E3–T60 Digital Autocollimator Data Sheet (23 August 2022)

1.0 Introduction

The T60 optical head is designed for use with the E3 digital controller. Together they form a stand alone high performance dual axis digital autocollimator. Measurement data is provided by the E3 via a color touch-screen display, analog outputs for each axis and an RS-232 serial output.

2.0 Manufacturer

Micro-Radian Instruments, 131 E. Grover St, Lynden, WA 98264 USA (CAGE 50223)

3.0 General Specifications

Beam diameter (nominal)	16 mm
Maximum recommended working distance	500 mm
Maximum calibrated measuring range (each axis)	±2500 arc-seconds (±0.69 degree)
RS-232 serial maximum measurement output rate (user-adjustable)	1000 readings-per-second
Analog maximum measurement output rate (user-adjustable)	4000 readings-per-second
Output resolution	0.01 arc-second
Output units (user-adjustable)	arc-seconds or micro-radians
Accuracy over entire measuring range (% of full scale)	>99.96%
Cross-coupling over entire measuring range (% of full scale)	<0.04%
Light source	red LED
Power input requirements	90 - 264 VAC, 47 - 63 Hz, 10 Watt
Operating temperature (calibrated)	20°C ±0.2°C
Operating/Storage temperature (maximum rated)	0°C to +52°C

4.0 Optical Head

The optical head is machined from a solid block of 6061 aluminum and black anodized inside and out. The part number and serial number are permanently engraved on the bottom (mounting) surface.

5.0 E3 Digital Controller

The E3 digital controller has a color touch-screen LCD to display readings and enter operator commands. Displayed information includes optical head signal level, temperature, calibrated working distance, serial number, and the last calibration date. The electronics include digital signal processing and a full calibration covering the entire measuring range of the device. The time average of the data and data units are user-adjustable.

6.0 Optical Head Cable

The optical head cable is hard-wired to the optical head and terminates in a DB15 connector. The cable plugs into the front panel of the E3 controller via the DB15 connector. The cable is composed of shielded twisted pairs with an overall black PVC jacket and is nominally 6 feet long. Optional longer cables, vacuum-compatible cables, and cable extensions are available.

7.0 Analog Output Specifications

Analog output measuring range	±2500 arc-seconds
Analog output resolution	0.076 arc-second
Analog scale factor (Azimuth and Elevation)	±2.4VDC for ±2500 arc-seconds
D/A converter	16-bit
D/A converter resolution	16 bit per ±2.4VDC
Output sampling rate (samples/second)	4000
Output connectors	BNC
Output load resistor for calibrated output	10K ohm

8.0 RS-232 Output Specifications

Output rates (readings/second)	0.01, 0.1, 1, 10, 100, 500 (optional 1000)
Baud Rate	115.2K baud (optional 230.4K baud)
Output format	ASCII text, comma separated variable
Serial communication cable requirement	DB9 null modem (not provided)

The serial port outputs angle readings, data status, and head temperature in degrees Celsius. Data status is 1 if the angle readings are valid and 0 if invalid.

Output sequence for the 500 and optional 1000 samples/second settings is as follows:

signed integer-only AZ data,signed integer-only El data,status<carriage return>

For example:

+1234,-4321,0<carriage return>

Output sequence for 100, 10, 1, 0.1 and 0.01 samples/second settings is as follows:

signed AZ data,signed El data,status,signal level,head temperature °C<carriage return>

For example:

+1234.567,-7654.321,0,98,21.5<carriage return>

9.0 RS-232 Serial Port commands

9.1 The following commands can be sent via the serial port to the autocollimator. Command letters are case-sensitive and only the command letter should be sent. Sending an additional character such as carriage return or line feed or an undefined character will be interpreted as an E command and will terminate data transmission.

9.2 To request data from the autocollimator, use one of the following three commands:

Command	Result
A	One reply is sent immediately
B	One reply is sent after a delay of one Output Average period
C	Replies are sent continuously at the rate of the Output Average period

9.3 To change any of the user-adjustable settings, use the following commands. The user-adjustable settings in use at the time that the autocollimator is powered down will be the default settings when the autocollimator is next powered up.

Command	Result
E	Stop data transmission
F	Turn off Zero Offset
G	Turn on Zero Offset
H	Set data units to Arc-Seconds
I	Set data units to Micro-Radians
J	Turn off Head Data display
K	Turn on Head Data display
L	Set Display Average to 1 second
M	Set Display Average to 10 seconds
N	Set Display Average to 100 seconds
a	Set to output 500 (optional 1000) samples/sec (output averaging of 0 second)
b	Set to output 500 (optional 1000) samples/sec (output averaging of 0.001 second)
c	Set to output 100 samples/sec (output averaging of 0.01 second)
d	Set to output 10 samples/sec (output averaging of 0.1 second)
e	Set to output 1 sample/sec (output averaging of 1 second)
f	Set to output 0.1 sample/sec (output averaging of 10 seconds)
g	Set to output 0.01 sample/sec (output averaging of 100 seconds)

10.0 Modulation and Sampling

The optical head light source is modulated at 4 kHz and the autocollimator samples once per modulation cycle at all times regardless of the user-adjustable settings. This is one sample every 250 microseconds. The modulation source is built-in so no external modulation source is required.

For the digital output, the time period average (moving average) of this over-sampled data is user-adjustable. For example, the 1 sample/sec setting gives the moving average of the last 1 second of data with a delay of 250 microseconds. The maximum data rate from the serial port output is 500 (optional 1000) samples/sec with a 250 microsecond delay.

The analog output is updated once per modulation cycle for output averaging settings of 0, 0.001, 0.01, and 0.1 second. For settings of 1, 10, or 100 seconds, the output is updated every 0.1 second.

The display is updated twice per second with user-adjustable averaging settings of 1, 10, or 100 seconds. For example, if the display is set to 10 second averaging, the running average over the last 10 seconds is calculated and displayed every 500 milliseconds.

11.0 Calibration

The autocollimator uses digital signal processing and data from all outputs is fully calibrated. Errors in the detector are corrected using a 33x33 point look-up table. The table is generated by comparing the autocollimator outputs to an angle standard calibrated by the Swiss Federal Institute of Metrology (METAS) in Wabern, Switzerland. Once the autocollimator is programmed with the look-up table, verification scans are performed to confirm that the corrected outputs match the standard. "As left" test data and a certificate of traceability to METAS are included with each autocollimator. Calibration stickers are attached to both the optical head and the E3 controller.

The calibration is performed at 20°C ±0.2°C and with a 50mm, >93% reflective mirror. The mirror is flat to 1/10 wave. All calibration measurements are taken with the autocollimator in its 1 sample/sec setting.

Because the look-up table and the other calibration constants (such as electronic gains) are specific to a given optical head, the optical head and the E3 controller that are calibrated together become a matched set and must be used together in order for the calibration to remain valid. Operating a non-matched optical head and controller will not damage either component but the E3 outputs will not be accurate.

Periodic recalibration is recommended at least every 2 years and Micro-Radian Instruments can provide this service for a nominal fee. The autocollimator must be returned to the factory to be recalibrated. Recalibrated autocollimators are returned to the customer with "as found" and "as left" test reports, a certificate of traceability to METAS, and updated calibration stickers attached to both the optical head and the E3 controller.

12.0 Outline and Mounting (inches)

Clear Aperture 0.62
Optical Axis
1.23
0.58
0.000
0.000
0.53

Blind Tap #4-40
0.25 deep 3 places
1.23
1.115
0.615
0.115
0.000
Power and Signal Cable
3.4 nominal
2.43
1.845
0.345
0.000

7.5
5.4
0.5
0.000
8.2
0.000

Front
Color Data Display
Sensor Cable Connector

Azimuth Analog Output
Serial Data Output
Elevation Analog Output
Rear
Power Connector

10.4
0.000
Side