HiLin™

High-accuracy Linear Magnetic Encoder System

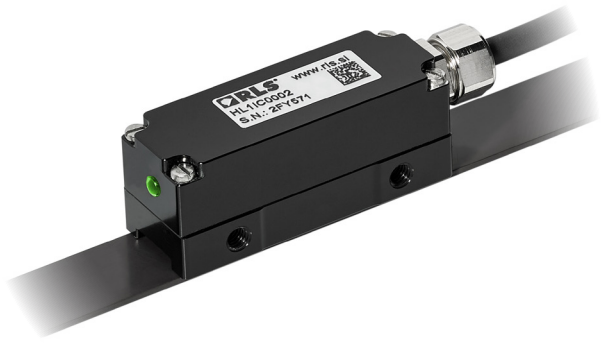
HIGH ACCURACY

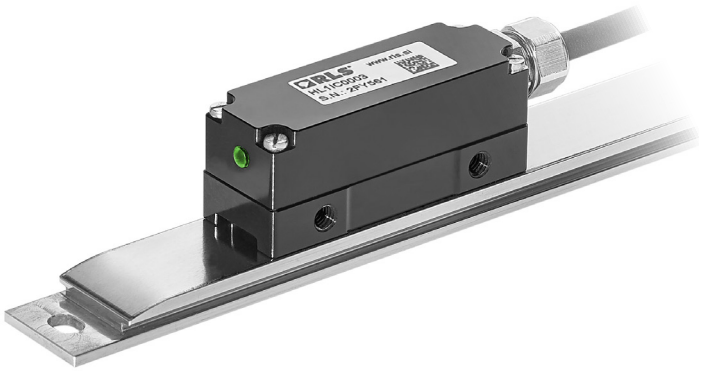
ROBUST DESIGN

HIGH SPEED

The HiLin series of high accuracy magnetic encoders is a family of linear incremental systems suitable for a variety of demanding applications. The incremental encoder system consists of a compact sealed readhead and a separate magnetic scale.

The readheads are available in high resolution and upon request offer customer-selectable interpolation factors that allow much more freedom in designing advanced systems. At the same time, low hysteresis and low interpolation error can be easily achieved, while maintaining a ride height tolerance within 0.2 ±0.1 mm.





Features and benefits

- Customer selectable resolutions down to 0.1 µm
- Unique, periodic or distance-coded reference mark
- Low hysteresis: ≤1 µm
- Low interpolation error (SDE): ±1.5 µm
- High speed: 25 m/s with 1 µm resolution
- Industry-standard digital incremental RS422 output
- Wide operating temperature range from –40 °C to +75 °C

LINEAR MOTOR | PRINTING TECHNOLOGY | SMT PICK AND PLACE | SERVO MECHANISMS | HARSH ENVIRONMENT

General information

The encoders provide an industry standard digital RS422 output. The readheads are fully sealed and feature high IP67 environmental protection, ensuring reliable operation in environments contaminated with particles, vapours and liquids. If damaged, a readhead can be easily replaced due to a detachable cable, which reduces costs.

Depending on the requirements of the application, different magnetic scale options can be selected. The most cost effective, lightweight and compact option is a self-adhesive scale with an accuracy of ±10 µm/m, which allows longer measuring lengths.

If higher accuracy is required, a solid stainless steel substrate scale with an accuracy class of ±5 µm/m is the solution. The stainless steel substrate allows thermal expansion and improves thermal compensation, while the welded cover foil completely encapsulates the scale and protects it from aggressive industrial chemicals. In addition, the scale does not have a fixed screw hole pattern, allowing greater installation flexibility.

The non-contact, frictionless design of the HiLin encoder system eliminates the need for special guide and sealing systems in aluminium profiles. The size of the readhead and scale can therefore be reduced considerably without affecting the speed or the robustness of the system. The HiLin encoder systems are a reliable solution for a variety of machines, e.g. lathes, EDM, precise laser or water jet cutting, grinding or milling machines, printers, presses, etc.

Choose your HiLin system

HiLin + MS19 or MS20 magnetic scale

HiLin + HMS solid magnetic scale

HiLin + HMS solid magnetic scale with welded cover foil

The pictures above do not represent all variants.

The HiLin readhead is available with 9-pin D type plug, connector only or flying lead.

Storage and handling

Storage temperature

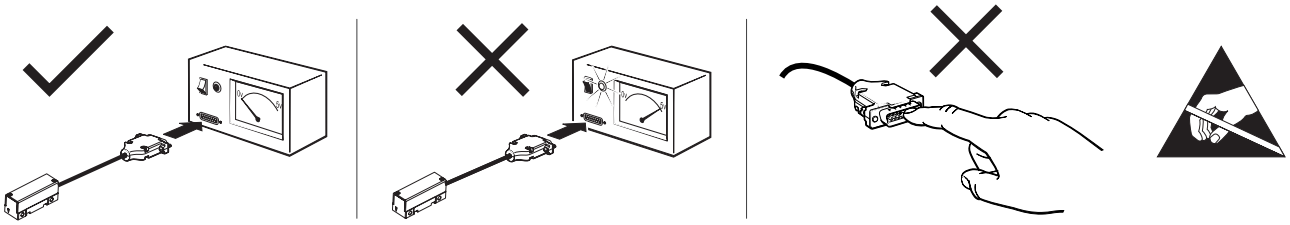
–40 °C to +75 °C

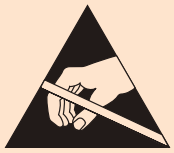
Operating temperature

–40 °C to +75 °C

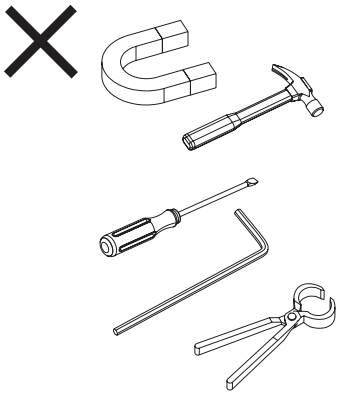
Humidity

High resistance to humidity





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



HANDLE WITH CARE

HiLin encoder system is a high performance metrology product and should be handled with the same care as any other precision instrument. The use of industrial tools during installation or exposure to strong magnets such as a magnetic base is not recommended as it carries the risk of damaging parts of the system which as a result might not perform in accordance with specifications.

Packaging

Readhead	Each readhead is packed individually in an antistatic bag, according to EMC.
Magnetic scale	Each magnetic scale is packed in a spiral.
Solid magnetic scale	Each solid magnetic scale is packed individually in a wooden box. Fasteners and washers are packed in a separate bag.

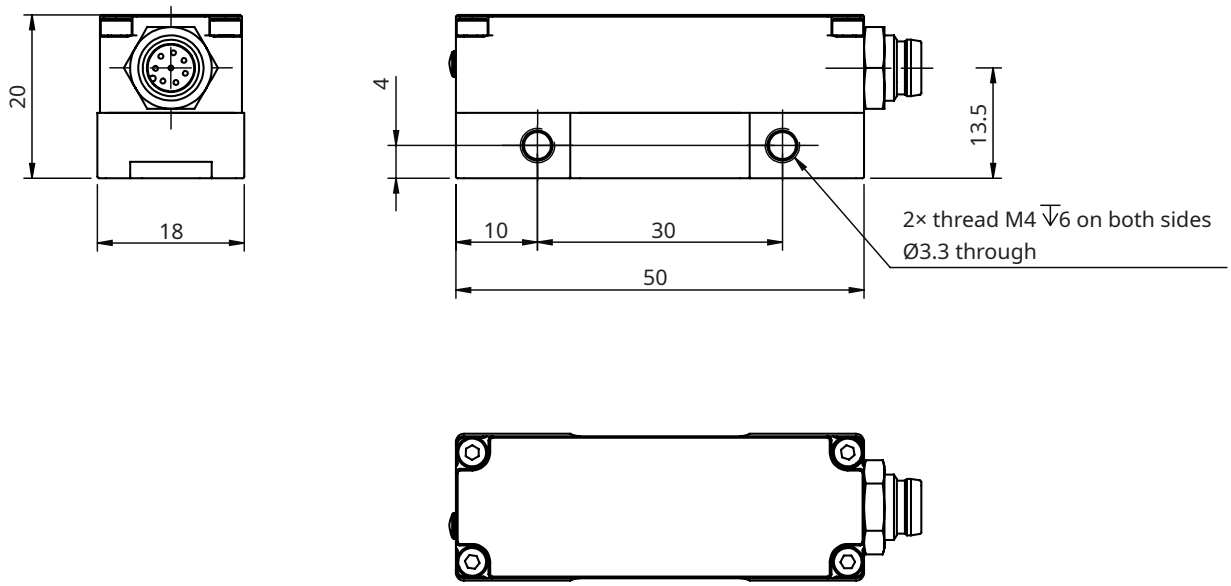
All MS magnetic scales have 12 months shelf life and should be installed within this period.

Dimensions and installation drawings

Dimensions and tolerances are in mm.

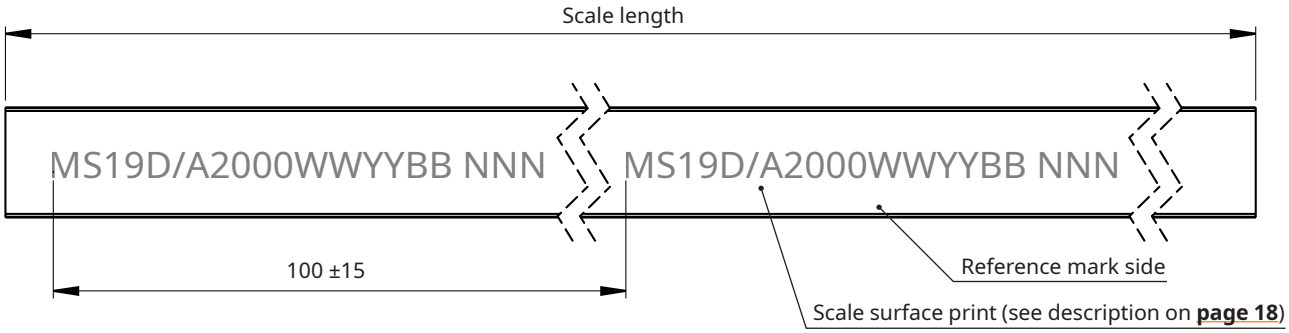
Readhead

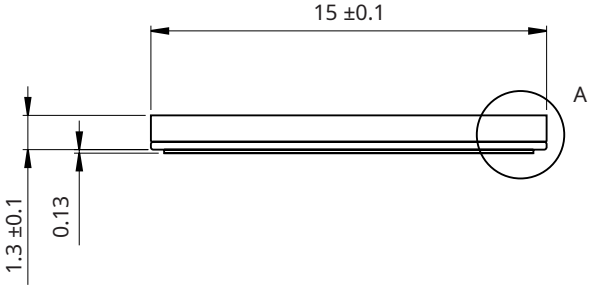
HiLin magnetic encoder

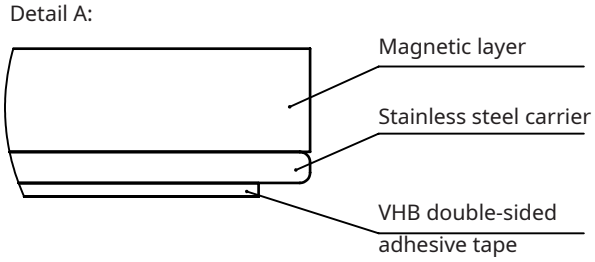


Magnetic scales

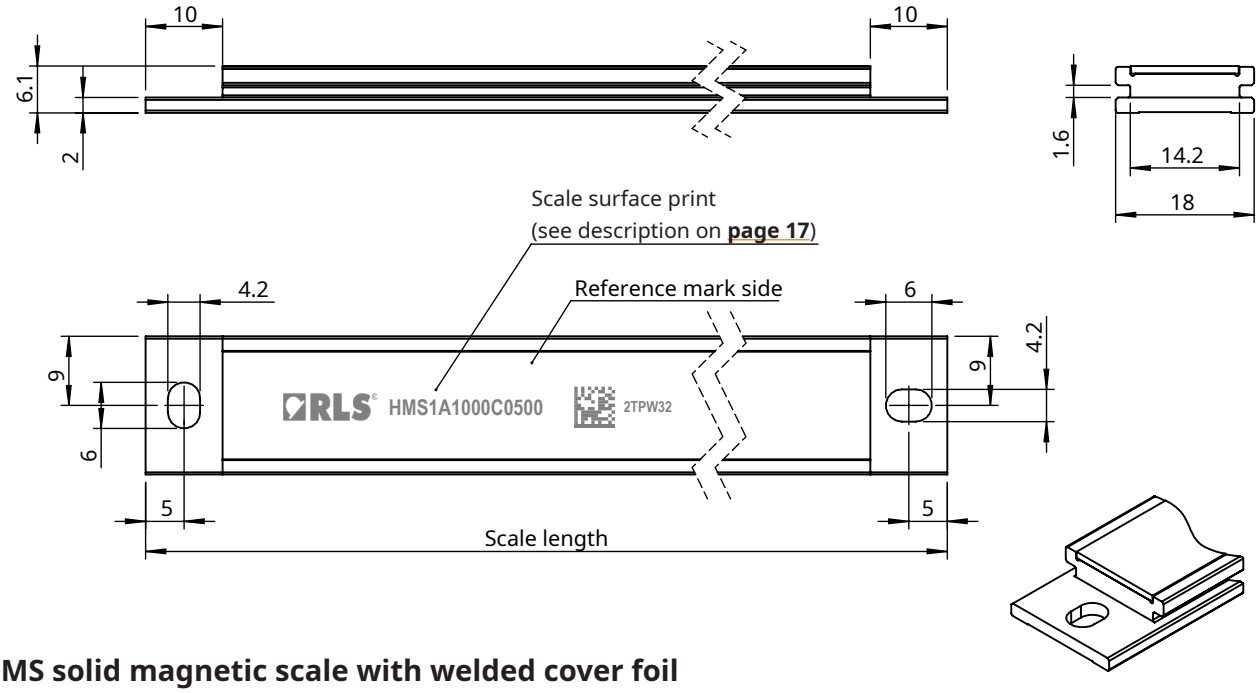
MS19 and MS20 magnetic scales



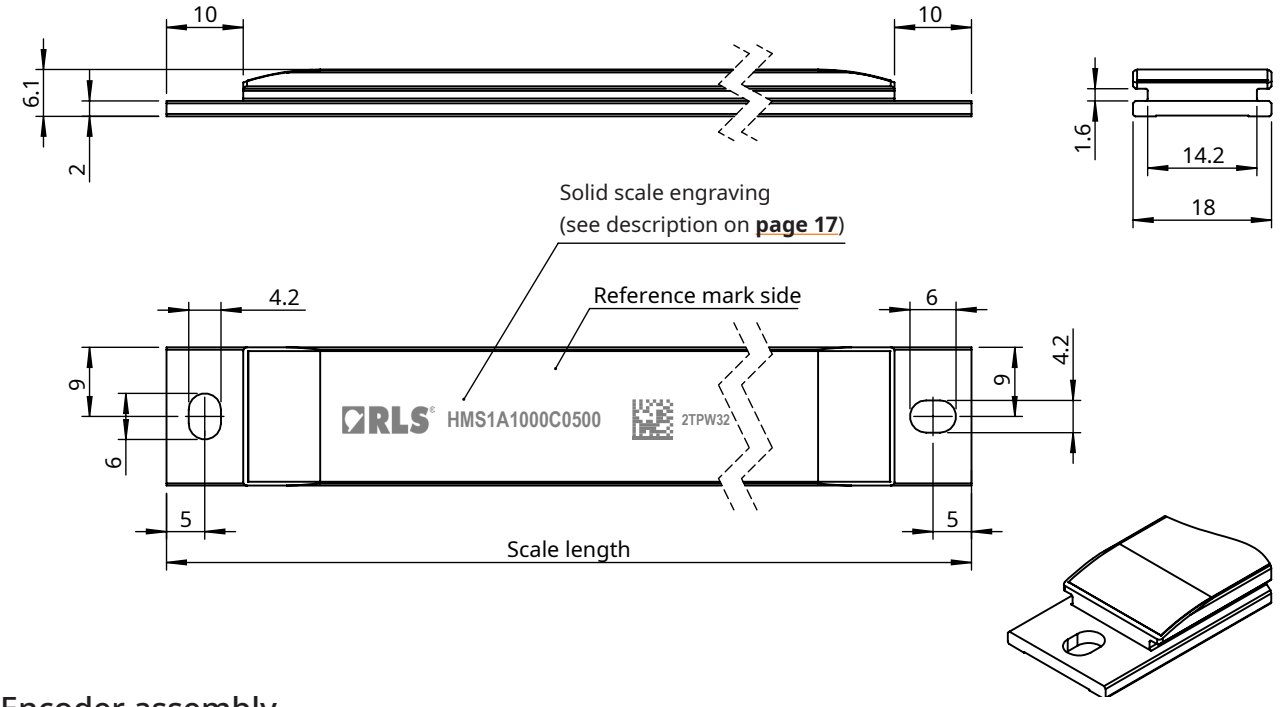




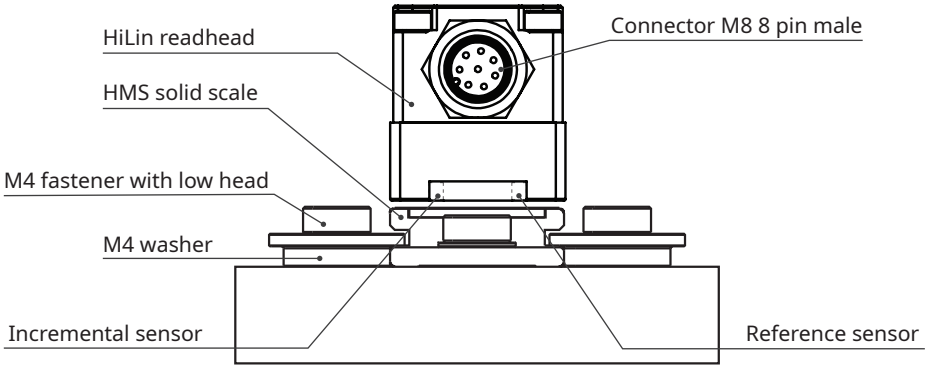
HMS solid magnetic scale



HMS solid magnetic scale with welded cover foil



Encoder assembly



Installation instructions

Installation of MS19/20 magnetic scale with adhesive tape

Installation surface preparation

MS19 and MS20 magnetic scales are equipped with VHB backside adhesive tape. Most substrates are best prepared by cleaning with a 50:50 mixture of isopropyl alcohol and water before applying the magnetic scale. Exceptions to the general procedure that may require additional surface preparation include:

- Heavy oil/grease: To remove heavy oil or grease from a surface, a degreaser or solvent-based cleaning agent may be required, followed by cleaning with IPA/water.
- Abrasion: Sanding a surface and then cleaning with IPA/water can remove heavy dirt or oxidation and improve adhesion.
- Adhesion promoters: Priming a surface can significantly improve initial and ultimate adhesion to many materials such as plastics and paints.
- Porous surfaces: Most porous and fibrous materials such as wood, chipboard, concrete, etc. must be sealed to provide a unified surface.
- Unique materials: Special surface preparation may be required for glass and glass-like materials, copper and copper-containing metals, plastics or rubber containing migrating components (e.g. plasticisers).

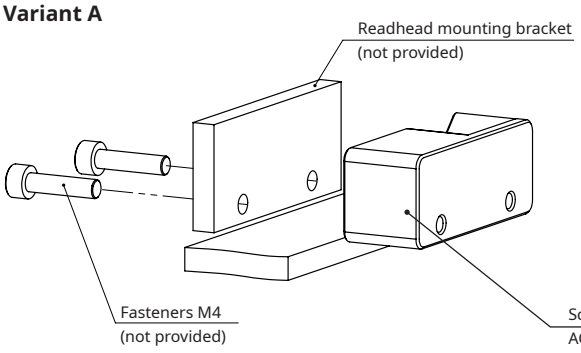
Further information can be found under "**Surface Preparation for 3M™ VHB™ Tape Applications**".

Scale application

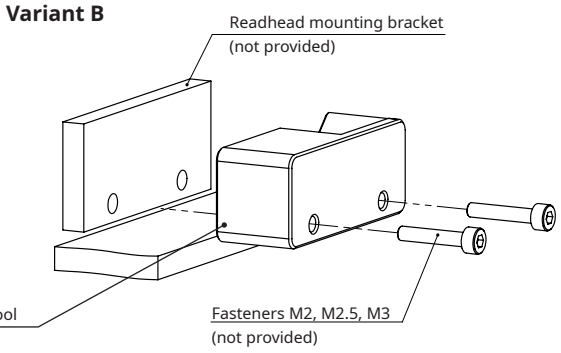
To simplify the scale installation use the scale applicator tool ACC047. Mount the applicator tool to the readhead mounting bracket. Use two fasteners as per readhead mounting configuration.

Fastener mounting variants

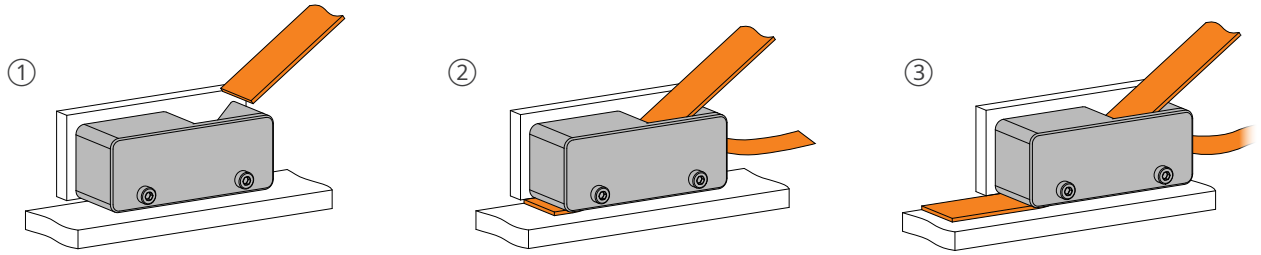
Variant A



Variant B



Good surface contact can be achieved by applying a pressure of about 100 kPa. At room temperature, approximately 50 % of the final bond strength is achieved after 20 minutes, 90 % after 24 hours and 100 % after 72 hours. Dynamic overlap shear (peak force to separate is measured after 72 hours dwell time): 830 kPa.



Load the scale into the applicator tool.
Separate the backing paper from the first 40 mm of scale and feed the scale into the applicator tool.

Apply the scale.
Push the scale carefully through to the end of scale mark, ensuring that it does not stick to the mounting surface until it is in position. Attach the end of the scale to the mounting surface with light finger pressure.

Ensure complete adhesion.
Apply firm finger pressure along the full length of the scale from the centre outwards to each end.

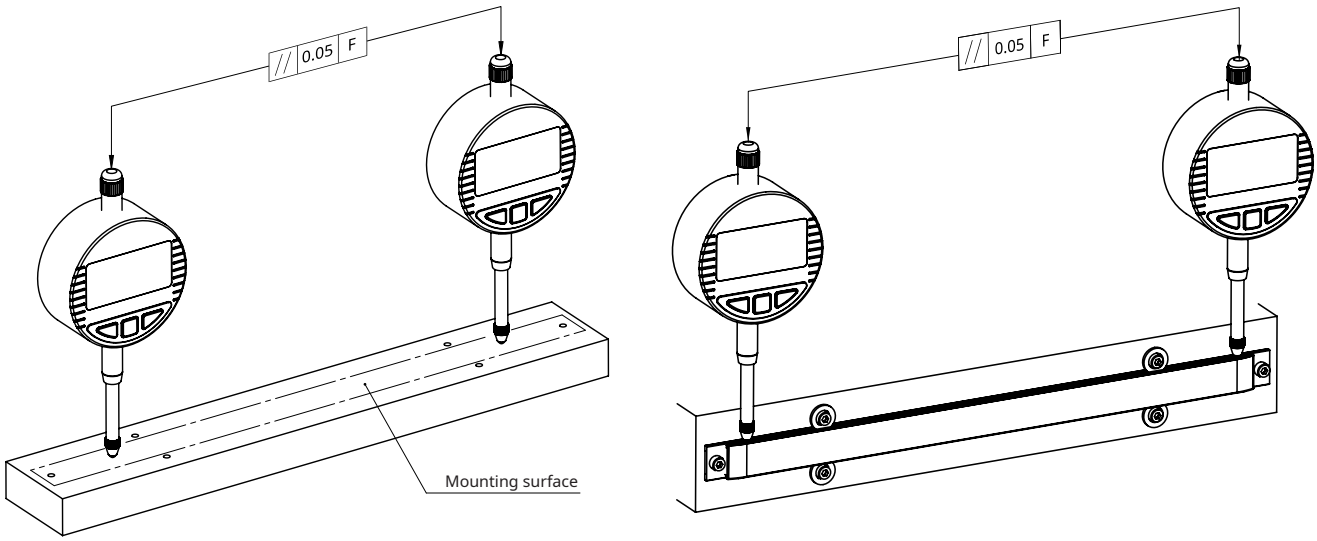
Traverse the axis through its full travel at a slow, steady speed. While moving the axis apply a light pressure (with a finger) to the scale behind the applicator tool to attach it to the mounting surface and gently pull the backing paper away from the applicator tool as it is separated.
When the scale has been applied unbolt the applicator tool from the readhead mounting bracket.

Solid magnetic scale installation

Mounting on steel substrate with similar coefficient of thermal expansion (CTE) – recommended

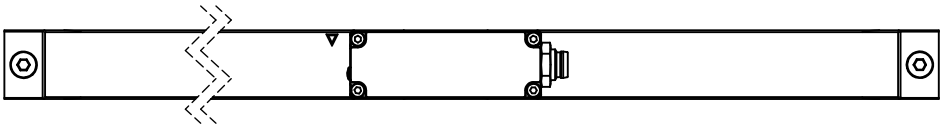
Make sure that the mounting surface of the magnetic scale has been cleaned and degreased before you proceed.

To achieve specified performance, maintain the mounting surface and the readhead guideway inside 0.05 mm parallelism according to the machine guideway.



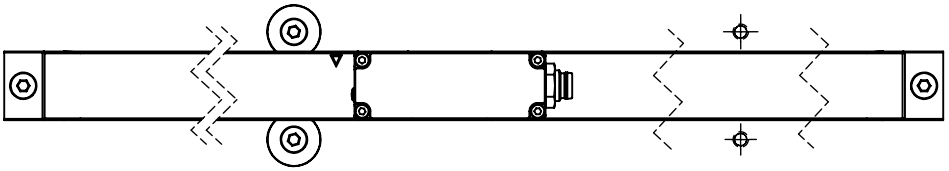
F: Machine guideway

For scales up to 150 mm long:
Mount the left-most and right-most fasteners with a force of 1.2 Nm (no washers required).

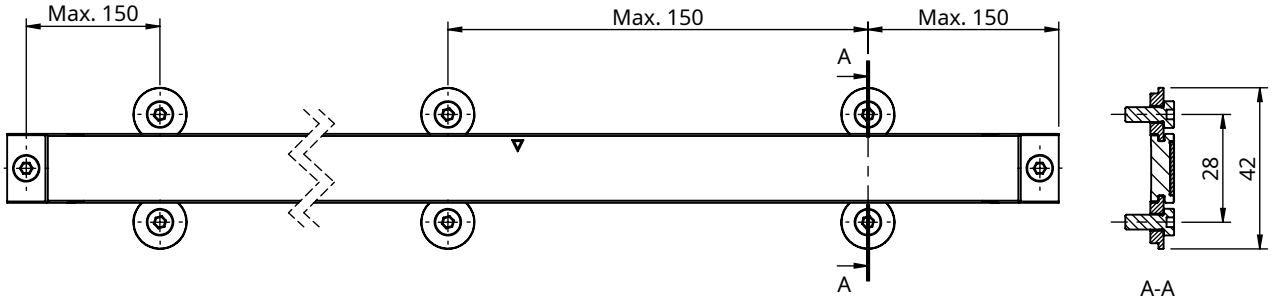


For scales longer than 150 mm:

Use washers every 150 mm along the scale to prevent deflection. Mount the left-most and rightmost fasteners with force of 1.2 Nm. A required number of fasteners and washers is supplied with the scale.



Example of HMS scale mounting (top view):
Dimensions and tolerances are in mm.



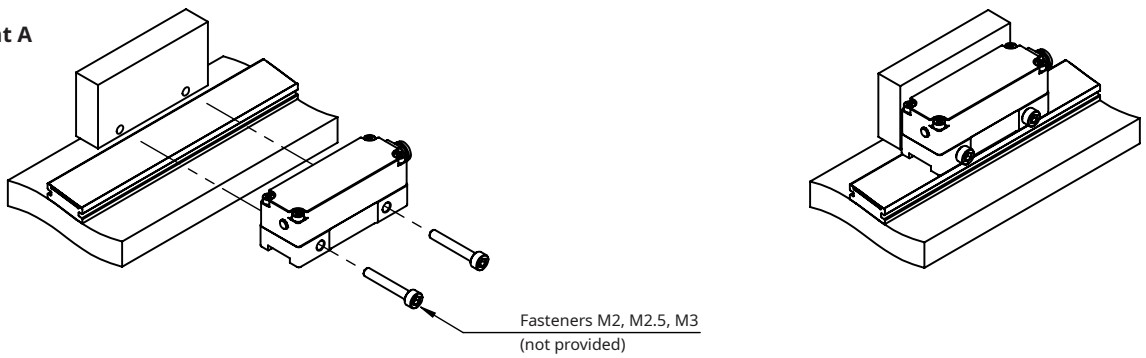
Readhead installation

The readhead LED must be green at all measuring length positions. Otherwise the installation is not performed correctly. To facilitate installation, the readhead is supplied with a 0.2 mm thick spacer. After mounting the magnetic scale, place the spacer and the readhead on the magnetic scale. Ensure that the readhead, spacer and magnetic scale are in full contact. Before removing the spacer, tighten the readhead with M3 fasteners to the holder.
Make sure that the readhead is correctly aligned. There is a triangular mark on the side of the reference sensor.
The triangular mark on the readhead and the scale reference mark must be on the same side for the alignment to be correct.

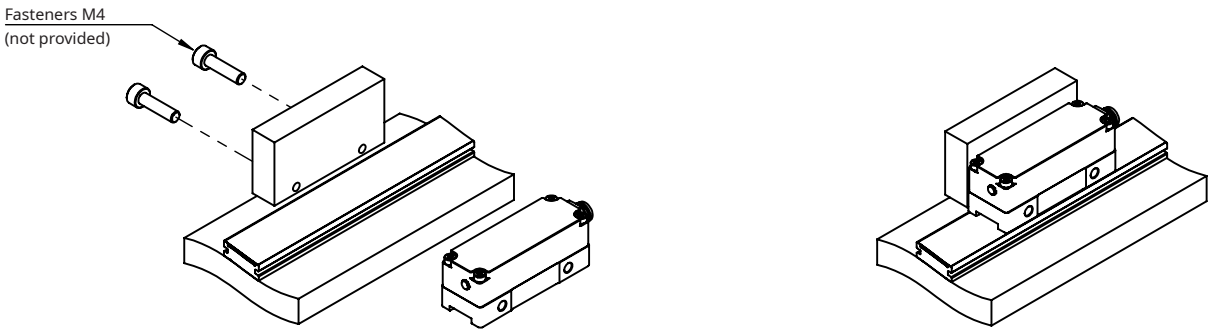
The magnetic encoder system must be used in accordance with the specified degree of protection. The following factors must be taken into account: IP protection class, operating temperature, external magnetic field, mechanical load and EMC compatibility.
The magnetic encoder system is sensitive to external magnetic fields. The extent to which the magnetic encoder system is affected 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. Field strengths greater of more 1 mT can cause the system to malfunction, resulting in the readhead reporting an invalid position. Magnetic field strengths of more than 25 mT cause irreversible damage to the magnetic scale and must be replaced.

Readhead mounting variants

Variant A



Variant B

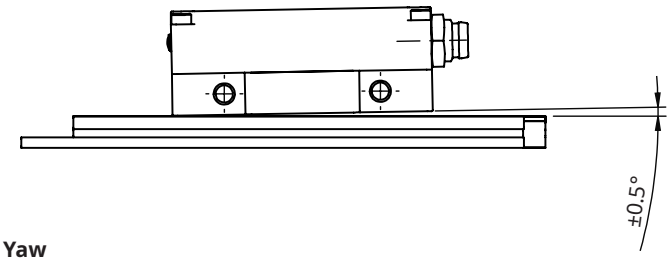


Installation tolerances

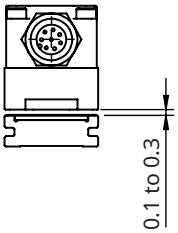
Dimensions and tolerances are in mm.

HiLin readhead with HMS solid magnetic scale

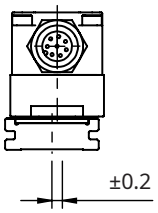
Pitch



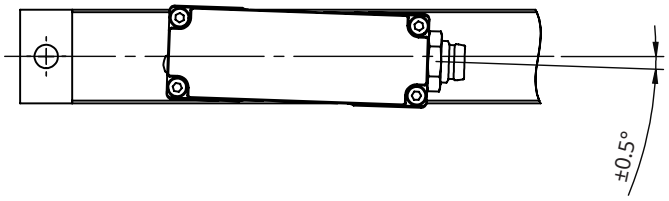
Ride height



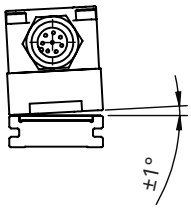
Lateral offset



Yaw

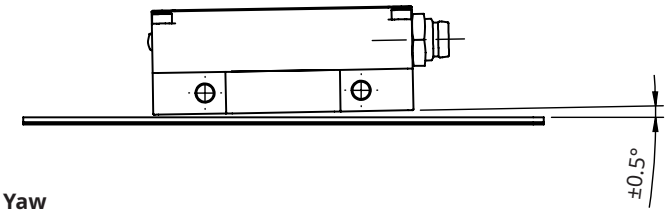


Roll

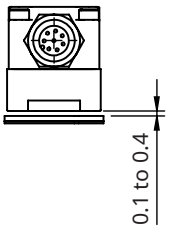


HiLin readhead with MS19/MS20 magnetic scale

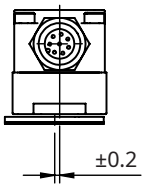
Pitch



Ride height



Lateral offset



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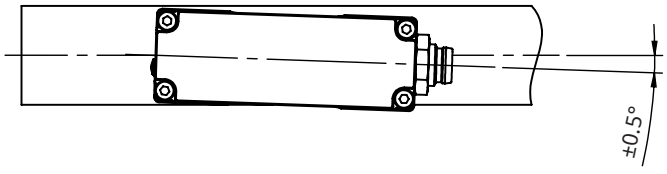
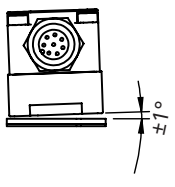


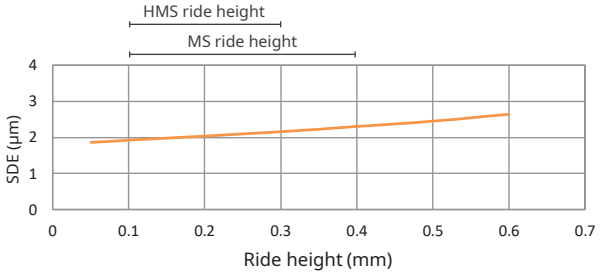
Roll



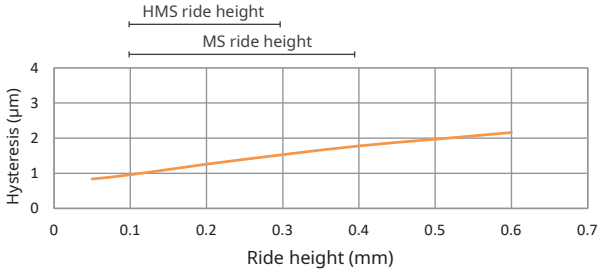
Technical specifications

System data

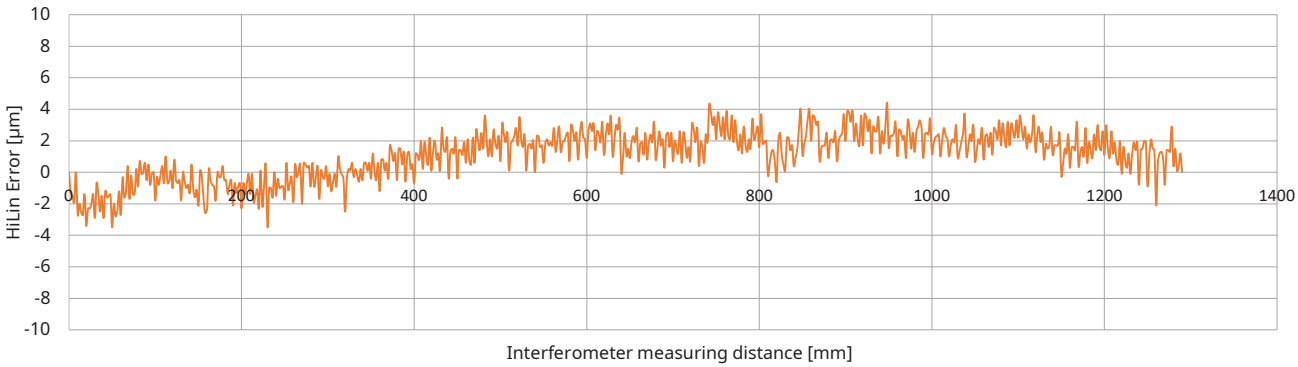
	HiLin + MS19/MS20 magnetic scales	HiLin + HMS solid magnetic scale
Pole length	MS19: 2 mm MS20: 2.032 mm	2 mm, 2.032 mm
Reference mark	MS19: Unique / periodic MS20: No reference mark	Unique / periodic / DCRM
Accuracy (at 20 °C)	±10 µm/m	±5 µm/m
Short length (30 mm) accuracy (at 20 °C)	±5 µm	±3 µm
Repeatability (unidirectional)	±0.4 µm	±0.4 µm
Hysteresis	≤1 µm	≤1 µm
Ride height	From 0.1 mm to 0.4 mm	From 0.1 mm to 0.3 mm
SDE	±2 µm	±1.5 µm



Graph 1: Increase of sub-divisional error (SDE) with ride height



Graph 2: Increase of hysteresis with ride height



Graph 3: Accuracy error plot

All magnetic scales are magnetised at 20 °C.

Electrical data

Power supply		4.75 V to 12 V – voltage on readhead Reverse polarity and overvoltage protection (up to 15 V)
Current consumption	With termination	<450 mA
	Without termination	<250 mA
Start-up time		<1 s
Latency		<24 µs
EMC Immunity		EN 61000-6-2
EMC Emission		EN 61000-6-4

Mechanical data

Readhead		
Cable length	Max. 10 m	
Readhead connector	M8, 8 pin, male	
Mass	32 g (with connector, without cable)	

Magnetic scale		MS19/MS20 scales	HMS solid scale
Material	Carrier	1.4310 stainless steel	1.4016 stainless steel
	Magnetic scale	NBR elastoferrite	NBR elastoferrite
Thickness		1.43 ±0.1 mm *	6.08 ±0.03 mm
Mass		64 g/m	700 g/m
Width		15 ±0.1 mm	18 ±0.05 mm
Maximum measuring length		20 m	1.3 m
Coefficient of thermal expansion (CTE)		~17 × 10^{-6} [m/mK]	10.4 × 10^{-6} [m/mK]
Minimum bending radius		75 mm	/

* MS19/20 magnetic scales with double-sided acrylic adhesive tape VHB 3M9469PC.

Environmental data

		HiLin + MS19/MS20 magnetic scales	HiLin + HMS solid magnetic scale
Temperature	Operating and storage	–40 °C to +75 °C	–40 °C to +75 °C
Vibration		400 m/s² (55-2000 Hz; IEC 60068-2-6:2007)	
Shock		1000 m/s² (6 ms; IEC 60068-2-6:2007)	
Environmental sealing		Resistance to dirt and dust	IP67 *
Maximum external magnetic field during operation		1 mT	

* IP protection is only guaranteed when suitable connector with same or higher IP is used.

Cable

Number of wires		8 (2 × 26 AWG + 6 × 28 AWG)
Outer sheath		PUR
Outer diameter		Max. 4.5 mm
Bend radius (internal radius)		50 mm
DC resistance at 20 °C	26 AWG	Max. 139.3 Ω/km
	28 AWG	Max. 226.7 Ω/km

Maximum speed table

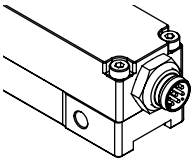
Interpolation factor	Maximum speed (m/s)						
20000	2.53	1.26	0.64	0.32	0.16	0.08	0.02
10000	5.06	2.53	1.28	0.64	0.32	0.16	0.04
04000	12.64	6.32	3.20	1.60	0.79	0.39	0.10
02000	25.28	12.64	6.40	3.20	1.58	0.79	0.20
01000	50.56	25.28	12.80	6.40	3.16	1.58	0.40
00400	126.40	63.20	32.00	16.00	7.90	3.95	0.99
Min. edge separation (µs)	0.03	0.06	0.10	0.25	0.51	1.01	4.05
Max. count frequency (MHz)	32	16	8	4	2	1	0.25

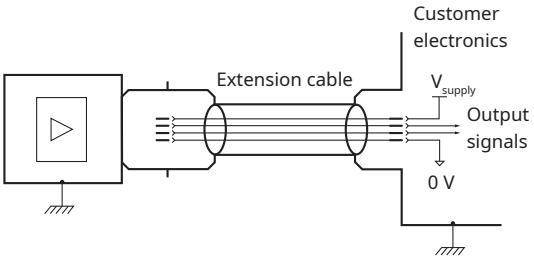
For more information, please go to **Part numbering** or **contact RLS**.

Electrical connections

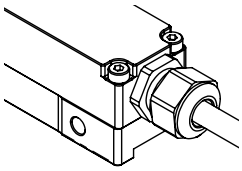
Function	Signal	Readhead connector pinout	Flying leads (option F)	9 pin D type plug (option A)
Power*	Vcc	2	Brown	5
	GND	8	White	9
Incremental / analogue signals	A	5	Green	4
	A–	6	Yellow	8
	B	7	Blue	3
	B–	1	Red	7
Reference signals	Z	3	Pink	2
	Z–	4	Grey	6
Cable shield	Chassis	Case	–	Case

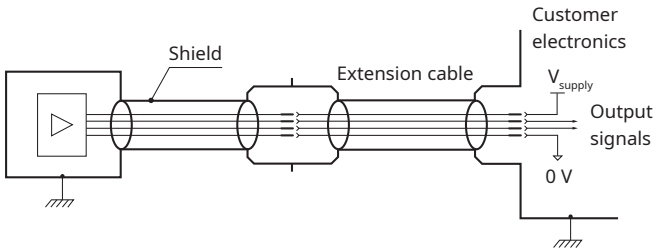
With connector on the readhead





With cable





Outer shield of the cable should be connected to the connector housing.

Communication interface

Digital output signals, RS422

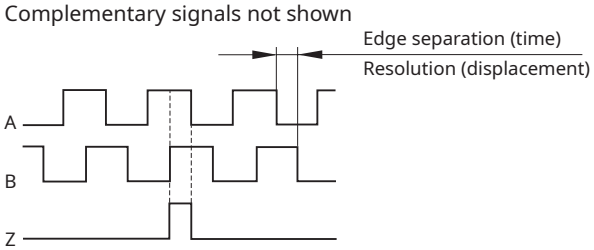
HLxIC

Specifications

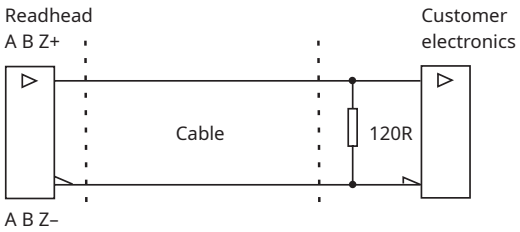
Power supply	4.75 V to 12 V – voltage on readhead Reverse polarity and overvoltage protection (up to 15 V)
Current consumption	<250 mA (without termination) <450 mA (with termination)
Voltage drop over cable	1.3 V (worst case; lowest supply voltage, maximum load, maximum cable length)
Power supply rise time	0.1 ms - 100 ms
Response time	30 µs
Output signals	3 square-wave signals A, B, Z and their inverted signals A–, B–, Z–
Reference signal	1 or more square-wave pulse Z and its inverted pulse Z–
Signal level	Differential line driver compatible with EIA standard RS422
Permissible load	$Z_0 \geq 100\ \Omega$ between associated outputs Outputs are protected against short circuit Only one output shorted at a time
Alarm / Error signalisation	High impedance on output lines A, B, A–, B–, Z, Z–
Switching time (10 to 90 %)	145 ns
Cable length	Max. 10 m

Timing diagram

Complementary signals not shown

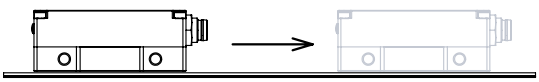


Recommended signal termination



Positive direction

Digital output signals – A leads B (magnetic scale is stationary)



The arrow shows the direction of the positive counting.

Reference mark options

Unique reference mark

The readhead must be ordered with reference mark option A (see **Part numbering**). The magnetic scale must be ordered with reference mark.

Periodic reference mark

The readhead must be ordered with reference mark option C (see **Part numbering**). The magnetic scale must be ordered without reference mark option. The position information is output in incremental quadrature format with periodic reference pulses every 2 mm.

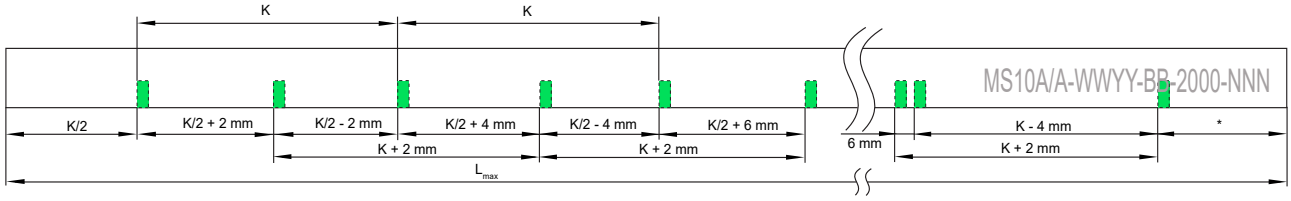
Distance coded reference marks (DCRM)

The readhead must be ordered with reference mark option A (see **Part numbering**). This option is only available for HMS Solid magnetic scale which must be ordered with a reference mark option D and a basic increment value stated as K (see available values in the table below). The distance coded reference mark option provides multiple magnetised reference marks that are individually spaced according to a specific mathematical algorithm. The absolute position is calculated after traversing 2 consecutive reference marks. Maximum length and minimum traverse depend on basic spacing (K) between reference marks.

Table of available basic increment values for specific scale lengths.

Scale length (L) (mm)	160	210	260	310	360	460	560	660	760	860	960	1060	1160	1260	1360
Measuring length (mm)	100	150	200	250	300	400	500	600	700	800	900	1000	1100	1200	1300
K	24	28	32	36	40	44	48	52	56	60	64	68	72	72	76

The distribution of the reference marks is shown in the figure below. DCRMs are produced by additional magnetisation of the magnetic scale.



* Depends on scale length.

Basic increment (K in mm) - Represents the distance in mm between odd reference marks; it determines the maximum codable length over which the absolute position can be defined. It also determines the minimum distance which needs to be traversed to capture 2 neighbouring reference marks. The basic distance should be divisible by the length of 2 poles (in mm). K is customer selectable.

Maximum codable length (L_{max} in mm) - Is the maximum length of the magnetic scale over which the DCRM feature can be applied and still provide a unique absolute position. Lengths shorter than the maximum length can also be used.

Pole length (P in mm) - Is the length of one magnetised pole.

How the absolute position is evaluated

The absolute position of the first traversed reference mark is calculated by the following formula:

$$RI1 = \left[\frac{1}{P} \times abs(2 \times \Delta RI - K) - sgn(2 \times \Delta RI - K) - 1\right] \times \frac{K}{2} + [sgn(2 \times \Delta RI - K) - sgn(D)] \times \frac{abs(\Delta RI)}{2}$$

Variables

RI1 - Absolute position of first traversed reference mark (in mm)
ΔRI - Distance between two successively traversed reference marks (in mm)
K - Basic increment between two fixed reference marks (in mm)
D - Direction of movement (+1 or -1)

Operators

abs - Absolute value
sgn - Sign function (+1 or -1)

Timing of reference mark capturing

The minimum distance between 2 successive reference marks equals 3 × P. Subsequent electronics must be able to capture position of 2 successive reference marks under the maximum speed condition. Minimum time at which 2 successive reference marks appear is given by formula:

$$T_{Rimin} = \frac{3P}{v_{max}}$$

T_{Rimin} - Minimum time between 2 successive reference marks (in ms)
P - Pole length (in mm)
v_{max} - Maximum traverse speed (in m/s)

Part numbering

Readhead part numbering

HL 1 IC 04000 B A 10C A 00

Pole length

1 - 2 mm
2 - 2.032 mm (DPI)

Output type

IC - Incremental, RS422, 5 V

Interpolation factor (Resolution)

20000 - 0.10 µm (DPI 0.1016 µm)
10000 - 0.20 µm (DPI 0.2032 µm)
04000 - 0.50 µm (DPI 0.508 µm)
02000 - 1.00 µm (DPI 1.016 µm)
01000 - 2.00 µm (DPI 2.032 µm)
00400 - 5.00 µm (DPI 5.08 µm)

Customer selectable resolutions available.
For more options please go to **RLS FAQ website**.

Minimum edge separation (µs)

A - 0.031 (32 MHz)
B - 0.063 (16 MHz)
D - 0.125 (8 MHz)
H - 0.25 (4 MHz)
N - 0.5 (2 MHz)
T - 1 (1 MHz)
Z - 4 (0.25 MHz)

For more options please go to **RLS FAQ website**.

Reference mark

A - With reference mark
B - Without reference mark
C - Periodic reference mark

Cable length

30C - 0.3 m
50C - 0.5 m
10D - 1 m
15D - 1.5 m
20D - 2 m
25D - 2.5 m
30D - 3 m
50D - 5 m
10M - 10 m
000 - No cable, connector only

Other cable lengths available per special request. Minimum cable length is 10 cm, maximum cable length is 10 m.

Connector

A - 9 pin D type plug
C - Connector only, M8, 8 pin, male
F - Flying lead, no connector

Special requirements

00 - No special requirements (standard)

Table of available combinations

Series	Pole length	Output type	Interpolation factor	Minimum edge separation	Reference mark	Cable length	Connector	Special requirements
HL	1 / 2	IC	xxxxx	x	A / B / C	50C / xxD / 10M	A / F	00
						000	C	

Solid magnetic scale part numbering

HMS 1 A 1100 A 0020

Pole length

1 - 2 mm
2 - 2.032 mm (DPI)

Special requirement

A - N/A (no special requirement)

Measuring scale length (max. 1300 mm)

0050 - 50 mm	**0250 -** 250 mm	**0600 -** 600 mm	**1000 -** 1000 mm
0100 - 100 mm	**0300 -** 300 mm	**0700 -** 700 mm	**1100 -** 1100 mm
0150 - 150 mm	**0400 -** 400 mm	**0800 -** 800 mm	**1200 -** 1200 mm
0200 - 200 mm	**0500 -** 500 mm	**0900 -** 900 mm	**1300 -** 1300 mm

Options

A - No cover foil
C - Welded cover foil

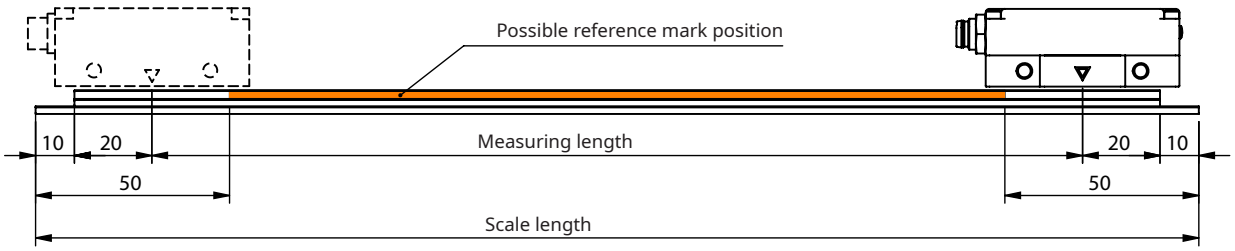
Reference mark

0000 - No reference mark
Dxxx - Distance coded reference mark; where xxx equals basic increment K in mm
xxxx - Reference mark; xxxx equals position of reference mark in cm
(Reference mark position will be within ±1 mm from requested position. xxxx has to be an even number.)
Mxxx - Reference mark; xxx equals position of reference mark in mm
(Reference mark position will be within ±1 mm from requested position. xxx has to be an even number.)

Table of available combinations

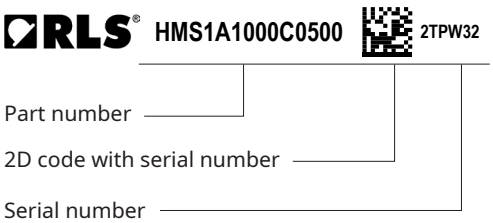
Series	Pole length	Special requirement	Measuring scale length	Options	Reference mark
HMS	1	A	xxxx	A / C	0000 / Dxxx / xxxx / Mxxx
	2				

How to define scale and measuring length



Scale length (mm)	110	160	210	260	310	360	460	560	660	760	860	960	1060	1160	1260	1360
Measuring length (mm)	50	100	150	200	250	300	400	500	600	700	800	900	1000	1100	1200	1300

Solid magnetic scale engraving description



Magnetic scale part numbering

MS 19 D 1000 A 0010

Scale type

19 - 2 mm pole length
20 - 2.032 mm pole length (DPI)

Accuracy class

D - ±10 µm/m

Scale length

xxxx - Where xxxx equals scale length in cm
Mxxx - Where xxx equals scale length in mm

Maximum scale length is 20 m.

Options

A - VHB back adhesive tape (standard)

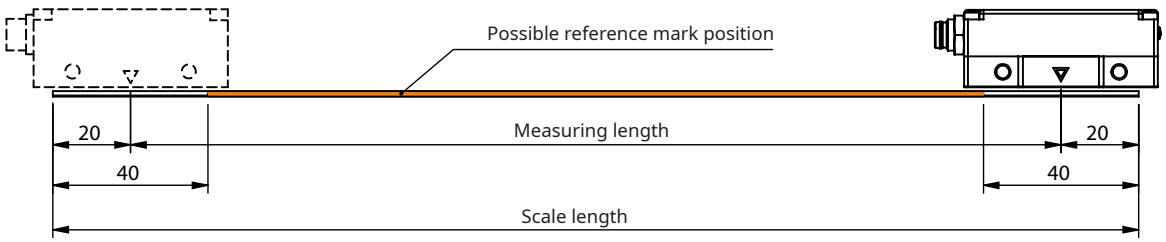
Reference mark

0000 - No reference mark
xxxx - Reference mark; xxxx equals position of reference mark in cm
(Reference mark position will be within ±1 mm from requested position)
Mxxx - Reference mark; xxxx equals position of reference mark in mm
(Reference mark position will be within ±1 mm from requested position)

Table of available combinations

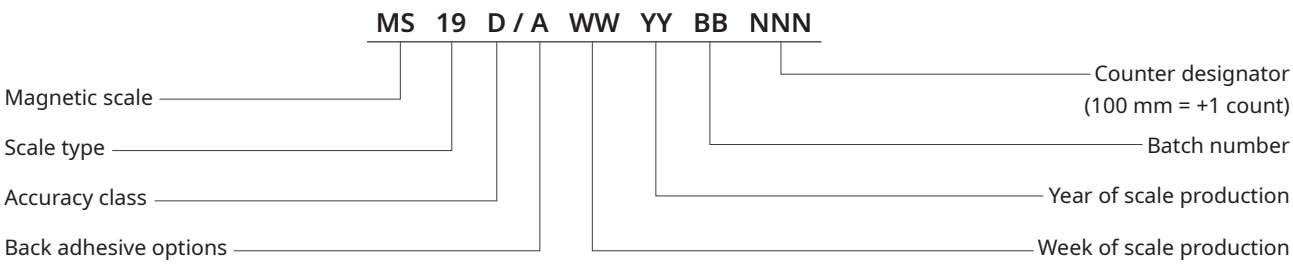
Series	Pole length	Accuracy class	Scale length	Options	Reference mark
MS	19	D	xxxx / Mxxx	A	0000 / xxxx / Mxxx
	20				0000

How to define scale and measuring length



Scale surface print description

Scale surface print appears every 100 mm and contains the RLS logo and a unique code.



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 (counts per inch)/DPI (pulse per inch)

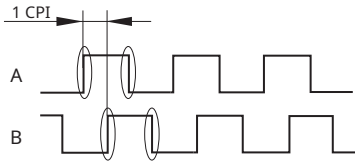
$$\text{Resolution [µm]} = \frac{\text{Pole length [µm]}}{\text{Interpolation factor}} = \frac{2032}{\text{Interpolation factor}}$$

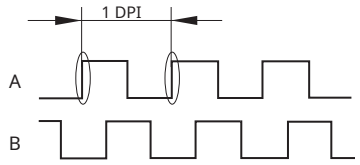
$$\text{Resolution [CPI]} = \frac{\text{Inch [µm]}}{\text{Resolution [µm]}} =$$

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

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

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





Accessories

Scale applicator tool
ACC047

Head office

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Document issues

Issue	Date	Page	Description
1	20. 1. 2021	14, 17	Measuring and scale length amended
2	10. 6. 2021	11	Maximum speed table amended
3	25. 11. 2021	4, 5, 7-9, 14, 17-18	New installation drawings, available cable lengths amended
4	31. 1. 2023	9, 10	Accuracy unit amended, resolution calculation added
5	8. 1. 2024	1-2, 4-5, 8-9, 12	Images and drawings amended to represent new body without M3 holes
6	5. 2. 2024	13	Positive direction chapter added
		11	Environmental data amended
7	29.3.2024	8, 11	Maximum external magnetic field added

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