

# Mercury™ 3000Si Dual Axis Averager Encoder Systems

## Motion Control Feedback Using Average of Two Sensors

Reflective Linear and Rotary Encoder Systems



### 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

High Speed Serial Word  
in SPI Format

The new Mercury 3000Si 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 3000Si 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. The industry-standard SPI serial data interface is ideal for encoders and produces extremely high resolution at high motion speed - up to 30X faster than A-quad-B encoders. The SPI standard is supported by many DSP chip manufacturers and is easy to implement in your OEM controller design.

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
- Small sensor with ultra-low Z height and broad alignment tolerances
- Advanced SmartPrecision electronics built into shielded D-sub connector
- Serial Word output with interpolation in binary steps for resolutions to 0.020µm\* (linear); 16.8M CPR (rotary)
- LED set up indicators for easy sensor alignment and index location
- 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
- SmartPrecision Software



\* Resolution values shown are approximate - see page 4 for exact values.

# System Configurations

## Standard and Optional Equipment

### Mercury 3000Si Dual Axis Averager Standard Equipment



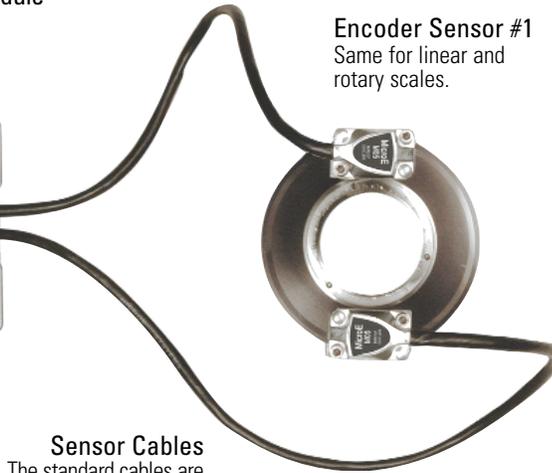
Linear and Rotary Scales  
See pages 9-10.

SmartPrecision™ 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.

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### Mercury 3000Si Dual Axis Averager Optional Equipment



USB Cable  
USB cable with Mini-B  
connector.

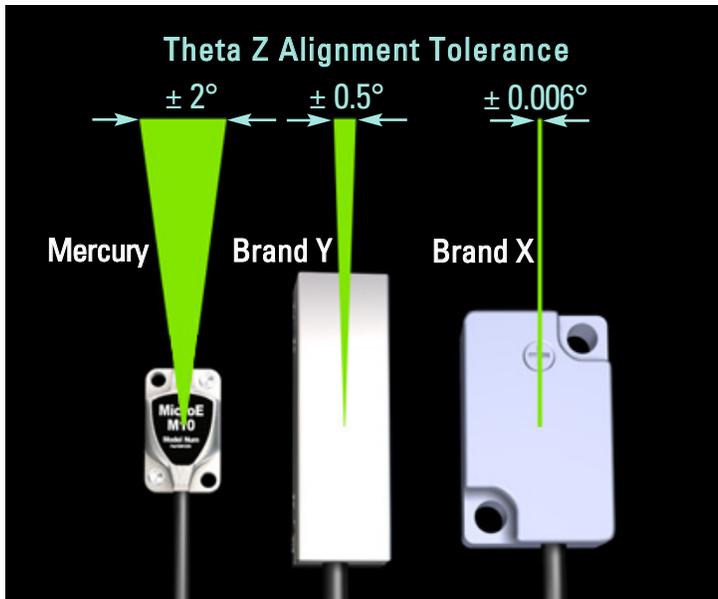


#### SmartPrecision™ Software

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 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\*\*

	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

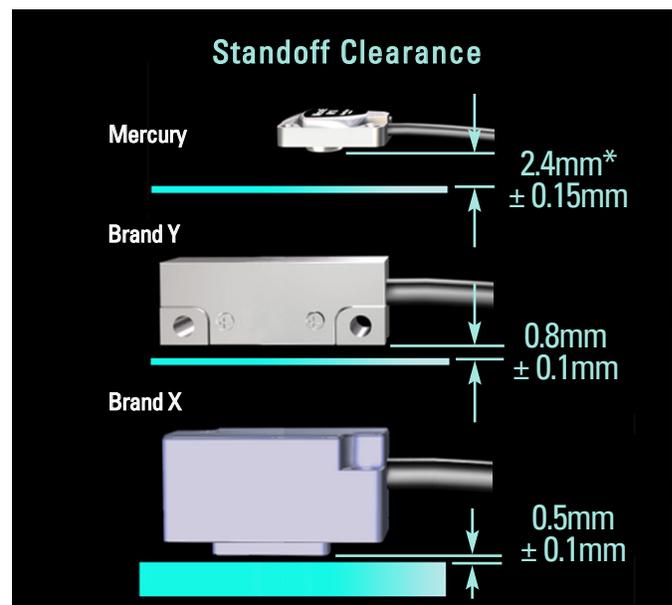
Mercury's sensor height is 44% shorter than competitive encoders, making it easy to fit into your design. This reduction can also cut total system weight and cost by allowing the use of smaller motors and stages. Safe system operation is also enhanced thanks to Mercury's generous standoff clearance—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

Mercury 3000Si Dual Axis Averager systems have interpolation from x4 to x1024 in binary steps. Below is a table of values. Unlike A-quadrant encoders, the M3000Si Dual Axis Averager's resolution does not drop off with speed.

### Linear - 20µm grating pitch

Interpolation	Resolution	Maximum Speed
x4	5.000 µm/count	7200mm/s
x8	2.500 µm/count	7200mm/s
x16	1.250 µm/count	7200mm/s
x32	0.6250 µm/count	7200mm/s
x64	0.3125 µm/count	7200mm/s
x128	0.15625 µm/count	7200mm/s
x256	0.078125 µm/count	7200mm/s
x512	0.0390625 µm/count	7200mm/s
x1024	0.01953125 µm/count	7200mm/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 binary steps; example values below.				
0.472" [12.00mm]	1650 CPR	x4	x128	x256	x1024	
		interpolated resolution (CPR)	6,600	211,200	422,400	1,689,600
		interpolated resolution (arc-sec/count)*	196.4	6.14	3.08	0.767
		interpolated resolution (µrad/count)*	952	29.7	14.86	3.79
		maximum speed (RPM)	13090	13090	13090	13090
0.750" [19.05mm]	2500 CPR	x4	x128	x256	x1024	
		interpolated resolution (CPR)	10,000	320,000	640,000	2,560,000
		interpolated resolution (arc-sec/count)*	129.6	4.05	2.03	0.506
		interpolated resolution (µrad/count)*	628.3	19.6	9.8	2.5
		maximum speed (RPM)	8640	8640	8640	8640
1.250" [31.75mm]	4096 CPR	x4	x128	x256	x1024	
		interpolated resolution (CPR)	16,384	524,288	1,048,576	4,194,304
		interpolated resolution (arc-sec/count)*	79.1	2.47	1.24	0.309
		interpolated resolution (µrad/count)*	383.5	11.9	6.0	1.5
		maximum speed (RPM)	5273	5273	5273	5273
2.250" [57.15mm]	8192 CPR	x4	x128	x256	x1024	
		interpolated resolution (CPR)	32,768	1,048,576	2,097,152	8,388,608
		interpolated resolution (arc-sec/count)*	39.6	1.23	0.618	0.154
		interpolated resolution (µrad/count)*	191.7	5.99	3.0	0.7
		maximum speed (RPM)	2637	2637	2637	2637
4.250" [107.95mm]	16384 CPR	x4	x128	x256	x1024	
		interpolated resolution (CPR)	65,536	2,097,152	4,194,304	16,777,216
		interpolated resolution (arc-sec/count)*	19.7	0.68	0.309	0.0772
		interpolated resolution (µrad/count)*	95.9	3.0	1.5	0.4
		maximum speed (RPM)	1318	1318	1318	1318

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

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	20 $\mu$ m
Signal Period	20 $\mu$ m
System Resolution	5 $\mu$ m - 0.01953125 $\mu$ m in binary interpolation steps.
Linear accuracy*	
Interpolation accuracy:	Better than $\pm 0.12\mu$ m over any 20 $\mu$ m movement
Long-travel accuracy:	$\pm 1\mu$ m accuracy available - consult MicroE Better than $\pm 3\mu$ m for scales up to 130mm Better than $\pm 5\mu$ m for scales 155mm to 1m Better than $\pm 5\mu$ 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	$\pm 100$	$\pm 21$
	19.05mm	$\pm 63$	$\pm 13$
	31.75mm	$\pm 38$	$\pm 7.8$
	57.15mm	$\pm 19$	$\pm 3.9$
	107.95mm	$\pm 10$	$\pm 2.1$

\*Based on ideal scale mounting concentricity

## Sensor Size

W:	12.70mm	0.500"
L:	20.57mm	0.810"
H:	8.38mm	0.330"

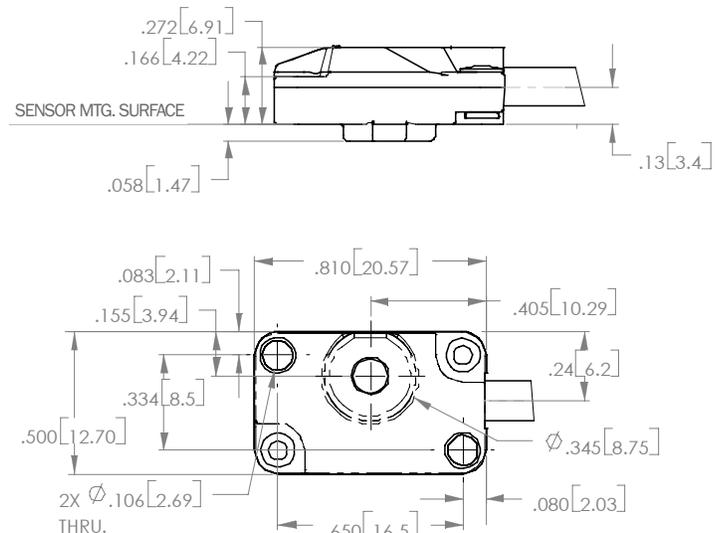
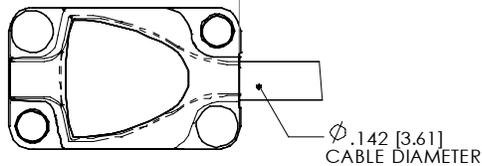
## Operating and Electrical Specifications

Power Supply	5VDC $\pm 5\%$ @ approx. 550mA (With no outputs terminated; termination will increase power required). Value includes power for two Mercury sensors.
Temperature	
Operating:	0 to 70°C
Storage:	-20 to 70°C
Humidity:	10 - 90% RH non-condensing
EMI:	Entire system is EMI/RFI protected
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 10 <sup>6</sup> cycles @ 20mm bending radius

## Mechanical Information - Sensor

### Cable Length

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



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# SmartPrecision™ Electronics Module

The heart of the Mercury 3000Si Dual Axis Averager encoder system is its SmartPrecision 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 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
- 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
- Low signal alarm TTL output
- USB computer interface - for setup, monitoring and diagnostics using SmartPrecision Software
- Superior EMI / RFI immunity

## High Speed Serial Interface

Motion system engineers who are optimizing their system can boost its performance by interfacing their SPI-compatible controller with the Mercury 3000SiDAA. Its industry standard SPI high-speed serial data interface is supported by multiple DSP chip manufacturers, including TI, Motorola and Analog Devices, and provides a robust connection that is ideal for encoder interfacing. With the Mercury 3000SiDAA, encoder position values are sent directly into the controller's DSP. Limitations of encoders with A-quadrant output are completely eliminated. Standard Mercury 3000SiDAA features include:

- Very high motion speed with high encoder resolution - up to 7.2m/s movements with 0.005µm\* resolution
- 10MHz max. input clock frequency / 250kHz position word sample rate
- RS422 voltage levels are resistant to Electro Magnetic Interference and support long cable runs
- Five different modes for adjusting or zeroing serial position data relative to the index mark on the scale. Consult the Installation Manual or MicroE Applications Engineering for further details.

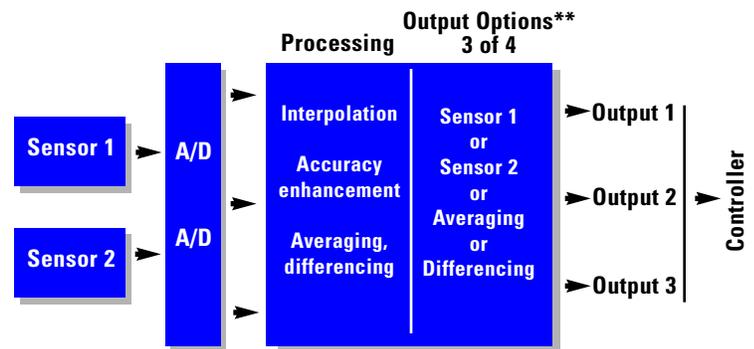
- Mode 0: No changes are made to the position word at the index mark.
- Mode 1: Zeros the fringe counter at the first encounter with index mark after power up.
- Mode 2: Zeros the fringe counter at every encounter with index mark.
- Mode 3: Zeros the fringe counter at the first encounter with index mark after power up and subtracts the index position from the calculated position making the index mark the zero position of the encoder.
- Mode 4: Zeros the fringe counter at every encounter with index mark and subtracts the index position from the calculated position making the index mark the zero position of the encoder.

The index mode can be factory set or selected by the customer using SmartPrecision Software - see page 8 for software features.

\* Resolution values shown are approximate - see p. 4 for exact values.



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



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

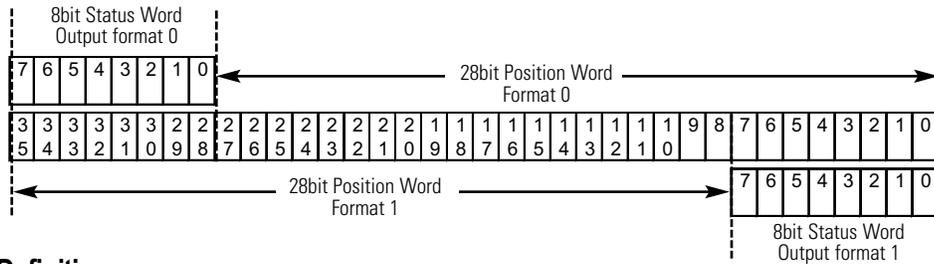
## Mercury 3000Si Dual Axis Averager Outputs:

25-pin standard  
Male D-sub connector

PIN	FUNCTION	
1	Serial Data Out 1+ (SDO1+)	→ <b>Output 1</b>
2	Serial Data Out 1- (SDO1-)	
3	Chip Select 1+ (CS1+)	
4	Chip Select 1- (CS1-)	
5	Serial Clock In 1+ (SCLKIN1+)	
6	Serial Clock In 1- (SCLKIN1-)	
7	Serial Data Out 2+ (SDO2+)	→ <b>Output 2</b>
8	Serial Data Out 2- (SDO2-)	
9	Chip Select 2+ (CS2+)	
10	Chip Select 2- (CS2-)	
11	Serial Clock In 2+ (SCLKIN2+)	
12	Serial Clock In 2- (SCLKIN2-)	
13	Serial Data Out 3+ (SDO3+)	→ <b>Output 3</b>
14	Serial Data Out 3- (SDO3-)	
15	Chip Select 3+ (CS3+)	
16	Chip Select 3- (CS3-)	
17	Serial Clock In 3+ (SCLKIN3+)	
18	Serial Clock In 3- (SCLKIN3-)	
19	Feedback Clock+ (FBCLK+)	
20	Feedback Clock- (FBCLK-)	
21	(USB) D-	
22	(USB) D+	
23	ALARMOUT	
24	+5 VDC	
25	Ground	

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## Serial Data Format



## Status Word Definition

The data word, which includes the status and position words, is transferred with the most significant bit (MSB) first. The data word length is up to 36 bits long. The most significant 8 bits are the status word. The next 28 bits are the position word. This position word is large enough to keep track of a measurement length of 5.24 meters. The interpolation depth of the Mercury 3000SiDAA is X1024. If the user prefers smaller interpolation depths then fewer spiClock signal clocks can be sent to the interpolator and fewer bits will be shifted out. The Status Word may be set to occur at either the beginning or end of the 36 bit Data Word by using SmartPrecision Software to set the Format to 0 or 1 (units are shipped with the output format set to 0).

## Status Word Definitions for Sensor 1 and Sensor 2 outputs

Bit	Name	Description
0	Red Alarm	Asserted low if sensor signal level is out of range
1	Orange Alarm	Asserted low if sensor signal level is near out of range
2	Calibration Status	Asserted high when calibration is in process
3	Index Window	Asserted high when encoder is within physical window
4 to 7	CRC	Cyclic Redundancy Check**

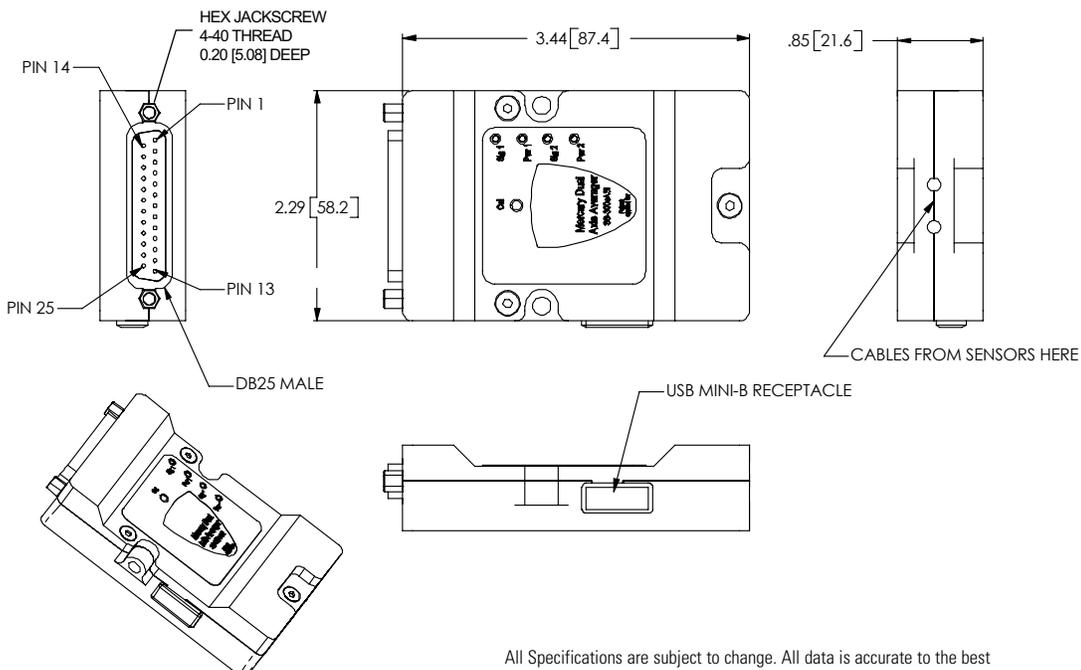
## Status Word Definitions for Average output

Bit	Name	Description
0	Red Alarm	Asserted low if signal level is out of range from either sensor
1	Orange Alarm	Asserted low if signal level is near out of range from either sensor
2	Alarm Channel Indicator	Indicator for which sensor has alarms (see Installation Manual for definition)
3	Index Window	Asserted high when sensor designated for index is within physical window*
4 to 7	CRC	Cyclic Redundancy Check**

\* Sensor 1 is designated to report the index by default. Sensor 2 may be designated instead using SmartPrecision Software.

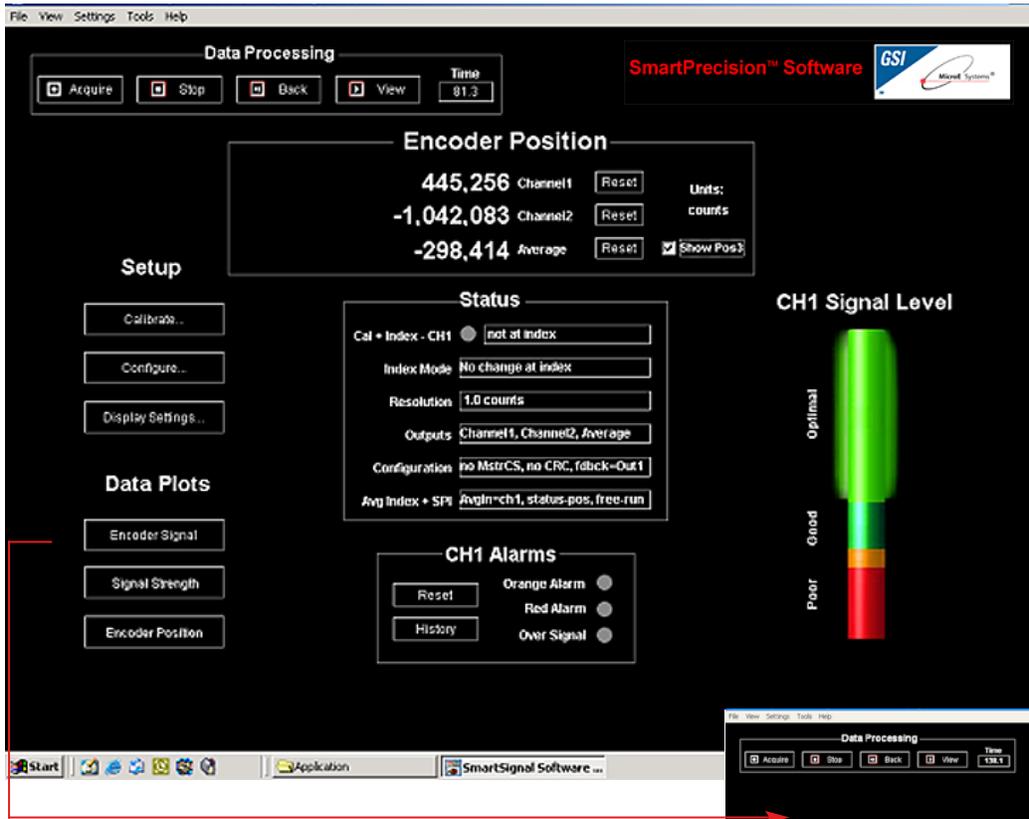
\*\* The Cyclic Redundancy Check is off by default and its bits are set to 0. It can be activated using SmartPrecision Software.

## Mechanical Information - electronics module



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# SmartPrecision™ Software for Mercury™ 3000Si Dual Axis Averager Encoder Systems



SmartPrecision Software makes Mercury the industry's easiest to use encoder. It helps you program, set up, use, and diagnose Mercury 3000Si 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 index modes and calibration settings
- Configure outputs to provide feedback from individual sensors, their average or their difference
- Set serial interface settings, including data word format, master chip select and cyclic redundancy

## Install Mercury Encoder System

- Align sensors 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

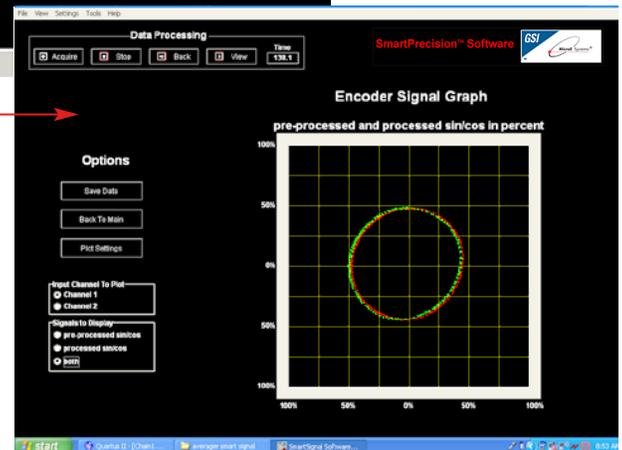
- Read encoder position in engineering units of your choice using three configurable digital readouts
- Read the encoder's hour meter to monitor system usage
- Capture alarms while system operates unattended

## 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 SmartPrecision 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 SmartPrecision Software

To Purchase the SmartPrecision 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

# 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:

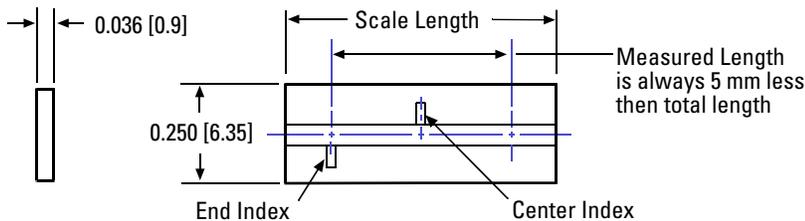
- *Standard linear*: 18mm - 2m
- *Standard rotary*: 12mm - 107.95mm diameter, with or without hubs
- *Custom linear\**: special lengths, widths, thickness, index mark locations and special low CTE materials
- *Custom rotary\**: special ID's, OD's (up to 304.8mm), index mark outside the main track and 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]



### Specifications

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

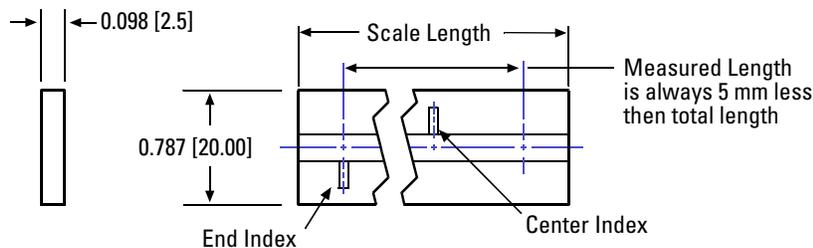
Model	L30	L55	L80	L105	L130
Scale Length	1.181 [30]	2.165 [55]	3.150 [80]	4.134 [105]	5.118 [130]
Measured Length	0.984 [25]	1.969 [50]	2.953 [75]	3.937 [100]	4.921 [125]

Custom scales available

## Standard Long Linear Scales

### 155mm and Longer

Key: inches[mm]



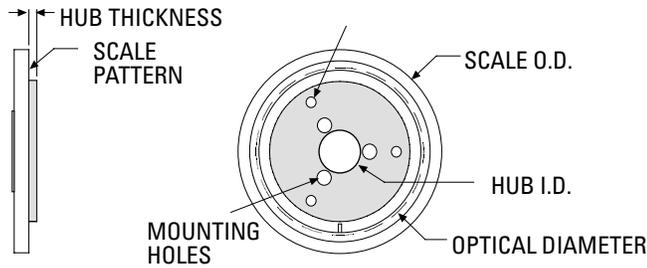
### Specifications

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 3000Si Dual Axis Averager

To specify your Mercury 3000Si Dual Axis Averager System with the desired cable length, index mode, output channel assignments, scale 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 [508] 903-5000

Example: M3000SiDAA-M10-M10-1024-1-1-R1910-HA

<u>M3000SiDAA</u>	-	<u>Cable Length</u> Sensor 1	-	<u>Cable Length</u> Sensor 2	-	<u>Interpolation</u>   1024	-	<u>Index Mode*</u>   0 = No Index 1 = Zero first time 2 = Zero every time 3 = Zero first time - subtract 4 = Zero every time - subtract	-	<u>Output</u> Configurations   1 = Sensor 1, Sensor 2 & Average (most common) 2 = Sensor 1, Sensor 2 & Difference 3 = Average, Difference & Sensor 1 4 = Difference, Average & Sensor 2	-	<u>Scale Model</u>   Lxxx or Rxxxx	-	<u>Scale Mounting</u>   For linear scales: T = Tape mounting C1 = 3 scale clamps** C2 = 10 scale clamps***  Hubs for Rotary Scales: NH = Without Hub HE = for R1290 HA = for R1910 HB = for R3213 HC = for R5725 HD = for R10851
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\* See page 6 for details

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

## How to Order SmartPrecision Software

SmartPrecision 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

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