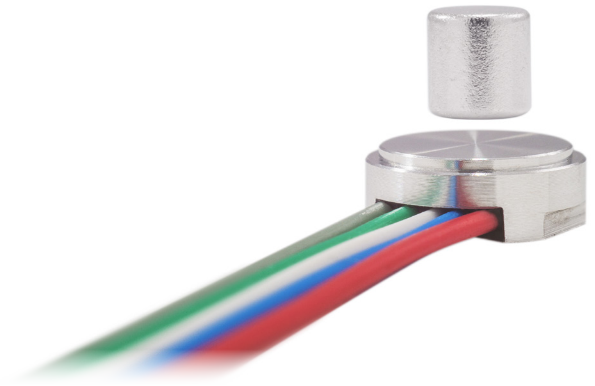
Data sheet
**RM08D01_08**
Issue 8, 10th February 2016

# RM08 super small non-contact rotary encoder




**The RM08 is a compact, sealed, super small, high speed rotary magnetic encoder designed for use in space limited applications. The non-contact two part design removes the need for seals or bearings ensuring long-term reliability and simple installation.**

**The encoder consists of a magnet and a separate sensor board. Rotation of the magnetic actuator is sensed by a custom encoder chip within the body, and processed to give incremental, SSI or linear voltage outputs.**

The encoder chip processes the signals received to provide resolutions to 12 bit (4,096 counts per revolution) with high operational speeds.

The compact encoder body is just 8 mm in diameter and provides degree of protection to IP68.

The RM08 encoder has been designed for direct integration to high volume OEM applications and can be used in a wide range of applications including motor control and industrial automation.

**Product range**

**RM08A**
Analogue sine/cosine, one periode/revolution.

**RM08I**
Incremental with 8 to 1,024 pulses per revolution (32 to 4,096 counts per revolution).

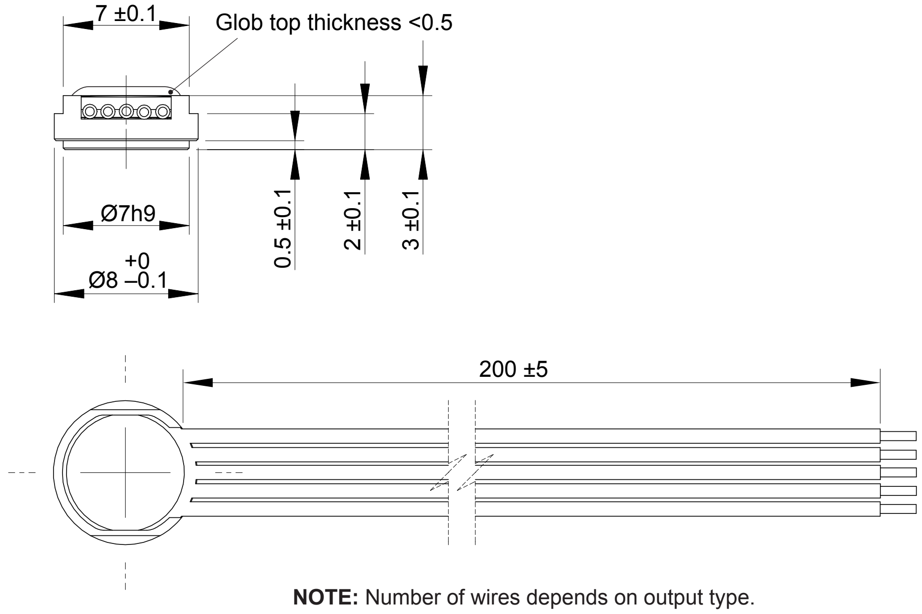
**RM08S**
Synchro serial with 5 to 12 bit resolution (32 to 4,096 positions per revolution).

**RM08V**
Linear voltage with ramp from 0 V to 5 V.

- Super small size – 8 mm diameter body
- Non-contact, frictionless design
- 3.3 V or 5 V power supply versions
- High speed operation to 30,000 rpm
- Industry standard analogue sinusoidal, incremental, SSI and linear voltage output formats
- Accuracy to ±0.3°
- RoHS compliant (lead free)

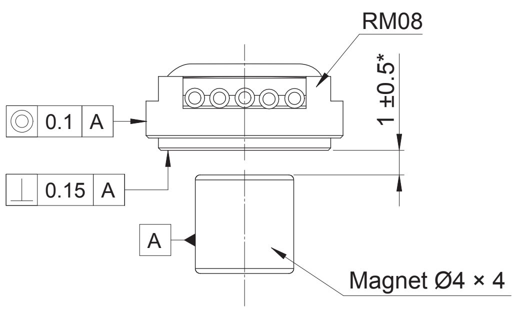
## RM08 dimensions

Dimensions and tolerance in mm.

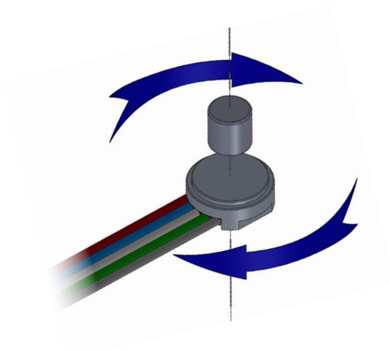



**NOTE:** Number of wires depends on output type.

## Mounting instructions




* Ø3 × 1 mm magnet: 0.5 mm
(more info: see part numbering on page 8).



Clockwise rotation of magnet.

## RM08 technical specifications

| | |
|---|---|
| **Mechanical data** | |
| **Encoder housing material** | Aluminium |
| **Encoder mass** | < 2 g (with 200 mm long wires) |
| **Wire thickness** | AWG30 |
| **Magnet material** | SmCo ($Sm_{17}Co_2$), NiCuNi coated |
| **Magnet mass** | 0.4 g |
| **Environmental data** | |
| **Operating and storage temperature** | –40 °C to +85 °C |

## RM08A - Analogue sinusoidal

Two sinusoidal output signals (90° phase shifted, single ended)

| | |
|---|---|
| **Power supply** | $V_{dd}$ = 5 V or 3.3 V ± 5 % |
| **Power consumption** | Typ. 26 mA |
| **Sinusoidal outputs** | |
| Signal amplitude (A) | 1.6 ± 0.4 V |
| Signal offset (Agnd) | 1.55 ± 5 mV |
| Phase difference | 90° ± 0.2° |
| **Max. speed** | 30,000 rpm |
| **Temperature** | –40 °C to +85 °C |

* Valid for Ø4 × 4 mm magnets only.

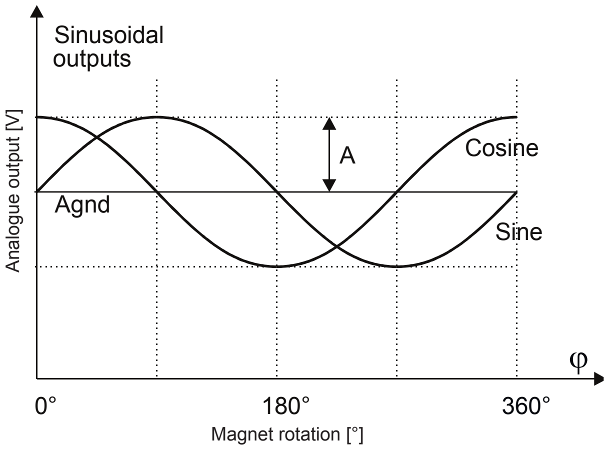



*Fig. 1: Timing diagram for clockwise rotation of magnet*

### Connections

| Signal | Colour |
|---|---|
| $V_{dd}$ | Red |
| GND | Blue |
| Sin | White |
| Cos | Grey |

## RM08I - Incremental output, single ended, 5 V

| | |
|---|---|
| **Power supply** | $V_{dd}$ = 5 V or 3.3 V ± 5 % |
| **Power consumption** | Typ. 26 mA |
| **Output signals** | A, B, Z (single ended) |
| **Resolution** | 32, 64, 128, 256, 512, 1024, 2048, 4096 cpr |
| **Max. speed** | 30,000 rpm |
| **Accuracy*** | ±0.3° |
| **Hysteresis** | 0.17° |
| **Temperature** | –40 °C to +85 °C |

* Valid for Ø4 × 4 mm magnets only.

### Connections

| Signal | Colour |
|---|---|
| $V_{dd}$ | Red |
| GND | Blue |
| Z | White |
| B | Green |
| A | Grey |

There are three signals for the incremental output: A, B and Z. Signals A and B are quadrature signals, shifted by 90°, and signal Z is a reference mark. The reference mark signal is produced once per revolution. The width of the Z pulse is 1/4 of the quadrature signal period and it is synchronised with the A and B signals. The position of the reference mark is at zero. Figure 2 shows the timing diagram of A, B and Z signals with clockwise rotation of the magnet. B leads A for clockwise rotation.

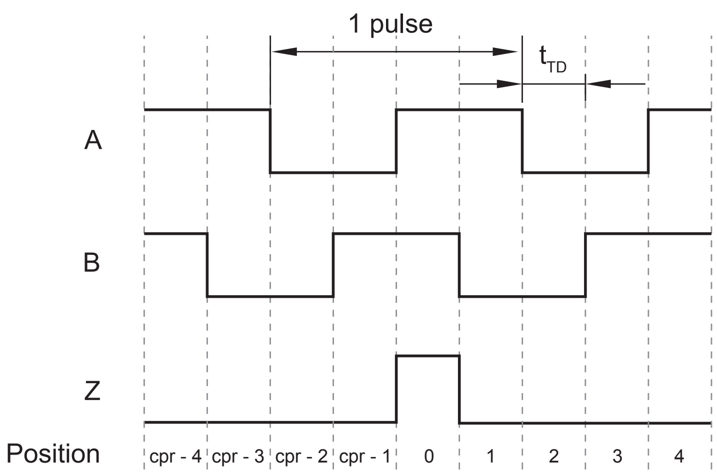



*Fig. 2: Timing diagram for incremental output*

The transition distance time ($t_{TD}$) is the time between two output position changes. The transition distance time is limited by the interpolator and the limitation is dependent on the output resolution. The counter must be able to detect the minimum transition distance to avoid missing pulses.

With incremental outputs it is important to know the difference between ppr (pulses per revolution) and cpr (counts per revolution = 4 × ppr). **Pulses per revolution** is the number of periods on one of the quadrature signals in one revolution. **Counts per revolution** is the number of changes of state on both channels in one revolution and is achieved by electronically multiplying by four, using both the rising and the falling edges on both channels.

## RM08S - Synchro serial interface (SSI), single ended, 5 V

| | |
|---|---|
| **Power supply** | $V_{dd}$ = 5 V or 3.3 V ± 5 % |
| **Power consumption** | Typ. 26 mA |
| **SSI Data output** | Data (single ended) |
| **SSI Clock input** | Clock (single ended) |
| **Resolution** | 5, 6, 7, 8, 9, 10, 11, 12 bit |
| **Max. speed** | 30,000 rpm |
| **Clock frequency** | ≤ 4 MHz |
| **Accuracy*** | ±0.3° |
| **Hysteresis** | 0.17° |
| **Temperature** | –40 °C to +85 °C |

* Valid for Ø4 × 4 mm magnets only.

### Connections

| Signal | Colour |
|---|---|
| $V_{dd}$ | Red |
| GND | Blue |
| Clock | White |
| Data | Green |

Serial output data is available in up to 12 bit natural binary code through the SSI protocol. With the clockwise magnet rotation, the value of the output data increases.

| Parameter | Symbol | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| **Clock period** | $t_{CL}$ | 0.25 | | 2 × $t_m$ | µs |
| **Clock high** | $t_{CHI}$ | 0.1 | | $t_m$ | µs |
| **Clock low** | $t_{CLO}$ | 0.1 | | $t_m$ | µs |
| **Monoflop time** | $t_m$ | 15 | 19 | 25 | µs |

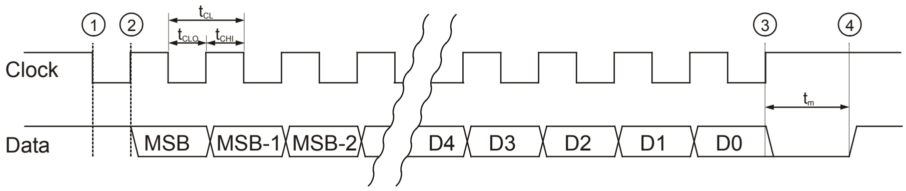



*Fig. 3: Timing diagram for SSI output*

The controller interrogates the encoder for its positional value by sending a pulse train to the Clock input. The Clock signal must always start from high. The first high/low transition (point 1) stores the current position data in a parallel/serial converter and the monoflop is triggered. With each transition of the Clock signal (high/low or low/high) the monoflop is retriggered. At the first low/high transition (point 2) the most significant bit (MSB) of the binary code is transmitted through the Data pin to the controller. At each subsequent low/high transition of the Clock the next bit is transmitted to the controller. While reading the data the $t_{CHI}$ and $t_{CLO}$ must be less than $t_{mMin}$ to keep the monoflop set. After the least significant bit (LSB) is output (point 3) the Data goes to low. The controller must wait longer than $t_{mMax}$ before it can read updated position data. At this point the monoflop time expires and the Data output goes to high (point 4).

If the controller continues sending the Clock pulses after the data is read without waiting for $t_m$, the same data will be output again and between the two outputs one logic zero will be output. The length of the data depends on the resolution of the encoder.

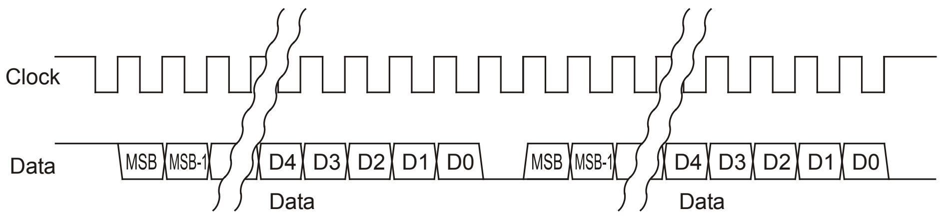



*Fig. 4: SSI multi-read of the same position data*

## RM08Vx - Linear voltage, 5 V

| | |
|---|---|
| **Power supply** | $V_{dd}$ = 5 V ± 5 % |
| **Power consumption** | Typ. 26 mA |
| **Output voltage** | 0 V to $V_{dd}$ |
| **Output load** | Max. 2 mA |
| **Resolution of DAC** | 10 bit |
| **Max. speed** | 30,000 rpm |
| **Nonlinearity*** | 1 % |
| **Temperature** | –40 °C to +85 °C |

* Valid for Ø4 × 4 mm magnets only.

### Connections

| Signal | Colour |
|---|---|
| $V_{dd}$ | Red |
| GND | Blue |
| $V_{out}$ | Green |

The digital relative angular position information is converted into linear voltage with a built-in 10 bit D/A converter. The linear output voltage swing ranges from 0 V and $V_{dd}$ (5 V). The number of periods within one revolution ($N_{period}$) can be 1, 2, 4 or 8, representing one full swing over an angle ($\varphi_{period}$) of 360°, 180°, 90° or 45° respectively. The signal is made up of steps which represent the angular movement needed to register a change in the position ($\varphi_{step}$) and the resulting change in the output voltage ($V_{step}$). The number of steps in one period ($N_{step}$) is given in the table below.

For clockwise rotation of the magnetic actuator, the output voltage increases. For counterclockwise rotation, the output voltage decreases.

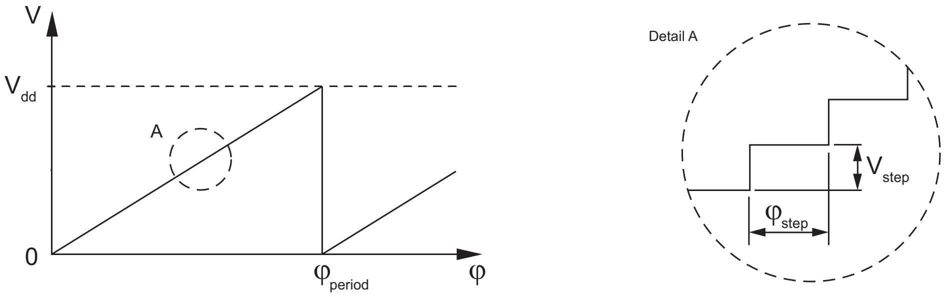



*Fig. 5: Timing diagram for linear voltage output*

$$\varphi_{step} = \frac{\varphi_{period}}{N_{step}} \qquad V_{step} = \frac{V_{dd}}{N_{step}}$$

$\varphi_{period}$ = Angle covered in one period (one sawtooth)
$V_{period}$ = Output voltage range for one period
$\varphi_{step}$ = Step angle (angular movement needed to register a change in the position)
$V_{step}$ = Output voltage range for one step
$N_{period}$ = Number of periods in one revolution
$N_{step}$ = Number of steps in one period

| $\varphi_{period}$ | $N_{period}$ | $N_{step}$ | $\varphi_{step}$ |
|---|---|---|---|
| **360°** | 1 | 1024 | 0.35° |
| **180°** | 2 | 1024 | 0.18° |
| **90°** | 4 | 1024 | 0.09° |
| **45°** | 8 | 512 | 0.09° |

### Output type and electrical variant

| $\varphi_{period}$ / Rotation | 360° | 180° | 90° | 45° |
|---|---|---|---|---|
| **Clockwise** | VA | VB | VC | VD |
| **Counterclockwise** | VE | VF | VG | VH |

## Position error

The position error or nonlinearity is defined as the difference between the actual angular position of the magnet and the angular position output from the encoder.

**Differential nonlinearity** is the difference between the measured position step and the ideal position step. The position step is the output position difference between any two neighbouring output positions, while the ideal position step is 360° divided by the resolution. Differential nonlinearity is mainly caused by noise. Differential nonlinearity is always less than one position step because there is a system that prevents missing codes. Figure 6 shows a typical differential nonlinearity plot of the encoder with 10 nF filtering and default parameters.

**Integral nonlinearity** is the total position error of the encoder output. Integral nonlinearity includes all position errors but does not include the quantisation error. Integral nonlinearity is minimised during production to better than ±0.2°. Figure 7 shows a typical integral nonlinearity plot of the encoder, a perfectly aligned magnet and 10 nF filtering.

**(Valid for Ø4 × 4 mm magnets only)**

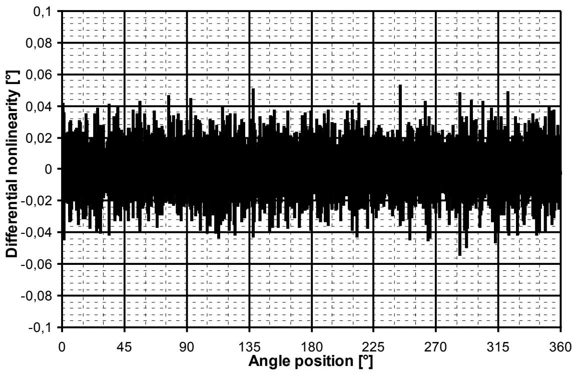



*Fig. 6: Typical differential nonlinearity*

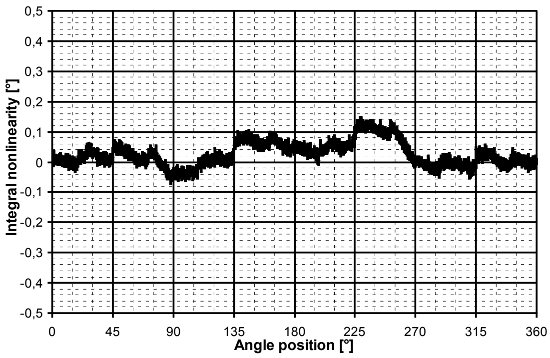



*Fig. 7: Typical integral nonlinearity at optimal parameters*

## RM08 ordering code

**RM08 ID 00 12B 02 L 2 G 00**

**Output type**
**AC** - Analogue sinusoidal
**ID** - Incremental, single ended
**SD** - Absolute binary synchro-serial (SSI), single ended
**Vx** - Linear voltage:

| **Linear voltage output 0 - 5 V, supply 5 V DC** | | | | |
|---|---|---|---|---|
| | 360° | 180° | 90° | 45° |
| CW | **VA** | **VB** | **VC** | **VD** |
| CCW | **VE** | **VF** | **VG** | **VH** |

**Shaft size**
**00** - N/A (standard)

**Resolution**
**For AC:**
**01S** - One sine/cosine wave per revolution
**For ID and SD** (counts or positions per revolution):
**05B** - 32
**06B** - 64
**07B** - 128
**08B** - 256
**09B** - 512
**10B** - 1024
**11B** - 2048
**12B** - 4096
**For Vx:**
**10B** - 1024 steps per revolution

**Cable length (length of leads)**
**02** - 0.2 metre (standard for leads)

**Connector option**
**L** - Leads only (no connector)

**Body style and cable exit**
**2** - Cylindrical body, radial cable/leads exit

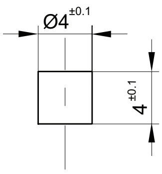
**Environment and material**
**G** - IP68, no EMC grade, aluminium body (standard)

**Special requirements**
**00** - None (standard)
**33** - 3.3 V power supply (for **AC, ID** and **SD** only)

## Magnet ordering information

### Magnet for direct recessing in non-ferrous shafts

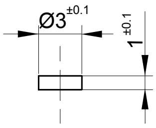
Fixing: Glue (recommended - LOCTITE 648 or LOCTITE 2701)




**Part numbers:**

For resolutions up to 9 bit absolute (512 cpr incremental)
**RMM44A2A00** (individually packed) – for sample quantities only
**RMM44A2C00** (packed in tubes)

For resolutions from 10 bit absolute (800 cpr incremental) and above
**RMM44A3A00** (individually packed) – for sample quantities only
**RMM44A3C00** (packed in tubes)




**Part number:**

**RMM3010A1B00**

**NOTE:** RMM3010 magnets are only tested (not graded). Specified accuracy cannot be achieved by using magnet RMM3010.

## Head office

**RLS merilna tehnika d.o.o.**
Poslovna cona Žeje pri Komendi
Pod vrbami 2
SI-1218 Komenda
Slovenia

**T** +386 1 5272100
**F** +386 1 5272129
**E** mail@rls.si
**www.rls.si**

### Document issues

| Issue | Date | Page | Corrections made |
|---|---|---|---|
| 1 | 20. 11. 2013 | - | New document |
| 2 | 5. 3. 2014 | 2 | Mounting instruction image added |
| 3 | 12. 9. 2014 | 2 | Dimensional drawing tolerance added |
| 4 | 7. 1. 2015 | 2 | Glob top thickness added |
| | | 5 | RM08V: Vout wire colour changed to green |
| | | 7 | 3.3 V power supply option and Ø3 × 1 mm magnet added |
| 5 | 24. 4. 2015 | 7 | Loctite information added |
| 6 | 3. 12. 2015 | 2 | Mounting instructions technical drawing corrected |
| 7 | 20. 1. 2016 | 1, 2, 8 | RM08A added |
| 8 | 10. 2. 2016 | 3, 4, 5, 8 | 3.3 V power supply added |