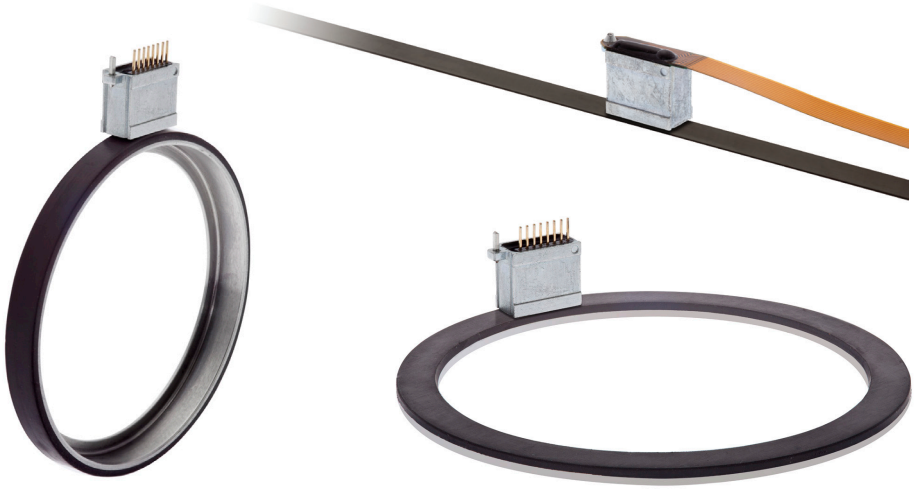
RLM
Miniature Incremental Magnetic Encoder

MINIATURE DESIGN

UNIQUE REFERENCE MARK

SELF-DIAGNOSTIC FUNCTION

RLM is a component-level encoder system consisting of a RLM readhead and a magnetic scale or ring. It is designed as a position control loop element for embedded motion control applications. The encoder also has a self-diagnostic function for error detection.
The state-of-the-art position detection guarantees a highly repeatable position measurement under wide installation tolerances and temperature ranges. Position information is output in incremental quadrature and parallel, SSI or BiSS C format.



Features and benefits

- Miniature design
- Pin or flexible cable option
- Unique or periodic bidirectional reference mark
- Incremental ABZ TTL or RS422, BiSS C or SSI output
- Suitable for use with linear scales, radial and axial rings
- High system accuracy up to ±10 µm
- High-speed operation
- Non-contact and wear-free measuring principle

SMT PICK AND PLACE | IN SMALL SIZE | GIMBALS | MEDICAL | ROBOTIC JOINTS

General information

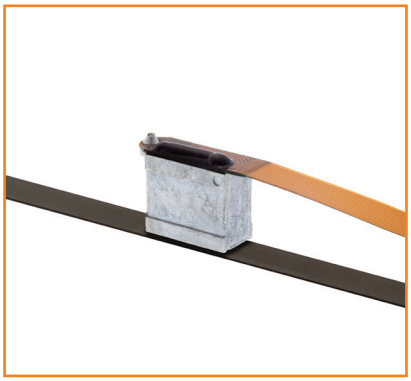
RLM is a rotary and linear encoder in a miniature housing and can be used in space-constrained applications. The readhead can be ordered with an integral flex cable or with pins only. Position information can be provided either with a unique periodic reference mark or without it.

Choose your RLM2 system

The robust RLM2 readhead is compatible with the RLS incremental scale MS05 as well as the RLS axial and radial rings. You can select the length of the MS05 scale up to 50 m. There is also a wide range of axial and radial incremental rings available.

To ensure safety and reliability, the scale MS05 and the radial rings can be optionally covered with a protective stainless steel foil. Unique or distance-coded reference marks are also available to provide an even more reliable solution.

RLM2 + magnetic scale



More about the MS magnetic scales can be found in the MSD01 at **RLS Media center.**

RLM2 + radial ring

More about the radial rings can be found in the MR02D02 at **RLS Media center.**

RLM2 + axial ring

More about the axial rings can be found in the MR01D01 at **RLS Media center.**

Encoder variants

RLM2 with pins

RLM2 with pins can be fixed by soldering. It comes with SSI, BiSS C and incremental single-ended outputs ABZ.

RLM2 with flex cable

RLM2 with flex cable can be fixed with mounting brackets. It comes with SSI, BiSS C and incremental single-ended outputs ABZ.

RLM2 with RS422 with flex cable

RLM2 with RS422 flex cable can be fixed with mounting brackets. It comes with differential incremental outputs ABZ (RS422).

Storage and handling

All data given below refer to the readhead only. Complete systems with magnetic scale or ring may have other limitations. For more information, see the MSD01, MR02D02 or MR01D01 data sheet at **RLS Media center.**

Storage temperature

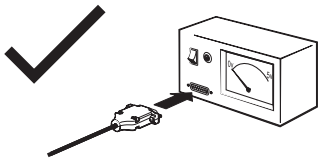
–40 °C to +85 °C

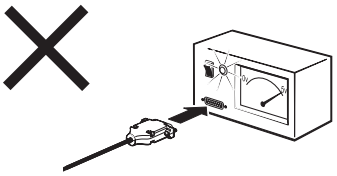
Operating temperature

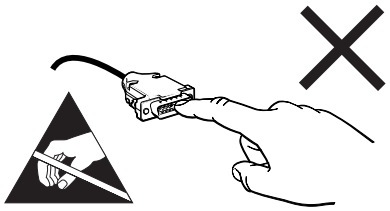
Without flex cable: –40 °C to +85 °C
With flex cable: –20 °C to +85 °C

Humidity

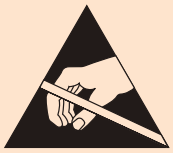
Up to 70 % non-condensing







The encoder is a mechanically sensitive component. Handle it by its edges, touch it lightly, minimize pressure and eliminate bending while maintaining a secure grip to prevent falls. Maximize cleanliness. When not in use, place it in an ESD protective packaging (box or tray).



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.

Packaging

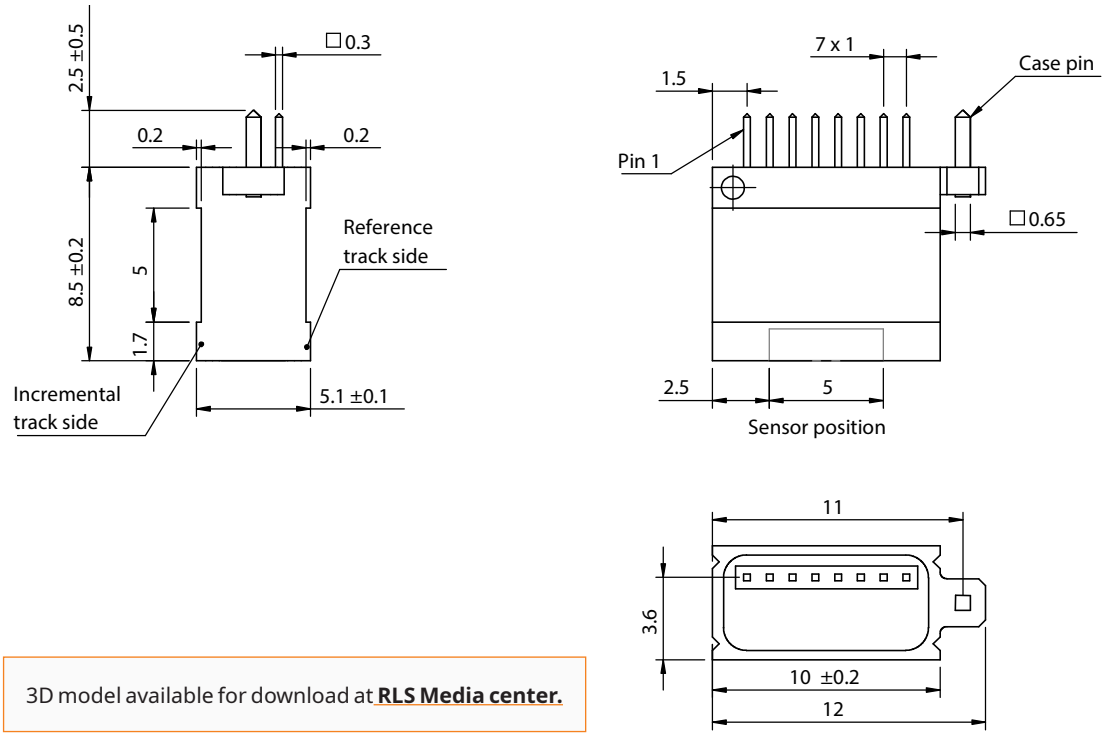
Less than 20 readheads are individually packed in antistatic boxes. For quantities of 20 pieces or more, the readheads are packed in antistatic trays (see table below). The trays are packed together in a cardboard box (10 trays per box).

Part	Tray size	Box size
Connector option 00	120 units per tray	17 trays per box
Connector options 04 / 15 / 16	16 units per tray	

Dimensions and installation drawings

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

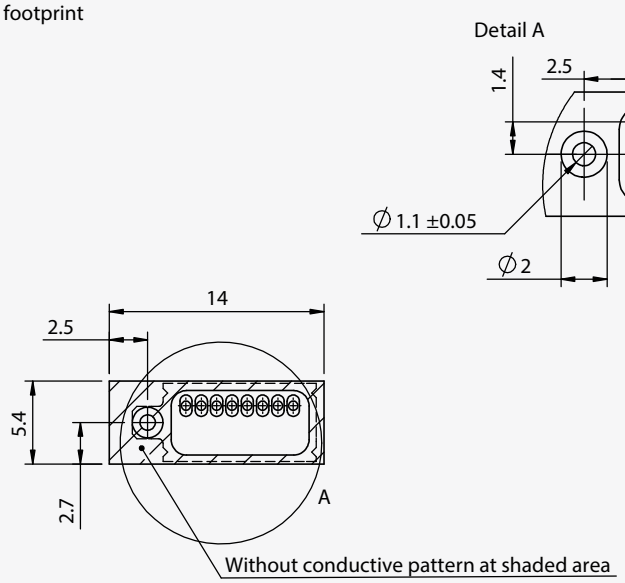
RLM2 readhead with pins for direct soldering to PCB (RLM2HD, RLM2DE, RLM2SJ)



3D model available for download at **RLS Media center.**

* The orientation of the readhead relative to the MS05 magnetic scale or axial/radial ring is essential when using a unique reference mark. For more information, see the MSD01, MR02D02 or MR01D01 data sheet at **RLS Media center.**

PCB footprint

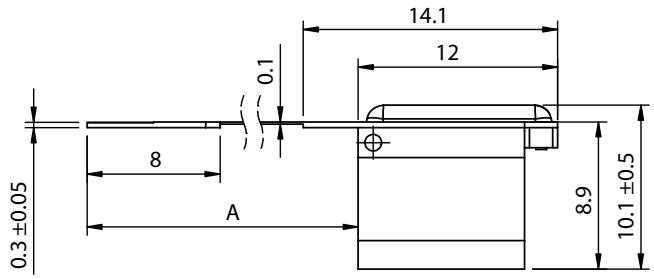


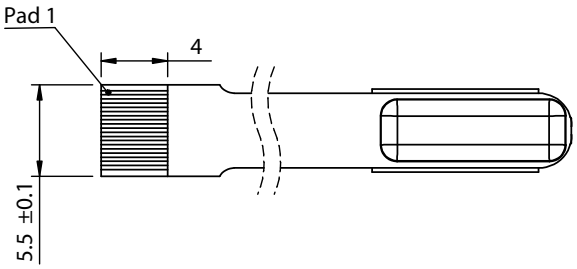
Flow soldering not allowed. Hand soldering temperature: T_{max} 260 °C; t_{max} 5 s

Pinout for RLM2 readhead with pins

Pin	Function	RLM2HD (incremental output)	RLM2DE (BiSS C output + incremental output)	RLM2SJ (SSI output + incremental output)
1	Output	NC	SLO	DATA
2	Input	NC	MA	CLK
3	Output	Error	Error	Error
4	Power	V_{dd} (+5 V)	V_{dd} (+5 V)	V_{dd} (+5 V)
5	Power	GND (0 V)	GND (0 V)	GND (0 V)
6	Output	A	A	A
7	Output	Z	Z	Z
8	Output	B	B	B

RLM2 readhead with flex cable (RLM2HD, RLM2DE, RLM2SJ)



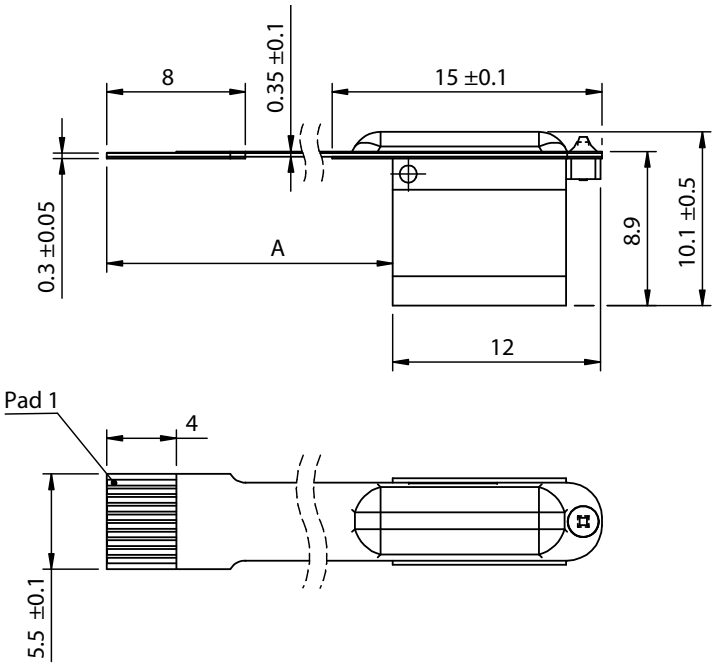


For other (universal) dimensions see **RLM2 readhead with pins**.

Electrical connection for RLM2 readhead with flex cable

Pad (flex cable)	Function	RLM2HD (incremental output)	RLM2DE (BiSS C output + incremental output)	RLM2SJ (SSI output + incremental output)
1	Shielding	Case	Case	Case
2	Output	NC	SLO	DATA
3	Input	NC	MA	CLK
4	Output	Error	Error	Error
5	Power	V_{dd} (+5 V)	V_{dd} (+5 V)	V_{dd} (+5 V)
6	Power	GND (0 V)	GND (0 V)	GND (0 V)
7	Output	A	A	A
8	Output	Z	Z	Z
9	Output	B	B	B
10	Shielding	Case	Case	Case

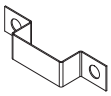
RLM2 readhead with RS422 flex cable (RLM2IC)



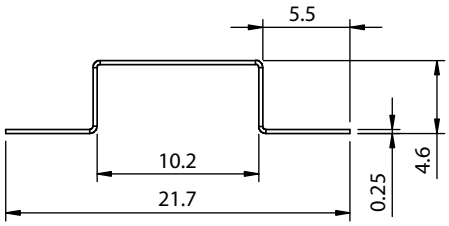
Electrical connection for RLM2 readhead with RS422 flex cable

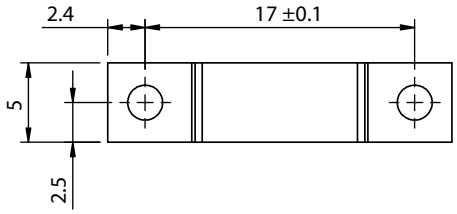
Pad	Function	RLM2IC
1	Shielding	Case
2	Output	A
3	Output	A-
4	Output	B-
5	Power	V_{dd} (+5 V)
6	Power	GND (0 V)
7	Output	B
8	Output	Z-
9	Output	Z
10	Shielding	Case

For other (universal) dimensions see **RLM2 readhead with pins**.



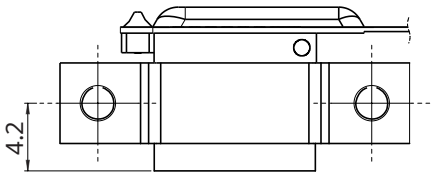
Mounting bracket





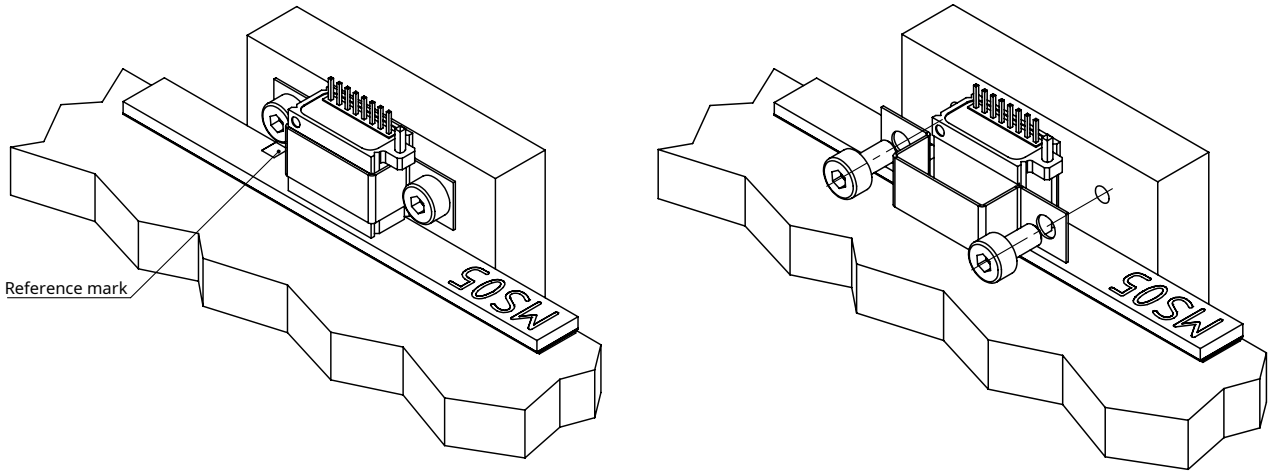
Position of installation holes

Recommended use of M2 fasteners with washers. For more information see **Table of recommended fastener tightening torques** at **RLS Media center.**



Installation instructions

When mounting the RLM2 readhead please make sure that orientation relative to the magnetic scale or ring is correct.
All permissible distance and angle tolerances must be strictly complied according to the mounting instructions found at MSD01, MR01D01 or MR02D02 data sheet at **RLS Media center.**



Images are for illustration purposes only. Valid for all three versions.

Position of installation holes

Recommended use of M2 fasteners with washers. For more information see **Table of recommended fastener tightening torques** at **RLS Media center.**

- The magnetic encoder system is sensitive to external magnetic fields. The magnitude of the influence on the magnetic encoder system depends on the magnitude and direction of the external magnetic field. In particular, the rapidly changing stray magnetic fields affect the system and can change its function. Magnetic field strength within 1 mT reduces the accuracy of the system. Field strengths greater than 1 mT could cause the system to malfunction and, as a result, the readhead reports an incorrect incremental position over ABZ or BiSS C/SSI channels with the active error output/status. Magnetic field strengths greater than 25 mT will cause irreparable damage to the magnetic scale or ring and must be replaced.
- The RLM2 readhead in considered as a PCBA type due to the exposed connection pins therefore cannot be specified with the IP rating.
- The flex cable requires adequate strain relief to ensure the integrity and avoid side forces that can loosen or damage the flex cable or connector on the controller side. Refer to the **mechanical data** table for the dynamic and static bending radius of the flex cable. The mechanical design in which the RLM2 is integrated must strictly comply with the specifications given.
- The encoder system and flex cable must be appropriately integrated into the application to minimize electromagnetic interference.

Technical specifications

System data

Pole length		2 mm
Maximum measuring length		50 m
System accuracy	Linear application MS05 magnetic scale	±10 µm/m / ±20 µm/m / ±40 µm/m Different accuracy grades of MS05 magnetic scale available. Refer to MSD01 available at **RLS Media center.**
	Rotary application	**Axial:** Refer to MR01D01 available at **RLS Media center.** **Radial:** Refer to MR02D02 available at **RLS Media center.**
Hysteresis		< 3 µm (at 0.3 mm ride height)
Repeatability (unidirectional)		< 1 µm
Reference mark		Unique / Periodic
Hand soldering (for pin variant only)		T_{max} 260 °C; t_{max} 5 s
Set-up time		< 50 ms (after power supply voltage is set in operating range)
Resolution		Max. 13 bit (~0.244 µm) For details refer to the **Table of available resolutions**.
Maximum speed	Linear application	Refer to MS speed calculator available at **RLS website**.
	Rotary application	**Axial:** Refer to speed calculator available at **RLS website**. **Radial:** Refer to speed calculator available at **RLS website.**

Electrical data

Power supply	5 V ±0.25 V – voltage on readhead
Current consumption	< 30 mA without 120 Ω termination < 130 mA with 120 Ω termination (valid for RS422 version)
Reverse polarity protection	With reverse polarity protection.
Maximum cable length	Flex cable: 75 mm, 100 mm or 136 mm. **Contact RLS** for other lengths.

Mechanical data

Mass	1.4 g (without flex), 1.6 g (with flex)
Mounting bracket material	Nickel-Silver
Readhead housing material	ZnAl4Cu1 - zamak 5
Dynamic bend radius	With flex cable: 20 mm With RS422 flex cable: not recommended
Static bend radius	With flex cable: 4 mm With RS422 flex cable: 10 mm
Mating connector for RLM2 flex version (not provided)	Molex - 51281-1094 Molex - 52745-1097 Molex - 52746-1071 JST - 10FLH-SM1-TB JST - 10FLH-RSM1-TB

Environmental data

Temperature (readhead)	Operating	With flex cable:	–20 °C to +85 °C
		Without flex cable:	–40 °C to +85 °C
	Storage	–40 °C to +85 °C	
Vibrations (55 Hz to 2000 Hz)		300 m/s² (IEC 60068-2-6)	
Shocks (6 ms)		300 m/s² (IEC 60068-2-27)	
RoHS		Compliant with EU Directive 2002/95/EC	
Moisture level		MSL6 (IPC/JEDEC-J-STD-020)	
External magnetic field during operation		< 1 mT	
ESD immunity		HBM, Class 2 ±2 kV	

Output types

Incremental ABZ, no line driver output

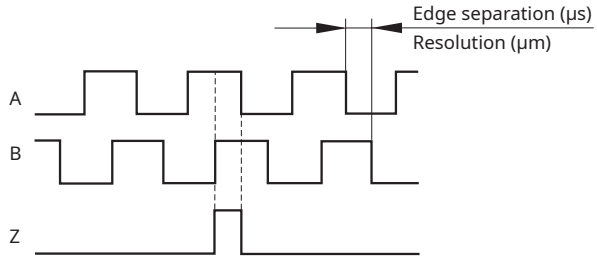
RLM2DE, RLM2HD, RLM2SJ

Specifications

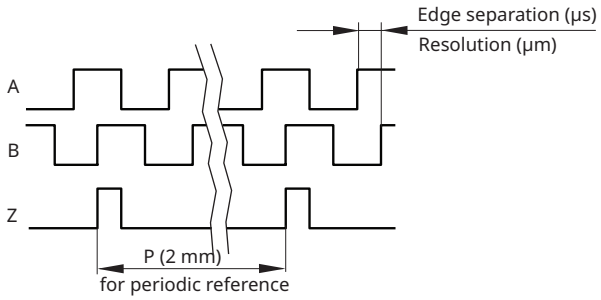
Output signals	Digital – TTL-level (A, B, Z)
Reference signal	1 or more square-wave pulse Z
Saturation voltage hi (I = –4 mA)	V_{dd} – 0.4 V
Saturation voltage lo (I = 4 mA)	0.4 V
Rise and fall time (c_c = 50 pF)	60 ns

Timing diagram

Incremental - unique reference mark



Incremental - periodic reference mark

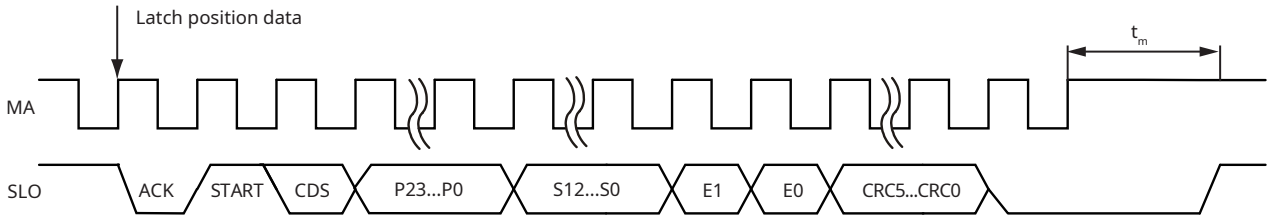


BiSS C output

RLM2DE

Specifications

Output signals	Digital − TTL-level (MA and SLO)
Threshold voltage Hi (MA input)	2 V
Threshold voltage Lo (MA input)	0.8 V
Saturation voltage hi (I = −4 mA) (SLO output)	V_{dd} − 0.4 V
Saturation voltage lo (I = 4 mA) (SLO output)	0.4 V
Rise and fall time (c_c = 50 pF) (SLO output)	60 ns
Type of interface	BiSS C unidirectional (point to point)
Maximum MA clock frequency	8 MHz
Minimum MA clock frequency	670 kHz (SLO line goes high)
Length of ACK	1 to 2 bits
Length of period counter	From 0 to 24 bits (length depends on the selected period counter settings)*
Length of position data	From 3 to 13 bits (length depends on the selected resolution)
Length of status data	2 bits - E1 and E0
Length and type of CRC data	6 bit (inverted bit output, MSB first - polynomial 0x43)
Latency time	0.63 µs at 8 MHz MA freq.; otherwise 4 MA clock periods
Timeout (t_m)	1.5 µs



Data	Length	Description
P23 – P0	0 to 24 bit	Period counter value (length depends on the selected period counter)*
S12 – S0	3 to 13 bit	Position inside the period (length depends on the selected resolution)
E1 – E0	2 bit	Error data
CRC5 – CRC0	6 bit	Cyclic redundancy check data; polynomial 0 × 43; inverted bit output

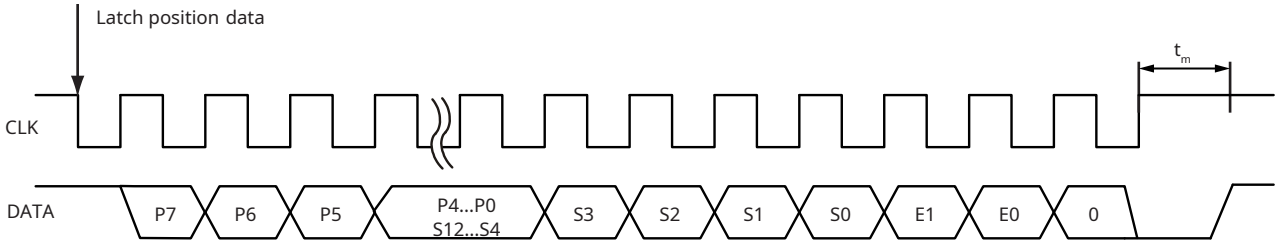
* The period counter is a data field in BiSS C or SSI output that reflects the number of magnetic poles passed during a linear or rotational movement. The period counter feature is especially useful for counting the poles in rotary applications and thus making the incremental ring absolute once the unique reference mark is passed. This can be done if the option of resetting the period counter on the unique reference mark is chosen (options E, F and G under the “period counter length”).

SSI output

RLM2SJ

Specifications

Output signals	Digital − TTL-level (CLK and DATA)
Threshold voltage Hi (MA input)	2 V
Threshold voltage Lo (MA input)	0.8 V
Saturation voltage hi (I = −4 mA) (SLO output)	V_{dd} − 0.4 V
Saturation voltage lo (I = 4 mA) (SLO output)	0.4 V
Rise and fall time (c_c = 50 pF) (SLO output)	60 ns
Type of interface	SSI (point to point)
Maximum CLK clock frequency	4 MHz
Minimum CLK clock frequency	50 kHz
Length of period counter	From 0 to 24 bits (length depends on the settings chosen)*
Length of position data	From 3 to 13 bits (length depends on the resolution chosen)
Length of status data	2 bits - E1 and E0
Latency time	125 ns at 4 MHz CLK freq.
Timeout (t_m)	20 µs



Data	Description
P0 - P7	Period counter value (length depends on the settings chosen)*
S0 - S12	Position inside the period (length depends on the resolution)
E1 - E0	Error data

* The period counter is a data field in BiSS C or SSI output that reflects the number of magnetic poles passed during a linear or rotational movement. The period counter feature is especially useful for counting the poles in rotary applications and thus making the incremental ring absolute once the unique reference mark is passed. This can be done if the option of resetting the period counter on the unique reference mark is chosen (option E, F and G under the “period counter length”).

Error for BiSS C and SSI output (RLM2DE and RLM2SJ)	E1	E0
No error (position data is valid)	1	1
Amplitude error (position data is not valid) Possible causes: • The distance between the readhead and the magnetic scale is too large. • Incorrect orientation of the readhead and the magnetic scale. • The readhead is out of alignment with the magnetic scale or the magnetic scale is demagnetised.*	0	1
Frequency error (position data is not valid) Possible causes: • Velocity too high**	1	0
Undervoltage; EEPROM Configuration; System error (position data is not valid)	0	0

*The Amplitude error (E1) does not indicate non-optimal installation of the readhead such as accuracy outside of specified or reference mark functionality.

For max. speed table for axial rings refer to the MR01D01 at **RLS Media center or speed calculator for radial rings at **RLS website.**
For max. speed table for magnetic scales refer to the MSD01 at **RLS Media center**.

Incremental, RS422

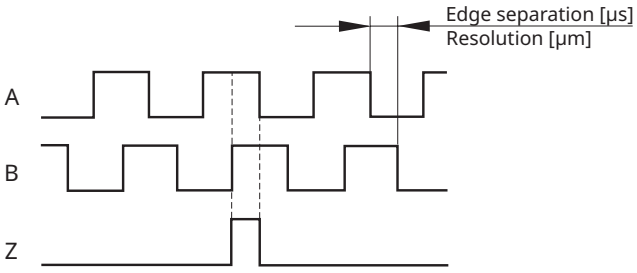
RLM2IC

Specifications

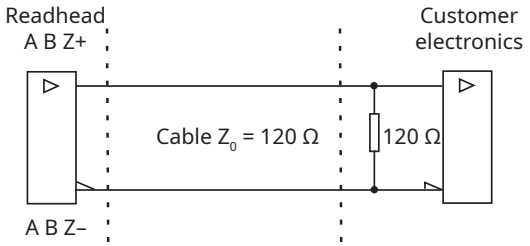
Output signals	3 square-wave signals A, B, Z and their complementary signals A–, B–, Z–
Reference signal	1 or more square-wave pulse Z and its complementary pulse Z–
Signal level	Differential line driver according to EIA standard RS422
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs

Timing diagram

Complementary signals not shown



Recommended signal termination



Error output

RLM2HD, RLM2DE and RLM2SJ

To enable successful error diagnosis, different types of errors are signaled on the error line with a PWM formatted code as described below. In case of an amplitude or frequency error, the PWM cycle frequency is approximately 16.5 Hz (cycle duration: 60.7 ms).

Failure mode	Error output	Possible causes
No error (position data is valid)	High	-
Amplitude error (position data is not valid)	Low: 75 % High: 25 %	• The distance between the readhead and the magnetic scale is too large. • Incorrect orientation of the readhead and the magnetic scale. • The readhead is out of alignment with the magnetic scale or the magnetic scale is demagnetised.*
Frequency error (position data is not valid)	Low: 50 % High: 50 %	Velocity too high**
System error (position data is not valid)	Low	Undervoltage EEPROM Configuration

* The Amplitude error (E1) does not indicate non-optimal installation of the readhead such as accuracy outside of specified or reference mark functionality.

For max. speed table for axial rings refer to the MR01D01 at **RLS Media center or speed calculator for radial rings at **RLS website.** For max. speed table for magnetic scales refer to the MSD01 at **RLS Media center**.

If an amplitude error occurs, the conversion process is stopped and the incremental output signals are terminated. An amplitude error excludes the possibility of a frequency error.
The error output is an open collector type with a built-in pull-up resistor. It can be used in a “wired-OR” digital logic configuration with other error signals in the system.

Part numbering

RLM 2 HD A 13B A 00 A 00

Pole length

2 - 2 mm

Output type

DE - BiSS C + Incremental, no line driver, 5 V
HD - Incremental, no line driver, 5 V
IC - Incremental, RS422, 5 V
SJ - SSI + Incremental, no line driver, 5 V

Period counter length

A - 0 bit (default)
B - 8 bit
C - 12 bit
D - 24 bit
E - 8 bit, reset by reference mark
F - 12 bit, reset by reference mark
G - 24 bit, reset by reference mark

Interpolation factor — Max Speed Calculators

13B - 8192 (0.244 µm)	**09B** - 512 (3.906 µm)	**D10** - 100 (20 µm)
12B - 4096 (0.488 µm)	**D50** - 500 (4 µm)	**D08** - 80 (25 µm)
11B - 2048 (0.977 µm)	**D40** - 400 (5 µm)	**06B** - 64 (31.250 µm)
2D0 - 2000 (1 µm)	**D32** - 320 (6.250 µm)	**D04** - 40 (50 µm)
1D6 - 1600 (1.250 µm)	**08B** - 256 (7.813 µm)	**05B** - 32 (62.500 µm)
10B - 1024 (1.953 µm)	**D20** - 200 (10 µm)	**04B** - 16 (125 µm)
1D0 - 1000 (2 µm)	**D16** - 160 (12.500 µm)	**03B** - 8 (250 µm)
D80 - 800 (2.500 µm)	**07B** - 128 (15.625 µm)	

For DPI resolution see **Table of available resolutions**.

Minimum edge separation — Max Speed Calculators

K - 0.07 µs (15 MHz)
A - 0.12 µs (8 MHz)
B - 0.5 µs (2 MHz)
C - 1 µs (1 MHz)
D - 2 µs (0.5 MHz)
E - 4 µs (0.25 MHz)
F - 5 µs (0.2 MHz)
G - 10 µs (0.1 MHz)
H - 20 µs (0.05 MHz)

The customer's controller must support the selected edge separation time even if the encoder is used below the maximum speed.

Connector

00 - Pins only
04 - Flex cable, length 75 mm
15 - Flex cable, length 136 mm
16 - Flex cable, length 100 mm (RLM2IC only)

Reference mark

A - With reference mark
Magnetic scale or ring must be ordered with reference mark. If required, the cover foil can be installed over the reference mark.
B - No reference sensor
C - Periodic reference impulse as per scale pitch (every 2 mm)
Reference periods correspond to pole length of magnetisation. Magnetic scale or ring must be ordered with **no** reference mark.

Special requirements

00 - No special requirements (standard)
05 - DPI version

Not all part number combinations are valid. Please refer to the table of available combinations on the next page for available options.

Table of available combinations

Series	Output type	Period counter length	Interpolation factor	Minimum edge separation	Connector	Reference mark	Special requirements
RLM2	IC	A	xxx[a]	K / A / B / C / D / E / F / G / H	15 / 16	A / B / C	00 / 05
			04B	A / B / C / D / E / F / G / H		B / C	
			03B	B / C / D / E / F / G / H			
	HD		xxx[a]	K / A / B / C / D / E / F / G / H	00 / 04 / 15	A / B / C	
			04B	A / B / C / D / E / F / G / H		B / C	
			03B	B / C / D / E / F / G / H			
	DE / SJ	A / B / C / D / E / F / G	xxx[a]	K / A / B / C / D / E / F / G / H		A / B / C	
			04B	A / B / C / D / E / F / G / H		B / C	
			03B	B / C / D / E / F / G / H			

* Please check the table on the next page for available interpolation factors.

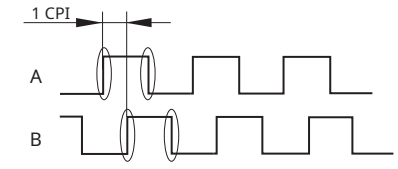
For the part numbering of the MS incremental magnetic scale or the MR radial and axial incremental magnetic ring, refer to data sheets MSD01, MR02D02 and MR01D01 at **RLS Media center**.

Available resolutions

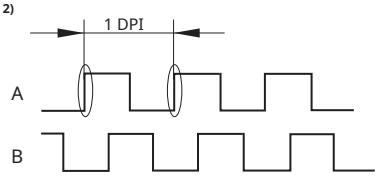
Table of available resolutions

Part number	Interpolation factor	Resolution		
		In µm with 2 mm poles	CPI (counts per inch 2,032 mm)[1]	DPI (pulse per inch 2,032 mm)[2]
13B	2^{13}	0.244140625	102,400	25,600
12B	2^{12}	0.48828125	51,200	12,800
11B	2^{11}	0.9765625	25,600	6,400
2D0	2000	1	25,000	6,250
1D6	1600	1.25	20,000	5,000
10B	2^{10}	1.953125	12,800	3,200
1D0	1000	2	12,500	3,125
D80	800	2.5	10,000	2,500
09B	2^{9}	3.90625	6,400	1,600
D50	500	4	6,250	1,562.5
D40	400	5	5,000	1,250
D32	320	6.25	4,000	1,000
08B	2^{8}	7.8125	3,200	800
D20	200	10	2,500	625
D16	160	12.5	2,000	500
07B	2^{7}	15.625	1,600	400
D10	100	20	1,250	312.5
D08	80	25	1,000	250
06B	2^{6}	31.25	800	200
D04	40	50	500	125
05B	2^{5}	62.5	400	100
04B	2^{4}	125	200	50
03B	2^{3}	250	100	25

1)



2)



Resolutions calculation

$$\text{Resolution [µm]} = \frac{\text{Pole length [µm]}}{\text{Interpolation factor}} = \frac{2000}{\text{Interpolation factor}}$$

For ring applications:

CPR – Counts per revolution (resolution)

Resolution [CPR] = Pole number* x Interpolation factor

PPR – Pulses per revolution

$$\text{Resolution [PPR]} = \frac{\text{Resolution [CPR]}}{4}$$

Resolutions calculation for CPI/DPI

$$\text{Resolution [µm]} = \frac{\text{Pole length [µm]}}{\text{Interpolation factor}} = \frac{2032}{\text{Interpolation factor}}$$

$$\text{Resolution [CPI]} = \frac{\text{Inch [µm]}}{\text{Resolution [µm]}} =$$

$$= \frac{\text{Inch [µm]} \times \text{Interpolation factor}}{\text{Pole length [µm]}} =$$

$$= \frac{25400 \times \text{Interpolation factor}}{2032}$$

$$\text{Resolution [DPI]} = \frac{\text{CPI}}{4}$$

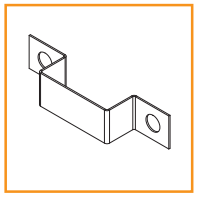
*See pole numbers in the MR01D01 or MR02D02 data sheet at **RLS Media center.**

Accessories

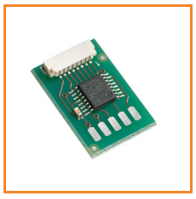
USB encoder interface (Quadrature output ABZ)
E201-9Q

Connector adapters FFC to DB9 (connect to E201):
RLACC001 (RLM2IC)
RLACC002 (RLM2HD)
RLACC003 (RLM2DE and RLM2SJ)
RLACC004 (RLM2IC)

USB encoder interface (BiSS C and SSI output)
E201-9S



Mounting bracket
RLMMB01



Line driver board for incremental encoders
LDB01

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Document issues

Date	Issue	Page	Description
5. 1. 2022	10	General	Redesign, general amendment
6. 10. 2022	11	General	Repeatability, DPI calculation, dimensions and installation drawings amended, humidity and external magnetic field data added
3. 4. 2023	12	11	Error for BiSS C and SSI output table amended
15. 9. 2023	13	13	Menu (button) Max Speed Calculators added
13. 10. 2023	14	8	Set-up time amended
25. 1. 2024	15	7	Positive direction chapter added
6. 9. 2024	16	16	LDB01 added