Laser Technology, Inc.

TruSense® T-Series

User's Manual

LASER TECHNOLOGY INC
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LTI TruSense® T-Series User's Manual
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LTI TruSense T-Series User's Manual (p/n 0144850) Change Log

- **3rd Edition** October 2014
  - Added TruSense Control User Interface Program Section. Pages 4-15
  - Changed "long gate" to "long gate or virtual fence". Pages 12, 20, 24-25
  - Updated Configuration Matrix to list measurement modes in numerical order. Page 22
  - Updated Sample Output Matrix to list measurement modes in numerical order. Page 23
  - Updated Command Set Quick Reference to list measurement modes in numerical order. Page 24
- **2nd Edition** August 2014
  - Added LTI-brand cover page with hex design, inside cover page with copyright/patent/trademark/LTI contact information. Pages i-ii
  - Added Introduction Section, Basic Package List and Accessory Items List. Page 2
- **1st Edition** May 2013

Table of Contents

Introduction

Thank you for your purchase of the TruSense T-Series sensors. LTI traffic sensors are being used by transit authorities, the department of transportation as well as both public and private traffic engineering managers. The uses for these rapid and highly accurate sensors are limitless. Our sensors can measure speed, height, and complete vehicle quantities in helping with your profile measurements. Detecting and counting vehicles can be easily managed with these sensors in collecting and reporting all the data you will ever need when you submit your traffic studies for future infrastructure improvements or major additions. If you are looking for an event trigger, our sensors have multiple outputs so projects such as toll booth management and axle counts becomes extremely manageable with our highly reliable results. Our sensors are just one of the many reasons that make **Laser Technology…measurably superior**.

Basic Package

- ☐ T100 or T200 Sensor
- ☐ T100/ULS Power Cable or T100 to T200 6 Position Cable (based on sensor)
- ☐ TruSense T-Series User's Manual
- ☐ TruSense T-Series Control/Setup Utility as Required
- ☐ Engineering Diagrams as Required
- ☐ LTI Limited Warranty

Accessory Items

- ☐ Beam Spreading lens Set for T100 or T200
- ☐ T100/T200 Mounting Bracket

Safety Precautions

- ***Avoid staring directly at the laser beam for prolonged periods.***
  The TruSense T100 and T200 are designed to meet FDA eye safety requirements and is classified as eye safe to FDA (CFR21) Class I 7 mm limits, which means that virtually no hazard is associated with directly viewing the laser output under normal conditions.

- ***As with any laser device, however, reasonable precautions should be taken in its operation.***
  It is recommended that you avoid staring into the transmit aperture while firing the laser.
  The use of optical instruments with this product may increase eye hazard.

- ***Never point the instrument directly at the sun.***
  Exposing the lens system to direct sunlight, even for a brief period, may permanently damage the laser transmitter.

Before You Begin Using this Sensor

The sensor ships with preset factory defaults. These defaults allow you to observe that the sensor(s) automatically begin measuring when power is cycled following the power up and power down procedure in the Command Set Quick Reference (Page 24).

It is important that you take the time to read this document thoroughly. It is organized for quick reference and includes in-depth explanations of all sensor functions and installation questions.

TruSense Control User Interface Program

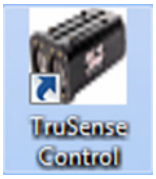
The TruSense T-Series sensors is the TruSense Control User Interface Program is an optional tool for controlling the operation of sensor. This configuration software, developed by LTI allows you to modify key operating parameters to best suit your individual application.

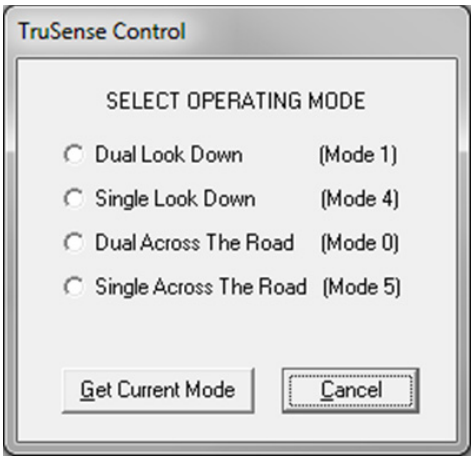
The interface program offers four operating modes:

- Look Down (Mode 1)
- Single Look Down (Mode 4)
- Dual Across the Road (Mode 0)
- Single Across the Road (Mode 5)

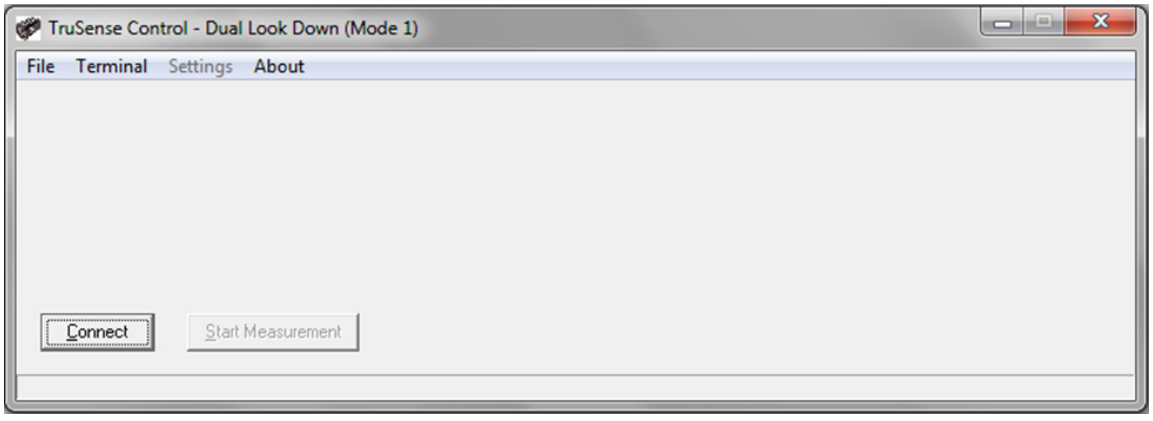
Open the Program

1. To open the program and display the TruSense Control User Interface Program, double-click the TruSense Control icon on the PC screen.
2. Select the desired operating mode.
   For the Control Interface for traffic, select the Dual Look Down [Mode1].





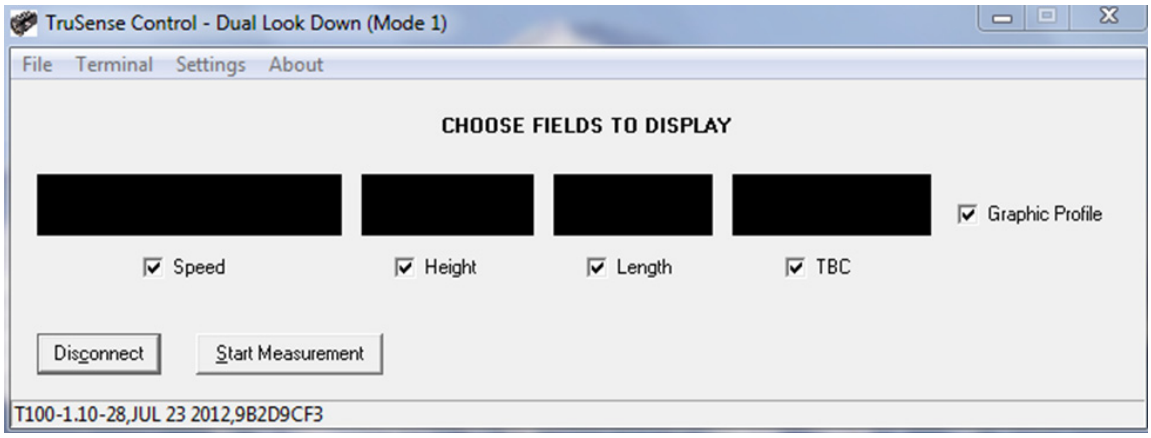
Dual Look Down [Mode 1]



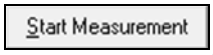
1. Click 

.

2. The program will find the sensor and connect. The window below will appear.



- **If the sensor's configuration was saved Manual Start,** the above screen will appear.

  In the window, click 

, the sensor will start to calculate the distance to the floor.

- **If the sensor's configuration was saved as Auto Start,** this will be explained under settings, then the sensor will automatically start. The Start/Stop button will show the opposite of the status.

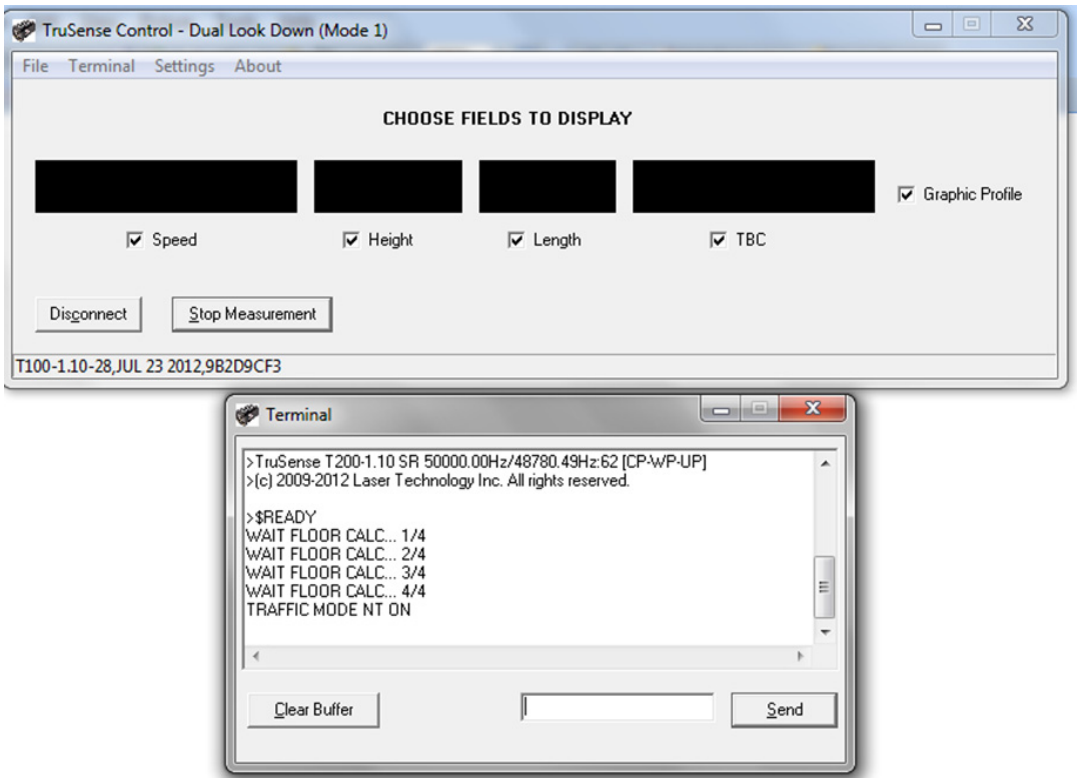
  Example, below the button shows Stop Measurement, meaning the sensor is running, and clicking on the button will Stop Measurement. If the Start Measurement is showing, then the sensor is stopped, and clicking on the button will start the sensor.

Alert: Stop / Start Measurement button shows the action that will be executed.

Terminal Window

It is recommended to click on "Terminal" in the menu bar at the top of the screen. This will display the terminal box as shown below. The box will show >$Ready, meaning the sensor is ready to start its self calibration, it is not ready for sensing vehicles. Only after the sensor has calculated, 4/4 and shows TRAFFIC MODE NT ON, will the sensor start measuring and calculating.

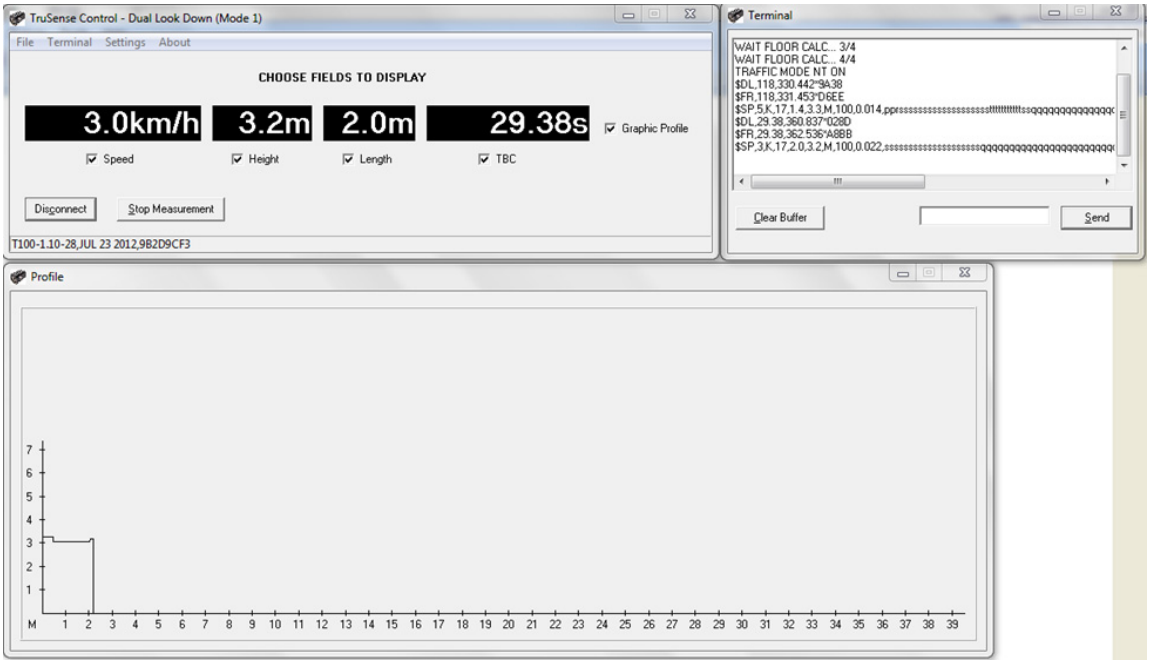
Alert: The ">$READY" command in the terminal box does not mean the sensor is ready to operate, it only means the sensor is ready to start the calibration measurement to the ground.



The system is now ready to measure vehicles. A bench demonstration can be performed by placing the sensors on a desktop facing a wall to simulate the sensors looking down from an overpass gantry. Passing cardboard boxes past the sensors will simulate vehicles. Different size boxes will show different heights.

Alert: The system is only ready to measure after all 4/4 calibrations are finished, and "TRAFFIC MODE NT ON" displays.

For ease of viewing, move the "Terminal" box to the side.The figure below shows an initial example Dual Look Down Mode.



When a vehicle passes under the sensors, going from the T100 to the T200, a graphic display box will appear showing the height and distance. A vehicle has to pass the T100, then the T200 in that direction. To replicate an actual vehicle, both sensors must be tracking the vehicle at the same time, i.e., the sensors cannot be spaced a distance longer then the vehicle.

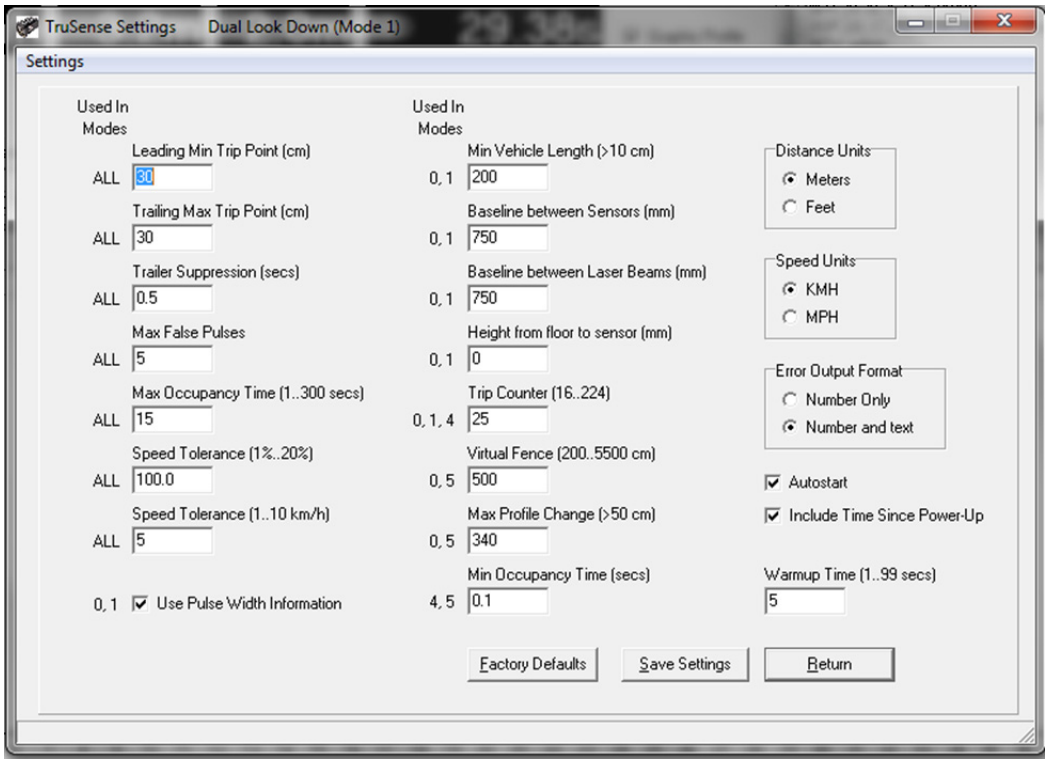
The vertical graph shows the vehicle height, while the horizontal graph shows the vehicle length.

In the display text boxes, the speed, height, length, and the time between cars (TBC), will be shown.
The terminal window will show the raw data.

The screen below shows a second of example Dual Look Down Mode. It includes a vehicle speed of 3.0 km/h, the vehicle was 3.2 meters high, 1.8 meters long, and 9.18 seconds passed since the previous vehicle.

Settings

The settings tab will open the setting box shown below.



For Demonstration purposes, Factory Defaults settings will be adequate.
The Distance Units and Speed Units are factory set and cannot be changed.

Below is a chart showing the settings, which modes the settings are used in, the factory default values, and the command and the description as described in Command Set Quick Reference (Page 24).

Used in Modes	Default	Command	Description from User's Manual
ALL	Leading Min Trip Point [cm]		
	30	TP	leading minimum height of the vehicle from reference point
ALL	Trailing Max Trip Point [cm]		
	30	FL	Trailing minimum height of the vehicle from the reference plane for triggering
ALL	Trailer Suppression (sec)		
	0.5	TL	Time delay since last measurement
ALL	Max False Pulses		
	5	MX	Maximum number of false pulse before a reading is ignored
ALL	Max Occupancy Time [1..300 sec)		
	15	TO	Vehicle timeout
ALL	Speed Tolerance [1%..20%]		
	100	SJ	Percentage of speed difference of a vehicle passing through both sensors
ALL	Speed Tolerance [1..10Kkm/h]		
	5	SK	Maximum speed difference in mph or km/h
0, 1	☐	RW	Use Pulse Width Information
			Pulse width information is used for measurement

Used in Modes	Default	Command	Description from User's Manual
0,1	Min Vehicle Length [>10 cm]		
	300	ML	Vehicle minimum length
0, 1	Baseline between Laser Beams [mm]		
	750	GE,n1	Distance between two mounted sensors center to center
0, 1	Baseline between Laser Beams [mm]		
	750	GE,n2	Distance between beams center to center at grade
0, 1	Height from floor to sensor [mm]		
	0	GE,n3	Height of the sensor from face plate to grade
0,1, 4, 5	Trip counter 16.225		
	25	CT	Minimum number of valid returns
0, 5	Virtual Fence		
	1100	OS	Long gate distance, any vehicles beyond this distance will be ignored
0, 5	Max Profile Change [>50 cm]		
	200	OV	Maximum distance change in profile - any vehicle with a larger profile change will be ignored
4, 5	Min Occupancy Time [sec]		
	0.1	MT	Minimum time the vehicle must remain under the sensor time

- The Distance Units cannot be changed due to the regulatory requirements of speed data.
- The Speed Units cannot be changed due to the regulatory requirements of speed data.
- Error Output Format will allow the user to either display error is numerical format only, or to include description text.
- Autostart, MA is preferred, so system will automatically re-start after a power outage without requiring a manual re-start.
- Warm up Time, WU, factory default is 5.

Log Data

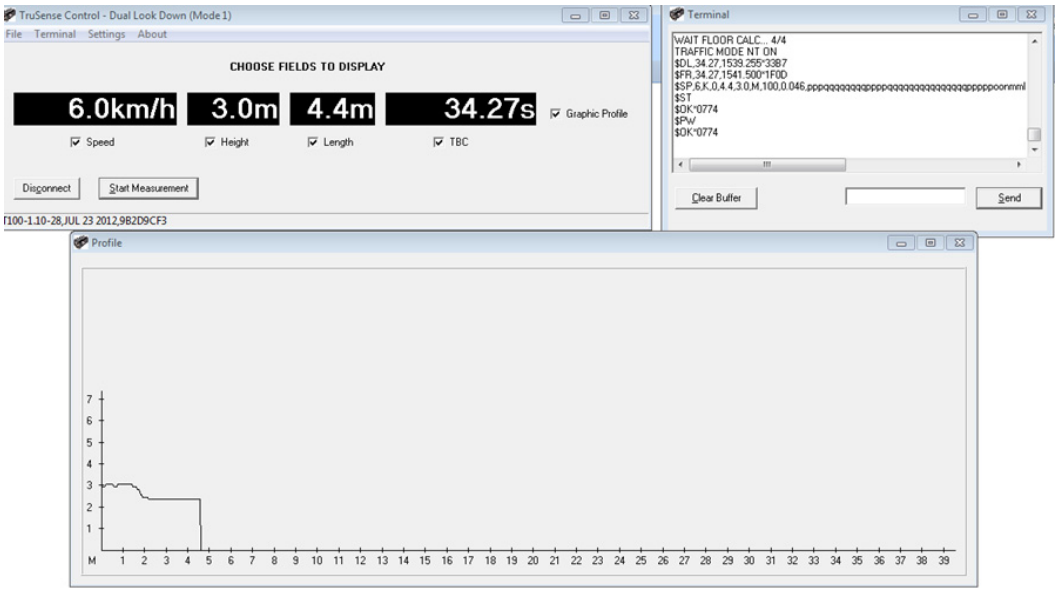
In order to save a log:

1. Click on "File" in the menu bar at the top of the screen, and then click a check mark next to "Log Everything".

2. Re-open the File menu
3. Click on "Start Log.."

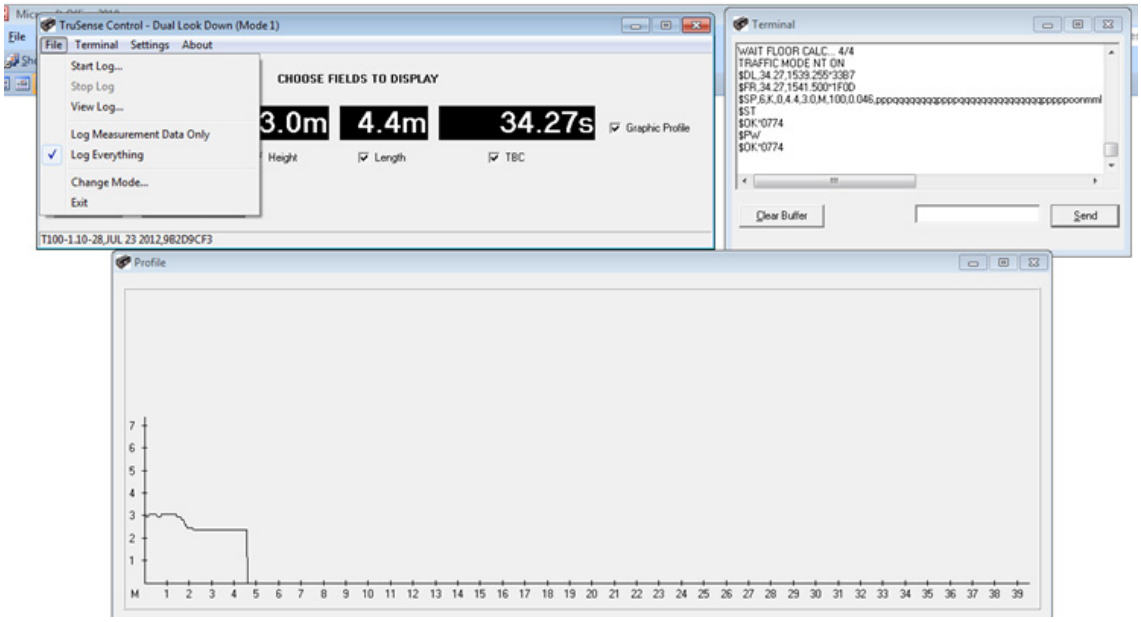
   A window will open allowing the user to choose where the file will be stored and to create a File name. A folder labeled Logs will be created. On the bottom, a file name must be typed in next to "File name:".

4. Start recording data.

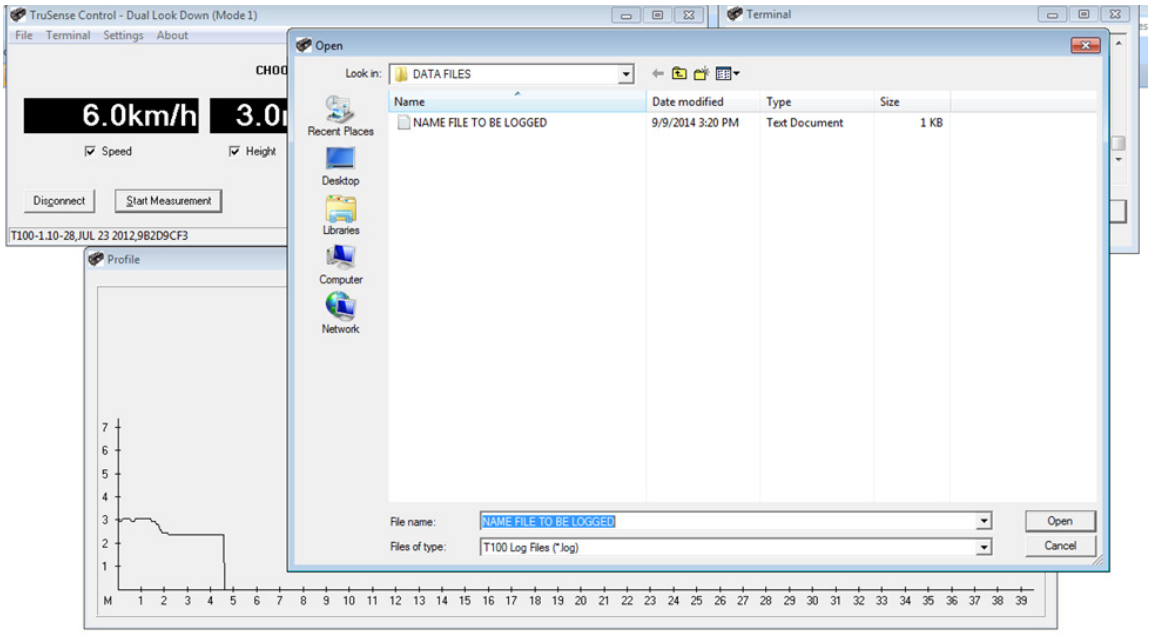


After data is recorded:

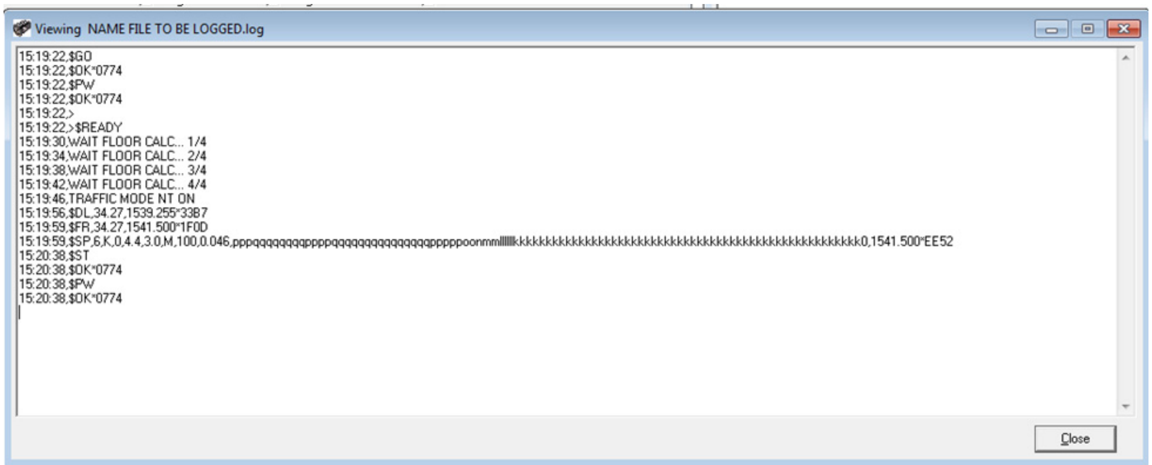
1. Stop Measurement.
2. Open the File Menu.
3. Stop Log.
4. Open View Log.



5. Select the file to open, and double click.



6. The log opens and shows the time stamp and the commands.

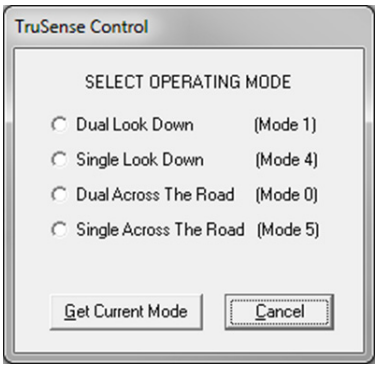


7. Data can be copied and special pasted into Microsoft Excel. The figure below shows an example of an Excel spreadsheet of log data.

15:19:22	,$GO							
15:19:22	,$OK	*	774					
15:19:22	,$PW							
15:19:22	,$OK	*	774					
15:19:22	,>							
15:19:22	,>$R	E	ADY					
15:19:30	,WAI	T	FLOOR	CAL	C...	1/4		
15:19:34	,WAI	T	FLOOR	CAL	C...	2/4		
15:19:38	,WAI	T	FLOOR	CAL	C...	3/4		
15:19:42	,WAI	T	FLOOR	CAL	C...	4/4		
15:19:46	,TRA	F	FIC MO	DE N	T ON			
15:19:56	,$DL	,	34.27,	1539	0.255	*33B7		
15:19:59	,$FR	,	34.27,	1541	0.5	*1F0D		
15:19:59	,$SP	,	6,K,0,	4.4,	3.0,	M,100,	0.046,	pppqqqqqqqkkkkk0,1541.500*EE52
15:20:38	,$ST							
15:20:38	,$OK	*	774					
15:20:38	,$PW							
15:20:38	,$OK	*	774					

Change Operating Mode

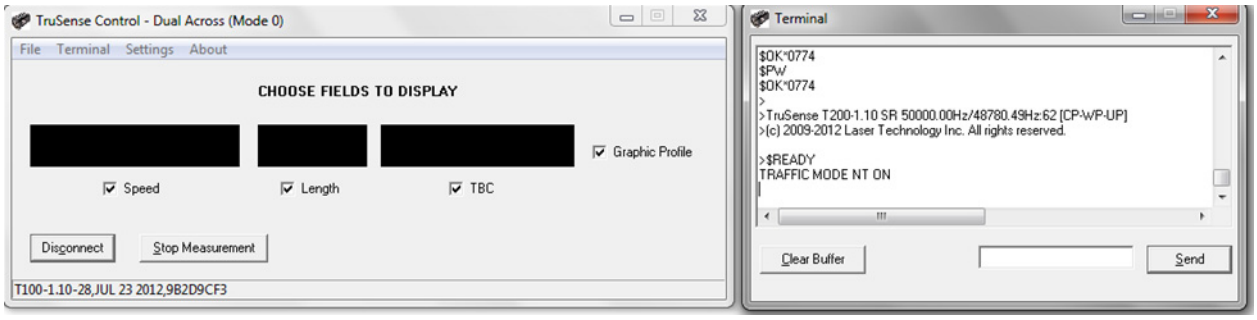
1. Stop measurements by clicking on Stop Measurement and then Disconnect.
2. Select "File" and then click "Change Mode…".
   The pop up window will appear.
3. Select the desired operating mode.



Dual Across Mode [Mode 0]

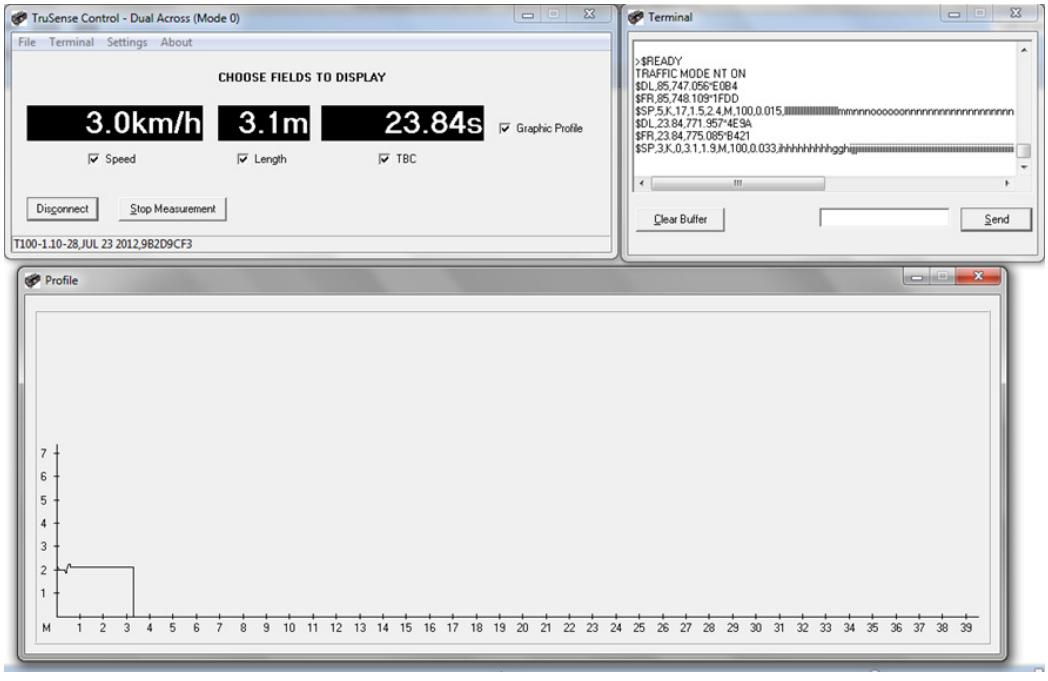
Dual Across Mode is shown below, follow the above procedure.
The Dual Across Mode does not provide height.

Alert: Make sure long gate or Virtual Fence is set properly in Settings.

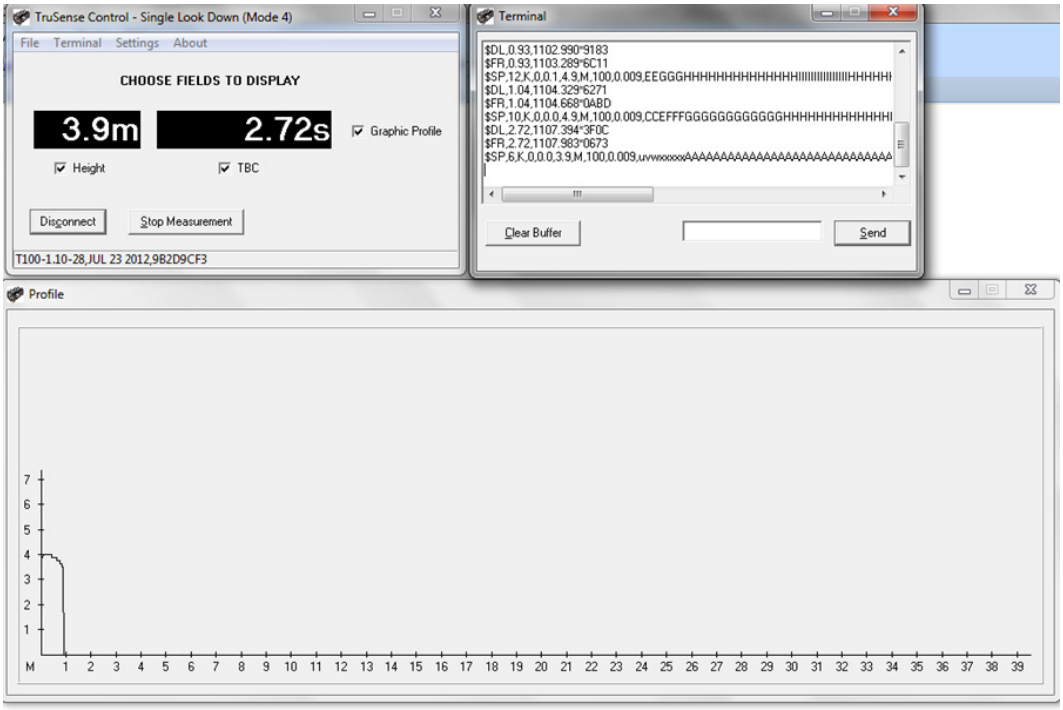


If the Virtual Fence is set too long, error ER22 will show. The system is ready to operate when the Terminal screen shows "TRAFFIC MODE NT ON".

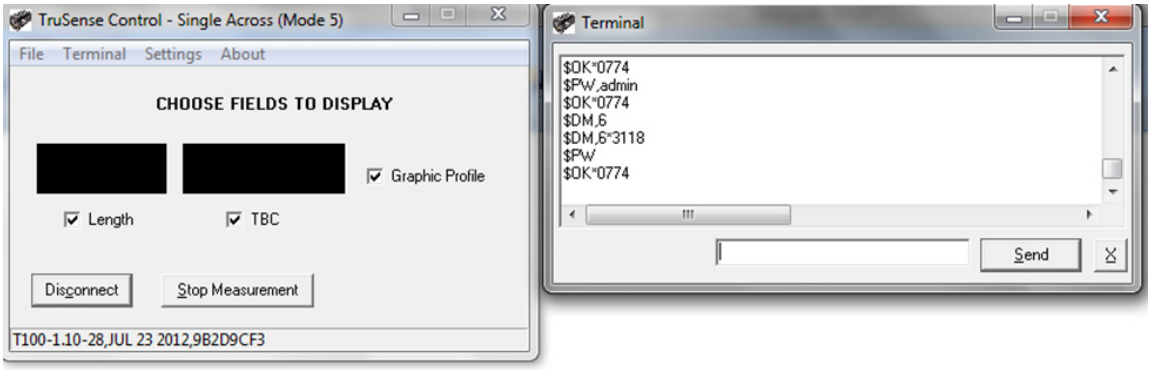
When a vehicle passes, the Profile window will appear along with Speed, Length, and time between cars (TBC).



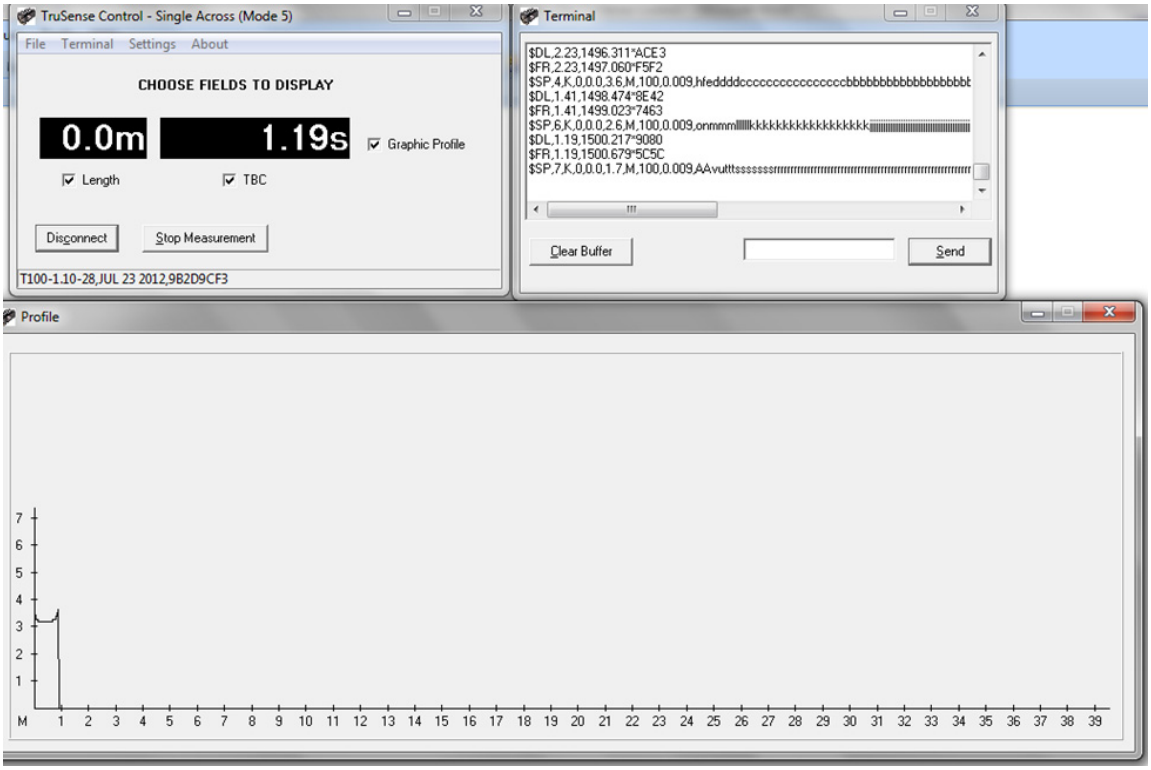
Single Sensor Look Down [Mode 4]



Single Sensor Side-fire [Mode 5]



Single Across Mode does not provide Length although the box is shown.



Single sensor

Follow the same procedure above to change the operating mode to Single Look Down, [Mode 4], and Single Across The Road, [Mode 5].

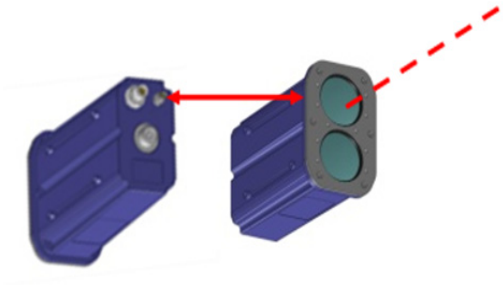
Frequently Asked Questions

What measurement technique is used with the T100?

The T100 uses infrared laser light to measure distance. This invisible light is emitted from the transmit lens of the sensor, reflects off of the vehicle and returns to the receive lens of the senor. The exact distance is then calculated by comparing the return time to the speed-of-light constant.

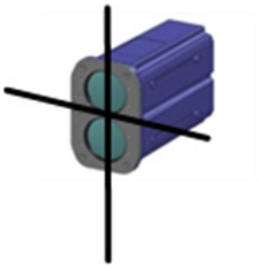
Which side is the transmit lens?

The same side as the connectors on the top of the sensor.



The measured distance is using what reference?

Distance measurements are from the sensor front plate to the vehicle.



Does the sensor need additional protection when using outdoors?

Keep direct moisture and sun rays (heat) from coming in contact with the sensor. Direct sun rays on the sensor housing can easily heat the sensor above its operating temperature. An open-ended shroud is recommended if this is the case. A complete enclosure is not necessary, but a simple sun shade is highly recommended.

Can the sensor measure to my vehicle?

The ability of a laser sensor to measure to a vehicle depends on the vehicle's reflectance and any interference between the sensor and vehicle such as dust, fog, foliage or other. Reflectance is determined by color, opacity, distance, and the reflection angle as well as the density of any ambient interference between the sensor and the vehicle. For example, a lighter vehicle is more reflective than a darker one and thick dust will reduce the signal strength more than light dust. The T100 is a highly-sensitive precision sensor and can measure to most vehicles within its range specification.

A good rule of thumb when measuring through fog or dust is if you can visually see the vehicle, the sensor likely can as well.

Is the beam eye safe?

Yes, but it is always a good practice not to stare directly into the transmit aperture of any light transmitting device.

What is the beam diameter?

With the beam expanding optics the beam is expanded to an elongated oval with the longer dimension given in this chart. Without beam expanding optics the spot is a square.

	Beam Width at Target	
Distance from Sensor to Target meters (feet)	*With Beam Expanding Optics* meters (feet)	*Without Beam Expanding Optics* centimeters (inches)
1.0 (3.3)	0.5 (1.5)	4.6 (1.8)
2.0 (6.6)	0.9 (3.1)	4.9 (1.9)
3.0 (9.8)	1.4 (4.5)	5.2 (2.0)
4.0 (13.1)	1.8 (6.1)	5.5 (2.2)
5.0 (16.4)	2.3 (7.6)	5.8 (2.3)
6.0 (19.7)	2.8 (9.1)	6.1 (2.4)
7.0 (23.0)	3.2 (10.6)	6.4 (2.5)
8.0 (26.2)	3.7 (12.1)	6.7 (2.6)
9.0 (29.5)	4.2 (13.7)	7.0 (2.8)
10.0 (32.8)	4.6 (15.2)	7.3 (2.9)

Notes:

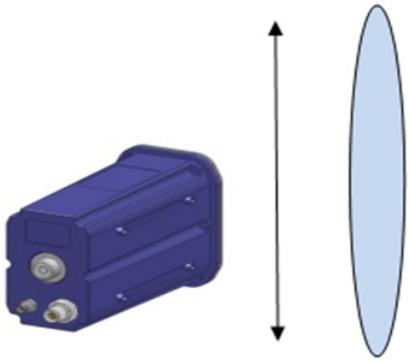
- Noted beam width is "at pavement" for lookdown installation and "at vehicle" for side-fire installation, therefore is noted "at target" in the table.
- For lookdown installation, best results dictate the expanded beam should not extend past a lane width.
- For side-fire installation if a small spot on the vehicle is required (as in axle counting) or if the sensor(s) are offset from the road by a large distance where the expanded beam extends over and under the vehicle, best results are obtained without the use of beam expanding optics.

Examples:

- *Without Beam Expanding Optics*
  The beam diameter at 5 meters:
  Distance to vehicle (d) = 5m
  Divergence (D) = 3mrad
  Lens free aperture (a) = 43mm
  Spot size = a + (D x d) or .043 + (.003 x 5) = 5.8 cm

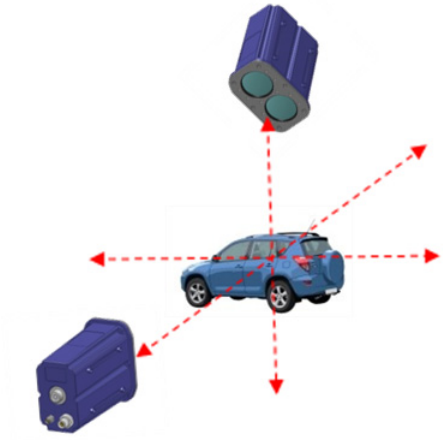
- *With Beam Expanding Optics* (note beam orientation to sensor)
  The beam diameter at 5 meters:
  Distance to vehicle (d) = 5m
  Divergence (D) = 26 degrees
  Spot size (long axis) = tan(13) = x/5
  Spot size (long axis) = 1.15 x 2 = 2.3 meters

  The minor axis is limited to 3 mrad divergence and is negligible for beam expanding purposes.



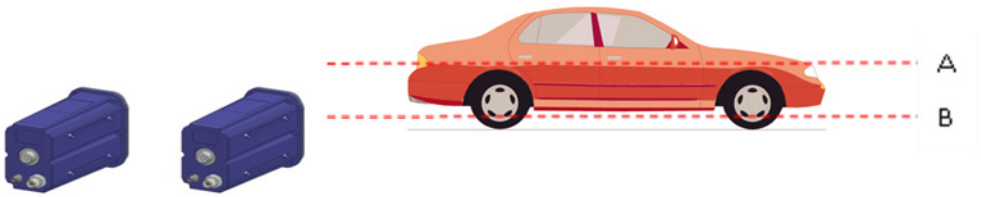
How do I align the sensors and how do I know where the beam is in my measurement field?

In both side-fire and lookdown installations, best results are obtained by mounting the sensor(s) perpendicular to the vehicle. Good installation practice ensures the sensors are level and square to the vehicle.



Side-fire Configuration

For side-fire installation, best results are obtained by positioning the sensor midway on vehicle side on line A. For axle counting the sensor should be mounted on line B so that the beam tracks over each tire and under the vehicle to distinguish one tire from two or more.



Level and square the sensor(s) to the desired point on the passing vehicle. Align the long axis of the sensor(s) perpendicular to grade.

Side View

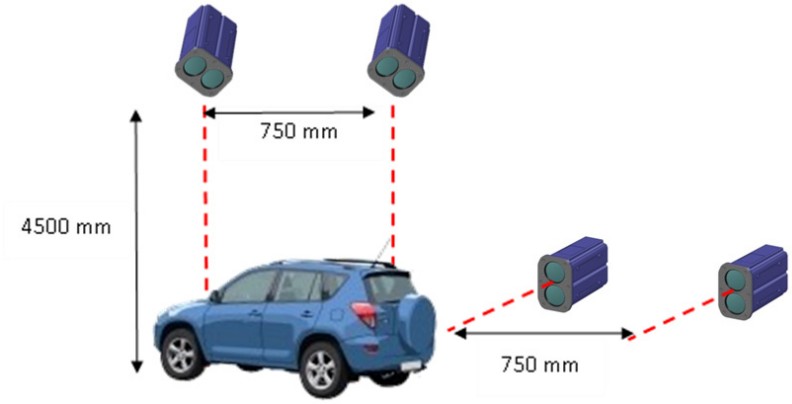
MM2, DM2 may be used for precise alignment for applications not using beam expanding optics as in an axle count configuration. -'Place a reflector at the target height and scan the sensor in the x and y direction noting the maximum signal strength of each pass-this is the center of your beam location. For best results, ensure the sensors are level and square with the target, in this case the reflector.

Averaging Mode (MM2, DM2)

For unique incident angles in other applications, it may be necessary to find the precise location of the beam. You can use a field reflector and MM2 DM2 which outputs the signal strength to locate and center the beam on the reflector. Because it is difficult to locate a small reflector it is recommended that the user construct an array of reflectors or reflective strips approximately 30 cm in diameter and practice using the reflector at a short distance. You will observe a significant increase in signal strength when the sensor finds the reflector.

How do I setup the dual sensor?

For best performance and accuracy when using two sensors, mount them in parallel using the bubble indicator to level the sensors.



In this example, there is a 750 mm distance between the two sensors and a distance of 4500 mm from the sensor face plate to the pavement - input this information as:

$GE, (baseline between sensors),(baseline between beam on pavement),(height from pavement to sensor face)
$GE,750,750,4500

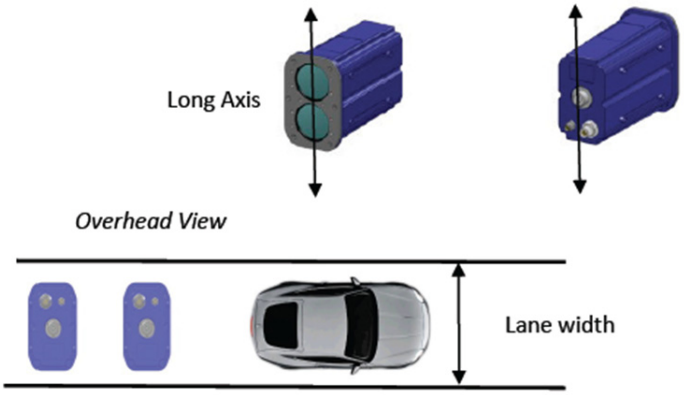
Note: For best speed accuracy, mount the sensors a minimum of 75 cm apart and both sensors must be tracking vehicle at same time - i.e., the sensors cannot be spaced a distance longer than the vehicle.

$TP = Trigger point for detection. This should be a distance at the low to midpoint of the vehicle. Whenever a vehicle enters and exceeds this distance, the sensor will begin to take measurements.

$FL = Serves the opposite, when the vehicle is no longer above this distance, the sensor will terminate taking measurements. This measurement is usually the same as $TP.

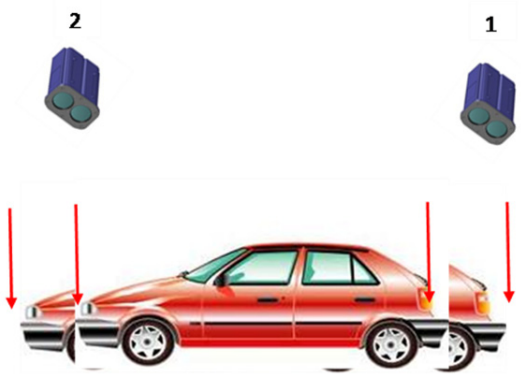
Look Down Configuration

For lookdown configuration center and square the sensor(s) to the traffic lane and center the bubble level to ensure the sensor(s) are level and perpendicular to the pavement. The beam center-to-center distance will then equal the sensors center-to-center distance. Align the long axis of the sensor(s) perpendicular to the lane width.



A vehicle passing under the dual sensor may speed up or slow down.

$SJ = Speed difference ratio during profile matching.
$SK = Maximum speed difference during profile matching.



In this example, the vehicle passes sensor 1 at 100 km/h and passes sensor 2 at 98 km/h.

The speed difference is 1-(98/100) = 2% and the speed difference is 2 km/h.

If the speed differences are greater than set values, the readings will be disregarded.

How do I determine the timing parameters for trailer suppression ($TL)?

This command should be used when you want to consider a tractor and trailer as one entity.

In this example we calculate the amount of time for the space between a tractor and trailer to pass a single point or a single sensor.

Metric:	Convert the speed to centimeters/second and the length to centimeters.
Imperial:	Convert the speed to inches/second and length to inches.

This example uses metric units:

$$Time = \frac{Length}{Speed}$$

Example:

- *Speed* = 89 km/h = 2472 cm/s
- *Length*= 1 meter = 100 cm
- *Time* = ?

$$Time = \frac{100\ cm}{2472\ {}^{cm}/_{sec}} = 0.04\ sec$$

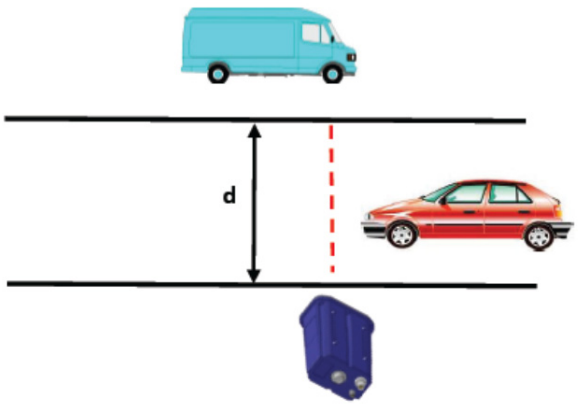
So in this example, our fastest time for the space between the trailer and tractor to pass by a sensor is 40 ms. So we will set trailer suppression as "$TL,0.04" and any trailer detected in 40 ms or faster (closer) behind a tractor will be considered one entity and the sensor will not detect a second vehicle.

Note: If you choose to ignore this command and consider all entities as separate vehicles, set trailer suppression as "$TL,0".

How do I set a long gate (virtual fence)?

The $OS command is used to set a long gate (virtual fence) - the sensor will ignore vehicles beyond the set distance.

The example below shows a side-fire installation where the distance (d) from the sensor's face plate to the end of the first lane is 5 meters. By entering "$OS, 500", only the red vehicle will be seen and the blue van will be ignored.



What is the user offset ($OF)?

If constraints require the sensors to be placed either if front of or behind a reference and it is required to measure the distance from this reference, the offset would add or subtract the distance from the sensor face plate to this reference.

Configuration Matrix

Notes:

- MM0: length and height measurements are not obtainable.
- MM4 and MM5: Output used for detection only. Disregard serial data.

		Measurement Mode (MM)					
		MM0	MM1	MM2	MM3	MM4	MM5
		Dual Sensor		Single Sensor		Single Sensor	
		Side Fire	Look Down	Look Down *or* Side Fire		Look Down	Side Fire
	Output	speed,tbc,length, height, profile	speed,tbc	averaging	median	detection	
Display Mode (DM) and Data Fields	DM1	$DL,<time between vehicles>*CRC16 $S1,<speed>,<speed unit>*CRC16		$A1,<distance>,<unit>*CRC16	$M1,<distance>, <unit>*CRC16	±-6VDC output on pin 4 of 12 pin connector	
	DM2	$DL,<time between vehicles>*CRC16 $S2,<speed>,<speed unit>, <length>,<height>, <unit for length and height>*CRC16		$A2,<distance>,<unit>, <signal strength>*CRC16	no output		
	DM3	$DL,<time between vehicles>*CRC16 $S3,<speed>,<speed unit>,<height>,< unit for height>*CRC16		$A3,<distance for T100>, <0>, <unit>,<number of valid samples in T100>,<0>*CRC16	no output		
	DM4	$FE,<time stamp at previous measurement>, <current time stamp>*CRC16 $FR,<time between vehicles>*CRC16 $S4,<speed>,<speed unit>,<error code>,<length>, <height>, <unit for length, height>,<profile number>,<profilewidth>, <profile>*CRC16		$A4,<distance>,<unit>, <number of valid samples> *CRC16	no output		
	DM6	$DL,<time between vehicles>*CRC16 $FR,<time between vehicles>*CRC16 $SP,<speed>,<speed unit>,<error code>,<length>,<height>, <unit for length, height>,<profile number>,<profile width>, <profile>*CRC16		$AV,<distance>,<unit>, <signal strength>, <number of valid samples>, <error code>*CRC16	$MD,<distance>, <unit>,<error code> *CRC16		

The chart above displays the measurement modes and the different display modes available. The measurement modes (MM) are displayed across the top. Select either Dual Sensor or Single Sensor, then select whether it is Look Down or Side Fire. The next row is Output. Reading across, it shows the type of data that will be displayed.

Examples: MM1, Dual Sensor, Look Down, would be "speed, tbc, length, height, profile".
MM3, Single Sensor, Look Down or Side Fire, it is either "averaging" or "median".

Next, read down the left column under Display Mode, (DM) and select DM1 through DM6, and then read across to see the data field that would be displayed.

Sample Output Matrix

Notes:

- MM0: length and height measurements are not obtainable.
- MM4 and MM5: Output used for detection only. Disregard serial data.

		Measurement Mode (MM)					
		MM0	MM1	MM2	MM3	MM4	MM5
		Dual Sensor		Single Sensor		Single Sensor	
		Side Fire	Look Down	Look Down *or* Side Fire		Look Down	Side Fire
	Output	speed,tbc,length, height, profile	speed,tbc	averaging	median	detection	
Display Mode (DM) and Data Fields	DM1	$DL,1487*EA86 $S1,120,K*C24D		$A1,1.73,M,4408.005* FD09	$M1,1.70,M, 4747.789*2B1E	±-6VDC output on pin 4 of 12 pin connector	
	DM2	$DL,1487*EA86 $S2,120,K,3.3,1.1,M*C24D		$A2,1.72,M,782, 4427.969*57B7	no output		
	DM3	$DL,0.02*1261 $S3,120,K,1.1,M*348F		$A3,1.72,0.00,M,1000,0,4 446.261*98D1	no output		
	DM4	$FE,103701128,103674094,4148.184*AF82 $FR,1.08,4148.303*E9FE $S4,117,0,0.8,M,100,0.010,7777888888888888888888888888 8888888888888888888887777000,4148.303*E7B8		$A4,1.72,M,1000, 4462.689*720B	no output		
	DM6	$DL,1.99*7927 $FR,1.99*0707 $SP,120,K,0,5.7,1.1,M,100,0.058,555777999aaaaaaaaaaaaa aaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaaa		$AV,1.71,M,782,1000,0,4 567.246*0945	$MD,1.70,M,0, 4717.255*3F80		

The chart above displays an example of the returned string for each measurement mode and display mode. The measurement modes (MM) are displayed across the top. Select either Dual Sensor or Single Sensor, then select whether it is Look Down or Side Fire. The next row is Output. Go to the selected output and read down to the chosen Display Mode (DM) to see the example of the returned string.

Command Set Quick Reference

Recommended Power Sequence when Configuring the Sensor:

Power up Sequence

- Connect power/communication cable to sensor.
- Enable power to sensor.
- Connect" HyperTerminal communication with sensor.
- Cycle power for the instrument to automatically start measuring with $MA,1 enabled.

NOTES

- Each command and reply starts with a '$' sign and ends with <CR><LF>.
- Default RS232 communication parameters: 115200 bps, no parity, 8 data bits, 1 stop bit, no flow control.
- Commands are not case sensitive, but the password is.
- No spacing between characters.
- Parameter changes must be followed with a sensor verification.
- All user entered distance and time units are in centimeters and seconds unless otherwise noted.

To Change Settings

- "$ST" to stop measurement.
- "$PW,admin".
- Make changes.
- "$SU" to save user settings.

Power down Sequence

- Disconnect the terminal emulation program or stop communication with the sensor.
- Disable power from the sensor.
- Disconnect power/communication cable from the sensor

Measurement Mode Command	Factory Default Values	Explanation
MM,0 (Dual Sensor Side-fire) *and* **MM,1** (Dual Sensor Look Down)		
$CT,*n*	25	*n* = Minimum number of valid returns to indicate a good reading. Min = 16 Max = 224
$FL,*n*	30	*n* = Trailing minimum height of the vehicle from the reference plane for triggering. Generally $FL = $TP. Min = 0 Max = 5500
$GE,*n1*,*n2*,*n3*	*n1* = 750 *n2* = 750 *n 3* = 5000 **units are millimeters*	*n1* = Distance between two mounted sensors center to center. *n2* = Distance between beams center to center at grade. *n3* = Height of the sensor from face plate to grade. If sensor is mounted level and square to grade, *n1* = *n2*. Min = 0 Max = 55000

$ML,*n*	300	*n*= Vehicle minimum length. Min = 10 Max = 2900
$MX,*n*	5	*n* = Maximum number of false pulses before a reading is ignored. Raise or lower this value depending on target integrity. Min = 0 Max = 32500
$OS,*n*	1100	*n* = Long gate distance (virtual fence) distance — any vehicles beyond this distance will be ignored. Min = 100 Max = 5500 Note: $MM,0 mode only (for firmware revision 1.10.15 and newer)
$OV,*n*	200	*n* = Maximum distance change in profile — any vehicle with a larger profile change than this will be ignored. $MM,0 mode only. Min = 50 Max = 2900
$PM,*n*	0	*n* = 0 = MM0,MM1,MM4, MM5 = GP_OUT will trigger low on target detection. *n* = 1 = MM0,MM1,MM4, MM5 = GP_OUT will trigger high on target detection.
$RW,*n*	0	*n* = 0 = Normal operation — pulse width information is used for measurement. *n* = 1 = Remove pulse width only if weak vehicles exists. $MM,1 mode only.
$SJ,*n*	100	*n* = Percentage speed difference of a vehicle passing through both sensors. Entered value is divided by 10, so if *n = 100,* the speed difference will be 10% This is an "AND" condition with "$SK". Min = 10 Max = 200
$SK,*n*	5	*n* = Maximum speed difference in mph or km/h. This is an "AND" condition with "$SJ" Min = 1 Max = 10
$TL,*n*	0.5	*n* = Time delay since last measurement. If a second vehicle is detected within *n* time after the preceding vehicle, this vehicle will be ignored. *n* = 0 to disable time between vehicles condition. Min = 0.01 Max = 85899
$TO,*n*	15	*n* = Vehicle timeout. This is the maximum time a vehicle may be stopped under the sensor — beyond this period, the reading will be ignored. Note: If an object exceeds $TO, the object is seen as a stopped vehicle and the speed calculation is ignored. Min = 1 Max = 10,800

$TP,*n*	30	*n* = leading minimum height of the vehicle from the reference plane for triggering Generally $TP = $FL. Min = 0 Max = 5500

Measurement Mode Command	Factory Default Values	Explanation
MM,2 (Averaging)		
$AB,*n*	50	*n* = Maximum distance allowed between data points overall. Min = 1 Max = 5500
$AM,*n*	1000	N = Longest reading to average. Min = 2 Max = 5500
$PO,*n*	100	N = Number of data points averaged for each reading. Increasing this value lowers output rate (output rate=25000/*n*) Min = 1 Max = 100000000
$RD,*n*	400	N = Target trigger distance. Min = 1 Max = 5500
$RL,*n*	2	*n* = 0 = Disable relay mode. *n* = 1 = MM2,MM3 Relay mode active if target is out of $RD distance. *n* = 2 = MM2,MM3 Relay mode active if target is inside of $RD distance.
$AB,*n*	50	*n* = Maximum distance allowed between data points overall. Min = 1 Max = 5500

Measurement Mode Command	Factory Default Values	Explanation
MM,3 (Median)		
$ME,*n*1,*n*2	*n*1 = 600 *n*2 = 1000	*n*1 = Minimum range for determining median. *n*2 = Maximum range for determining median. Setting these ranges minimize the amount of computation required to calculate the median. Min = 2 Max = 5500
$PO,*n*	100	*n*= Number of data points averaged for each reading. To slow output increase this value (this output will be 25000/n=output rate). Min = 1 Max = 100000000

$RD,*n*	400	*n* = Target trigger distance. Min = 1 Max = 5500
$RL,*n*	2	N = 0 = Disable relay mode. N = 1 = MM2,MM3 Relay mode active if target is out of $RD distance. N = 2 = MM2,MM3 Relay mode active if target is inside of $RD distance.

Measurement Mode Command	Factory Default Values	Explanation
MM,4 (Single Sensor Look Down Detection) *and* **MM,5** (Single Sensor Side-Fire Detection)		
$CT,*n*	25	*n* = Minimum number of valid returns to indicate a good reading. Min = 16 Max = 224
$FL,*n*	30	*n* = Trailing minimum height of the vehicle from the reference plane for triggering. Generally $FL = $TP. Min = 0 Max = 5500
$MT,*n*	0.10	N = Minimum time the vehicle must remain under the sensor in order to be detected. Vehicle under sensor time ≥ *n* for accepted detection. Set to 0 to ignore command. Min = 0 Max = 85899
$MX,*n*	5	*n* = Maximum number of false pulses before a reading is ignored. Raise or lower this value depending on target integrity. Min = 0 Max = 32500
$OS,*n*	1100	*n* = Long gate (virtual fence) distance — any vehicles beyond this distance will be ignored. Min = 100 Max = 5500 Note: $MM,0 mode only (for firmware revision 1.10.15 and newer)
$OV,*n*	200	*n* = Maximum distance change in profile — any vehicle with a larger profile change than this will be ignored. Min = 50 Max = 2900 Note: $MM,5 mode only.
$PM,*n*	0	*n* = 0 = MM0,MM1,MM4, MM5 = GP_OUT will trigger low on target detection. *n* = 1 = MM0,MM1,MM4, MM5 = GP_OUT will trigger high on target detection.
$RW,*n*	0	*n* = 0 = Normal operation — pulse width information is used for measurement. *n* = 1 = Remove pulse width only if weak vehicles exists. $MM,4 mode only.

$TL,*n*	0.5	*n* = Time delay since last measurement. If a second vehicle is detected within *n* time after the preceding vehicle, this vehicle will be ignored. *n* = 0 to disable time between vehicles condition. Min = 0.01 Max = 85899
$TP,*n*	30	*n* = Leading minimum height of the vehicle from the reference plane for triggering. Generally $TP = $FL. Min = 0 Max = 5500

Measurement Mode Command	Factory Default Values	Explanation
All MM — Sensor ID Status and Password		
$CL,*n*	n/a	*n* = Enter error code to define.
$ID	n/a	Display version and model number.
$IS	n/a	Show current instrument status.
$OZ	n/a	Show current temperature.
$PS,*x*	n/a	Change password to *x.* Where *x* represents another password of your choice. Use this sequence to change the password: "$PW,admin" "$PS,*new password*" "$PS,*new password*" "$SU" or "$PD" (Both "$SU" and "$PD" will save changes) Verify new password by typing "PW,*new password*". The sensor will respond with "OK".
$PW,x	admin	Default factory password is "admin". Password must be entered to change settings.
$SN	n/a	Display unit serial number.

Measurement Mode Command	Factory Default Values	Explanation
All MM — Setup and Control		
$BA,*n*	115200 from factory $FD will not reset user setting will remain	Baud rate for main serial port RS232. Min = 9600 Max = 230400
$BR,*n*	115200	Baud rate for auxiliary serial port RS485/422.
$BS,*n*	1	*n* = 0 = No beam expanding optics. *n* = 1 = Beam expanding optics.

$DB,*n*	1	Display banner when unit is powered on. *n* = 0 To disable. *n* = 1 To enable.
$DE,*n*	0	Define error code in data field. *n* = 0 To disable. *n*= 1 To enable.
$DM,*n*	3	D = Display mode.
$DT,*n*	0	Display time since power on. *n* = 0 To disable. *n* = 1 To enable.
$FD	n/a	Factory default reset.
$GO	n/a	Start measurement. $GO measures with the previous setting. For example, if $GO,0 is entered, all successive $GO commands will be $GO,0.
$GO,*n*	0	*n* = 0 = Continuous measurement. *n* = 1 and above = Limits the measurement iterations to this value.
$MA,*n*	1	Automatically begin measuring on power up. *n* = 0 To disable. *n* = 1 To enable.
$MM,*n*	2	n=measurement mode
$MU,*n*	0 from factory $FD will not reset user setting will remain	Measurement units. *n* = 0 = speed = km/h, distance = meter. *n* = 1 = speed = mph, distance = meter. *n* = 2 = speed = km/h, distance = feet. *n* = 3 = speed = mph, distance = feet.
$OF,*n*	0 from factory. $FD will not reset, user setting will remain	*n* = Fixed offset can be either positive or negative.
$PD	n/a	Power down and restart unit using the new settings. Also referred to as sensor soft reboot.
$SM,*n*	0 from factory $FD will not reset user setting will remain	RS485 data set *n* = 0 To disable RS485/422. *n* = 1 for RS232 copy mode where RS485/422 is same as RS232 output (RS485 baud rate must be equal to or higher than RS232). *n* = 2 = Binary out where erroneous readings = 0. *n* = 3 = Binary out where erroneous readings are output. *n* = 4 = Binary speed only out. RS485 maximum output rate *n* = 0 = 0 Hz *n* = 1 = 500 Hz *n* = 2 = 18 kHz *n* = 3 = 18 kHz *n* = 4 = 30 kHz
$ST	n/a	Stop measurement.
$SU	n/a	Save settings.

$TE,*n*	1	RS485 Option. *n* = 0 = Disable RS485. *n* = 1 = Enable RS485.
$TG,*n*	0	External trigger mode. *n* = 0 To disable. *n* = 1 To enable. $GO and $ST will conflict if external trigger is enabled.
$WU,*n*	5	Initial sensor warm-up period. N = 0 To disable. N = 1 To 99 To enable and set warm up period. Min = 1 Max = 99

Error Codes

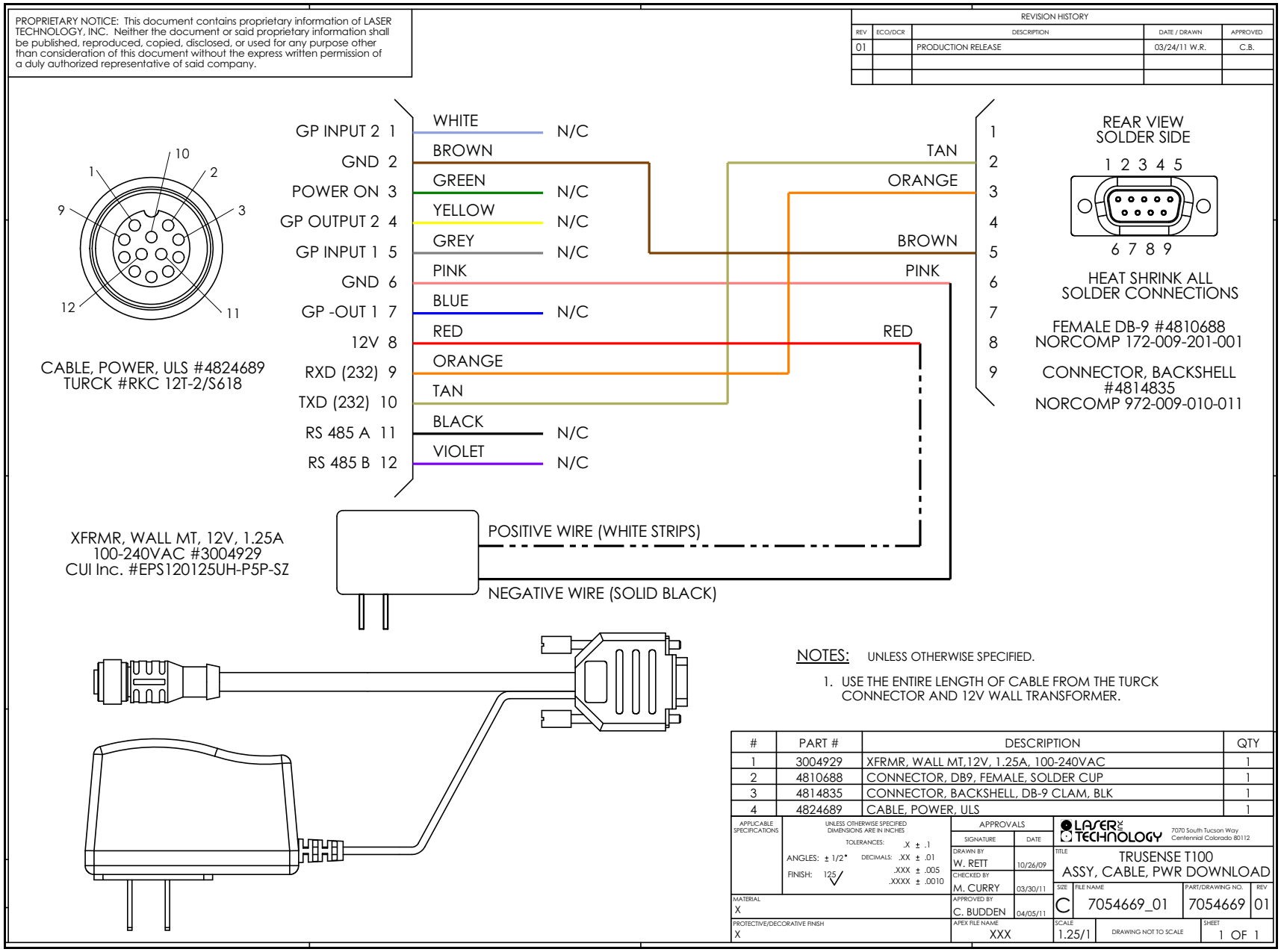
Error Codes	Description
0	Good. No error.
01	No target found.
02	Insufficient data.
07	Jam detected. Light interference. Normally, old fashion jammer, sunshine, lamp, etc.
12	Too fast speed (factory setting is 322km/h)
14	Speed calculation error (Timing violation), No output
15	Speed calculation error (profile mismatch), Refer $SK and $SJ
16	Timeout (too long vehicle or too slow movement), Refer to $TO
17	Small object, Refer $ML
18	Speed calculation error (Too much noise), No output
20	Undefined command.
21	Profile error, NOTE: Refer $OV in Roadside (mode 0)
24	Incorrect password.
25	Authorization required. The attempted command requires the user password be active.
36	Failed execution. Laser may be active, issue $ST command and then retry the failed command.
52	Temperature is cold (-25° Celsius). Allow unit to warm up by firing for 30 to 60 seconds.
53	Temperature is too hot (70° Celsius). Stop operation.
56	SPAN Error. It gives up to 75 cm error. Discard it if 75cm error is critical.
58	ADC Error. It gives up to 5 cm error. Discard it if 5 cm error is critical. NOTE: If it persists, call LTI for service.
59	RX_CAL Error. It gives up to 5 cm error. Discard it if 5cm error is critical.
63 to 67	Memory Error. Call LTI for service.
68	High voltage error: RX or TX boards may be wrong.
71	If this error persists, call LTI for service.
All Others	Non-critical errors.
NOTE: If critical errors happen more than 5 times, the T100 will re-boot automatically. Therefore, if unit reboots periodically, contact LTI for service.	

Specifications

Min range	1.5 ft (0.46 m)
Max range (reflective/non-reflective)	25 kHz version:165 ft (50 m) 4kHz version: 650 ft (200m)
Accuracy	profile=3.9 in (10cm) speed=2% w/ 29.5 in (75 cm) spacing in dual mode (larger spacing increases speed accuracy)
Resolution	0.01 ft (0.01 m)
Pulse repetition frequency	25 kHz or 4kHz depending on model
Data output rate	25 kHz version: RS232 = 500Hz, RS485 = 25 kHz 4kHz version: RS232 = 500Hz, RS485 = 4kHz
Target modes	Depending if side-fire or overhead installation: profile, speed (dual sensor), time between cars (tbc), height, length, distance
Self check	on boot up and during operation
Timing	from shutdown to ready = 60sec
Wavelength	905 nm (near IR)
Divergence (without beam expanding optics)	3 mrad (equal to 1 ft beam diameter @ 328 ft or 30 cm @ 100 m)
Free aperture	1.7 in (43 mm)
Cordset	
12 pin	F gender, straight, shielded, 12 pin, Turck Eurofast RKC 12T-*/S618 (*=cable length)
6 pin	F gender, straight, shielded, 6 pin, Turck Picofast PKG 6M-*/S90/S618 (*=cable length)
I/O	
12 pin	pin 1=RS232 aux A in, pin 2=gnd, pin 3=power on, pin 4=RS232 aux A out, pin 5= RS232 aux B in, pin 6=gnd, pin 7=RS232 aux B out, pin 8=power in, pin 9=RS232 Rx, pin 10=RS232 Tx, pin 11=RS 485 A, pin 12=RS 485 B
6 pin (for dual sensors)	pin1=RS232 Tx, pin 2=external flash, pin 3=RS232 Rx, pin 4=gnd, pin 5=external flash, pin 6=power in
Baud rate min / max	9600 / 230400
Input power	12-24 VDC (12 VDC recommended)
Current draw	150 mA (@12 VDC)

Dimensions (L x W x H)	6.8 in x 2.9 in x 4.5 in (17.2 cm x 7.4 cm x 11.4 cm)
Housing/chassis material type	glass filled polycarbonate
Weight1	8.2 oz (517.10 g)
Eye Safety	Class 1, 7mm (FDA, CFR21) Class 1m (IEC 60825-1:2001)
Shock/Vibration	MIL-STD-810E
Moisture	IP67, NEMA 6
Operating temperature	-20° to 140° F (-28° to 60° C)

Diagrams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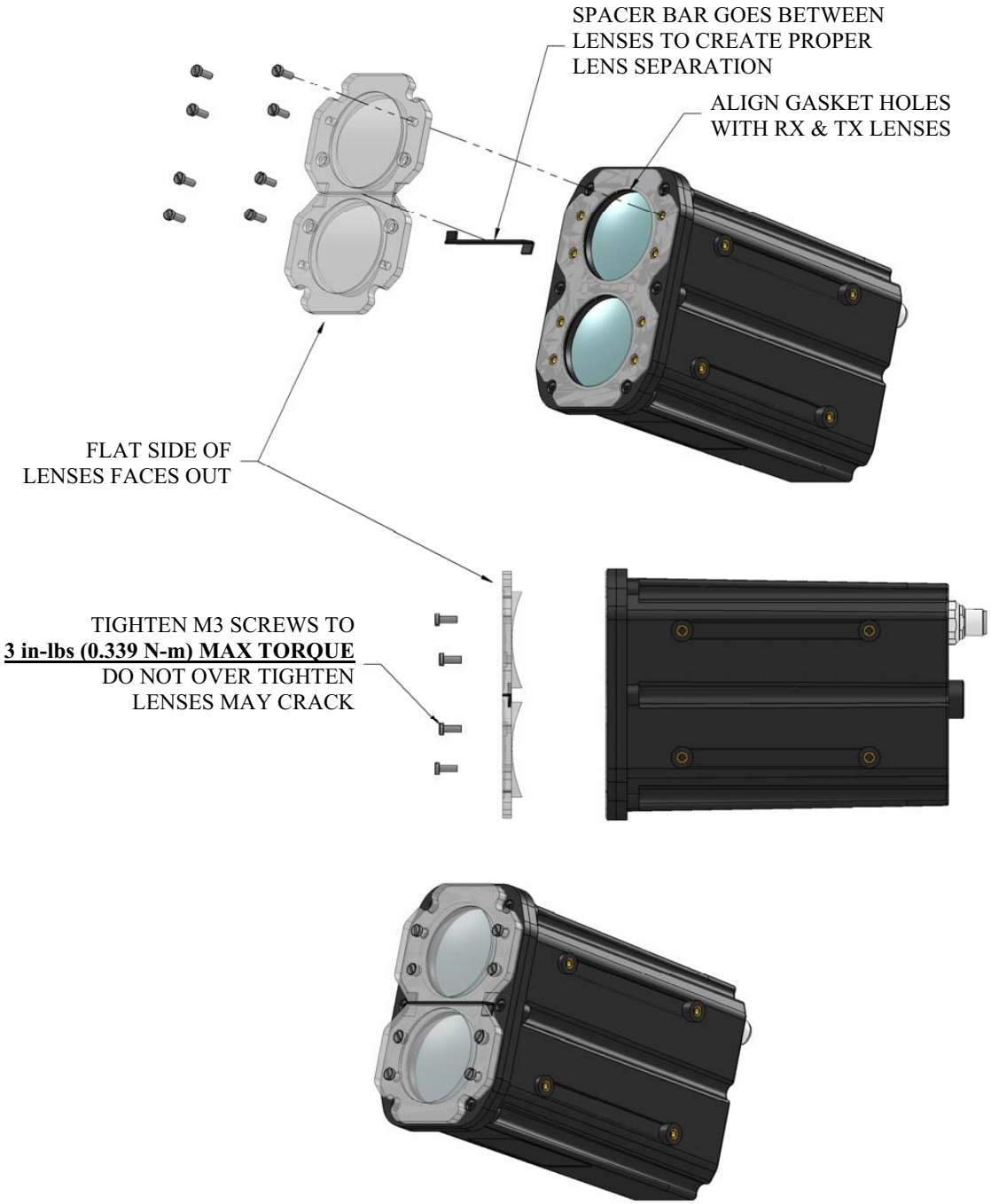
REVISION HISTORY
REV | ECO/DCR | DESCRIPTION | DATE / DRAWN | APPROVED
01 | | PRODUCTION RELEASE | 03/24/11 W.R. | C.B.
GP INPUT 2 1 WHITE N/C
GND 2 BROWN
POWER ON 3 GREEN N/C
GP OUTPUT 2 4 YELLOW N/C
GP INPUT 1 5 GREY N/C
GND 6 PINK
GP -OUT 1 7 BLUE N/C
12V 8 RED
RXD (232) 9 ORANGE
TXD (232) 10 TAN
RS 485 A 11 BLACK N/C
RS 485 B 12 VIOLET N/C
TAN
ORANGE
BROWN
PINK
RED
1 2 3 4 5 6 7 8 9
REAR VIEW
SOLDER SIDE
1 2 3 4 5
6 7 8 9
HEAT SHRINK ALL
SOLDER CONNECTIONS
FEMALE DB-9 #4810688
NORCOMP 172-009-201-001
CONNECTOR, BACKSHELL
#4814835
NORCOMP 972-009-010-011
CABLE, POWER, ULS #4824689
TURCK #RKC 12T-2/S618
XFRMR, WALL MT, 12V, 1.25A
100-240VAC #3004929
CUI Inc. #EPS120125UH-P5P-SZ
POSITIVE WIRE (WHITE STRIPS)
NEGATIVE WIRE (SOLID BLACK)
NOTES: UNLESS OTHERWISE SPECIFIED.
1. USE THE ENTIRE LENGTH OF CABLE FROM THE TURCK CONNECTOR AND 12V WALL TRANSFORMER.
| PART # | DESCRIPTION | QTY
1 | 3004929 | XFRMR, WALL MT,12V, 1.25A, 100-240VAC | 1
2 | 4810688 | CONNECTOR, DB9, FEMALE, SOLDER CUP | 1
3 | 4814835 | CONNECTOR, BACKSHELL, DB-9 CLAM, BLK | 1
4 | 4824689 | CABLE, POWER, ULS | 1
APPLICABLE SPECIFICATIONS
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES: ± 1/2° FINISH: 125 DECIMALS: .X ± .1 .XX ± .01 .XXX ± .005 .XXXX ± .0010
APPROVALS
SIGNATURE DATE
DRAWN BY W. RETT 10/26/09
CHECKED BY M. CURRY 03/30/11
APPROVED BY C. BUDDEN 04/05/11
APEX FILE NAME XXX
MATERIAL X
PROTECTIVE/DECORATIVE FINISH X
LASER TECHNOLOGY 7070 South Tucson Way Centennial Colorado 80112
TITLE
TRUSENSE T100
ASSY, CABLE, PWR DOWNLOAD
SIZE C
FILE NAME 7054669_01
PART/DRAWING NO. 7054669
REV 01
SCALE 1.25/1
DRAWING NOT TO SCALE
SHEET 1 OF 1

LASER TECHNOLOGY INC
Measurably Superior

ISO 9001 CERTIFIED QUALITY SYSTEM

ATTACHING BEAM SPREADING OPTICS TO THE LASER

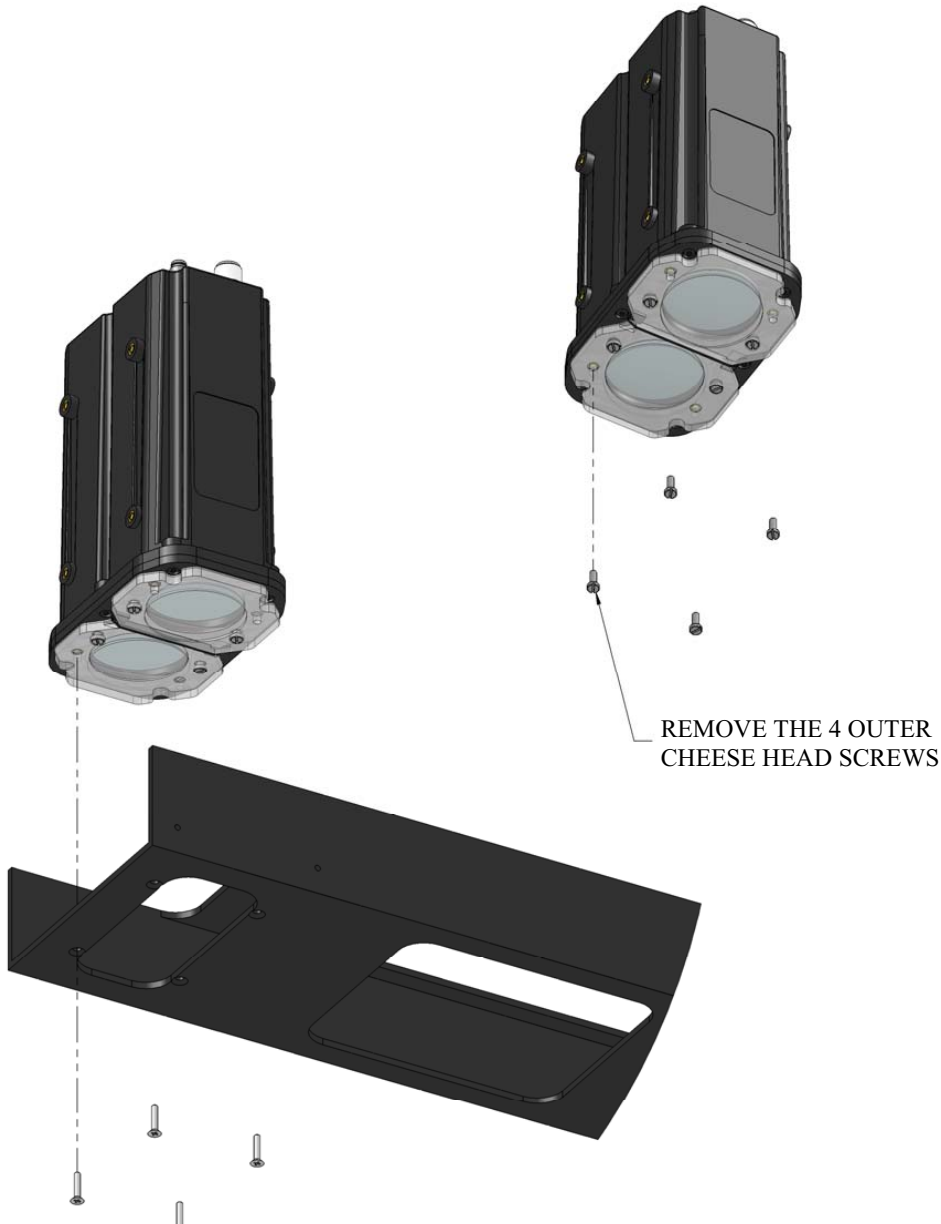


7070 S. Tucson Way, Centennial, CO 80112 USA / Phone: 1 (303) 649-1000 / Fax: 1 (303) 649-9710 / www.lasertech.com

LASER TECHNOLOGY INC
Measurably Superior

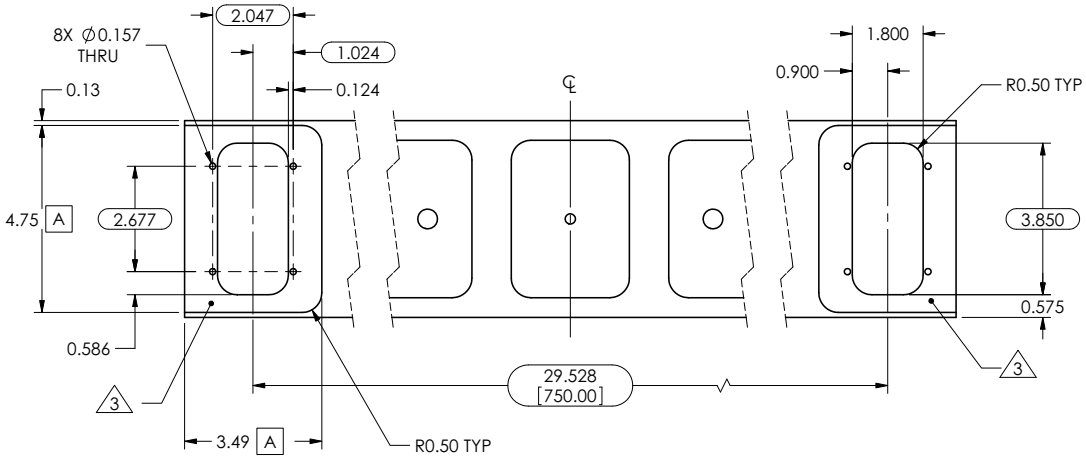
ISO 9001 CERTIFIED QUALITY SYSTEM

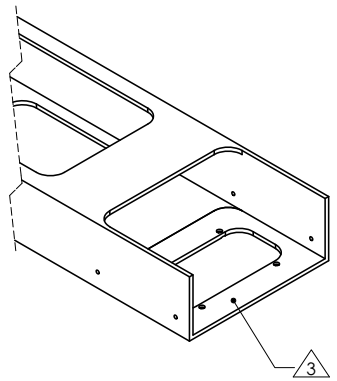
ATTACHING THE LASER WITH BEAM SPREADING OPTICS TO THE BRACKET

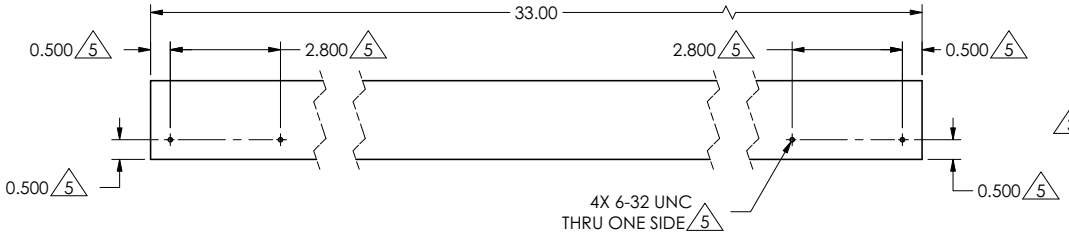


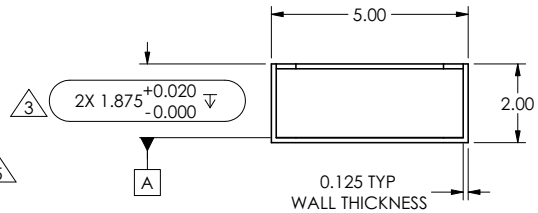
7070 S. Tucson Way, Centennial, CO 80112 USA / Phone: 1 (303) 649-1000 / Fax: 1 (303) 649-9710 / www.lasertech.com

REVISION HISTORY				
REV	ECO/DCR	DESCRIPTION	DATE / DRAWN	APPROVED
01		PRODUCTION RELEASE	03/30/11 W.R.	C.B.









NOTES: UNLESS OTHERWISE SPECIFIED.

INDICATES INSPECTION DIMENSION

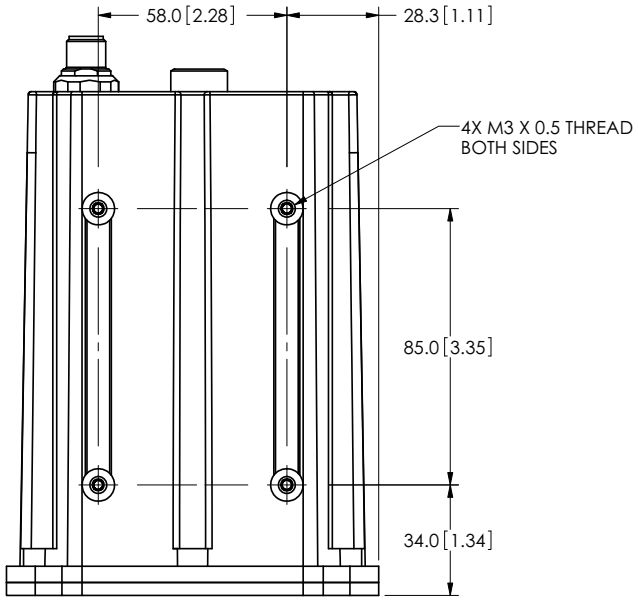
1. DIMENSIONS TYPICAL BOTH SIDES.
2. DIMENSIONS IN [ ] ARE MILLIMETERS.
3. MACHINE FLAT MOUNTING SURFACES ON THE BOTTOM INNER FACE
4. FINISH: BRUSH OUTSIDE SURFACES & BLACK ANODIZE

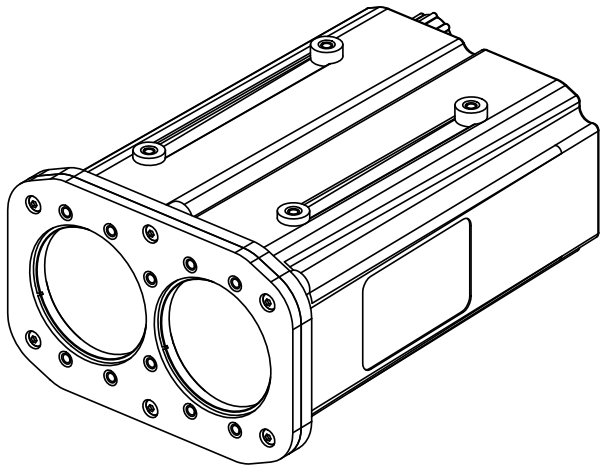
5 DIMENSIONS TYPICAL BOTH SIDES

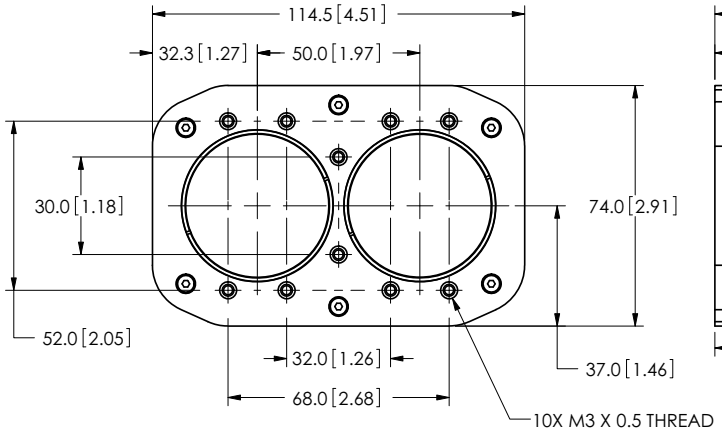
APPLICABLE SPECIFICATIONS	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: .X ± ANGLES: ± 1/2° DECIMALS: .XX ± .010 .XXX ± .005 FINISH: 125 .XXXX ±	APPROVALS SIGNATURE / DATE	LASER TECHNOLOGY 7070 South Tucson Way Centennial Colorado 80112
		DRAWN BY W. RETT 3/24/09	TITLE: T100/T200 BRACKET, CENTER, 750mm
		CHECKED BY M. CURRY 03/30/11	SIZE C · FILE NAME 1154815_01 · PART/DRAWING NO. 1154815 · REV 01
MATERIAL: ALUMINUM RECTANGULAR TUBE		APPROVED BY C. BUDDEN 04/05/11	
PROTECTIVE/DECORATIVE FINISH: SEE NOTES — SEE LTI SURFACE STANDARDS 0430001		APEX FILE NAME XXX	SCALE 1/2 · DRAWING NOT TO SCALE · SHEET 1 OF 2

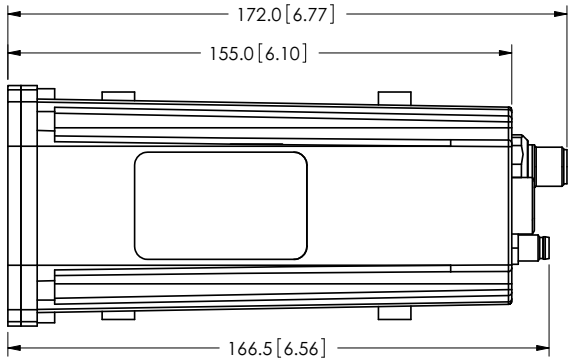
PART/DRAWING NO. 1154815 · SHEET 1 OF C · REV 01

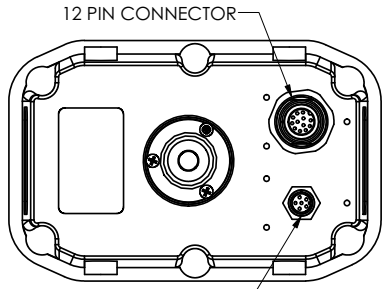
REVISION HISTORY				
REV	ECO/DCR	DESCRIPTION	DATE / DRAWN	APPROVED
A		CREATED DRAWING	10/21/08 W.R.	
B		UPDATED DRAWING TO CURRENT DESIGN	02/27/09 W.R.	
C		CHANGED SCALE FROM 1/1.25 TO 1/1	12/15/09 W.R.	











NOTES: UNLESS OTHERWISE SPECIFIED.

1. DIMENSIONS ARE IN MILLIMETERS AND [INCHES].

APPLICABLE SPECIFICATIONS	UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: .X ± .1 ANGLES: ± 1/2° DECIMALS: .XX ± .01 .XXX ± .005 FINISH: 125 .XXXX ± .0010	APPROVALS SIGNATURE / DATE DRAWN BY: W. RETT 10/21/08 CHECKED BY	LASER TECHNOLOGY 7070 South Tucson Way Centennial Colorado 80112 TITLE: T100 DIMENSIONS AND PIN OUT
MATERIAL: X		APPROVED BY	SIZE: C FILE NAME: XXXXXXX PART/DRAWING NO.: XXXXXXX REV: C
PROTECTIVE/DECORATIVE FINISH: X		APEX FILE NAME: XXX	SCALE: 1/1 DRAWING NOT TO SCALE SHEET: 1 OF 1