
B2 - B4	Position + E/W
B5	(Signed binary) Sensor temperature in (°C). This value is typically 10 to 15 °C higher than ambient. Tolerance of readout is ±5 °C.
Command 'a'	
Byte transmitted	**Contents**
B1	ASCII header 'a'
B2 - B4	Position + E/W
B5 - B6	(Unsigned binary) Signal level Value is proportional to the distance between the sensor and ring. To calculate real distance see formula on page 13.
Command 'i'	
Byte transmitted	**Contents**
B1	ASCII header 'i'
B2	Self calibration status - see document MBD03
Command 'v'	
Byte transmitted	**Contents**
B1	ASCII header 'v'
B2 - B8	ASCII identification string 'AksIM-2'
B9	ASCII space character
B10 - B17	ASCII serial number (8 characters)
B18	Space character
B19 - B34	ASCII part number (16 characters)
B35	Space character
B36	Binary firmware major version
B37	Binary firmware minor version
B38	Binary communication interface version
B39 - B42	Binary revision
B43	Space character
B44 - B59	ASCII extended serial number (16 characters)

Structure of Detailed status bits (two bytes)

Detailed status (part 1)	
b15	Error - Multiturn counter mismatch. Encoder was rotated for more than ±90° during power-down. Cycle the power to clear this error or apply new multiturn counter value.
b14	Error - Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present.
b13	Warning - Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present.
b12	Error - Magnetic sensor. Cycle power to the encoder.
b11	Error - Sensor reading error, probably caused by electrical interference, ground loop or RFI.
b10	Error - Encoder not configured properly.
General status	
b9	Error. If bit is set, position is not valid.
b8	Warning. If bit is set, encoder is near operational limits. Position is valid. Resolution and / or accuracy might be lower than specified.
Error and Warning bits can be set at the same time; in this case Error bit has priority. The colour of the LED on the readhead housing indicates the value of the General status bits: Red = Error, Orange = Warning, Green = Normal operation, No light = no power supply. The warning or error status is more closely defined by the Detailed status bits.	
Detailed status (part 2)	
b7	Warning - Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present.
b6	Warning - Signal amplitude low. The distance between the readhead and the ring is too large.
b5	Error - Signal lost. The readhead is out of alignment with the ring or the ring is damaged.
b4	Warning - Temperature. The readhead temperature is out of specified range.
b3	Error - Power supply error. The readhead power supply voltage is out of specified range.
b2	Error - System error. Malfunction inside the circuitry or 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	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.
b0	Error - Acceleration error. The position data changed too fast. A stray magnetic field is present or metal particles are present between the readhead and the ring.

Encoder programming

Encoder supports changing default baud rate, running self-calibration function, reading signal level value, temperature, detailed status bits and setting automatic transmission of selected data packet at programmable frame rate.
This additional information can be found in the "Application note: Programming encoders with Async serial interface", document number MBD03_02.

PWM - Pulse width modulation interface

The PWM communication interface consists of two digital signals: the Status signal and the PWM Out signal.

Electrical connection

The Status and PWM Out signals are 3.3 V TTL compatible. These signal outputs have weak ESD protection, therefore the readhead must be handled with additional care in ESD controlled environment and with ESD protection.
Maximum current sourced from or sunk into signal lines should not exceed 5 mA.

Status signal

The Status signal indicates the current status of the encoder. The Status signal is high for normal operation and valid position information. The low state of the Status signal indicates an error state of the encoder which can be caused by:

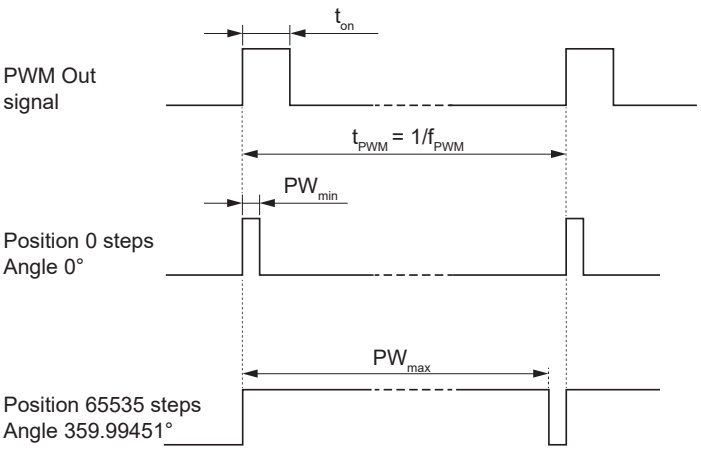
- Operation outside the installation tolerances
- Invalid or damaged magnetisation of the ring
- Sensor malfunction
- System error
- No power supply

When the Status signal is low, the PWM Out signal is low and no pulses are output.
The encoder position is latched on the rising edge of the PWM Out signal. The Status signal should also be checked at the rising edge of the PWM Out signal. If the Status signal changes during the PWM period, it does not affect the currently transmitted position information. Status output signal is not linked to the PWM output cycle and is updated every encoder internal cycle. Pulses can be present as short as 50 µs.

PWM Out signal

The PWM Out is a pulse width modulation output with 16-bit resolution whose duty cycle is proportional to the measured position. The change of the pulse width by PW_{min} corresponds to a change in position by one count (change in angle for 360° / 65536 ≈ 0.00549°).

PWM Out signal timing diagram



Communication parameters

Communication interface variant in the part number defines the PWM frequency and all other dependent parameters.

		Communication interface variant						
Parameter	**Symbol**	**A**	**B**	**C**	**D**	**E**	**Unit**	**Note**
PWM frequency	f_{PWM}	122.07	274.66	366.21	549.32	1098.63	Hz	
Signal period	t_{PWM}	8192	3640.89	2730.67	1820.44	910.22	µs	
Minimum pulse width	PW_{min}	0.125	0.0556	0.0417	0.0278	0.0278 **	µs	Position 0 (Angle 0°)
Maximum pulse width	PW_{max}	8191.875	3640.83	2730.63	1820.42	910.20 **	µs	Positions 65534 and 65535 *
Min. counter frequency	f_{CNTR}	8	18	24	36	72	MHz	Receiving counter frequency
Resolution		16 Bit	16 Bit	16 Bit	16 Bit	16 Bit		Fixed; resolution in part number must be set as "16B"

* Positions 65535 and 65534 are joined together; readout as 65534 (PW_{max}).

** At frequency 1099 Hz positions 0 and 1 are joined together; readout as 1 (PW_{min}). Positions 65535, 65534 and 65533 are joined together; readout as 65533 (PW_{max}).

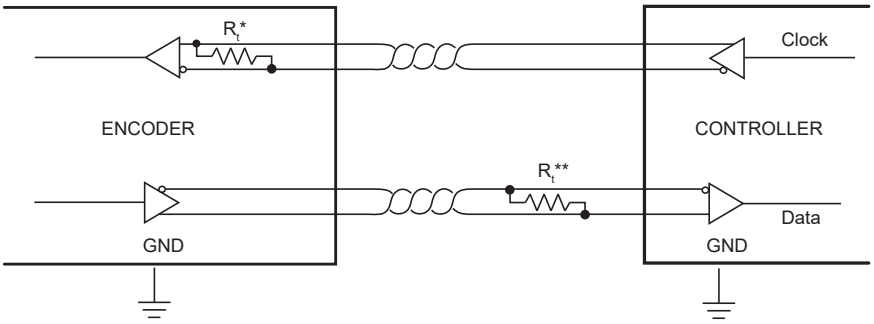
$$\textit{Position}\ [\text{counts}] = \frac{t_{on} \times 65536}{t_{PWM}} - 1 \qquad \textit{Position}\ [°] = \frac{(t_{on} - PW_{min}) \times 360°}{t_{PWM}}$$

SSI - Synchronous serial interface

SSI interface is supported for legacy applications and is not recommended for new design.

The encoder position, in up to 20 bit natural binary code, and the encoder status are available through the SSI protocol. The position data is left aligned. After the position data there are two general status bits followed by the detailed status information. SSI interface is not recommended for closed-loop applications and motor feedback due to low update speed and noticeable (variable) latency.

Electrical connection

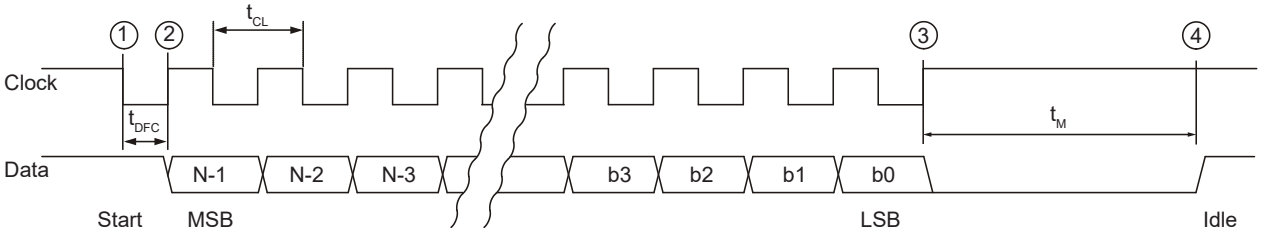


* The Clock and Data signals are 5 V RS422 compatible differential pairs with RC termination inside the readhead.
** Termination at the controller is required, if total cable length is longer than 5 m. The nominal impedance of the cable is 120 Ω.

Output protection

Excessive output current and power dissipation caused by faults or by bus contention 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



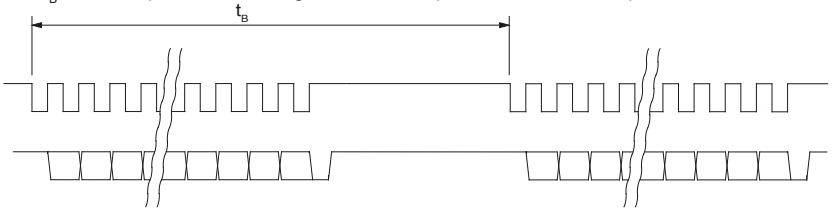
NOTE: See table "Structure of data packet" on the page 27.

The controller interrogates the readhead for its position and status data by sending a pulse train to the Clock input. The Clock signal always starts from high. The first falling edge ① latches the last position data available and on the first rising edge ② the most significant bit (MSB) of the position is transmitted to the Data output. The Data output should then be latched on the following falling edge. On subsequent rising edges of the Clock signal the next bits are transmitted. If time between ① and ② is extended for additional 1 µs, then maximum clock frequency limit is 2 MHz instead of 500 kHz. This function is called "Delay First Clock" and must be supported by the controller to which the encoder is connected.

After the transmission of the last bit ③ the Data output goes to low. When the t_M time expires the Data output is undefined ④. The Clock signal must remain high for at least t_M before the next reading can take place.

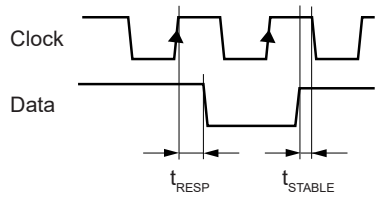
While reading the data the period t_{CL} must always be less than t_M. However, reading the encoder position can be terminated at any time by setting the Clock signal to high for the duration of t_M.

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.



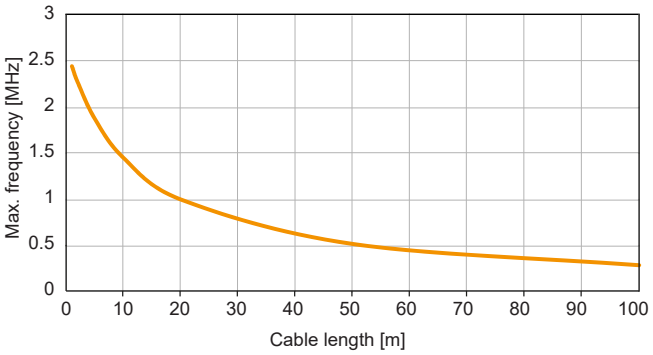
The power supply must be applied at least 100 ms before the clock sequence is being sent to the encoder.

Maximum frequency



The readhead needs 170 ns to respond to incoming clocks (t_{RESP}). Change on Data signal is delayed for 170 ns after the rising edge on Clock line. Additional delay is caused by the time the signal needs to propagate through cable to the readhead and back (t_{PROP}). This delay is typically 14 ns per 1 meter of cable. Data signal must be stable for at least 10 % of the clock period length before the value is latched.
The clock frequency must be reduced with a longer cable. Total cable length must be taken into account, from the encoder to the receiver.
$t_{DELAY} = t_{RESP} + t_{PROP} \times$ cable length

Frequency derating versus cable length:



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}	50 kHz		500 kHz (2.5 MHz *)
Timeout (monoflop time)	t_M		20 µs	
Request rate	t_B	55 µs		
Readhead response delay	t_{RESP}		170 ns	
Latency		55 µs		110 µs

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

Start bit and idle line value are defined by the *Communication interface variant*.

Communication interface variant	Line state selection	Usage
B	Start bit = 1; idle line = 1	Standard

Structure of data packet

	Bit number			
Singleturn resolution	**Multiturn counter***	**Encoder position**	**General status**	**Detailed status**
20 bits	b45 : b30	b29 : b10	b9 : b8	b7 : b0
19 bits	b44 : b29	b28 : b10	b9 : b8	b7 : b0
18 bits	b43 : b28	b27 : b10	b9 : b8	b7 : b0
17 bits	b42 : b27	b26 : b10	b9 : b8	b7 : b0

* If selected in part number

Multiturn counter (if selected in part number)		
First 16 bits (see table above)		Multiturn counter - Occupying full 16 bits. Can be interpreted as signed number (±32768) or unsigned number (0 to 65535) that represents number of shaft turns.
Encoder position		
Following 17 to 20 bits (see table above)		Encoder position – Left aligned, MSB first, LSB last.
General status		
	b9	Error bit. If set, the position is not valid.
	b8	Warning bit. If set, the encoder operational is close to its limits. The position is still valid, but the resolution and/or accuracy might be out of specification.
	The Error and Warning bits can be set at the same time, in this case the Error bit has priority. The colour of the LED on the readhead housing indicates the value of the General status bits: Red = Error, Orange = Warning, Green = Normal operation, No light = No power supply. The warning or error status is more closely defined by the Detailed status bits.	
Detailed status		
	b7	Warning - Signal amplitude too high. The readhead is too close to the ring or an external magnetic field is present.
	b6	Warning - Signal amplitude low. The distance between the readhead and the ring is too large.
	b5	Error - Signal lost. The readhead is out of alignment with the ring or the ring is damaged.
	b4	Warning - Temperature. The readhead temperature is out of specified range.
	b3	Error - Power supply error. The readhead power supply voltage is out of specified range.
	b2	Error - System error or Multiturn error. Malfunction inside the circuitry or 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	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.
	b0	Error - Acceleration error. The position data changed too fast. A stray magnetic field is present or metal particles are present between the readhead and the ring.

Readhead part numbering

MB 049 DC C 18B D N A 00

Series
MB - AksIM board-level readhead

MRA ring compatibility
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

Communication interface
DC - BiSS-C, RS422
SF - Asynchronous serial, RS422
PW - Pulse Width Modulation (PWM), LVTTL
SC - Synchronous serial interface (SSI), RS422 **(NRND)**

Communication interface variant
See table next to the description of the chosen communication interface for detailed information
For **DC**: **C -** BiSS-C, bidirectional, 13 ACK bits, with register access
For **SC**: **B -** Start bit and idle data line 1 (standard)
For **SF**: Link speed in kbps:

A	B	C	D	E	F
115.2	128	230.4	256	500	1000

For **PW:** Base frequency in Hz:

A	B	C	D	E
122	275	366	549	1099

Resolution
16B - 16 bits per revolution (for PW output only)
17B - 17 bits per revolution
18B - 18 bits per revolution
19B - 19 bits per revolution (for sizes 039 and up)
20B - 20 bits per revolution (for sizes 053 and up)

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 (for size 039 and up)
20M - 20 bits per revolution + 16 bits multiturn counter (for size 053 and up)

Shape and connector orientation
D - Partial arc, radial connector exit (only for sizes 049, 064, 080)
E - Partial arc, tangential connector exit (only for sizes 039, 049, 053, 064)
F - Full circle, radial connector exit (only for size 029)

Connector option
D - Molex 501568-1107 locking connector (NRND) (only for sizes 39, 53, 64)
N - FCI 10114830-11108LF
P - Soldering pads

Option
A - No options (obsolete)
T - Extended temperature range (standard)
P - High pressure (up to 600 bar)*
***** Check with local sales representative for availability of this option

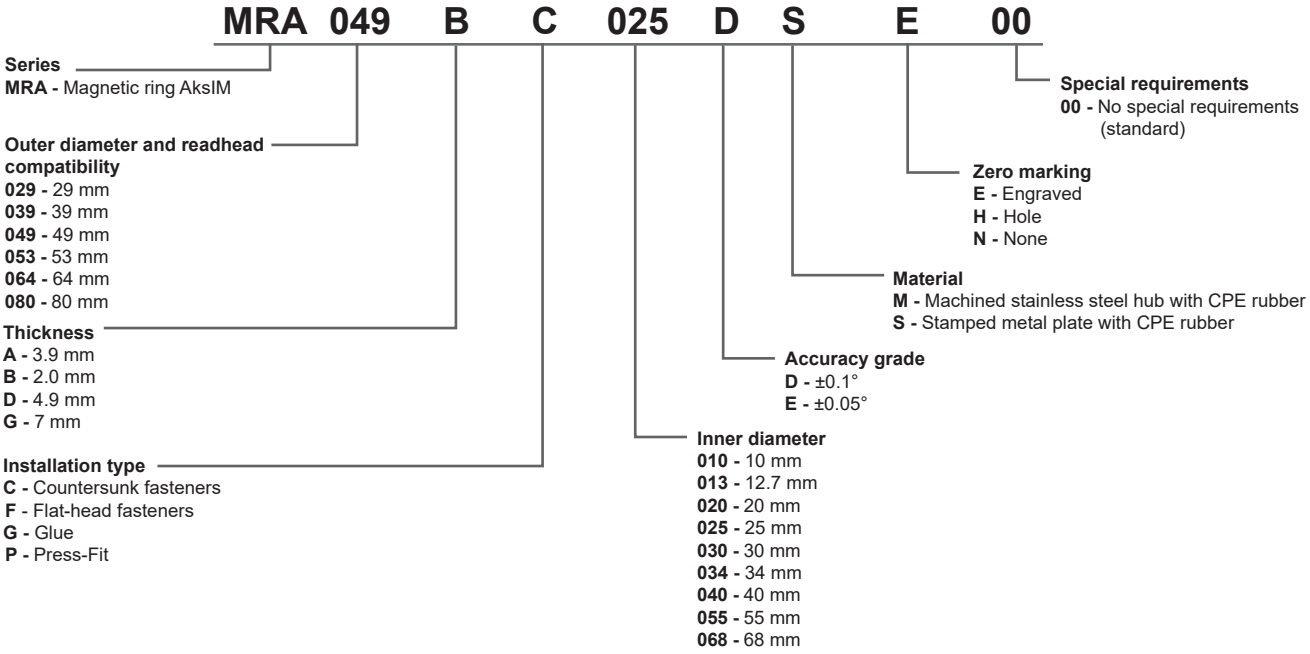
Special requirements
00 - No special requirements (standard)
05 - Temperature sensor Pt1000 added

Available combinations for readheads:

Series	Ring Compatibility	Communication Interface & Variant	Resolution	Shape & connector	Option	Special requirements
MB	029	DC-C SF-A/B/C/D/E/F PW-A/B/C/D/E (SC-B*)	17B - 18B 17M - 18M	FN	T P ** (A***)	00 / 05
	039		17B - 19B 17M - 19M	EN ED*		
	049			DN EN		
	053		17B - 20B 17M - 20M	ED* EN		
	064			DN ED*		
	080			DN		

* - Not recommended for new design
** - Check with local sales representative for availability of high pressure option on desired encoder configuration.
*** - Obsolete

Ring part numbering



Available combinations for rings:

Series	Outer diameter and readhead compatibility	Thickness	Installation type	Inner diameter	Accuracy grade	Material	Zero marking	Special requirements
MRA	029	B	C	010	D	S	E	00
		G	P	013		M	N	
	039	B	C	020		S	E	
	049	A	F	025	E	M	H	
		B	C		D	S	E	
			G	034			N	
	053		C	030			E	
	064			040				
	080	A	F	055	E	M	H	
		B	C		D	S	E	
		D	F	068		M	H	

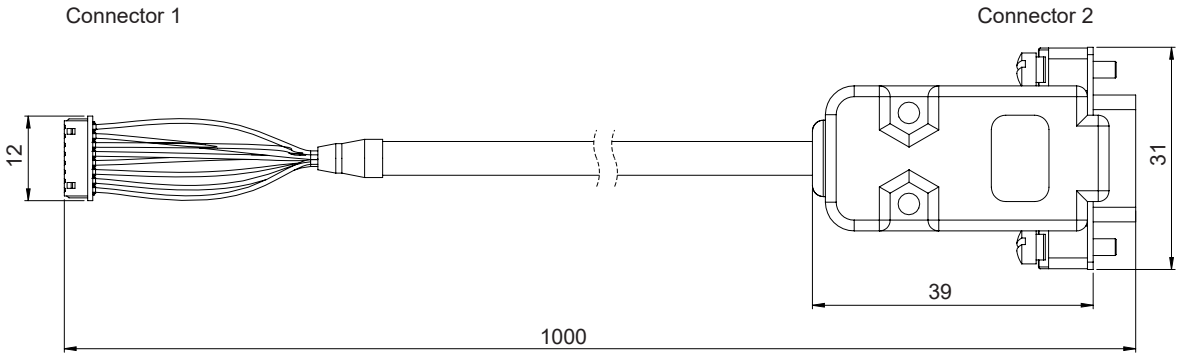
Available ring part numbers:

MRA029BC010DSE00
MRA029GP013DMN00
MRA039BC020DSE00
MRA049AF025EMH00
MRA049BC025DSE00
MRA049BG034DSN00
MRA053BC030DSE00
MRA064BC040DSE00
MRA080AF055EMH00
MRA080BC055DSE00
MRA080DF068DMH00

Accessories

Cables with crimped connectors

Compatible readhead	Part number	Length	Connector 1	Connector 2	Notes
MB029-N MB039-N MB049-N MB053-N MB064-N MB080-N	**ACC015**	1.0 m	FCI 10114826-00008LF and 10114827-002LF	Flying leads	Single-shielded
	ACC016			DSUB-9 M	
MB053-D MB064-D MB039-D	**ACC012**	1.0 m	Molex 501330-1100 and 501334-0000	Flying leads	
	ACC024	3.0 m			
	ACC027	1.0 m		DSUB-9 M	



Connector 1 pin	Connector 2 pin	Wire color	BiSS-C	Asynchronous serial	PWM	SSI
	1	Shield				
1	5	Brown	V_{DD}			
2	9	White	GND			
3	8	Pink	Temperature sensor pin 1			
4	4	Grey	Temperature sensor pin 2			
5	2	Red	MA+	Cmd+	Status out	Clock+
6	3	Blue	MA–	Cmd–	-	Clock–
7	6	Green	SLO+	Data+	PWM out	Data+
8	7	Yellow	SLO–	Data–	-	Data–

Cable specifications

Part numbers	ACC012, ACC015, ACC016, ACC024, ACC027
Cable specifications	LI12YC12Y
Configuration	4 × 2 × 0.14 mm^2
Sheath colour	Grey (RAL7032)
Rated voltage	250 V
Temperature range	Operating –30 °C to +125 °C Storage –40 °C to +130 °C Not valid for cables with DSUB-9 M connector.
Environmental conformation	RoHS conform 73/23/EWG-Guideline CE conform Halogen free
Chemical resistance	Largely resistant to acids, bases and usual oils. Free from lacquer damaging substances and silicone.

ACC016 and ACC027 can be used for direct connection to E201-9S or E201-9B USB encoder interface.

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Document issues

Issue	Date	Page	Corrections made
1	18. 12. 2017	General	New document
2	26. 6. 2019	21, 22	UART commands
		2-10, 30	New ring sizes added
		3-10, 13	Dimensions, installation drawings and installation tollerances updated
		12	Chemical resistance chart ammended
		11, 16, 17, 25	PWM communication interface added
		16	11-pin connector marked as NRND
		2-10, 29	Different shapes and connector options added
		18	Latency chapter added
			Multiturn counter description added
		31	New cables added as Accessories