

## T15D Autocollimator Data Sheet (6 April 2018)

### 1.0 Introduction

The T15D is a compact digital autocollimator designed for use with a computer. Power input and data output are via a single USB 2.0 connection. Optional RS-232, RS-485 and analog outputs are also available.

### 2.0 Manufacturer

Micro-Radian Instruments, 485 W. Horton Road, Bellingham, WA 98226 USA

### 3.0 General Specifications

Beam diameter (nominal)	7 mm
Maximum recommended working distance	25 mm
Recommended minimum target mirror size	10 mm diameter
Maximum calibrated measuring range	$\pm 10,800$ arc-seconds ( $\pm 3$ degrees)
Maximum measurement output rate (user-adjustable)	4000 readings-per-second
Output resolution	0.1 arc-second
Accuracy over entire measuring range (% of full scale)	>99.5%
Cross-coupling over entire measuring range (% of full scale)	<0.2%
Light source	red LED
Power input requirements	+5VDC $\pm 5\%$ , 1 Watt
Weight	95 g
Operating temperature (calibrated)	20°C $\pm 0.2$ °C
Operating/Storage temperature (maximum rated)	-40°C to +70°C

### 4.0 Housing

The standard T15 housing is used. It 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 surface.

### 5.0 Electronics

The T15D contains digital electronics and outputs data via USB 2.0. 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 Cable assembly specifications

Cable connector	USB 2.0
Cable length	3 meters
Cable shielding	internal metal braid
Cable jacket	overall black PVC
Connector pinouts	
Connector pin 1 = +5VDC $\pm$ 5% input	
Connector pin 2 = USB DM	
Connector pin 3 = USB DP	
Connector pin 4 = Power ground	

## 7.0 USB output specifications

Maximum measuring range	$\pm$ 10,800 arc-seconds ( $\pm$ 3 degrees)
Output resolution	0.1 arc-second
Output sampling rates (samples/second)	4000, 1000, 100, 10, 1, 0.1 and 0.01
Output units (user-adjustable)	arc-seconds or micro-radians
BIT output	0 or 1, corresponding to invalid (0) or valid (1) angle data
Output format	comma separated ASCII text
Output sequence for the 4000 and 1000 samples/second settings is as follows:	

signed integer-only AZ data,signed integer-only EI data,BIT<carriage return>

For example:

+12345,-54321,0<carriage return>

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

signed AZ data,signed EI data,BIT,signal level,head temperature in °C <carriage return>

For example:

+12345.678,-87654.321,0,98,21.5<carriage return>

## 8.0 BIT (built in test) output

The BIT status output indicates whether the current data being sent by the autocollimator is valid or invalid. Invalid data will result if the mirror angle is out of range or if the autocollimator is otherwise not receiving a signal. The BIT output reads 1 when readings are valid and 0 when readings are invalid.

## 9.0 USB Port Commands

**9.1** The following commands can be sent via the USB 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:

<u>Command</u>	<u>Result</u>
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.

<u>Command</u>	<u>Result</u>
E	Stop data transmission
H	Set data units to Arc-Seconds
I	Set data units to Micro-Radians
O	Sends identification message
a	Set to output 4000 samples/sec (output averaging of 0 second)
b	Set to output 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)

## 9.4 Identification message

The identification message reply from sending the O command includes information specific to the autocollimator. The format of the identification message is as follows:

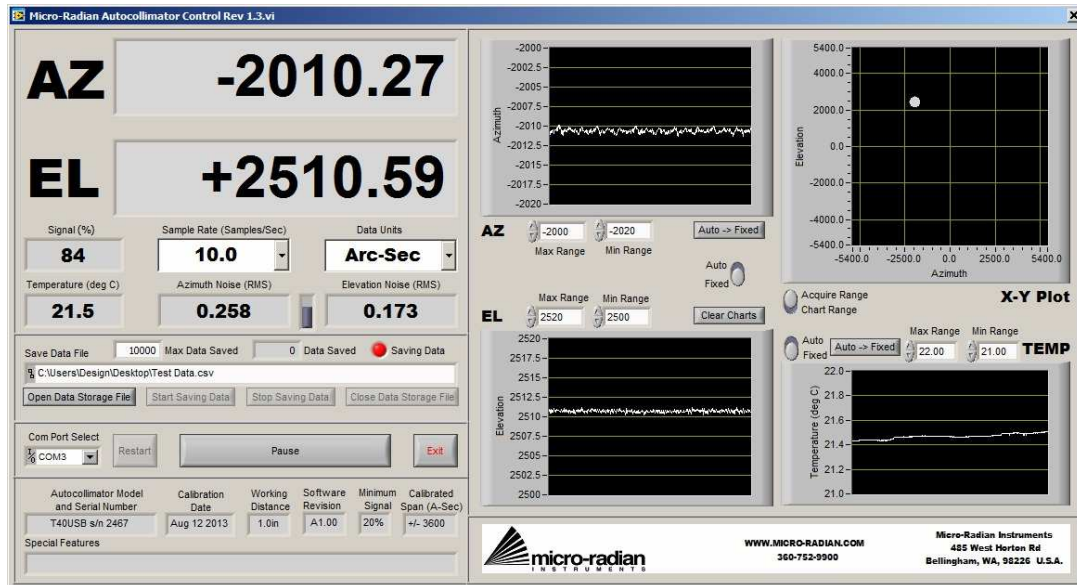
(U1AI) message identifier, autocollimator model and serial number, last calibration date, working distance, autocollimator software revision, output averaging, units, required minimum signal %, calibrated span, special calibration message

For example:

U1AI,T15D s/n 1234,MAR 18 2013,2.0 in,A1.00,0.1 sec,Arc-Sec,20,10800,Special Calibration Message

## 10.0 Graphical User Interface (GUI)

The autocollimator includes an USB driver and LabView-based GUI suitable for Windows XP, Vista, 7, 8 and 10. All USB port commands (section 9.0) can be controlled by the GUI, and data from the autocollimator is displayed numerically and graphically. The maximum data rate that the GUI can display is 100 readings-per-second.



## 11.0 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. No external modulation source is required.

For the USB output, the time period average (moving average) of this oversampled 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 USB output is 4000 samples/sec with a 250 microsecond delay.

## 12.0 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, a certificate of traceability to METAS, and a calibration sticker are included with each autocollimator.

The calibration is performed at  $20^{\circ}\text{C} \pm 0.2^{\circ}\text{C}$  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.

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 data, a certificate of traceability to METAS, and an updated calibration sticker.

### **13.0 Measurement Orientation and Mounting**

The optical head contains no moving parts and can be mounted in any orientation. However, references to azimuth and elevation are correct when the optical head mounting (bottom) surface is parallel to the earth. The optical head is designed to be mounted using three #4-40 threaded holes on its mounting surface.

All measurements from the optical head are of the actual target angle and no compensation is required to convert beam angle to target angle.

### **14.0 Optional Output Formats**

The autocollimator is available with any one of the following output options at the time of order: USB only; RS-232 only; RS-485 only; analog only; USB and RS-232; USB and RS-485; USB and analog; RS-232 and analog; RS-485 and analog; USB, RS-232 and analog; USB, RS-485 and analog.

Cable connector (USB only output)	USB 2.0
Cable connector (all others)	male 9-pin micro-D
Maximum measurement output rate (analog, fixed)	4000 readings-per-second
Maximum measurement output rate (RS-232 @230.4K baud)	1000 readings-per-second
Maximum measurement output rate (RS-485 @921.6K baud)	4000 readings-per-second
Output resolution (analog)	12-bit per $\pm 3.0\text{VDC}$
Output resolution (RS-232)	0.1 arc-second
Output resolution (RS-485)	0.1 arc-second

## 15.0 Outline and Mounting (inches)

