MS 25
EXPOSED LINEAR ENCODERS
WITH SINGLEFIELD SCANNING
TERM-EXPLANATIONS

Grating pitch (interval)
A grating is a continuous series of lines and spaces printed on the scale. The width of one line and one space is called the pitch (sometimes referred to as the interval) of the grating. The lines and spaces are accurately placed on the scale.

Signal period
When scanning the grating, the encoder head produces sinusoidal signals with a period equal to the grating pitch.

Interpolation
The sinusoidal signal period can be electronically divided into equal parts. The interpolation circuitry generates a square-wave edge for each division.

Measuring step (resolution)
The smallest digital counting step produced by an encoder.

Reference pulse (reference mark)
There is an additional track of marks printed next to the grating to allow a user to find an absolute position along the length of the scale. A one increment wide signal is generated when the encoder head passes the reference mark on the scale.

This is called a “true” reference mark since it is repeatable in both directions. Subsequent electronics use this pulse to assign a preset value to the absolute reference mark position.

Error signal (US)
This signal appears when a malfunctioning encoder generates faulty scanning signals.

Online signal stabilization (HSP)
During moving the amplitude, offset-error, amplitude differences and phase shift error are measured and stabilized cyclic.

Abbe error
Measuring error due to lateral distance between the measuring system and the machining level.

Yaw angle, pitch angle, roll angle, lateral shift, airgap
Mounting tolerances of the encoder head relative to the scale.
REQUIREMENTS ON AN EXPOSED LINEAR ENCODER

- Contamination resistance
- Immunity against aging and temperature changes
- High traversing speed
- Easy mounting
- Compact dimensions
- Operating cycles
- No mechanical backlash
- Zero frictional force
- Two separate switch signals
- High accuracy
- Resolution: 10 µm – 0.05 µm

SCANNING PRINCIPLE

The incremental MS 25 linear encoders work with the imaging, photoelectric measuring principle and a singlefield reflective scanning method. A scale graduation pattern on a steel tape (gold grating) or a glass scale (chrome grating) with 40 µm grating pitch is used.

The regulated light of an infrared LED is collimated by a condenser lens and passes through the grid of the reticle. After being reflected from the scale, the infrared LED generates a periodic intensity distribution on the structured sensor.

The sensor generates high quality sinusoidal signals which are highly insensitive to possible contaminations.

The regulation of the LED ensures a constant signal amplitude, guaranteeing stability in the case of temperature fluctuations as well as with long-run operation.
ACCURACY DEFINITION

The accuracy of a linear encoder is mainly determined by the baseline error of the scale unit, the interpolation error of the optoelectronic scanning and the position noise.

The baseline error is the error of the scale unit identified in a measurement room under optimum conditions, along a determined measuring length, without any interpolation error and position noise.

The indicated accuracy grade represents the maximum possible baseline error. It is calculated within any section with a maximum length of one meter.

Effect of contamination on the quality and amplitude of scanning signal
Steel tape scale contaminated by fluids, dust, particles, fingerprints etc.

Effect of contamination on the interpolation error
Steel tape scale contaminated by fluids, dust, particles, fingerprints etc.
ACCURACY CHART

The accuracy of the linear encoder is classified with a "± tolerance" in µm/m (e.g. ± 5 µm/m).

The accuracy and tolerance apply to any meter within the measuring length. For measuring lengths less than 1000 mm, the accuracy specification applies to the whole measuring length.

For best system accuracy, the encoder should be mounted near the machining level and as parallel as possible to the motion direction.

Example of a typical calibration chart for a MS 25 scale tape:
PIN ASSIGNMENT

Pin assignment

<table>
<thead>
<tr>
<th>Pin</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sinusoidal voltage signals 1 Vpp</td>
<td>Test*</td>
<td>0 V</td>
<td>Sensor</td>
<td>Occupied</td>
<td>R1-</td>
<td>A2-</td>
<td>A1-</td>
<td>V+</td>
<td>Sensor</td>
<td>V+</td>
<td>0 V</td>
<td>S1***</td>
<td>S2***</td>
<td>R1+</td>
<td>A2+</td>
</tr>
<tr>
<td>Square-wave signals via line driver</td>
<td>Test**</td>
<td>0 V</td>
<td>Sensor</td>
<td>US</td>
<td>T1</td>
<td>T2</td>
<td>T1</td>
<td>V+</td>
<td>Sensor</td>
<td>V+</td>
<td>0 V</td>
<td>S1***</td>
<td>S2***</td>
<td>RI</td>
<td>T2</td>
</tr>
</tbody>
</table>

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* Test = Analog signal switch-over for set-up.
  By applying +5 V to the test pin, the NOT corrected test signals (1 Vpp) are switched to the output connector.

** Test = Analog signal switch-over for set-up.
  By applying +5 V to the test pin, the test signals (sinusoidal micro-current signals 11 µApp) are switched to the output connector.

S1, S2 = Switch signals.

*** Version without switch signals (version K) = without function.

Sensor: The sensor pins are bridged in the connector chassis with the particular power supply.

The shield is connected with the connector chassis.

Pins or wires marked "occupied" or "nc" must not be used by the customer.

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RSF standard pin assignment, other pin assignments on request.
OUTPUT SIGNALS

SINUSOIDAL VOLTAGE SIGNALS 1Vpp

(drawings show “positive counting direction”)

**Power supply:** +5 V ±10%, max. 130 mA (unloaded)

**Track signals** (differential voltage A1+ to A1− resp. A2+ to A2−):
Signal amplitude 0.6 Vpp to 1.2 Vpp; typ. 1 Vpp
(with terminating impedance Zo = 120 Ω between A1+ to A1− resp. A2+ to A2−)

**Reference mark** (differential voltage RI+ to RI−):
Square-wave pulse with an amplitude of 0.8 up to 1.2 V; typical 1 V
(with terminating impedance Zo = 120 Ω between RI+ to RI−)

**Advantage:**
- High traversing speed with long cable lengths possible.

SQUARE-WAVE SIGNALS

(drawings show “positive counting direction”)

With an interpolation electronics (for times -1, -2, -5, -10, -20, -25, -50, -100 or -200) the photoelement output signals are converted into two square-wave signals that have a phase shift of 90°. The output signals are „differential“ via line driver (RS 422). One measuring step reflects the measuring distance between two edges of the square-wave signals.

The controls/DRO’s must be able to detect each edge of the square-wave signals. The minimum edge separation \( \Delta t_{\text{min}} \) is listed in the technical data and refers to a measurement at the output of the interpolator (inside the scanning head). Propagation-time differences in the line driver, the cable and the line receiver reduce the edge separation.

**Propagation-time differences:**
- Line driver: max. 10 ns
- Cable: 0.2 ns per meter
- Line receiver: max. 10 ns referred to the recommended line receiver circuit

To prevent counting errors, the controls/DRO’s must be able to process the resulting edge separation.

**Example:**
\[
\Delta t_{\text{min}} = 200 \text{ ns}, 10 \text{ m cable}
\]
\[
200 \text{ ns} - 10 \text{ ns} - 10 \times 0.2 \text{ ns} - 10 \text{ ns} = 178 \text{ ns}
\]

**Power supply:** +5 V ±10%, max. 165 mA (unloaded)

**Advantage:**
- Noise immune signals
- No further subdividing electronics necessary

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**Recommended line receiver circuit**

**Counting direction**
SWITCH SIGNAL OUTPUT

For individual special functions there are two additional switch tracks on the glass scale/metal tape. The switching point position can be chosen by the user by placing self-adhesive covering tapes.

For version with selectable reference mark there is just one switch signal available. The second track of this version is used to select the reference mark. This feature makes the selection of the reference mark position, by the user, very easy.
TECHNICAL DATA

Scanning head: 40 µm signal period

<table>
<thead>
<tr>
<th>Model</th>
<th>Output signals</th>
<th>System resolution [µm]</th>
<th>Integrated interpolation</th>
<th>Max. velocity [m/s]</th>
<th>Max. output frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS 25 1Vpp</td>
<td>~</td>
<td>Depending on external interpolation</td>
<td>~</td>
<td>10.00</td>
<td>250</td>
</tr>
<tr>
<td>MS 25 TTLx1</td>
<td>B</td>
<td>10</td>
<td>Times 1</td>
<td>10.00</td>
<td>500 ns</td>
</tr>
<tr>
<td>MS 25 TTLx2</td>
<td>B</td>
<td>5</td>
<td>Times 2</td>
<td>10.00</td>
<td>250 ns</td>
</tr>
<tr>
<td>MS 25 TTLx5</td>
<td>B</td>
<td>2</td>
<td>Times 5</td>
<td>6.40</td>
<td>300 ns</td>
</tr>
<tr>
<td>MS 25 TTLx10</td>
<td>B</td>
<td>1</td>
<td>Times 10</td>
<td>3.20</td>
<td>300 ns</td>
</tr>
<tr>
<td>MS 25 TTLx20</td>
<td>B</td>
<td>0.5</td>
<td>Times 20</td>
<td>2.40</td>
<td>200 ns</td>
</tr>
<tr>
<td>MS 25 TTLx25</td>
<td>B</td>
<td>0.4</td>
<td>Times 25</td>
<td>1.92</td>
<td>200 ns</td>
</tr>
<tr>
<td>MS 25 TTLx50</td>
<td>B</td>
<td>0.2</td>
<td>Times 50</td>
<td>1.92</td>
<td>100 ns</td>
</tr>
<tr>
<td>MS 25 TTLx100</td>
<td>B</td>
<td>0.1</td>
<td>Times 100</td>
<td>0.96</td>
<td>100 ns</td>
</tr>
<tr>
<td>MS 25 TTLx200</td>
<td>B</td>
<td>0.05</td>
<td>Times 200</td>
<td>0.96</td>
<td>50 ns</td>
</tr>
</tbody>
</table>

Edge separation amin

<table>
<thead>
<tr>
<th>Model</th>
<th>Edge separation amin</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS 25 TTLx1</td>
<td>10  Times 1</td>
</tr>
<tr>
<td>MS 25 TTLx2</td>
<td>10  Times 2</td>
</tr>
<tr>
<td>MS 25 TTLx5</td>
<td>10  Times 5</td>
</tr>
<tr>
<td>MS 25 TTLx10</td>
<td>10  Times 10</td>
</tr>
<tr>
<td>MS 25 TTLx20</td>
<td>10  Times 20</td>
</tr>
<tr>
<td>MS 25 TTLx25</td>
<td>10  Times 25</td>
</tr>
<tr>
<td>MS 25 TTLx50</td>
<td>10  Times 50</td>
</tr>
<tr>
<td>MS 25 TTLx100</td>
<td>10  Times 100</td>
</tr>
<tr>
<td>MS 25 TTLx200</td>
<td>10  Times 200</td>
</tr>
</tbody>
</table>

Interpolation error

Permissible shock:

750 m/s² (8 ms)

Permissible vibration:

150 m/s² (55 to 2000 Hz)

Permissible temperature:

-20 °C to +70 °C (storage)

0 °C to +60 °C (operation)

RoHS-conformity:

MS 25 linear encoders comply with the guideline of the RoHS-directive 2011/65/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

SCALE UNIT: Graduation carrier: Glass, glass ceramic or steel

**Mechanical features of the scale unit**

<table>
<thead>
<tr>
<th>Graduation carrier</th>
<th>Steel</th>
<th>Glass, Glass ceramic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grating pitch (T)</td>
<td>40 µm</td>
<td>40 µm</td>
</tr>
<tr>
<td>Accuracy grades</td>
<td>±5, ±15 µm/m</td>
<td>±3, ±5 µm/m</td>
</tr>
<tr>
<td>Non-linearity</td>
<td>--</td>
<td>± ≤ 1 µm/70 mm</td>
</tr>
<tr>
<td>Baseline error</td>
<td>± ≤ 0,75 µm/50 mm (typical)</td>
<td>± ≤ 0,30 µm/10 mm</td>
</tr>
<tr>
<td>Maximum measuring length (ML)</td>
<td>20 000 mm</td>
<td>Glass: 3140 mm, Glass ceramic: max. 1940 mm *</td>
</tr>
<tr>
<td>Switch tracks</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Reference marks (RI)</td>
<td></td>
<td>Standard: 50 mm (equidistant)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Position selectable by customer</td>
</tr>
<tr>
<td></td>
<td></td>
<td>At any location, on request</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optional: distance-coded up to ML 6240 mm</td>
</tr>
</tbody>
</table>

* Longer lengths on request

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**Principle of the standard reference marks**

Reference mark (RI)

Activation sticker RI

50 equidistant

**Principle of the distance-coded reference marks**

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MS 25 MO/MK

- Version MO: Steel tape scale
- Version MK: Steel tape scale with adhesive tape

**Dimensions, mounting tolerances:**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Machine guideway</td>
</tr>
<tr>
<td>ML</td>
<td>Measuring length</td>
</tr>
<tr>
<td>OL</td>
<td>Overall length</td>
</tr>
<tr>
<td>C</td>
<td>Cable</td>
</tr>
<tr>
<td>R</td>
<td>Component (in mm)</td>
</tr>
<tr>
<td>T</td>
<td>Tolerances (in mm)</td>
</tr>
</tbody>
</table>

**Permissible position deviation:**

- Steel tape scale (reference plane A [B])
  - $\Delta Z = \pm 0.2 \text{ mm (gap)}$
  - $\Delta Y = \pm 0.5 \text{ mm (lateral)}$
  - $\theta = \pm 1.0 \text{ mrad} \text{ or } \pm 0.05^\circ \text{ (yaw angle)}$
  - $\varphi = \pm 3.6 \text{ mrad} \text{ or } \pm 0.2^\circ \text{ (pitch angle)}$
  - $\psi = \pm 5.0 \text{ mrad} \text{ or } \pm 0.29^\circ \text{ (roll angle)}$

**RI** = Selectable reference mark

- Any position of selected reference mark from the beginning of the ML
- Additional reference marks spaced every $n \times 50$
- $n = 1, 2, 3, ...$

**Mass (approx.):**

- Version MO: 20 g/m
- Version MK: 25 g/m
- Additional reference mark: 21 g scanning head + 20 g/m cable

Affixing cover tapes for the switch tracks and activation of the selectable reference marks see page 16.

**Tape mounting tool TMT 25 MK (optional)**

For safe and precise mounting of the steel tape scale:

- Mount TMT 25 MK instead of the scanning head MS 25
- Thread steel tape scale (version MK) and move along the scale length
- Remove TMT 25 MK, mount scanning head MS 25
MS 25 MA/MS

- Version MA: Steel tape scale on aluminum carrier
- Version MS: Steel tape scale on steel carrier
- Version MA, MS: Carrier bolted

Dimensions, mounting tolerances:

- Version MA: Steel tape scale on aluminum carrier
- Version MS: Steel tape scale on steel carrier
- Version MA, MS: Carrier bolted
MS 25 MP

- Steel tape scale in aluminum carrier with clamping element
- Carrier with adhesive tape

Dimensions, mounting tolerances:

- **Mass (approx.)**
  - 90 g/m + 15 g clamping element
  - 21 g scanning head
  - 20 g/m cable

**Dimensions, mounting tolerances:**

- **M** = Machine guideway
- **ML** = Measuring length
- **OL** = Overall length
- **f** = Any position of the clamping element
- **k** = Cable
- **J** = Required mating dimensions
- **L** = LED function control
- **R** = Bending radius; stat, R > 10, dyn, R > 20
- **S1, S2** = Switch signal

**RI** = Selectable reference mark

- k = Any position of selected reference mark from the beginning of the ML
- j = Additional reference marks spaced every n x 50
- n = 1, 2, 3...

**Mass (approx.):**
- 90 g/m + 15 g clamping element
- 21 g scanning head
- 20 g/m cable

- Permissible position deviation scanning head - steel tape scale (reference plane A 1B)
  - \( \Delta Z = \pm 0.2 / \pm 0.15 \text{ mm (gap)} \)
  - \( \Delta Y = \pm 0.5 \text{ mm (lateral)} \)
  - \( \angle = \pm 1.0 \text{ mrad or } \pm 0.06^\circ \text{ (yaw angle)} \)
  - \( \angle = \pm 3.6 \text{ mrad or } \pm 0.20^\circ \text{ (pitch angle)} \)
  - \( \angle = \pm 5.0 \text{ mrad or } \pm 0.29^\circ \text{ (roll angle)} \)

Affixing cover tapes for the switch tracks see page 16.
MS 25 MT

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted

Dimensions, mounting tolerances:

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted

Dimensions, mounting tolerances:

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted

Dimensions, mounting tolerances:

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted

Dimensions, mounting tolerances:

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted

Dimensions, mounting tolerances:

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted

Dimensions, mounting tolerances:

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted

Dimensions, mounting tolerances:

- Steel tape scale in aluminum carrier with clamping element
- Carrier bolted
MS 25 GK, BK

- Version GK: Glass scale with adhesive tape
- Version BK: Glass ceramic scale with adhesive tape

Dimensions, mounting tolerances:

- **GK**: Glass scale with adhesive tape
- **BK**: Glass ceramic scale with adhesive tape

Affixing cover tapes for switch tracks and activation of the selectable reference marks see page 16.

**Mass (approx.):**
- **GK**: 100 g/m
- **BK**: 70 g/m
  + 21 g scanning head
  + 20 g/m cable

Affixing cover tapes for switch tracks and activation of the selectable reference marks see page 16.
MS 25 GA

- Glass scale in aluminum carrier
- Carrier bolted

Dimensions, mounting tolerances:

- Mass (approx.):
  - 515 g/m
  - 21 g scanning head
  - 20 g/m cable

Affixing cover tapes for switch tracks and activation of the selectable reference marks see page 16.
SWITCH TRACKS

POSITIONING OF THE ACTIVATION TAPES

Switch track 1
Switch track 2

Measuring length (ML)

EXAMPLE

S1 = Switch point signal S1 from beginning of ML
X1 = Activation tape length
X1 = S1 + 10

EXAMPLE
S1: 20 mm from beginning of ML  X1 = 30 mm
S2: 40 mm before end of ML  X2 = 75 mm

REFERENCE MARK (RI)-SELECTION AND POSITIONING OF THE ACTIVATION TAPES

Reference mark track

Switch track 2

Measuring length (ML)

EXAMPLE

S2 = Switch point signal S2 from beginning of ML
X2 = Activation tape length
X2 = S2 + 10

EXAMPLE
S2: 20 mm from beginning of ML  X2 = 30 mm
S2: 40 mm before end of ML  X2 = 75 mm

Within the measuring length any RI-position is possible - additional reference marks can be selected at a distance of 50 mm.
# INSPECTION OF FUNCTION

<table>
<thead>
<tr>
<th>STATUS OF LED</th>
<th>INFORMATION</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without external test box</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Function-control main track</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED displays GREEN</td>
<td>Counting signals very good</td>
<td>After successful mounting</td>
</tr>
<tr>
<td>LED blinks GREEN</td>
<td>Counting signals good</td>
<td>At mounting not allowed → allowed during operation</td>
</tr>
<tr>
<td>LED blinks RED</td>
<td>Counting signals out of tolerance → error</td>
<td>Check mounting, clean scale</td>
</tr>
<tr>
<td><strong>Function-control reference impulse RI</strong></td>
<td></td>
<td>Only by passing the reference mark</td>
</tr>
<tr>
<td>LED blinks RED</td>
<td>RI out of tolerance</td>
<td>Check mounting, clean scale</td>
</tr>
<tr>
<td>LED blinks BLUE</td>
<td>RI within tolerance</td>
<td></td>
</tr>
<tr>
<td><strong>With external test box</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Function-control main track</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LED displays GREEN</td>
<td>Scanning head supplied with power</td>
<td>Evaluation of counting signals via LED not active</td>
</tr>
<tr>
<td><strong>Function-control reference impulse RI</strong></td>
<td></td>
<td>Only by passing the reference mark</td>
</tr>
<tr>
<td>LED blinks RED</td>
<td>RI out of tolerance</td>
<td>Check mounting, clean scale</td>
</tr>
<tr>
<td>LED blinks BLUE</td>
<td>RI within tolerance</td>
<td></td>
</tr>
</tbody>
</table>

**Note!** If the scanning head passes a further reference mark within 0.5 s the information of the reference mark will not be stated by the function control. Thus the information of the incremental signals will also be displayed at high traversing speed and/or many active reference marks.
EXTERNAL TESTING DEVICE PWT 100

Even though the MS 25 linear encoders allow large mechanical mounting tolerances, it is recommended to control the function of counting signals and reference impulse.

The signals can be controlled directly via the integrated LED function-control or connected to an oscilloscope and checked for conformity with signal specifications. The last mentioned method requires some effort.

The PWT 100 is a testing device for checking the function and adjustment of RSF Elektronik encoders. At encoders with pin assignment according to RSF standard (compare page 05) the pinout adapter PA2 must be used additionally. At alternative pin assignments other pinout adapters could be necessary.

Thanks to its compact dimensions and robust design, the PWT 100 is ideal for mobile use. A 4.3-inch touchscreen provides for display and operation.

Available functions
The performance range of the PWT 100 can be expanded by firmware update. Appropriate firmware files that can be imported to the PWT 100 through a memory card (not included in delivery) will be made available at www.heidenhain.de.
FURTHER PRODUCTS

MC 15
Absolute reflective scanning linear encoder with small dimensions
- Interface: EnDat 2.2 (others on request)
- Easy mounting as a result of large mounting tolerances
- High insensitivity against contaminations
- Max. measuring length: Steel tape scale: 6140 mm

MS 15
Reflective scanning linear encoder with integrated mounting control
- Easy mounting; no test box or oscilloscope needed
- Quality of the scanning signals is directly visible at the scanning head via a tricolored LED function
- Two independent switch tracks for individual special functions
- Position of reference mark selectable by customer
- High insensitivity against contamination
- High traversing speed
- Integrated subdividing: up to times 100
- Max. measuring length: Steel tape scale: 20,000 mm

MC 20
Modular angle measurement system with steel tape scale
- Segment version
- Grating pitch: 40 µm
- Accuracy of the grating (stretched): ±15 µm/m
- High circumferential speed
- Integrated subdividing: up to times 100

MSR 20
Modular angle measurement system with steel tape scale
- Full-circle or segment version
- Grating pitch: 200 µm
- Accuracy of the grating (stretched): ±30 µm/m
- High rotational speed resp. circumferential speed
- Integrated subdividing: up to times 100