

Mercury 3000 Dual Axis Averager Encoder Systems

Motion Control Feedback Using Average of Two Sensors

Reflective Linear and Rotary Encoder Systems



Resolution

Linear: 5 μ m to 0.020 μ m
Rotary: 6,600 to 16.8 M CPR

Accuracy

Linear: $\pm 1\mu$ m available
 $\pm 3\mu$ m to $\pm 5\mu$ m standard
Rotary: Up to ± 2.1 arc-sec

Output

**A-quadrant and Index Pulse
(both sensors) and
Average or Difference**

The new Mercury 3000 Dual Axis Averager encoder system provides unique capabilities for motion control. With real-time feedback of two encoders plus averaging (or difference), smallest sensor size, and easiest alignment, performance capabilities are unmatched.

Imagine what you can do with this!

The Mercury 3000 Dual Axis Averager provides unprecedented performance for high-accuracy rotary positioning applications. By averaging two Mercury encoder sensors at high speed, your motion system can use the average of the two signals directly for motion control feedback. Using two diametrically opposed sensors, eccentricity errors are eliminated and rotary accuracy is increased. For even faster motion system performance, the M3000SiDAA high-speed serial output version is available for the highest resolution and speed.

Mercury sensors are smaller, higher performing, faster to install, and easier to set up and align than any other encoder. The tiny sensor fits into very tight spaces, has broad alignment tolerances for fast and easy setup and works in both linear and rotary applications.

Applications

- Provides ultra-high accuracy for rotary positioning tables and rotary actuators - Averages two sensors to virtually eliminate eccentricity errors while maintaining high resolution and speed.
- Provides robustness for linear or rotary applications by enabling redundant sensors and real-time monitoring of the difference between the sensors - instantly detect a fault if an unexpected difference exists.
- Useful for centering rotary scales during motion system setup for maximum accuracy.

Standard features

- Averages (or calculates the difference of) two Mercury sensors at high speed for feedback in high speed, high-resolution servo control - see page 4 for specifications
- A-quadrant output with programmable interpolation in integer steps up to x1024 for resolutions to 0.020 μ m (linear); 16.8M CPR (rotary)
- Advanced SmartSignal electronics built into shielded D-sub connector
- LED set up indicators for easy sensor alignment and index location
- Fully shielded connector and cables with RS-422 compliant output for harsh industrial environments
- Small sensor with ultra-low Z height and broad alignment tolerances
- Bi-directional index signal is repeatable to encoder resolution

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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
- SmartSignal Software



System Configurations

Standard and Optional Equipment

Mercury 3000 Dual Axis Averager Standard Equipment



Linear and Rotary Scales
See pages 9-10.

SmartSignal™ Electronics Module Metal Enclosure Provides Best Noise Immunity



A 25 pin D-sub connector
mates to the customer controller.

Encoder Sensor #1 Same for linear and rotary scales.



Encoder Sensor #2 Same for linear and rotary scales.

Sensor Cables The standard cables are double shielded and available in lengths of 0.5m, 1m or 2m.

Mercury 3000 Dual Axis Averager Optional Equipment



USB Cable
USB cable with Mini-B
connector.

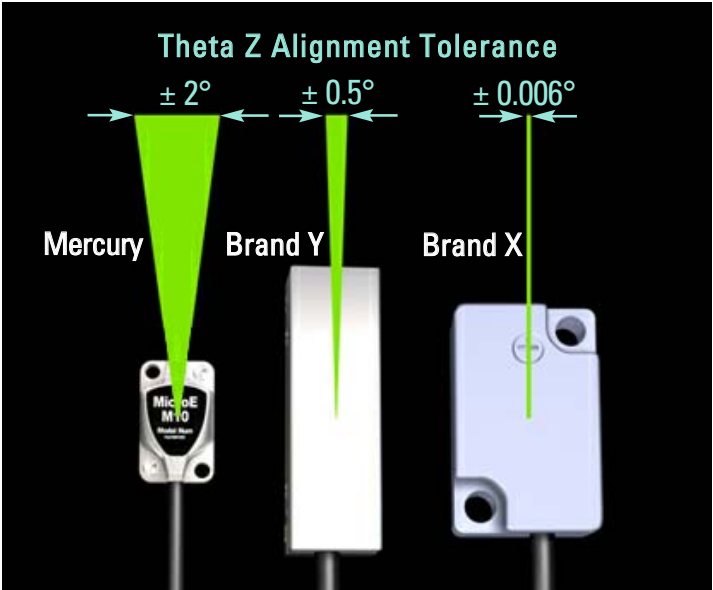


SmartSignal™ Software

The software 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 SmartSignal™ 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**

	Mercury*	Brand X	Brand Y	Mercury vs. Best Competitor
Z Standoff	± 0.15mm	± 0.1mm	± 0.1mm	Mercury is 50% better
Y	± 0.20mm for linear ± 0.10mm for rotary ≥19mm dia.	± 0.1mm	unspecified	Mercury is 100% better
theta X	± 1.0°	unspecified	± 1.0°	
theta Y	± 2.0°	± 0.1°	± 1.0°	Mercury is 100% better
theta Z	± 2.0°	± 0.006°	± 0.5°	Mercury is 300% better

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

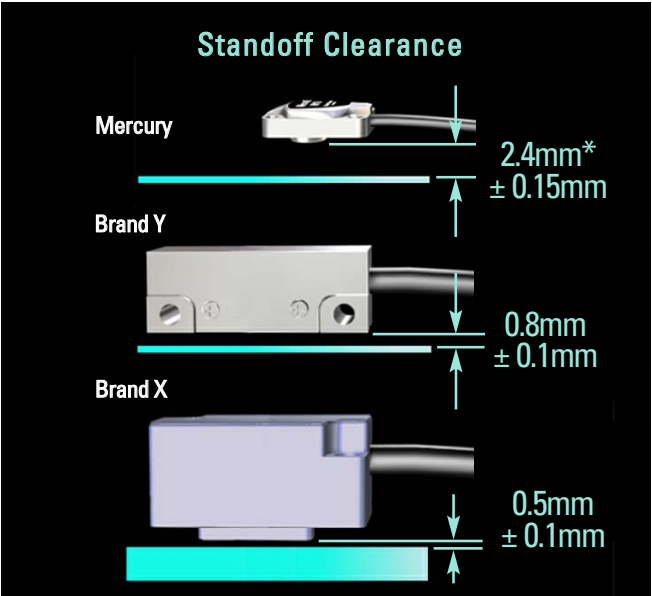
Mercury Can Reduce System Size and Cost

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**

	Mercury	Brand X	Brand Y	Mercury vs. Best Competitor
Sensor Z height	8.4mm	23mm	15mm	44% better
Standoff clearance	2.4mm	0.5mm	0.8mm	200% better
Standoff tolerance	± 0.15mm	± 0.1mm	± 0.1mm	50% better
System height	11.7mm	28.5mm	15.8mm	26% better

**Based on published specifications



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

System Specifications

Resolution and Maximum Speed

The Mercury 3000 Dual Axis Averager has programmable interpolation from x4 to x1024 in integer steps. Below is a table of sample values.

Linear - 20µm grating pitch

Interpolation	Resolution	Maximum Speed*
x4	5.000µm/count	7200mm/s
x10	2.000µm/count	7200mm/s
x20	1.000µm/count	7200mm/s
x40	0.500µm/count	7200mm/s
x80	0.250µm/count	7200mm/s
x100	0.200µm/count	6000mm/s
x200	0.100µm/count	3000mm/s
x400	0.050µm/count	1500mm/s
x1000	0.020µm/count	600mm/s

To calculate desired linear interpolation multiplier, use the following equation

$$\text{Interpolation Multiplier} = \text{Grating Period (20}\mu\text{m)} / \text{Desired Resolution (}\mu\text{m/count)}$$

Rotary - 20µm grating pitch

Rotary Glass Scale Diameter	Fundamental Resolution	Interpolation			
		Note: The range of available values is x4 to x1024 in integer steps; example values below.			
0.472" [12.00mm]	1650 CPR	x4	x100	x256	x1024
		interpolated resolution (CPR)	6,600	165,000	422,400
		interpolated resolution (arc-sec/count)**	196.4	7.85	3.08
		interpolated resolution (µrad/count)**	952	38.0	14.86
		maximum speed* (RPM)	13090	10900	4260
0.750" [19.05mm]	2500 CPR	x4	x100	x256	x1024
		interpolated resolution (CPR)	10,000	250,000	640,000
		interpolated resolution (arc-sec/count)**	129.6	5.18	2.03
		interpolated resolution (µrad/count)**	628.3	25.1	9.8
		maximum speed* (RPM)	8640	7200	2810
1.250" [31.75mm]	4096 CPR	x4	x100	x256	x1024
		interpolated resolution (CPR)	16,384	409,600	1,048,576
		interpolated resolution (arc-sec/count)**	79.1	3.16	1.24
		interpolated resolution (µrad/count)**	383.5	15.3	6.0
		maximum speed* (RPM)	5273	4390	1710
2.250" [57.15mm]	8192 CPR	x4	x100	x256	x1024
		interpolated resolution (CPR)	32,768	819,200	2,097,152
		interpolated resolution (arc-sec/count)**	39.6	1.58	0.618
		interpolated resolution (µrad/count)**	191.7	7.7	3.0
		maximum speed* (RPM)	2637	2200	860
4.250" [107.95mm]	16384 CPR	x4	x100	x256	x1024
		interpolated resolution (CPR)	65,536	1,638,400	4,194,304
		interpolated resolution (arc-sec/count)**	19.7	0.791	0.309
		interpolated resolution (µrad/count)**	95.9	3.83	1.5
		maximum speed* (RPM)	1318	1100	430

*Maximum speed produces an encoder quadrature output of up to 30 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 rotary interpolation multiplier, use the following equation

$$\text{Interpolation Multiplier} = \text{Desired Resolution (CPR)} / \text{Fundamental Scale Resolution (CPR)}$$

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 SmartSignal Software)

Linear accuracy*

Interpolation accuracy:	Better than $\pm 0.12\mu\text{m}$ over any 20µm movement
Long-travel accuracy:	$\pm 1\mu\text{m}$ accuracy available - consult MicroE Better than $\pm 3\mu\text{m}$ for scales up to 130mm Better than $\pm 5\mu\text{m}$ for scales 155mm to 1m Better than $\pm 5\mu\text{m}$ 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 $\pm 5\%$ @ approx. 550mA (With no outputs terminated; termination will increase power required). Value includes power for two Mercury sensors.
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Temperature

Operating:	0 to 70°C
Storage:	-20 to 70°C

Humidity:	10 - 90% RH non-condensing
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EMI:	Entire system is EMI/RFI protected
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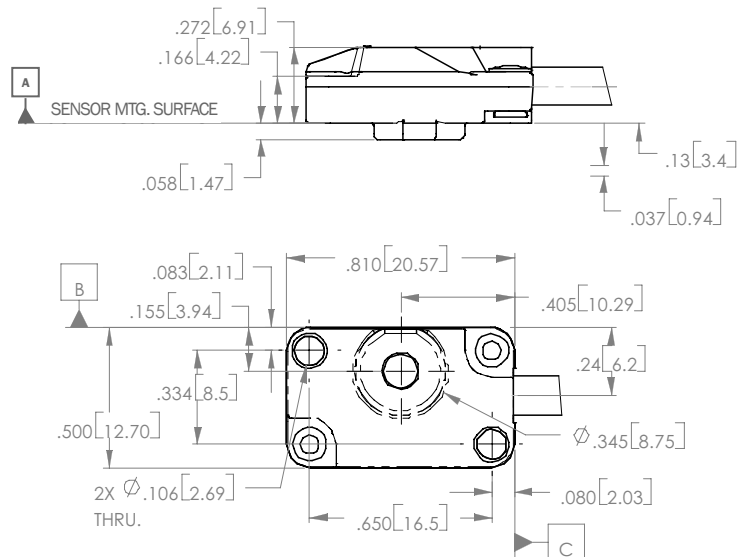
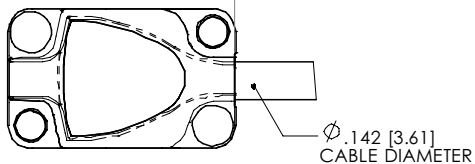
Shock:	1500G 0.5 ms half sine (Sensor)
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Sensor Weight:	5.0g (Sensor without cable)
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Cable:	Double Shield. Maximum length 2m. Diameter: 3.6mm (0.142") Flex Life: 20 x 10 ⁶ cycles @ 20mm bending radius
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Mechanical Information - Sensor

19.7 [500] or 39.4 [1000]
or 78.7 [2000] $\pm .50$ [12.7]



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SmartSignal™ Electronics Module

The heart of the Mercury 3000 Dual Axis Averager encoder system is its SmartSignal electronics module. This compact signal processing system's FPGA architecture performs averaging (and differencing) digitally, at ultra-high speed for high-precision, high-accuracy rotary control. Features include:

- Interpolation of two sensor head inputs - up to x1024 with up to 30 million quadrature states / sec. for each sensor
- Three simultaneous, synchronized outputs using pre-set configurations; any combination of three of the following: Sensor 1, Sensor 2, Average, or Difference
- Programmable interpolation level and output bandwidth
- Accuracy optimization - sensor signals are automatically optimized to improve system accuracy, maximize repeatability and provide smooth velocity control
- Sensor alignment LEDs speed setup - red / orange / green LEDs make setup easy and provide diagnostics at a glance
- Power-indicating LEDs
- Index centering - centers the bi-directional index output pulse for repeatability to 1LSB
- Low signal alarm TTL output
- USB computer interface - for setup, monitoring and diagnostics using SmartSignal Software
- Superior EMI / RFI immunity

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. Specify the interpolation value at the time of ordering or select the interpolation at your site using SmartSignal Software.

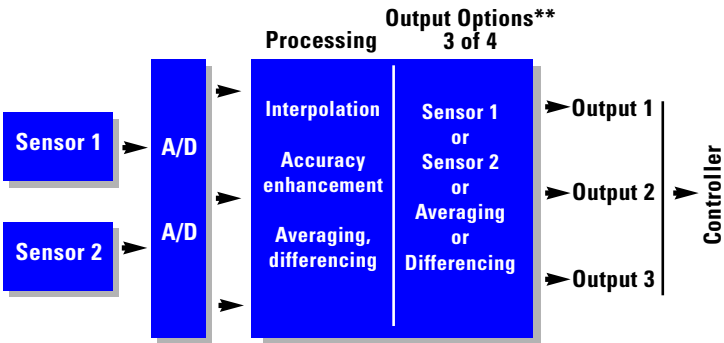
Programmable Maximum Output Frequency

For encoder applications combining high resolution and high speed, the SmartSignal electronics module supports up to 30 million quadrature state changes per second*. By specifying the maximum output frequency to match your controller's capability - ranging from 937,500 up to 30 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 using MicroE's SmartSignal Software. For even faster motion system performance, the M3000DAASi high-speed serial output version is available for the highest resolution and speed when used with OEM controllers that use a DSP chip.

* "Quadrature state changes per second" is the reciprocal of "dwell time" or "edge separation". For example, 30 million states per second = 0.0333µsec dwell time.



The Mercury 3000 Dual Axis Averager Module performs signal processing with outputs to your controller



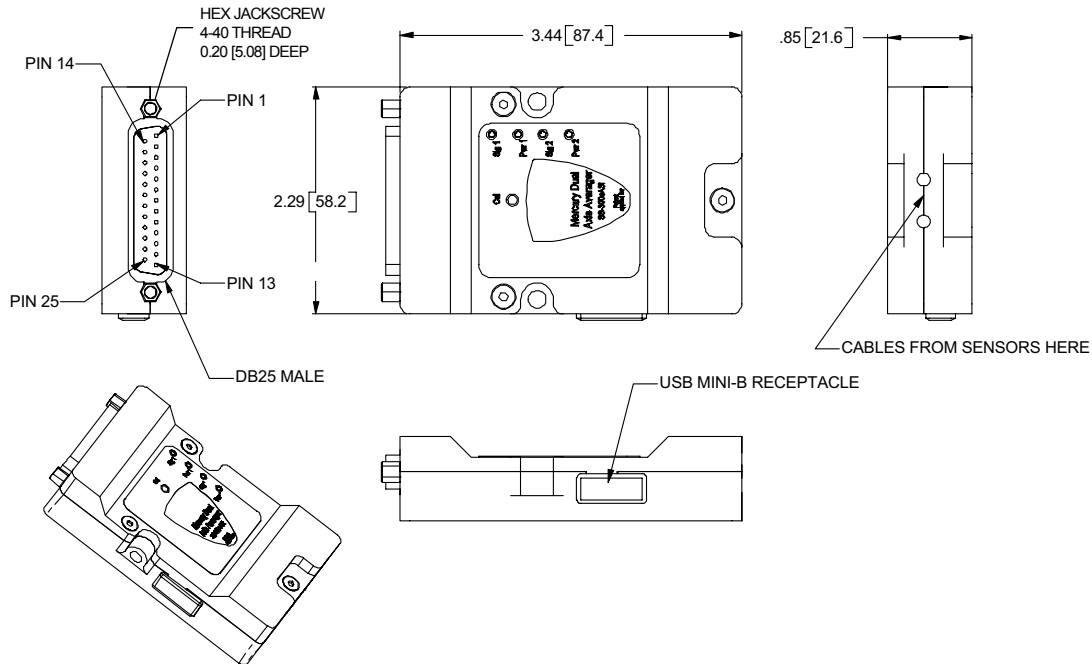
** See Output Configurations on Page 10 (How to Order section).

Mercury 3000 Dual Axis Averager Outputs:

25-pin standard Male D-sub connector

PIN	FUNCTION	
1	A1+	Output 1
2	A1-	
3	B1+	
4	B1-	
5	Index1+	
6	Index1-	
7	A2+	Output 2
8	A2-	
9	B2+	
10	B2-	
11	Index2+	
12	Index2-	
13	A3+	Output 3
14	A3-	
15	B3+	
16	B3-	
17	Index3+	
18	Index3-	
19	Reserved - do not connect	
20	Reserved - do not connect	
21	(USB) D-	
22	(USB) D+	
23	Alarm	
24	+5 VDC	
25	Ground	

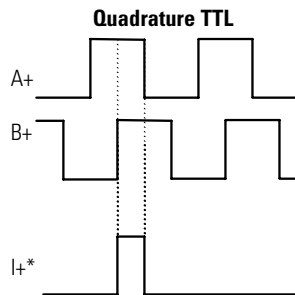
Mechanical Information - electronics module



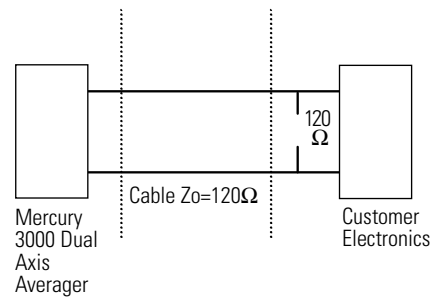
Maximum Quadrature Output Frequency

Output Frequency	A-quadr-B Output Rate	Dwell Time (or edge separation)
7.5MHz	30.0M quadrature states / sec	0.0333μsec
3.75MHz	15.0M quadrature states / sec	0.0667μsec
1.875MHz	7.5M quadrature states / sec	0.1333μsec
937.5kHz	3.75M quadrature states / sec	0.267μsec
468.75kHz	1.875M quadrature states / sec	0.533μsec
234.375kHz	937.5k quadrature states / sec	1.0667μsec

Output Signals



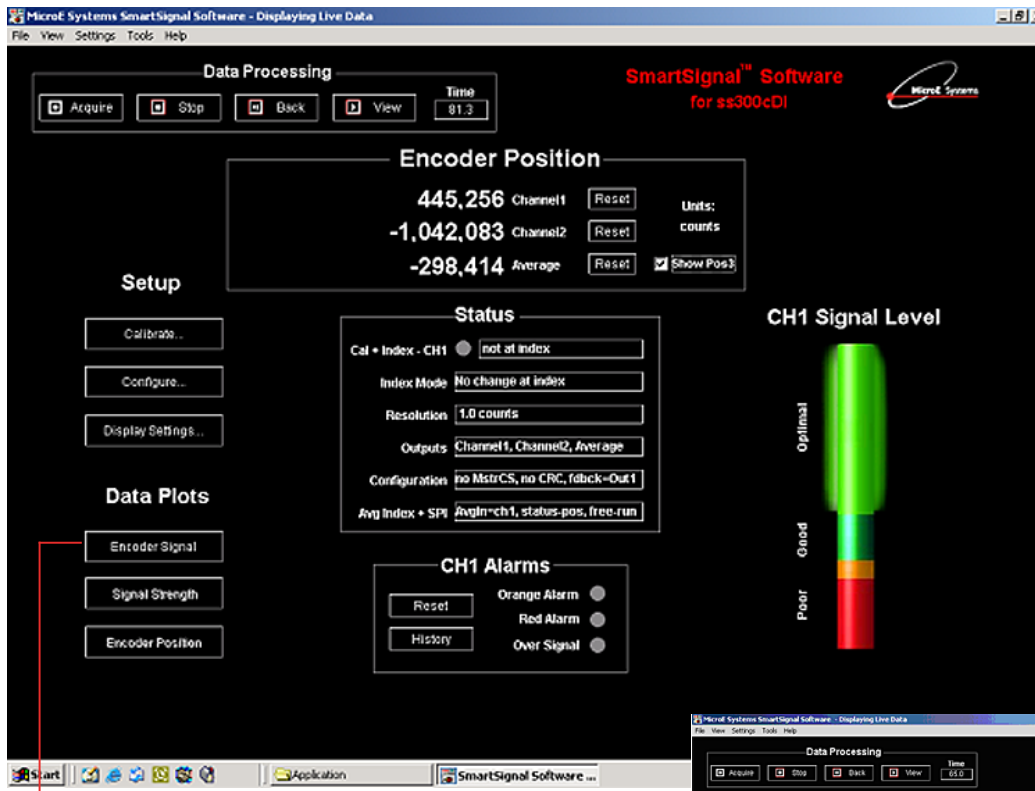
Signal Termination for A-Quad-B and Index



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

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

SmartSignal Software for Mercury 3000 Dual Axis Averager Encoder Systems



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

Program Mercury Encoder Electronics

- Selectable displays for Sensor 1 and Sensor 2
- Set interpolation in integer steps from x4 to x1024
- Configure outputs to provide feedback from individual sensors, their average or their difference
- 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

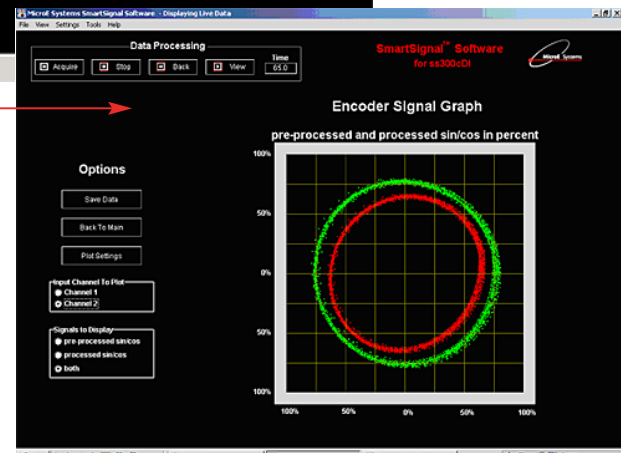
- Read encoder position in engineering units of your choice using three configurable digital readouts
- Read the encoder's hour meter to monitor system usage
- Capture alarms while system operates unattended

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 SmartSignal Software system includes Software on CD, a USB computer cable, and a power adapter.



The encoder signal plot, or Lissajous plot, reveals the underlying strength and uniformity of the sensor's output.

How to Order SmartSignal Software

To Purchase the SmartSignal Software system, order Model Number: SSWA-DAA-120 for 120 VAC, 60 Hz Standard 2-prong plug or SSWA-DAA-220 for 220 VAC, 50 Hz European Std. 2-prong plug

Note: software is also available for Mercury programmable models, as well as Mercury 1800, 1500, and 1000 encoder models.

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:

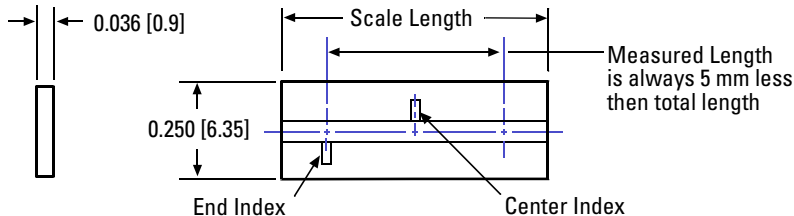
- *Standard linear*: 30mm - 2m
- *Standard rotary*: 12mm - 107.95mm diameter, with or without hubs
- *Custom linear**: special lengths, widths, thickness, index mark locations and special low CTE materials
- *Custom rotary**: special ID's, OD's (up to 304.8mm), index mark outside the main track and special 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]



Specifications

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

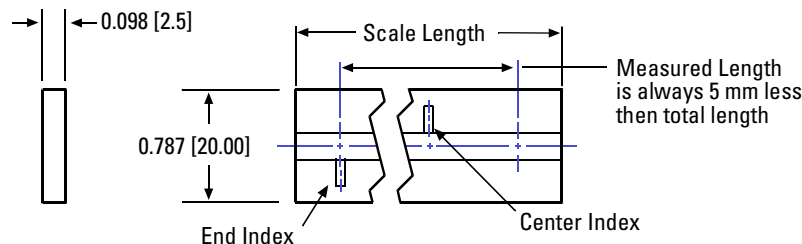
Model	L30	L55	L80	L105	L130
Scale Length	1.181 [30]	2.165 [55]	3.150 [80]	4.134 [105]	5.118 [130]
Measured Length	0.984 [25]	1.969 [50]	2.953 [75]	3.937 [100]	4.921 [125]

Custom scales available

Standard Long Linear Scales

155mm and Longer

Key: inches[mm]



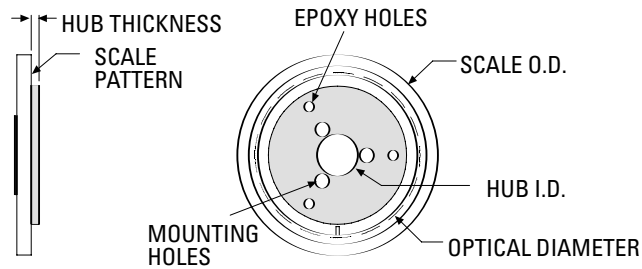
Specifications

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

Model	L155	L225	L325	L425	L525	L1025	L2025
Scale length	6.102 [155]	8.858 [225]	12.795 [325]	16.732 [425]	20.669 [525]	40.354 [1025]	79.724 [2025]
Measured length	5.906 [150]	8.661 [220]	12.598 [320]	16.535 [420]	20.472 [520]	40.157 [1020]	79.528 [2020]

Custom scales available

Standard Rotary Scales



Specifications

Material	Soda lime glass
Typical CTE	8ppm/°C

Key: inches[mm]

Model No.	Scale Outer Diameter	Scale Inner Diameter	Optical Diameter	Hub Inner Diameter +0.0005/-0.0000	Hub Thickness	Fundamental CPR
R1206	0.472 [12.00]	0.250 [6.35]	0.413 [10.50]	0.1253 [3.18]	0.040 [1.02]	1650
R1910	0.750 [19.05]	0.375 [9.52]	0.627 [15.92]	0.1253 [3.183]	0.040 [1.02]	2500
R3213	1.250 [31.75]	0.500 [12.70]	1.027 [26.08]	0.2503 [6.358]	0.050 [1.27]	4096
R5725	2.250 [57.15]	1.000 [25.40]	2.053 [52.15]	0.5003 [12.708]	0.060 [1.52]	8192
R10851	4.250 [107.95]	2.000 [50.80]	4.106 [104.30]	1.0003 [25.408]	0.080 [2.03]	16384

Custom scales available

How to Order Mercury 3000 Dual Axis Averager

To specify your Mercury 3000 Dual Axis Averager System with the desired scale, level of interpolation, maximum output frequency, output channel assignments, cable length and software, consult the chart below to create the correct part number for your order. Call MicroE Systems' Rapid Customer Response team for more information [800] 355-4047

Example: M3000DAA-M10-M10-1024-1-1-R1910-HA

M3000DAA	- Cable Length Sensor 1	- Cable Length Sensor 2	- Interpolation	- Output Configurations	- Maximum Output Frequency	- Scale Model Lxxx or Rxxxx	- Scale Mounting
	M05 = 0.5 m M10 = 1.0 m M20 = 2.0 m	M05 = 0.5 m M10 = 1.0 m M20 = 2.0 m	4 = x4 5 = x5 ↓ 1024 = x1024	1 = Sensor 1, Sensor 2 & Average (most common) 2 = Sensor 1, Sensor 2 & Difference 3 = Average, Difference & Sensor 1 4 = Difference, Average & Sensor 2	1 = 7.5 MHz 2 = 3.75 MHz 3 = 1.875 MHz 4 = 0.9375 MHz 5 = 0.46875 MHz 6 = 0.234375 MHz		For linear scales: T = Tape mounting C1 = 3 scale clamps* C2 = 10 scale clamps** Hubs for Rotary Scales: NH = Without Hub HA = for R1910 HB = for R3213 HC = for R5725 HD = for R10851

How to Order SmartSignal Software

SmartSignal Software
|
SSWA-DAA-120 for 120 VAC, 60Hz
US Standard 2-prong plug
or
SSWA-DAA-220 for 220 VAC, 50Hz
European Standard 2-prong plug

* 3 clamps for linear scales up to 130mm
** 10 clamps for linear scales 155mm or longer

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