The Mercury 3000 encoder represents the next level of encoder performance. With programmable interpolation, smallest sensor size, easiest alignment, and superior noise immunity, the M3000 delivers Best-in-Class performance.

**Imagine what you can do with this!**

The Mercury 3000 can reduce the cost and size of your system, and improve its performance all at once! MicroE Systems’ Mercury 3000 kit encoders are smaller, higher performance, faster to install, and easier to set up and align than any other encoder. The tiny sensor fits into very tight spaces and works in both linear and rotary applications.

**New features**

- New metal enclosure for SmartPrecision™ electronics
- Best-in-Class noise immunity for harsh environments
- Shorter length for smaller, tighter cabinets
- Frame mounting compatible for easy installation
- Robust metal housing with easy access locking screws
- Double shielded long life cable
- CE compliant

**Standard features**

- Smallest sensor- 1/3 the size of other encoders
- Revolutionary bolt-in alignment for many applications
- Advanced SmartPrecision electronics built into shielded D-sub connector
- A-quad-B output with programmable interpolation in integer steps for resolutions to 0.020μm (linear), 16.8M CPR (rotary)
- LED set up indicators for sensor alignment and index location
- Bi-directional index signal is repeatable to encoder resolution

**Resolution**

- **Linear:** 5μm to 0.020μm
- **Rotary:** 6,600 to 16.8 M CPR

**Accuracy**

- **Linear:** ± 1μm available
- ± 3μm to ± 5μm standard
- **Rotary:** Up to ± 2.1 arc-sec

**Output**

- A-quad-B and Index Pulse

**Optional features**

- Glass scale length or diameter
- Linear lengths from 5mm to 2m
- Rotary diameters from 12mm to 108mm
- Cable length of 0.5m, 1m, 2m, or custom
- SmartPrecision Software

**Table of Contents**

- **System & Sensor** pg 1-5
- **SmartPrecision Electronics** pg 6-7
- **SmartPrecision Software** pg 8
- **Scales** pg 9-10
- **Ordering Information** pg 10
**System Configurations**

**Standard and Optional Equipment**

**M3000 Smart Encoder Systems**

**Standard Equipment**

- **Encoder Sensor**
  - Same for linear and rotary scales.

- **Sensor Cable**
  - The standard cable is double shielded and available in lengths of 0.5m, 1m or 2m.

- **SmartPrecision™ Electronics Module**
  - New Metal Enclosure Provides Best-in-Class Noise Immunity

- **A 15 pin high density D-sub connector mates to the customer controller.**

**M3000 Optional Equipment**

- **RS 232 Interface Adapter**
  - The adapter provides connections to a PC, the encoder system and the controller.

- **SmartPrecision™ Software**
  - The software module enables all programmable and diagnostic features plus displays encoder output and signal strength.
  - See page 8 for details.
Broader Alignment Tolerances, Increased Standoff Clearance, Smallest Sensor and More

Why Mercury Encoders Make It Easier To Design High Performance Into Your Equipment

Eliminate the Frustration of Touchy Encoder Alignment

Mercury Solves this Problem for Good

Fussy alignment is no longer a concern. With Mercury's patented PurePrecision™ optics, advanced SmartPrecision™ electronics and LED alignment indicators, you can push the sensor against your reference surface, tighten the screws and you're finished. Try that with brand X or Y.

This performance is possible thanks to relaxed alignment tolerances, particularly in the theta Z axis. Mercury offers a ± 2° sweet spot-- that's a 300% improvement over the best competitive encoder. And that will result in dramatic savings in manufacturing costs.

No other commercially available encoder is easier to align, easier to use, or easier to integrate into your designs.

Alignment Tolerance Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Mercury*</th>
<th>Brand X</th>
<th>Brand Y</th>
<th>Mercury vs. Best Competitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z Standoff</td>
<td>± 0.15mm</td>
<td>± 0.1mm</td>
<td>± 0.1mm</td>
<td>Mercury is 50% better</td>
</tr>
<tr>
<td>Y</td>
<td>± 0.20mm for linear</td>
<td>± 0.1mm</td>
<td>unspecified</td>
<td>Mercury is 100% better</td>
</tr>
<tr>
<td></td>
<td>± 0.10mm for rotary &gt;19mm dia.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>theta X</td>
<td>± 1.0°</td>
<td>unspecified</td>
<td>± 1.0°</td>
<td>Mercury is 100% better</td>
</tr>
<tr>
<td>theta Y</td>
<td>± 2.0°</td>
<td>± 0.1°</td>
<td>± 1.0°</td>
<td>Mercury is 100% better</td>
</tr>
<tr>
<td>theta Z</td>
<td>± 2.0°</td>
<td>± 0.006°</td>
<td>± 0.5°</td>
<td>Mercury is 300% better</td>
</tr>
</tbody>
</table>

* Measured at a constant temperature for one axis at a time with all other axes at their ideal positions.

** Based on published specifications

Mercury Can Reduce System Size and Cost

Mercury's sensor height is 44% shorter than competitive encoders, making it easy to fit into your design. This reduction can also cut total system weight and cost by allowing the use of smaller motors and stages. Safe system operation is also enhanced thanks to Mercury's generous standoff clearance-- 200% greater than other encoders. And its standoff tolerance is 50% greater than the best alternative.

This significantly relaxes mechanical system tolerances, while reducing system costs.

Mechanical Dimension Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Mercury</th>
<th>Brand X</th>
<th>Brand Y</th>
<th>Mercury vs. Best Competitor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor Z height</td>
<td>8.4mm</td>
<td>23mm</td>
<td>15mm</td>
<td>44% better</td>
</tr>
<tr>
<td>Standoff clearance</td>
<td>2.4mm</td>
<td>0.5mm</td>
<td>0.8mm</td>
<td>200% better</td>
</tr>
<tr>
<td>Standoff tolerance</td>
<td>± 0.15mm</td>
<td>± 0.1mm</td>
<td>± 0.1mm</td>
<td>50% better</td>
</tr>
<tr>
<td>System height</td>
<td>11.7mm</td>
<td>28.5mm</td>
<td>15.8mm</td>
<td>26% better</td>
</tr>
</tbody>
</table>

** Based on published specifications

Standoff Clearance

- Mercury: 2.4mm ± 0.15mm
- Brand Y: 0.8mm ± 0.1mm
- Brand X: 0.5mm ± 0.1mm

* Dimensions shown illustrate encoder system standoff clearance; see Mercury Encoder Interface Drawings for correct design reference surfaces.
# System Specifications

## Resolution and Maximum Speed

Mercury 3000 systems have programmable interpolation from x4 to x1024 in integer steps. Below is a table of sample values.

### Linear - 20µm grating pitch

<table>
<thead>
<tr>
<th>Interpolation</th>
<th>Resolution</th>
<th>Maximum Speed*</th>
</tr>
</thead>
<tbody>
<tr>
<td>x4</td>
<td>5.000µm/count</td>
<td>7200mm/s</td>
</tr>
<tr>
<td>x10</td>
<td>2.000µm/count</td>
<td>7200mm/s</td>
</tr>
<tr>
<td>x20</td>
<td>1.000µm/count</td>
<td>7200mm/s</td>
</tr>
<tr>
<td>x40</td>
<td>0.500µm/count</td>
<td>7200mm/s</td>
</tr>
<tr>
<td>x80</td>
<td>0.250µm/count</td>
<td>7200mm/s</td>
</tr>
<tr>
<td>x100</td>
<td>0.200µm/count</td>
<td>5760mm/s</td>
</tr>
<tr>
<td>x200</td>
<td>0.100µm/count</td>
<td>2880mm/s</td>
</tr>
<tr>
<td>x400</td>
<td>0.050µm/count</td>
<td>1440mm/s</td>
</tr>
<tr>
<td>x1000</td>
<td>0.020µm/count</td>
<td>576mm/s</td>
</tr>
</tbody>
</table>

*Maximum speed produces an encoder quadrature output of up to 28.8 million states per second.

** Resolution values shown are approximate. To calculate exact resolution values, convert from CPR (Counts Per Revolution) to the desired units.

Note: Specifications assume XOR function which is available in all standard controllers. To calculate desired linear interpolation multiplier, use the following equation

\[
\text{Interpolation Multiplier} = \frac{\text{Desired Resolution (µm/count)}}{\text{Fundamental Scale Resolution (µm/count)}}
\]

### Rotary - 20µm grating pitch

<table>
<thead>
<tr>
<th>Glass Scale Diameter</th>
<th>Fundamental Resolution</th>
<th>Interpolation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.472&quot; [12.00mm]</td>
<td>1650 CPR</td>
<td>x4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (CPR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (arc-sec/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (µrad/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum speed* (RPM)</td>
</tr>
<tr>
<td>0.750&quot; [19.05mm]</td>
<td>2500 CPR</td>
<td>x4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (CPR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (arc-sec/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (µrad/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum speed* (RPM)</td>
</tr>
<tr>
<td>1.250&quot; [31.75mm]</td>
<td>4096 CPR</td>
<td>x4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (CPR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (arc-sec/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (µrad/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum speed* (RPM)</td>
</tr>
<tr>
<td>2.250&quot; [57.15mm]</td>
<td>8192 CPR</td>
<td>x4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (CPR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (arc-sec/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (µrad/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum speed* (RPM)</td>
</tr>
<tr>
<td>4.250&quot; [107.95mm]</td>
<td>16384 CPR</td>
<td>x4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (CPR)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (arc-sec/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>interpolated resolution (µrad/count)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td>maximum speed* (RPM)</td>
</tr>
</tbody>
</table>

* Specifications assume XOR function which is available in all standard controllers.

** Resolution values shown are approximate. To calculate exact resolution values, convert from CPR (Counts Per Revolution) to the desired units.

Note: The range of available values is x4 to x1024 in integer steps; example values below.

To calculate desired rotary interpolation multiplier, use the following equation

\[
\text{Interpolation Multiplier} = \frac{\text{Desired Resolution (CPR)}}{\text{Fundamental Scale Resolution (CPR)}}
\]

All Specifications are subject to change. All data is accurate to the best of our knowledge. MicroE Systems is not responsible for errors.
System Specifications

System
Grating Period 20µm
Signal Period 20µm
System Resolution 5µm - 0.020µm in integer interpolation steps (factory set or user programmed using MicroE SmartPrecision Software)

Linear accuracy*
Interpolation accuracy: Better than ±0.12µm over any 20µm movement
Interpolation accuracy: ±1µm accuracy available - consult MicroE
Long-travel accuracy: Better than ±3µm for scales up to 130mm
Long-travel accuracy: Better than ±5µm for scales 155mm to 1m
Long-travel accuracy: Better than ±5µm per meter for scales 1m or more

*Maximum peak to peak error over the specified movement when compared to a NIST-traceable laser interferometer standard, used at room temperature and with MicroE interpolation electronics.

Rotary Accuracy* Scale O.D. Microradians Arc-Seconds
12.00mm ±100 ±21
19.05mm ±63 ±13
31.75mm ±38 ±7.8
57.15mm ±19 ±3.9
107.95mm ±10 ±2.1

*Based on ideal scale mounting concentricity

Sensor Size
W: 12.70mm 0.500*
L: 20.57mm 0.810*
H: 8.38mm 0.330*

Operating and Electrical Specifications
Power Supply 5VDC ±5% 300mA (30mA for sensor)

Temperature
Operating: 0 to 70°C
Storage: -20 to 70°C
Humidity: 10 - 90% RH non-condensing
EMI: CE Compliant
Shock: 1500G 0.5 ms half sine (Sensor)
Sensor Weight: 5.0g (Sensor without cable)
Cable: Double Shield. Maximum length 2m. Diameter: 3.6mm (0.142")
Flex Life: 20 x 106 cycles @ 20mm bending radius

Mechanical Information - Sensor

All Specifications are subject to change. All data is accurate to the best of our knowledge. MicroE Systems is not responsible for errors.
The Mercury 3000 encoder system includes a SmartPrecision electronics module. This compact, fully-featured signal processing system performs the following functions:

- Interpolation - up to 1024X with 28.8 million quadrature states / sec.
- Programmable interpolation level and output bandwidth
- Accuracy optimization - sensor signals are automatically optimized to improve system accuracy and maximize repeatability
- Signal strength indication - red / yellow / green LEDs assist during setup and provide diagnostics at a glance
- Index centering - centers the bi-directional index output pulse for repeatability to +/-1LSB
- Low Signal/Over Speed alarm
- Power-indicating LED
- Computer interface - for programming and data acquisition using SmartPrecision software
- Superior EMI / RFI immunity - CE compliant
- Mounting options - all electronics are within the EMI-shielded connector housing and can be screwed directly into a mating connector that is bulkhead mounted, or the module may be mounted to the frame of your motion system and connected using an extension cable

Programmable Interpolation
The electronics module has programmable interpolation that is selectable over the range x4 to x1024 in integer steps, providing output resolutions that can be matched to your application requirements. This feature provides linear resolutions from 5µm to 0.020µm in convenient increments (e.g. x200 interpolation = 0.1µm) and rotary resolutions from 6,800 CPR to 16.8M CPR. Specify the interpolation value at the time of ordering or select the interpolation at your site using SmartPrecision Software.

Programmable Maximum Output Frequency
For encoder applications combining high resolution and high speed, the SmartPrecision electronics module supports up to 28.8 million quadrature state changes per second**. By specifying the maximum output frequency to match your controller’s capability - ranging from 900,000 up to 28.8 million quadrature state changes per second - the Mercury encoder system will never produce encoder counts faster than your controller can read them. Specify the encoder’s maximum output frequency at the time of ordering or select the setting at your site using MicroE’s SmartPrecision Software.

* The electronics module’s serial computer programming interface can be translated to be RS-232 compatible using the MicroE SmartPrecision Computer Interface Adapter or a voltage translation circuit of your own design.

** “Quadrature state changes per second” is the reciprocal of “dwell time” or “edge separation”. For example, 28.8 million states per second = 0.035µsec dwell time.

All Specifications are subject to change. All data is accurate to the best of our knowledge. MicroE Systems is not responsible for errors.

---

SmartPrecision module enclosure provides “Best-in-Class” noise immunity for high noise environments.

---

**Mercury 3000 Outputs:**

<table>
<thead>
<tr>
<th>PIN</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Reserved - Do not connect</td>
</tr>
<tr>
<td>2</td>
<td>Serial programming interface -transmit*</td>
</tr>
<tr>
<td>3</td>
<td>Serial programming interface -receive*</td>
</tr>
<tr>
<td>4</td>
<td>A- quadrature</td>
</tr>
<tr>
<td>5</td>
<td>A+ quadrature</td>
</tr>
<tr>
<td>6</td>
<td>Reserved - Do not connect</td>
</tr>
<tr>
<td>7</td>
<td>Reserved - Do not connect</td>
</tr>
<tr>
<td>8</td>
<td>Reserved - Do not connect</td>
</tr>
<tr>
<td>9</td>
<td>B- quadrature</td>
</tr>
<tr>
<td>10</td>
<td>B+ quadrature</td>
</tr>
<tr>
<td>11</td>
<td>Alarm</td>
</tr>
<tr>
<td>12</td>
<td>+5VDC</td>
</tr>
<tr>
<td>13</td>
<td>Ground</td>
</tr>
<tr>
<td>14</td>
<td>I+ index</td>
</tr>
<tr>
<td>15</td>
<td>I- index</td>
</tr>
</tbody>
</table>

Note: Contact MicroE for pin assignments and software protocols for the high speed serial output version.
Maximum Quadrature Output Frequency

<table>
<thead>
<tr>
<th>Output Frequency</th>
<th>A-quad-B Output Rate</th>
<th>Dwell Time (or edge separation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2MHz</td>
<td>28.8M quadrature states / sec</td>
<td>0.035µsec</td>
</tr>
<tr>
<td>3.6MHz</td>
<td>14.4M quadrature states / sec</td>
<td>0.069µsec</td>
</tr>
<tr>
<td>1.8MHz</td>
<td>7.2M quadrature states / sec</td>
<td>0.139µsec</td>
</tr>
<tr>
<td>900kHz</td>
<td>3.6M quadrature states / sec</td>
<td>0.278µsec</td>
</tr>
<tr>
<td>450kHz</td>
<td>1.8M quadrature states / sec</td>
<td>0.555µsec</td>
</tr>
<tr>
<td>225kHz</td>
<td>900k quadrature states / sec</td>
<td>1.111µsec</td>
</tr>
</tbody>
</table>

Output Signals

- Quadrature TTL
  - Pins 4 & 5: A+
  - Pins 9 & 10: B+
  - Pins 14 & 15*: I+

*Note: The index pulse may be aligned with A- or B- at some interpolation values.

Signal Termination for A-Quad-B and Index

- Mercury 3000 encoder
- Cable Zo=120Ω
- Customer Electronics

All Specifications are subject to change. All data is accurate to the best of our knowledge. MicroE Systems is not responsible for errors.
SmartPrecision Software for Mercury 2000 and 3000 Encoder Systems

SmartPrecision Software makes Mercury the industry’s easiest to use encoder. It helps you program, set up, use, and diagnose Mercury 2000 and 3000 encoders with the click of a mouse. Compatible with Windows 95, 98, ME, NT, 2000, and XP.

Program Mercury Encoder Electronics
- Set interpolation in integer steps from x4 to x256 (Mercury 2000) or x4 to x1024 (Mercury 3000)
- Set maximum output frequency to match your controller

Install Mercury Encoder System
- Align sensor using Signal Level display and Encoder Signal data plot
- Locate index and see when sensor is over the scale’s index mark
- Verify sensor output over length of scale using the Signal Strength plot

Monitor Mercury Encoder Operation
- Read encoder position in engineering units of your choice
- Read the encoder’s hour meter to monitor system usage
- Capture alarms while system operates unattended

Diagnose Mercury Encoder Performance
- Capture signal data and email it to MicroE for rapid diagnostic support
- Monitor alarms, view the alarm history log

System Description
The SmartPrecision Software system includes Software on CD, a computer interface adapter, computer cable, and a power adapter.

How to Order SmartPrecision Software
To Purchase the SmartPrecision Software system, use this Model Number: SSWA120 for 120 VAC, 60Hz US Standard 2-prong plug or SSWA220 for 220 VAC, 50 Hz European Std. 2-prong plug
Scale Specifications
Standard and Customized Scales

MicroE Systems offers a wide array of chrome on glass scales for the highest accuracy and best thermal stability. Easy to install, standard linear and rotary scales meet most application requirements. Customized linear, rotary, and rotary segment scales are available where needed. All scales include an optical index. Mercury’s glass scales save time by eliminating motion system calibrations or linearity corrections required by other encoders, and provide better thermal stability than metal tape scales.

Options include:
- **Standard linear**: 18mm - 2m
- **Standard rotary**: 12mm - 107.95mm diameter, with or without hubs
- **Custom linear**: special lengths, widths, thickness, index mark locations and special low CTE materials
- **Custom rotary**: special ID’s, OD’s (up to 304.8mm), index mark outside the main track and special low CTE materials
- **Mounting of hubs for rotary scales**: MicroE Systems can mount and align standard, custom, or customer-supplied hubs
- **Rotary segments**: any angle range; wide range of radius values

*Custom scales or rotary segments are available in OEM quantities. Contact your local MicroE Systems sales office.

### Standard Short Linear Scales
130mm and Shorter
Key: inches[mm]

<table>
<thead>
<tr>
<th>Model</th>
<th>L18</th>
<th>L30</th>
<th>L55</th>
<th>L80</th>
<th>L105</th>
<th>L130</th>
</tr>
</thead>
</table>

**Specifications**
- **Accuracy**: ±3µm standard, ±1µm available
- **Material**: Soda lime glass
- **Typical CTE**: 8ppm/°C
- **Index**: Center or End

### Standard Long Linear Scales
155mm and Longer
Key: inches[mm]

<table>
<thead>
<tr>
<th>Model</th>
<th>L155</th>
<th>L225</th>
<th>L325</th>
<th>L425</th>
<th>L525</th>
<th>L1025</th>
<th>L2025</th>
</tr>
</thead>
</table>

**Specifications**
- **Accuracy**: ±5 µm <1m, ±5 µm/m >1m
- **Material**: Soda lime glass
- **Typical CTE**: 8ppm/°C
- **Index**: Center or End

Custom scales available
How to Order Mercury 3000 Encoder Systems

To specify your Mercury encoder with the desired scale, level of interpolation, maximum output frequency, cable length and software, consult the charts below to create the correct part number for your order. Call Celera Motion technical support for more information, +1 781.266.5200.

### Specifications

<table>
<thead>
<tr>
<th>Material</th>
<th>Soda lime glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical CTE</td>
<td>8ppm/°C</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Scale Outer Diameter</th>
<th>Scale Inner Diameter</th>
<th>Optical Diameter</th>
<th>Hub Inner Diameter</th>
<th>Hub Thickness</th>
<th>Fundamental CPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1206</td>
<td>0.472 [12.00]</td>
<td>0.250 [6.35]</td>
<td>0.413 [10.50]</td>
<td>0.1253 [3.18]</td>
<td>0.040 [1.02]</td>
<td>1650</td>
</tr>
<tr>
<td>R1910</td>
<td>0.750 [19.05]</td>
<td>0.375 [9.52]</td>
<td>0.627 [15.92]</td>
<td>0.1253 [3.183]</td>
<td>0.040 [1.02]</td>
<td>2500</td>
</tr>
<tr>
<td>R3213</td>
<td>1.250 [31.75]</td>
<td>0.500 [12.70]</td>
<td>1.027 [26.08]</td>
<td>0.2503 [6.358]</td>
<td>0.050 [1.27]</td>
<td>4096</td>
</tr>
<tr>
<td>R5725</td>
<td>2.250 [57.15]</td>
<td>1.000 [25.40]</td>
<td>2.053 [52.15]</td>
<td>0.5003 [12.708]</td>
<td>0.060 [1.52]</td>
<td>8192</td>
</tr>
</tbody>
</table>

Custom scales available

### How to Order SmartPrecision Software

- **SSWA120** for 120 VAC, 60Hz US Standard 2-prong plug
- **SSWA220** for 220 VAC, 50 Hz European Std. 2-prong plug

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