Exposed Linear Encoders
with Singlefield Scanning
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
This signal appears when a malfunctioning encoder generates faulty scanning signals.

Accuracy
This is a fundamental characteristic, which is specified with an accuracy grade (e.g. ±5 µm/m).

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.
WHAT DO YOU REQUIRE IN AN EXPOSED LINEAR ENCODER?

- Contamination resistance
- Immunity against aging and temperature changes
- High resolution
- High traversing speed
- Large mounting tolerances
- Small dimensions

The MS 3x series meets all these requirements!

The trend today in motion control applications is for exposed 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 exposed, non-contact encoders fulfill all these requirements.

It is important for high resolution applications to minimize interpolation errors. Historically, the small grating periods used had the disadvantages of smaller mounting gaps and very tight overall mounting tolerances. The MS 3x encoders’ 20 µm grating period minimizes interpolation errors but can be mounted with a large mounting gap and liberal mounting tolerances.

A drawback of many exposed Linear Encoders is their sensitivity to dirt and contamination on the scale. The MS 3x encoders’ unique optical design minimizes the effect of dirt and contamination normally associated with the exposed Linear Encoders.

The MS 3x utilizes a unique scanning principle which allows high traversing speeds (up to 7 m/s), large mounting tolerances, and contamination on the scale.

Reference marks, accurate and repeatable from both traversing directions, are standard.

A wide range of interpolation electronics, integrated into the encoder head, enable resolutions from 5 µm to 50 nm. Square-wave signals, single ended, or via Line Driver RS 422, are provided at the output of the encoder head.

Units with sinusoidal output, 1 Vpp, are also available.

Two end of travel optical switch signals are available directly out of the reading head. The end of travel signal locations can be easily set by the user.

Due to recent advancements in technology, all of these benefits are now available in a small package design.

Signal amplitude vs. reading head gap
SCANNING PRINCIPLE

The model MS 3x incremental Linear Encoder works with the imaging, 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 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 light output, guaranteeing stability in the case of temperature fluctuations as well as with long-run operation.

**Effect of contamination on the quality and size of the measuring signal**

![Clean steel tape scale - optimal condition](image1.png)

![Contaminated steel tape scale - unfavorable condition](image2.png)

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

A high accuracy grating is deployed as scale graduation with 20 µm grating pitch. Depending on the model, glass (chrome grating) ($\alpha \approx 8.5 \times 10^{-6}$/K), glass ceramic (— — ) ($\alpha \approx 0 \times 10^{-6}$/K) or steel (gold grating) ($\alpha \approx 10.5 \times 10^{-6}$/K) is employed as base.

The grating is the consistent series of lines and spaces of the same width. The width of one line and one space is called a grating pitch (T).

Parallel to the grating, there are one or more reference marks (RI) on a second track. Within the measuring length, any position is possible and additional reference marks can be chosen in a distance of 50 mm.

Linear Encoders with a suffix “K” in the model designation are equipped with distance-coded reference marks. After traveling a distance of 40 mm at maximum, the absolute tool position is available with these models.

By dint of the optical scanning, a position-accurate evaluation of the reference marks is ensured.
Shielding, Pin Assignments

Shielded PUR-cable, Ø 4.3 mm, Bending radius fixed mounting > 10 mm, continuous flexing > 50 mm
Torsion > 300,000 cycles, Dragchain > 5,000,000 cycles
Cables for use in vacuum applications are available on request.

Shielding

- shield on housing of the reading head
- shield on chassis and on connector pin

Connector LD15 15-pin

<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>nc</td>
<td>0 V</td>
<td>sensor</td>
<td>nc</td>
<td>RI</td>
<td>A2</td>
<td>AT</td>
<td>+5 V</td>
<td>sensor</td>
<td>+5 V</td>
<td>0 V</td>
<td>S1**</td>
<td>S2**</td>
<td>RI</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>RI</td>
<td>T2</td>
<td>TT</td>
<td>+5 V</td>
<td>sensor</td>
<td>+5 V</td>
<td>0 V</td>
<td>S1**</td>
<td>S2**</td>
<td>RI</td>
<td>T2</td>
</tr>
</tbody>
</table>

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

- ** MS 30: S1, S2 = switch signals
- ** MS 31: S1 = conditionally useable as switch signal, S2 = switch signal
- ** MS 32: Version without switch signals (version 0) = nc
- Sensor: the sensor-pins are bridged with the particular power supply.
- The shield is additional connected with the chassis.

Max. permissible cable length according to power supply

power supply [V] on connector - control sided

- Square-wave
- Sinus
OUTPUT SIGNALS

Sinusoidal voltage signals 1Vpp
(drawing shows “positive counting direction”)
Two sinusoidal voltage signals A1 and A2 and one reference mark signal (all with inverted signals).

Power supply: +5 V ±5 %, max. 120 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):
Useable component 0.2 up to 0.85 V; typical 0.5 V
(with terminating impedance Zo = 120 Ω between RI to RI)

Advantage:
- High traversing speed with long cable lengths possible

Square-wave signals
(drawing shows “positive counting direction”)
With a Schmitt-Trigger (for times 1) or interpolation electronics
(for times -5, -10, -20, -25, -50 or -100) the photoelement output signals are converted into two square-wave signals that have a phase shift of 90°. Output signals either can be "single ended" or Line Driver “differential” (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 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:
\(a_{\text{min}} = 100\text{ ns}, 10\text{ m cable}\)
100 ns - 10 ns - 10 ns - 0.2 ns - 10 ns = 78 ns

Power supply: +5 V ±5 %, max. 200 mA (unloaded)

Advantage:
- Noise immune signals
- No further subdividing electronics necessary
SWITCH SIGNAL OUTPUT

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

With the MS 31.xx version 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

- Small dimensions
- Easy mounting as a result of large mounting tolerances
- High insensitivity to contamination by use of an extensive singlefield scanning principle
- High traversing speed
- Integrated subdividing electronics: for up to times 100 (before quadrature)
- Reference mark accurate and repeatable from both traversing directions

**MS 30:** Two independent switch signals (optical) for individual functions

**MS 31:** Position of reference mark can be selected by the customer
One switch signal (optical) for individual functions

**Reading head: 20 µm grating pitch**

<table>
<thead>
<tr>
<th>Scale 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 3x.03</td>
<td>1 Vpp</td>
<td>depending on external interpolation</td>
<td>--</td>
<td>7.0</td>
<td>350</td>
</tr>
<tr>
<td>MS 3x.23</td>
<td></td>
<td>5</td>
<td>times 1</td>
<td>4.0</td>
<td>800 ns</td>
</tr>
<tr>
<td>MS 3x.63</td>
<td></td>
<td>1</td>
<td>times 5</td>
<td>3.2</td>
<td>300 ns</td>
</tr>
<tr>
<td>MS 3x.73</td>
<td></td>
<td>0.5</td>
<td>times 10</td>
<td>1.6</td>
<td>300 ns</td>
</tr>
<tr>
<td>MS 3x.43</td>
<td></td>
<td>0.25</td>
<td>times 20</td>
<td>1.2</td>
<td>200 ns</td>
</tr>
<tr>
<td>MS 3x.53</td>
<td></td>
<td>0.2</td>
<td>times 25</td>
<td>0.96</td>
<td>200 ns</td>
</tr>
<tr>
<td>MS 3x.83</td>
<td></td>
<td>0.1</td>
<td>times 50</td>
<td>0.96</td>
<td>100 ns</td>
</tr>
<tr>
<td>MS 3x.93</td>
<td></td>
<td>0.05</td>
<td>times 100</td>
<td>0.48</td>
<td>100 ns</td>
</tr>
</tbody>
</table>

**Mounting-adjustment/Test:**
To optimize or check the mounting we recommend to use a compatible electronic signal test/set-up box PG1 or PG3 (page 18).

**Permissible vibration:** 150 m/s² (40 up to 2000 Hz)
**Permissible shock:** 750 m/s² (8 ms)

**Permissible temperature:**
-20 °C up to +70 °C (storage), 0 °C up to +50 °C (operation)
### Scale unit: Grating carrier: Glass or steel

<table>
<thead>
<tr>
<th>Mechanical features of the scale unit</th>
<th>MS 30</th>
<th>MS 31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grating carrier</td>
<td>glass</td>
<td>steel</td>
</tr>
<tr>
<td>Grating pitch (T)</td>
<td>20 µm</td>
<td>20 µm</td>
</tr>
<tr>
<td>Accuracy grades</td>
<td>±3, ±5 µm/m</td>
<td>±5, ±15 µm/m</td>
</tr>
<tr>
<td>Non-linearity</td>
<td>≤ ±1 ¬µm/70 mm</td>
<td>≤ ±3 ¬µm/1000 mm</td>
</tr>
<tr>
<td>Maximum measuring length (ML)</td>
<td>3140 mm</td>
<td>11 940 mm</td>
</tr>
</tbody>
</table>

### Reference marks (RI)

<table>
<thead>
<tr>
<th>Standard: 50 mm (equidistant)</th>
<th>■</th>
<th>■</th>
<th>■</th>
<th>■</th>
</tr>
</thead>
<tbody>
<tr>
<td>At any location, on request</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Distance-coded</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Distance-coded up to ML 3140 mm</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Position selectable by customer</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
</tr>
<tr>
<td>Switch tracks</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
MS 30, MS 31 MO, MK

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

Dimensions, mounting tolerances:

* = max. change in operation
M = machine guideway
(K) = required mating dimensions
k = any position of reference mark (RI) from the beginning of measuring length
j = additional reference marks (RI) separated by n x 50 mm

Weight (approx.):
- Version MO: 20 g/m
- Version MK: 25 g/m
+ 30 g (reading head without cable)

Affixing cover tapes for the switch points and activation of the selectable reference mark see page 16.

Tape mounting tool TMT 30 MK (optional)
For safe and precise mounting of the steel tape scale.

- Mount TMT 30 MK instead of the reading head MS 3x
- Thread steel tape scale (version MK) and move along the scale length
- Remove TMT 30 MK, mount reading head MS 3x
Dimensions, mounting tolerances:

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

**Weight (approx.):**
- **Version MA**: 530 g/m
- **Version MS**: 1525 g/m
  + 30 g (reading head without cable)

Affixing cover tapes for the switch points and activation of the selectable reference mark see page 16.
MS 30, MS 31 MP

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

Dimensions, mounting tolerances:

Overall length = measuring length + 45

Measuring length (min. 85 / max. 11940)

Weight (approx.):
- 85 g/m + 30 g clamping element
- 30 g (reading head without cable)

Affixing cover tapes for the switch points and activation of the selectable reference mark see page 16.

Arrangement of the segments at large measuring lengths

- Residual length left
- Segment 1000
- Clamping element
- Segment 1000
- Residual length right

Groove for alignment
Steel tape scale in aluminum carrier with clamping element

Carrier bolted

Dimension, mounting tolerances:

Overall length = measuring length + 45
Measuring length (max. 11 940)
Adjust to max. counting signal or ideal reference pulse position

Reference mark (reading head)

Mounting surface

Weight (approx.):
- 325 g/m + 30 g clamping element
- 30 g (reading head without cable)

Affixing cover tapes for the switch points and activation of the selectable reference mark see page 16.

Measuring length (ML) | A | B
---|---|---
120 | 40 | 50
170 | 40 | 75
from ML 220 | A | B
x20 | 40 | 100
e.g. 320 | 65 | 100
e.g. 770 | 50 | 100
xxx40 | 50 | 100
e.g. 11040

* = max. change in operation
M = machine guideway
(K) = required mating dimensions
k = any position of reference mark (RI) from the beginning of measuring length
j = additional reference marks (RI) separated by n x 50 mm

Weight (approx.):
- 325 g/m + 30 g clamping element
- 30 g (reading head without cable)

Affixing cover tapes for the switch points and activation of the selectable reference mark see page 16.
MS 30, MS 31 GK

- Glass scale with adhesive tape
- Standard: Sinusoidal output signals

Dimensions, mounting tolerances:

Overall length = measuring length + 45

Weight (approx.):
- 100 g/m
- + 30 g (reading head without cable)

Affixing cover tapes for the switch points and activation of the selectable reference mark see page 16
MS 30, MS 31 GA

- Glass scale in aluminum carrier
- Carrier bolted
- Standard: Sinusoidal output signals

Dimensions, mounting tolerances:

- Overall length = measuring length + 45
- Measuring length (max. 3140)
- Adjust to max. counting signal or ideal reference pulse-position

Weight (approx.):
- 515 g/m
- + 30 g (reading head without cable)

Affixing cover tapes for the switch points and activation of the selectable reference mark see page 16
**SWITCH POINTS, REFERENCE MARK (RI)-SELECT**

**MS 30: Positioning of the switch points**

- Switch track 2
- Switch track 1

Example:

- X1 = 26 mm (cover tape 1)
- X2 = 79 mm (cover tape 2)

E.g.: S1: 20 mm from the beginning of ML (left)
Length X1 = 20 mm + 6 mm = 26 mm

S2: 40 mm from the end of ML (right)
Length X2 = 40 mm + 39 mm = 79 mm

**MS 31: Reference mark (RI)-select, positioning of the switch points**

Example:

- X1 = 26 mm (cover tape 1)
- X2 = 79 mm (cover tape 2)

S1 = switch point 1
X1 = S1 + 6 (from left)

S2 = switch point 2
X2 = S2 + 39 (from right)
ACCURACY

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

The accuracy refers 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 3x scale tape:
Exposed Linear Encoders are adjusted at the factory to provide optimal signals at the specified mounting conditions.

Even though the Linear Encoders in the MS 3x 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-I / PG1-U** is an all-purpose signal test box where all the relevant signals are displayed on LCD Bars, and allows the quantitative as well as the qualitative evaluation of the encoder signals.

The **PG3-I / PG-U** test box checks all relevant signals; amplitude, phase and offset, and displays the results in a qualitative format on a polychromatic LED display.

**Intended PG-use**

<table>
<thead>
<tr>
<th>Output signals</th>
<th>Square-wave</th>
<th>Sinus (1 Vpp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG1-I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG1-U</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG2-I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PG-U</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Display of PG1-I**

- Bar-display “counting signals”
- The length shows the sum of the signal deviation (difference of amplitude, phase deviation and offset) of the measuring signal
- **125**
- **15**

**Display of PG1-U**

- Bar-display “reference mark signal”
- The length shows electrical width and position of the reference mark signal
- **135°**
- **360°**

- Intended
- -- not intended
**PRODUCT DIRECTORY**

**MS 14 Series**
Reflective scanning Linear Encoder with integrated mounting
- Easy mounting; no test box or oscilloscope needed
- Quality of the scanning signals is directly visible at the reading head via a 3-coloured LED
- Extremely small dimensions
- Easy mounting as a result of large mounting tolerances
- High insensitivity against contamination
- High traversing speed
- Integrated subdividing: up to times 100 interpolation
- Max. measuring length
  Steel tape scale: 20000 mm

**MS 2x Series**
Reflective scanning Linear Encoder with integrated mounting control (only MS 25, MS 26)
- Easy mounting; no test box or oscilloscope needed
- Quality of the scanning signals is directly visible at the reading head via a 3-coloured LED
- Two independent switch signals for individual special functions
- Position of reference mark selectable
- High insensitivity against contamination
- High traversing speed
- Integrated subdividing: up to times 100 interpolation
- Max. measuring length
  Glass scale: 3140 mm
  Steel tape scale: 20000 mm

**MS 45 Series**
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 reading head via a 3-coloured LED
- Small dimensions
- Easy mounting as a result of large mounting tolerances
- High insensitivity against contamination
- High traversing speed
- Integrated subdividing: up to times 100 interpolation
- Max. measuring length
  Steel tape scale: 30000 mm

**MS 82 Series**
Interferential Linear Encoder
- Two switch tracks for individual special functions
- Non-contact reflective scanning
- High traversing speed
- Small dimensions
- Scale unit: glass scale or ROBAX® glass ceramic scale with phasse grating
- Max. measuring length
  Glass scale: 3140 mm
  Glass ceramic: 1540 mm

**MSR 40**
Modular Rotary Encoder with steel tape scale
- Different versions
  - 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 interpolation

**MSR 20**
Segment version
- Grating pitch: 40 µm
- Accuracy of the grating (stretched): ±15 µm/m
- High circumferential speed
- Integrated subdividing: up to times 100 interpolation

**MSA 170 Series**
- Sealed version
- Guided by ball bearings
- Distance-coded reference marks
- Mounting holes on the extrusion ends
- Max. measuring length: 520 mm

**MSA 7xx, MSA 8xx Series** (small dimensions)
- Optimized thermal behavior
- Connection cable pluggable (optional)
- Sealed version
- Distance-coded reference marks
- Mounting holes at the ends or along the scale unit for improved vibration stability
- Max. measuring length: 3040 mm

**MSA 7xx, MSA 8xx Series** (large dimensions)
- Optimized thermal behavior
- Connection cable pluggable (optional)
- Sealed version
- Distance-coded reference marks
- Mounting holes at the ends or along the scale unit for improved vibration stability
- Max. measuring length: 3040 mm

**MSA 374 Series**
- With integrated guide rail system
- For application on presses bending machines and hydraulic cylinders
- Sealed version
- Roller bearing dual guided scanning carriage
- Free positionable switching magnets for special functions
- Distance-coded reference marks
- Mounting holes on the extrusion ends
- Max. measuring length: 720 mm
<table>
<thead>
<tr>
<th>Country</th>
<th>Contact Information</th>
</tr>
</thead>
</table>
| Austria    | RSF Elektronik Ges.m.b.H.  
             A-5121 Tarsdorf  
             +43 (0) 6278 8192-0  
             +43 (0) 6278 8192-79  
             e-mail: info@rsf.at  
             internet: www.rsf.at |
| France     | HEIDENHAIN FRANCE sarl  
             2 Avenue de la Christallerie  
             92310 Sèvres  
             +331 41 14 30 00  
             +331 41 14 30 30  
             e-mail: info@heidenhain.fr |
| United Kingdom | HEIDENHAIN (GB) Ltd.  
              200 London Road  
              Burgess Hill  
              West Sussex RH15 9RD  
              +44 (0)1444 238550  
              +44 (0)1444 870024  
              e-mail: sales@heidenhain.co.uk |
| Italy      | HEIDENHAIN ITALIANA S.r.l.  
             Via Asiago, 14  
             20128 Milano (MI)  
             +390227075-1  
             +390227075-210  
             e-mail: info@heidenhain.it |
| Switzerland | RSF Elektronik (Schweiz) AG  
              Vieristrasse 14  
              CH-8603 Schwerzenbach  
              +41 44 955 1050  
              +41 44 955 1051  
              e-mail: info@rsf.ch  
              internet: www.rsf.ch |
| Slovenia   | RSF Elektronik prodaja, d.o.o.  
             Jozeta Jame 14  
             SI-1210 Ljubljana  
             +386 (0) 1 519 88 80  
             +386 (0) 1 519 88 80  
             e-mail: mail@rsf-elektronik.si |
| China      | RSF Elektronik GmbH  
             Tian Wei San Jie,  
             Area A, Beijing Tianzu Airport Industrial Zone  
             Shunyi District  
             101312 Beijing  
             P.R. China  
             +86 (0) 1080420288  
             +86 (0) 1080420290  
             e-mail: cao.shizhi@rsf.cn  
             internet: www.rsf.cn |
| Korea      | HEIDENHAIN LTD.  
             201 Namsung Plaza, 9th Ace Techno Tower,  
             345-30, Gasan-Dong, Geumcheon-Gu,  
             Seoul, Korea 153-782  
             +82 (0) 22028 7430  
             e-mail: info@heidenhain.co.kr  
             internet: www.rsf.co.kr |
| USA        | HEIDENHAIN CORPORATION  
             333 East State Parkway  
             Schaumburg, IL 60173-5337  
             +1 847 4901191  
             e-mail: info@heidenhain.com  
             internet: www.rsf.net |

Date 04/2012  Art.No. 510205-27  Doc.Nr. D510205-00-A-26  Technical adjustments in reserve!