MS 40
Open Linear Encoder
with quasi-singlefield scanning

Special highlights:
• Easy mounting as a result of large mounting tolerances
• Contamination resistance
• High traversing speed
• “True” reference mark (accurate and repeatable from both traversing directions)
• Integrated subdividing electronics in the encoder head for up to times 100 interpolation
Grating Pitch (Interval)
A grating is a continuous series of lines and spaces printed on the scale. The width of the printed line and the space are the same. 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. Scales are manufactured with accuracy grades from ±15 microns per meter to ±1 micron per meter.

Signal Period
When scanning the grating, the encoder head produces a sinusoidal signal 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.

Reference Pulse (Reference Mark)
This 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 signal will be generated which is only one increment wide 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
This is a signal what happens at malfunctioning encoders automatically, i.e. at bad or missing signals and broken cables.

Measuring Step (Resolution)
This is the smallest digital counting step produced by an encoder.

Accuracy
This is a fundamental characteristic of a measuring system. It is the maximum permissible deviation of a measured value to a known value. Accuracy is stated in (±) microns per meter of travel. Scales are specified with an accuracy grade (i.e. ±5µm/m).

Abbe Error
Measuring error due to lateral misalignment between the measuring system and the machine guideway.

Yaw Angle, Pitch Angle, Roll Angle
Mounting tolerances of the encoder head relative to the scale.
The trend today in motion control applications is for Open Linear Encoder Systems. This is driven by steadily increasing demands for:
- Higher traversing speed
- Higher operating cycles
- Lower mechanical backlash
- Zero frictional force induced by the encoder.

Only open, non-contact encoders fulfill all these requirements. A drawback of many open linear encoders is their sensitivity to dirt and contamination on the scale. The MS 40 encoder’s unique optical design minimizes the effect of dirt and contamination normally associated with the open linear encoders.

The MS 40 utilizes a unique scanning principle which allows for high traversing speeds (up to 10 m/s), large mounting tolerances and contamination on the scale. A “true” Reference Mark (i.e. accurate and repeatable from both traversing directions) is standard. A wide range of interpolation electronics, integrated into the encoder head, enable resolutions from 10 µm to 0,5 µm. Squarewave signals, single ended, or via Line Driver RS 422, are provided at the output of the encoder head. Units with sinusoidal outputs 1Vpp are also available. Due to recent advancements in technology, all of these benefits are now available in a small package design.

What design characteristics do you require in an Open Linear Encoder?

- Contamination resistance
- High resolution
- High speed
- Large mounting tolerances
- Low Cost and High Quality

The new MS 40 meets all these requirements!
The model MS 40 incremental linear encoder works with the imaging, photoelectric measuring principle and a quasi-singlefield reflective scanning method. As scale graduation pattern is used a steel tape with 200 µm grating pitch. The light from an infrared LED with a small light emitting surface is collimated parallel by a condenser lens and directed through the scanning reticle to the scale. When the scale is moved relative to the encoder head, the light is modulated by the scale gratings and produces a periodic intensity signal that is converted into electrical signals by photo elements back in the encoder head. The scanning reticle is designed to allow for a large mounting gap and liberal mounting tolerances. This system is insensitive to waviness of the steel tape due to poor mounting conditions. Any minor differences in the grating period of the scale or the scanning reticle will not cause a measuring problem due to the large continuous pattern reflected onto the structured sensor. This sensor consists of multiple photo elements connected in a pattern to generate four sinusoidal signals, each shifted by 90°. All four signals are generated from one scanning field and all four signals are equally influenced by any contamination simultaneously. When all four signals are influenced at the same time by the same amount, interpolation error is eliminated.

**Effect of contamination on the quality and size of the scanning signal (before interpolation)**

Clean steel tape scale - optimal condition

Contaminated steel tape scale - unfavorable condition

High insensitivity to contamination by use of a new scanning principle.

**Cable and connector shielding, standard connector pin outs**

Encoder head shielding and cable type is determined by the signal type. The standard is a 3 meter cable with a PUR jacket material. Cables for use in vacuum applications to $10^{-7}$ torr are also available upon request.

**Connector LD15 15-pin**

<table>
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<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>
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<tbody>
<tr>
<td>PIN</td>
<td>nc</td>
<td>GND</td>
<td>n2</td>
<td>n2</td>
<td>n2</td>
<td>T1</td>
<td>T1</td>
<td>+5 V</td>
<td>+5 V</td>
<td>GND</td>
<td>nc</td>
<td>nc</td>
<td>T2</td>
<td>T1</td>
<td>Shield</td>
</tr>
<tr>
<td>Square wave signals via Line Driver</td>
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<td></td>
<td></td>
<td></td>
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**Square wave signals**

<table>
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<tr>
<th>PIN</th>
<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
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<th>7</th>
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<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
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</thead>
<tbody>
<tr>
<td>Voltage signals</td>
<td>nc</td>
<td>GND</td>
<td>nc</td>
<td>n2</td>
<td>A2</td>
<td>A1</td>
<td>+5 V</td>
<td>+5 V</td>
<td>GND</td>
<td>nc</td>
<td>nc</td>
<td>A2</td>
<td>A1</td>
<td>Shield</td>
<td></td>
</tr>
</tbody>
</table>

- The shield is connected with the chassis
Output signals

Sinusoidal voltage signals (Drawing in „positive counting direction“)
Two sinusoidal voltage signals A1 and A2 and one Reference index (all with inverted signals).

- **Power supply:** +5 V ±5%, max. 130 mA (unloaded)
- **Reference voltage of the output signals:** V+/2 (approx. 2.5 V)
- **Track signals (differential voltage A1 to A1 resp. A2 to A2):**
  - Phaseshift 90° ±10° el.
  - Signal amplitude 0.6 Vpp to 1.2 Vpp
  - typ. 1 Vpp with terminating impedance Zo = 120 Ω

- **Reference Mark (differential voltage RI to RI):**
  - El. position typical 135° (referenced to A1)
  - El. width typical 360°
  - Evaluating part of the signal peak 0.2 up to 0.85 V, typical 0.5 V (effective quota) with terminating impedance Zo = 120 Ω

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

Square wave signals (Drawing in „positive counting direction“)
The photoelement output signals are converted into two square wave signals that have a phase shift of 90° with interpolation electronics (for times 5, -10, -50 or -100).
That signals cannot be interpolated.

- **Output signals** can be either single ended or Line Driver differential (RS 422).
- **For measuring systems with single ended output signals**
  - the max. cable length is 10 m, complete with extension cable
- **One measuring step reflects the measuring distance between two edges of the square wave signals.**
- **Machine controls/DRO’s have a minimum allowable distance between A and B changes of state, measures in time (inverse of max. frequency).**
  - The minimum edge distance a_{min} is shown in the technical data.
- **Power supply:** +5 V ±5%, max. 165 mA (unloaded)

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

Counting direction
The „positive counting direction“ is defined, that the scanning unit moves to the right side (same direction as the cable access)
MS 40 Technical data

Features:
- Easy mounting as a result of large mounting tolerances
- High insensitivity to contamination by use of an extensive quasi-singlefield scanning principle
- High traversing speed
- "True" Reference Mark (accurate and repeatable from both traversing directions)
- Integrated subdividing electronics in the encoder head for up to times 100 interpolation (before quadrature)

Scanning unit: 200 μm grating pitch, system resolution from 10 μm to 0,5 μm

<table>
<thead>
<tr>
<th>Scale model</th>
<th>System resolution</th>
<th>Grating pitch</th>
<th>Integrated interpolation</th>
<th>Max. velocity</th>
<th>Max. output frequency resp. Edge distance a_min</th>
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</thead>
<tbody>
<tr>
<td>MS 40.06</td>
<td>depending on external interpolation</td>
<td>200 μm</td>
<td>--</td>
<td>10 m/s</td>
<td>50 kHz</td>
</tr>
<tr>
<td>MS 40.66</td>
<td>10 μm</td>
<td>200 μm</td>
<td>times 5</td>
<td>10 m/s</td>
<td>500 ns</td>
</tr>
<tr>
<td>MS 40.76</td>
<td>5 μm</td>
<td>200 μm</td>
<td>times 10</td>
<td>9 m/s</td>
<td>500 ns</td>
</tr>
<tr>
<td>MS 40.86</td>
<td>1 μm</td>
<td>200 μm</td>
<td>times 50</td>
<td>4.5 m/s</td>
<td>200 ns</td>
</tr>
<tr>
<td>MS 40.96</td>
<td>0.5 μm</td>
<td>200 μm</td>
<td>times 100</td>
<td>2.25 m/s</td>
<td>200 ns</td>
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</tbody>
</table>
## Scale unit: Grating carrier steel tape scale

### Mechanical features of the grating carrier

<table>
<thead>
<tr>
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<th>MS 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grating pitch</td>
<td>200 µm</td>
</tr>
<tr>
<td>Accuracy grades</td>
<td>±30 µm/m</td>
</tr>
<tr>
<td>Max. Measuring length</td>
<td>10040 mm</td>
</tr>
<tr>
<td>Standard measuring length (mm)</td>
<td>120, 170, 220, 270, 320, 370, 420, 470, 520, 620, 720, 770, 820, 920, 1040, 1140, 1240, 1340, 1440, 1540, 1640, 1740, 1840, 2040, 2240, 2440, 2640, 2840, 3040, 3240, 3440, 3640, 3840, 4040, 4240, 4440, 4640, 4840, 5040, 5240, 5440, 5640, 5840, 6040, 6240, 6440, 6640, 6840, 7040, 7240, 7440, 7640, 7840, 8040, 8240, 8440, 8640, 8840, 9040, 9240, 9440, 9640, 9840, 10040</td>
</tr>
</tbody>
</table>

- Reference Marks (RI) Standard: separated by distances of n x 100 mm
- Reference Marks (RI) at any location: selected by customer

| Steel tape scale without carrier | MS 40.xx MO |
| Steel tape scale with adhesive tape | MS 40.xx MK |
| Steel tape scale in aluminium profile with adhesive tape | MS 40.xx MP |

**Mounting-adjustment/Test:** With electronic signal test/set-up box PG or PS to optimize or check the mounting (see page 10)

**Permissible vibration:** 150 m/s² (40 bis 2000 Hz)

**Permissible shock:** 750 m/s² (8 ms)

**Permissible temperature:** -20°C bis +70°C (storage), 0°C bis +50°C (operation)

**Weight depending on scale version (approx.)**
- 35 g/m (MO = Steel tape scale without carrier, MK = Steel tape scale with adhesive tape)
- 115 g/m (MP = Steel tape scale in aluminium carrier, carrier glued) + 2 g clamping element + 15 g (scanning unit without cable)
MS 40.xx MO, MS 40.xx MK steel tape scale without carrier (MO) with adhesive tape (MK)

Dimensions, mounting tolerances, mounting possibilities:

Overall length = measuring length + 30 ± 1

M = Machine guideway
(K) = Required mating dimensions

Reference-Marks:
k = Any position of Reference-Mark from the beginning of the measuring length
j = Additional Reference-Marks separated by n x 100 mm

Hexagon nut applicable ISO 4032 - M3

ISO 4762 - M3

ISO 7092 - 3
MS 40.xx MP steel tape scale in aluminium carrier with clamping element, carrier with adhesive tape

Dimensions, mounting tolerances, mounting possibilities:

Overall length = measuring length + 30

Pos, RI-Mark k
min. 20 mm / max. ML - 20 mm

Measuring length (min. 40 mm)

Mounting surface

Reference Mark (RI) (reading head)

Clamping element

Thread hole for customer’s scope of supply M3³5

Hexagon nut applicable
ISO 4032 - M3

ISO7048 - M3x6

M = Machine guideway

K = Required mating dimensions

Reference-Marks:
k = Any position of Reference-Mark from the beginning of the measuring length
Open linear encoders are adjusted at the factory to provide the signal specifications at the specified mounting conditions.

Even though the linear encoders in the MS 4x series allow for large mechanical mounting tolerances, it is recommended to inspect the mounting by checking the quality of the output signals.

There are various methods of checking the quality of the output signals. The signals can be connected to an oscilloscope and checked for conformity with signal specifications. This method requires effort, training and expensive test equipment (oscilloscope). Often one or all of these items are unavailable to the installing technician. As an alternative to this method, RSF offers different signal test boxes. With these test boxes all encoder signals can be quickly and easily checked.

The PG1-U is an all-purpose signal test box where all the relevant signals are displayed on LCD Bars.

The PG1-U allows the quantitative as well as the qualitative evaluation of the encoder signals.

The PG-U, PG4 and PS4 test box checks all relevant signals; amplitude, phase and offset, and displays the results in a qualitative format on a polychromatic LED display. 

PG-U and PG4 = stand alone test

PS4 = in-circuit test

<table>
<thead>
<tr>
<th>Intended PG-use</th>
<th>MS 40</th>
<th>Output signals</th>
<th>square wave</th>
<th>sinus (1 Vpp)</th>
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<tbody>
<tr>
<td>PG1-U</td>
<td></td>
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<tr>
<td>PG-U</td>
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<tr>
<td>PG4</td>
<td></td>
<td></td>
<td>✓</td>
<td>--</td>
</tr>
<tr>
<td>PS4</td>
<td></td>
<td></td>
<td>✓</td>
<td>--</td>
</tr>
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</table>
Other RSF products, short description

**MS 20**
Linear Encoder with quasi-singlefield reflective scanning
- easy mounting as a result of large mounting tolerances
- high traversing speed
- high insensitivity to contamination
- „true“ reference mark
- integrated subdividing up to times 100 interpolation
- max. measuring length 10040 mm

**MS 30**
Reflective scanning Linear Encoder
- two independent switch signals for individual functions
- easy mounting as a result of large mounting tolerances
- high traversing speed
- high insensitivity to contamination
- integrated subdividing up to times 100 interpolation
- max. measuring length 8840 mm

**MS 8x**
Interferential Linear Encoder
- two switch tracks for individual special functions
- non-contact reflective scanning
- for high displacement velocities
- small version
- scale version: glass scale or ROBAX glassceramic with phase grating
- max. measuring length to 3040 mm

**TDE 60**
Two dimensional Encoder
- non-contact reflective scanning
- small version
- scale version: glass scale
- measuring range 360 x 360 mm

**MSA 170**
- enclosed version
- guided by ball bearings
- distance coded RI marks (K)
- extremely small cross section
- mounting holes on the extrusion ends
- max. measuring length 520 mm

**MSA 670**
- enclosed version
- distance coded RI marks (K)
- small cross-section
- mounting holes on the extrusion ends
- max. measuring length 2240 mm

**MSA 370**
- enclosed version
- distance coded RI marks (K)
- large cross-section
- rigid mounting
- mounting holes on the extrusion ends and with mounting supports
- max. measuring length 3040 mm

**Z 7x Reihe**
Digital Readouts for universal application
- number of alphanumeric axis
  - 1, 2 or 3 (depends on version)
- clearly readable display
- robust cast aluminium housing
- clear keyboard
- practice-oriented functions
- standard version for lathe or milling machine
- version for spark erosion machines and surface grinders on request
## RSF Offices

<table>
<thead>
<tr>
<th>Country</th>
<th>Address</th>
<th>Phone Numbers</th>
<th>Email</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Austria</td>
<td>RSF Elektronik Ges.m.b.H. A-5121 Tarsdorf</td>
<td>+43 (0) 6278 / 8192-0</td>
<td><a href="mailto:info@rsf.at">info@rsf.at</a></td>
<td><a href="http://www.rsf.at">www.rsf.at</a></td>
</tr>
<tr>
<td>Switzerland</td>
<td>RSF Elektronik (Schweiz) AG Mühistraße 18 CH-8320 Fehraltorf</td>
<td>+44 (0)1 955 10 50</td>
<td><a href="mailto:info@rsf.ch">info@rsf.ch</a></td>
<td><a href="http://www.rsf.ch">www.rsf.ch</a></td>
</tr>
<tr>
<td>Slovenia</td>
<td>RSF Elektronik prodaja, d.o.o. Jozeta Jame 14 SI-1210 Ljubljana</td>
<td>+386 1 519 88 80</td>
<td><a href="mailto:mail@rsf-elektronik.si">mail@rsf-elektronik.si</a></td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>RSF Electronics Inc. 2880 Gold Tailings Court Rancho Cordova, CA 95670</td>
<td>+1 916 852 - 6660</td>
<td><a href="mailto:info@rsf.net">info@rsf.net</a></td>
<td><a href="http://www.rsf.net">www.rsf.net</a></td>
</tr>
<tr>
<td>China</td>
<td>RSF Elektronik GmbH Tian Wei San Jie, Area A, Beijing Tianshu Airport Industrial Zone Shunyi District 101312 Beijing P. R. China</td>
<td>+86-10-8042-0288</td>
<td><a href="mailto:cao.shizhi@rsf-cn.com">cao.shizhi@rsf-cn.com</a></td>
<td><a href="http://www.rsf-cn.com">www.rsf-cn.com</a></td>
</tr>
<tr>
<td>Korea</td>
<td>RSF Electronics Ltd. 1224-7 SUNGSEOK-Dong ILSAN-Ku, KOYANG-Si, KYUNGGI-Do, Korea R.O.K.</td>
<td>+82-31-977-4136</td>
<td><a href="mailto:rsf@rsf.co.kr">rsf@rsf.co.kr</a></td>
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**RSF Elektronik**

Certified according to DIN EN ISO 9001 DIN EN ISO 14001

**Austria**

A-5121 Tarsdorf • +43 (0)6278 / 8192-0 • Fax +43 (0)6278 / 8192-79 • e-mail: info@rsf.at • Internet: www.rsf.at