MS 15
EXPOSED LINEAR ENCODERS
WITH HOMING AND LIMIT FUNCTION
SPECIAL FEATURES

- Online signal stabilization
- Display of the signal quality directly at the scanning head via 3-coloured LED function
- Permanent control of the signals over the whole measuring length
- High quality of the signals due to singlefield scanning
- Homing and limit function
- Reference mark position customizable

TERM EXPLANATIONS

Grating period
A grating is a continuous series of lines and spaces printed on the graduation carrier. The width of one line and one space is called the period of the grating. The lines and spaces are accurately placed on the graduation carrier.

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

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
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 graduation carrier. A one increment wide signal is generated when the scanning head passes the reference mark on the graduation carrier.

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 (OS)
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, displacement, gap tolerance
Mounting tolerances of the scanning head relative to the graduation carrier.

Δ...... Delta
φ...... Phi
PERFORMANCE CHARACTERISTICS

- Contamination resistance
- Immunity against aging and temperature changes
- High permissible traversing speed
- Easy mounting
- Small dimensions
- No mechanical backlash
- No frictional force
- Reference marks repeatable from both traversing directions
- Two separate switch signals
- Resolution: 10 µm – 0.05 µm

MS 15 MEETS ALL THESE REQUIREMENTS!

SCANNING PRINCIPLE

The model MS 15 incremental linear encoder system works with the photoelectric measuring principle and a singlefield reflective scanning method.

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

The baseline error is the error of the graduation carrier 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.

**Accuracy Definition**

The overall error is the sum of the baseline error, the interpolation error, and the position noise.

\[
\text{Overall error} = \text{Baseline error} + \text{Interpolation error} + \text{Position noise}
\]

**Effect of contamination on the quality and amplitude of scanning signal**

Graduation carrier contaminated by fluids, dust, particles, fingerprints etc.

**Effect of contamination on the interpolation error**

Graduation carrier contaminated by fluids, dust, particles, fingerprints etc.
SHIELDING, PIN ASSIGNMENT

Pin assignment (view on pins)

- **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.

- **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.

- S1, S2 = switch signals.

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

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

- The shield is connected with the chassis.

- Pins or wires marked “occupied” or “nc” must not be used by the customer.

Signal amplitude vs. scanning head gap

- With online signal stabilization
- Without online signal stabilization

**Notes:**

- Pin 1: 0 V Sensor
- Pin 2: Occupied
- Pin 3: A2-
- Pin 4: A1-
- Pin 5: V+
- Pin 6: Sensor
- Pin 7: 0 V
- Pin 8: S1
- Pin 9: S2
- Pin 10: RI
- Pin 11: A2+
- Pin 12: A1+
- Pin 13: nc
- Pin 14: T2
- Pin 15: T1
OUTPUT SIGNALS

SINUSOIDAL VOLTAGE SIGNALS 1 VPP
(drawing shows “positive counting direction”)

- Power supply: +5 V ±10 %, max. 160 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 permissible traversing speed with long cable lengths possible.

SQUARE-WAVE SIGNALS
(drawing shows “positive counting direction”)

- With the integrated interpolation electronics (for times -1, -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 \(a_{\text{min}}\) is listed in the technical data and refers to a measure-
  ment 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/m
  - 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:
  \[a_{\text{min}} = 100 \text{ ns}, 10 \text{ m cable}\]
  
  \[100 \text{ ns} - 10 \text{ ns} - 10 \times 0.2 \text{ ns} - 10 \text{ ns} = 78 \text{ ns}\]

- Power supply: +5 V ±10 %, max. 160 mA (unloaded)

- Advantages:
  - Noise immune signals.
  - No further subdividing electronics necessary.

- Recommended line receiver circuit

- Counting direction
For individual special functions there are two additional switch tracks on the steel tape scale. The switching point position can be chosen by the user by placing self-adhesive covering tapes.
TECHNICAL DATA

SCANNING HEAD: 40 µm signal period

<table>
<thead>
<tr>
<th>Scale model</th>
<th>Output signals</th>
<th>Measuring step [µm]</th>
<th>Integrated interpolation</th>
<th>Max. velocity [m/s]</th>
<th>Max. output frequency [kHz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS 15 1Vpp</td>
<td></td>
<td>Depending on external interpolation</td>
<td>--</td>
<td>10.00</td>
<td>250</td>
</tr>
<tr>
<td>MS 15 TTLx1u</td>
<td>∞</td>
<td>10.00</td>
<td>times 1</td>
<td>10.00</td>
<td>500 ns</td>
</tr>
<tr>
<td>MS 15 TTLx5</td>
<td>⊖</td>
<td>2.00</td>
<td>times 5</td>
<td>6.40</td>
<td>300 ns</td>
</tr>
<tr>
<td>MS 15 TTLx10</td>
<td>⊖</td>
<td>1.00</td>
<td>times 10</td>
<td>3.20</td>
<td>300 ns</td>
</tr>
<tr>
<td>MS 15 TTLx20</td>
<td>⊖</td>
<td>0.50</td>
<td>times 20</td>
<td>2.40</td>
<td>200 ns</td>
</tr>
<tr>
<td>MS 15 TTLx25</td>
<td>⊖</td>
<td>0.40</td>
<td>times 25</td>
<td>1.92</td>
<td>200 ns</td>
</tr>
<tr>
<td>MS 15 TTLx50</td>
<td>⊖</td>
<td>0.20</td>
<td>times 50</td>
<td>1.92</td>
<td>100 ns</td>
</tr>
<tr>
<td>MS 15 TTLx100</td>
<td>⊖</td>
<td>0.10</td>
<td>times 100</td>
<td>0.96</td>
<td>100 ns</td>
</tr>
<tr>
<td>MS 15 TTLx200</td>
<td>⊖</td>
<td>0.05</td>
<td>times 200</td>
<td>0.96</td>
<td>50 ns</td>
</tr>
</tbody>
</table>

Interpolation error with signal stabilization:
Typical ±65 nm (peak-peak)

Permissible vibration:
150 m/s² (55 to 2000 Hz)

Permissible shock:
750 m/s² (8 ms)

Permissible temperature:
-20 °C to +70 °C (storage)
0 °C to +50 °C (operation)

GRADUATION CARRIER

<table>
<thead>
<tr>
<th>Graduation carrier</th>
<th>Steel</th>
<th>Glass, glass ceramics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grating period</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>Coefficient of thermal expansion</td>
<td>α = 10 x 10⁻⁶ / K</td>
<td>Glass: α = 8.5 x 10⁻⁶ / K, glass ceramics: α = 0 x 10⁻⁶ / K</td>
</tr>
<tr>
<td>Non-linearity</td>
<td>±3 µm/m</td>
<td>±3 µm/m</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</td>
<td>20 000 mm</td>
<td>Glass: max. 3140 mm, glass ceramics: max. 1940 mm*</td>
</tr>
<tr>
<td>Reference mark</td>
<td>Standard: 50 mm equidistant</td>
<td>Standard: 50 mm equidistant</td>
</tr>
<tr>
<td></td>
<td>Position selectable by customer</td>
<td>Position selectable by customer</td>
</tr>
<tr>
<td></td>
<td>Distance-coded on request</td>
<td>Distance-coded on request</td>
</tr>
</tbody>
</table>

Principle of the standard reference marks

Reference mark (RI)  Activation sticker RI  50 equidistant

Principle of the distance-coded reference marks

T = Grating period

MS 15 linear encoders comply with the guideline of the RoHS-directive 2011/65/EU and also with the delegated directive 2015/863/EU on the restriction of the use of certain hazardous substances in electrical and electronic equipment.

* Longer lengths on request
MS 15 MK

- Steel tape scale with adhesive tape

Dimensions, mounting tolerances:

**Tape mounting tool TMT MS 15 MK (optional)**
For safe and precise mounting of the steel tape scale.

- Mount TMT MS 15 MK instead of the MS 15 scanning head.
- Thread steel tape scale (version MK) and move along the scale length.
- Remove TMT MS 15 MK, mount MS 15 scanning head.
MS 15 MP

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

Dimensions, mounting tolerances:

**Homing function possible**

- **CL** = Clamping element
- **OL** = Overall length
- **ML** = Measuring length
- **OL** = Overall length
- **RI** = Selectable reference mark(s)
- **k** = Any position of the selected reference mark from the beginning of the ML
- **j** = Additional reference marks spaced every n x 50
- **f** = OL/2 (standard) any position of the clamping element (optional)
- **C** = Cable
- **R** = Required mating dimensions
- **L** = LED function control
- **S1, S2** = Switch signal

Permissible position deviations reading head - steel tape scale, reference plane A | B

- **Δx**: Displacement, ±6.0 mm
- **Δy**: Gap tolerance, ±0.2 mm
- **ψx**: ±1.50 mrad or ±0.08° (yaw angle)
- **ψy**: ±3.50 mrad or ±0.20° (pitch angle)
- **ψz**: ±4.00 mrad or ±0.23° (roll angle)

**Mass (approx.)**

- Version MP: 90 g/m
- 16 g clamping element
- Scanning head: 11.5 g
- Connector D-sub, 15-pins: 26.5 g
- 30 g/m cable

Tolerancing ISO 8015:

- ±6 mm; ±0.2 mm
MS 15 GK, BK

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

Dimensions, mounting tolerances:

- Permissible position deviation scanning head-stee scale tape, reference plane A (B)
  - $\Delta_x = \pm 0.05 \text{ mm}$
  - $\Delta_y = \pm 0.10 \text{ mm}$
  - $\phi_x = \pm 1.00 \text{ mrad or } \pm 0.06^\circ$ (yaw angle)
  - $\phi_y = \pm 1.50 \text{ mrad or } \pm 0.20^\circ$ (pitch angle)
  - $\phi_z = \pm 0.50 \text{ mrad or } \pm 0.03^\circ$ (roll angle)

Mass (approx.)
- Version BK: 57 g/m
- Version GK: 55 g/m

Connector: D-sub, 15-pin: 26.5 g
- 30 g/m cable
REFERENCE MARK (RI)- AND SWITCH POINTS-SELECTION

Reference mark (RI)-selection

Selected reference mark is activated

RI-activation sticker

NOTE

MS 15 BK, GK and MK selection of the switch points

S2 = Switch point signal S2 from beginning of ML
X2_L = Activation tape length
X2_L = S2 + 19.5

EXAMPLE
S2: 20 mm from beginning of ML → X2_L = 39.5 mm
S1: 20 mm before end of ML → X1_R = 29 mm

MS 15 MP selection of the switch points

S2 = Switch point signal S2 from beginning of ML
X2_L = Activation tape length
X2_L = S2 + 24.5

EXAMPLE
S2: 80 mm from beginning of ML → X2_L = 104.5 mm
S1: 15 mm before end of ML → X1_R = 23 mm
## INSPECTION OF FUNCTIONS

<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>Function-control main track</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 graduation carrier</td>
</tr>
<tr>
<td>Function-control reference impulse RI</td>
<td></td>
<td>Only by passing the reference mark</td>
</tr>
<tr>
<td>▪ LED blinks BLUE</td>
<td>RI within tolerance</td>
<td></td>
</tr>
<tr>
<td>▪ LED blinks RED</td>
<td>RI out of tolerance</td>
<td>Check mounting, clean graduation carrier</td>
</tr>
<tr>
<td><strong>With external test box</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function-control main track</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>Function-control reference impulse RI</td>
<td></td>
<td>Only by passing the reference mark</td>
</tr>
<tr>
<td>▪ LED blinks BLUE</td>
<td>RI within tolerance</td>
<td></td>
</tr>
<tr>
<td>▪ LED blinks RED</td>
<td>RI out of tolerance</td>
<td>Check mounting, clean graduation carrier</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 reference marks.
Even though the MS 15 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 101 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 101 is ideal for mobile use. A 4.3-inch touchscreen provides for display and operation.

Available functions
The performance range of the PWT 101 can be expanded by firmware update. Appropriate firmware files that can be imported to the PWT 101 through a memory card (not included in delivery) will be made available at www.heidenhain.de.
**MC 15**  
Absolute exposed linear encoder with status display  
- Interface: EnDat 2.2 (others on request)  
- Status display directly at the scanning head via LED function  
- 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  
- Flat dimensions  
- Easy mounting due to large mounting tolerances  
- High insensitivity against contamination  
- High permissible traversing speed  
- Integrated subdividing: up to times 100  
- Max. measuring length  
  Steel tape scale: 10 000 mm

**MS 25**  
Exposed linear encoder with and without 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  
- Flat dimensions  
- Easy mounting due to large mounting tolerances  
- High insensitivity against contamination  
- High permissible traversing speed  
- Integrated subdividing: up to times 200  
- Max. measuring length  
  Glass scale: 3140 mm  
  Steel tape scale: 20 000 mm

**MS 45**  
Exposed 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  
- Flat dimensions  
- Easy mounting due to large mounting tolerances  
- High insensitivity against contamination  
- High permissible traversing speed  
- Integrated subdividing: up to times 100  
- Max. measuring length  
  Steel tape scale: 30 000 mm

**FURTHER PRODUCTS**

**MC 15 | MC 15**  
Absolute modular angle encoders with small dimensions  
- Display of the signal quality directly at the scanning head via a tricolored LED function  
- Easy mounting as a result of large mounting tolerances  
- High insensitivity against contaminations  
- Possible drum diameter: 50.00 mm to 350.23 mm (outside)  
- Steel tape scale from Ø 75 mm

**MSR 15 | MSS 15**  
Incremental modular angle encoders with small dimensions  
- Easy mounting as a result of large mounting tolerances  
- High insensitivity against contaminations  
- Possible drum diameter: 50.00 mm to 350.23 mm (outside)  
- Steel tape scale from Ø 75 mm

**MSR 20**  
Modular angle encoder with steel tape scale - various versions  
- Segment version  
- Grating pitch: 40 µm  
- Accuracy of the grating (stretched): ±15 µm/m  
- High permissible circumferential speed  
- Integrated subdividing: up to times 100  
- Possible diameter: Steel tape scale from Ø 50 mm

**MSR 45**  
Modular angle encoder with steel tape scale - various versions  
- Full-circle or segment version  
- Grating pitch: 200 µm  
- Accuracy of the grating (stretched): ±30 µm/m  
- High permissible rotational speed resp. circumferential speed  
- Integrated subdividing: up to times 100  
- Possible diameter:  
  Full-circle from Ø 146.99 mm  
  Segment from Ø 150 mm