



ILR Laser

Technical Operations Manual



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For ACCL-LAS-24V-01
and ACCL-LAS-120V-01

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Table of Contents

Important Notice	i
Section 1.0: Introduction	2
Section 2.0: Quick Start Guide	3
2.1 Software Interface:	3
2.2 Connecting the Accutron Industrial Laser Rangefinder to the PC:	3
Section 3.0: ILR Interface Advanced Description	6
3.1 ILR Control Buttons and Display:	6
3.2 Basic Setup:	8
3.3 Output Processing:.....	9
3.4 Measurement Mode:	11
3.5 Averaging Parameters:.....	12
3.6 Binning Parameters:.....	14
Section 4.0: Measurement Modes.....	16
4.1 Advantages and Disadvantages:	16
4.2 Laser Rangefinder Processing Structure	17
Section 5.0: Detailed Mode Applications.....	18
5.1 Averaging Mode Applications	18
5.2 Averaging Mode: Measuring Through Windows	18
5.3 Averaging Mode: Using Cooperative Targets	19
5.4 Averaging Mode: Limiting Parallax Effects.....	19
5.5 Averaging Mode: Accuracy vs. Data Rate	19
5.6 Averaging Mode: Using Dithering	20
5.7 Averaging Mode: Possible Setups	21
5.8 Last Target Mode Applications	21
5.9 Using Successive Gating	22
5.10 Last Target Mode: Measuring Through Windows	22
5.11 Last Target Mode: Using Cooperative Targets.....	22
5.12 Binning Mode Applications	22
5.13 Binning Mode: Using Proper Binning Parameters	23
5.14 Binning Mode: Selecting Targets	24
5.15 Binning Mode: Using Gates.....	24

5.16 Binning Mode: Possible Setups	24
5.17 Detection Mode Applications	25
5.18 Relative Detection Mode	25
5.19 Measuring Speed	26
5.20 Other Parameters	26
5.21 Absolute Detection Mode	27
5.22 Detection Mode: Relative Operation	27
5.23 Detection Mode: Absolute Operation	28
Section 6.0: 4-20 mA Analog Output Mode	30
6.1 Configuring Current Loop:	30
6.2 Calibrating the Current Loop:	31
Section 8.0: Specifications	32
8.1 Averaging Mode Specifications	33
8.2 Last Target Mode Specifications	34
8.3 Binning Mode Specifications	35
8.4 Accutron Laser Rangefinder Mounting Bracket	37
8.5 Accutron Laser Rangefinder Housing Dimensions	38
8.6 Accutron Laser Rangefinder General Layout	39
8.7 Connections Diagram – ACCL-LAS-24V-01	40
8.8 Connections Diagram – ACCL-LAS-120V-01	41
Section 9.0: Error Numbers	42
9.1 Interrupt Error Numbers	44
9.2 Table Checksum Error Numbers	44
9.3 4-20 Error Numbers	45

Safety Precautions

Visible Laser Pointer:

- Do not stare directly into the visible laser beam.
- The laser pointer's visible laser is not considered FDA (CFR21) Class I eye safe. It is Class II. Care should be taken when using any laser pointing device. We recommend only using the laser pointer for alignment during installation. It is not recommended to use the laser pointer during normal operation.

Pulsed Laser:

- Avoid staring directly at the laser beam for prolonged periods. The laser is 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.

Section 1.0: Introduction

The Accutron Industrial Laser Rangefinder is a user-configurable product, which allows you to adjust settings in order to optimize measurement performance in a variety of applications. The primary tool for controlling the operation of the Accutron Industrial Laser Rangefinder is the ILR Interface Program. This configuration software allows you to modify key operating parameters to best suit your individual application. After defining a given configuration, you can use the Interface Program to store the specific operating parameters in the laser's internal memory. This will allow the Laser Rangefinder to use the same settings each time it is powered on.

The Accutron Laser Rangefinder has four primary measurement modes:

- **Averaging Mode:** the laser takes a specified number of individual distance measurements and averages them into a single output result.
 - Key Benefits:
 - Provides the highest accuracy possible.
 - Provides the highest data rate possible.
 - Offers an adjustable return shot criteria.
- **Last Target Mode:** This mode has the same speed as Averaging Mode, but can penetrate more airborne particulates, such as dust or fog. A high-speed option is available in this mode that offers good performance in the presence of moderate particulates. There is also a successive gating option that dynamically eliminates known targets to find the last target available.
 - Key Benefits:
 - Best in airborne particulate penetration.
 - Automatic intermediate target discrimination.
- **Binning Mode:** Sends out individual laser pulses and places the pulse returns in fixed increments of flight time. When several pulses end up in a given time bin, the ULS determines that there is a target present. Increasing the bin size will increase the maximum acquisition distance, whereas decreasing it will improve measurement resolution and accuracy.
 - Key Benefits:
 - Enhanced measurement range capability.
 - Dynamically tracks multiple targets.
 - Adjustable target definition criteria.
- **Detection Mode:** This mode analyzes distance data on a pulse-to-pulse basis, providing the fastest possible response by minimizing timing latency for object presence detection. Distance data is not generated, but instead outputs a 'trip' signal that signifies object presence at a user-defined distance. A signal can also be sent when a minimum or maximum change in distance is detected.
 - Key Benefits:
 - Ultra quick detection with precision timing signals
 - 2 modes: One looks for a change in distance, the other looks for an object inside a desired range.

The Accutron Industrial Laser Rangefinder is configured via an RS232 configuration port. The configuration port provides input and output communications, allowing for sensor setup via the ILR Interface Program.

Section 2.0: Quick Start Guide

2.1 Software Interface:

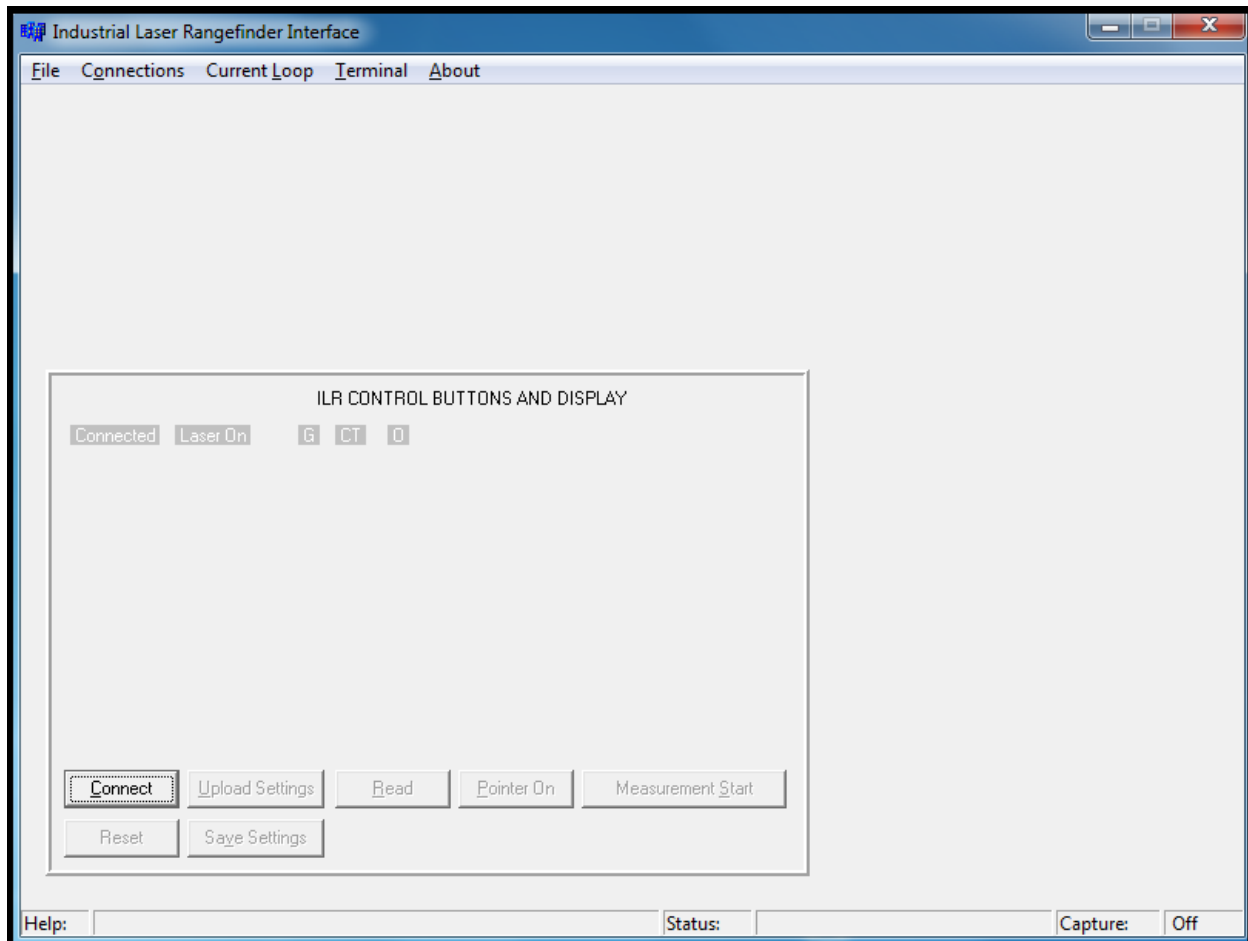
The Accutron Industrial Laser Rangefinder interface program is supplied on a USB flash drive. To install the program, insert the USB into the computer. Navigate to the LASER_Interface_Setup.exe file. An ILR Interface icon will be added to the computer's desktop during the installation process.

Note: ILR Software operates on Windows: XP, Vista, 7, 8, 10

2.2 Connecting the Accutron Industrial Laser Rangefinder to the PC:

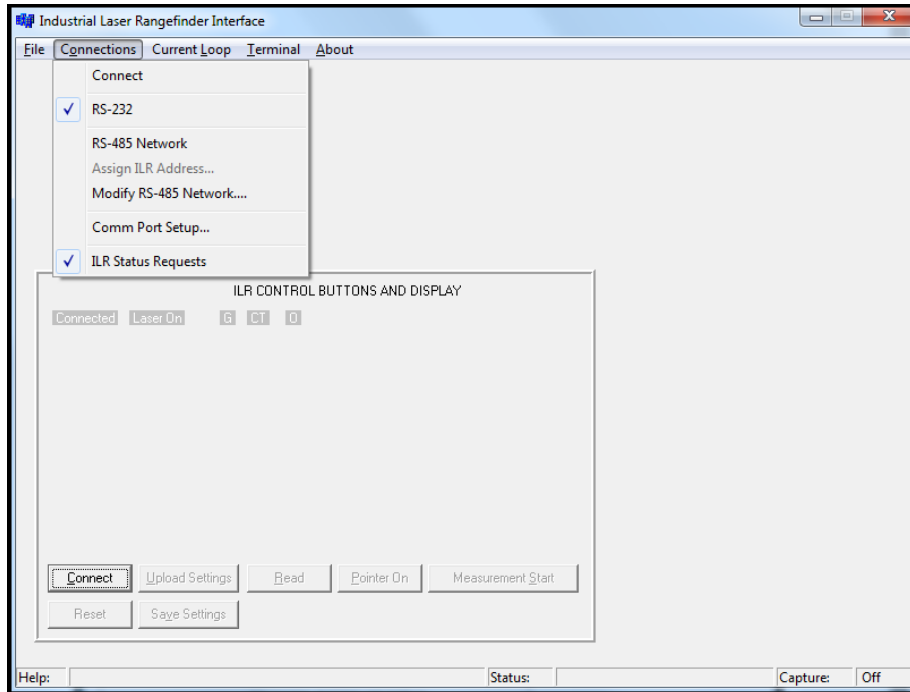
- Ensure the Laser Rangefinder is powered.
- Connect the Configuration Cable from the Laser Rangefinder, to that of the PC or adapter connecting to the PC (Cable supplied by Accutron).
- Open the ILR Software Interface (supplied on the USB).
- Once the Software Interface is open Figure 2.0 will be displayed.

Figure 2.0



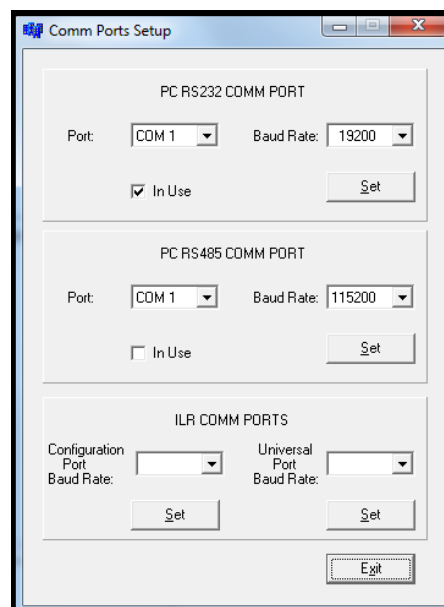
- For the PC to communicate with the Laser Rangefinder, select the Connections menu in the top left-hand corner of the interface.
- Once the connections menu is selected Figure 2.1 will be displayed.

Figure 2.1



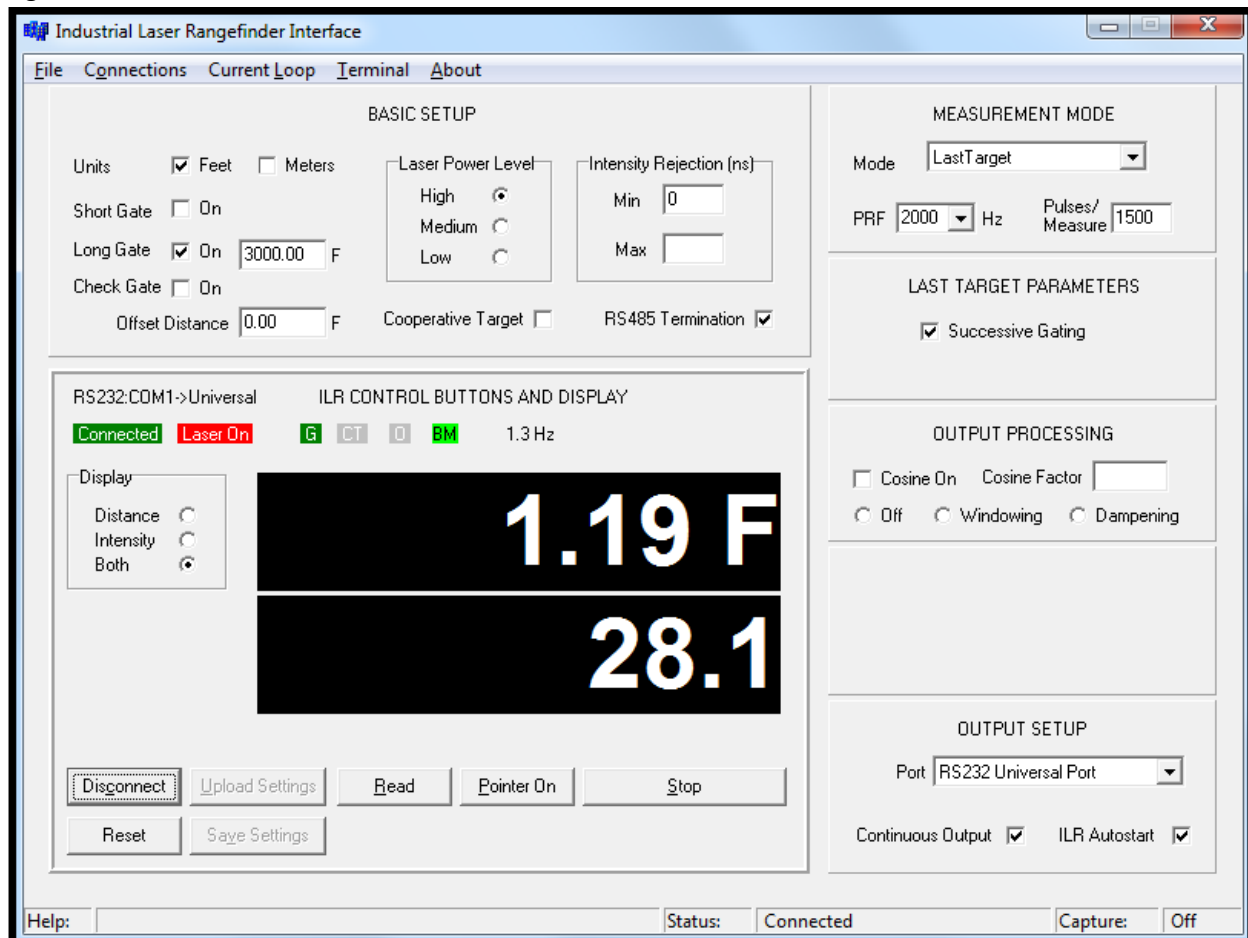
- In the drop-down menu shown in figure 2.1 select the **Comm Port Setup...**
- Once selected Figure 2.2 will be displayed

Figure 2.2



- Depending on the PC the Port: COM will have to be selected and changed.
- The Laser operates at a default Baud Rate of 19200, this can be changed.
- Once both the Port and Baud Rate are set to the proper settings press the Set Button below to set your values entered.
- To exit this menu and return to the ILR Software Interface, press the Exit button located at the bottom of the menu.
- Once back at the ILR Software Interface (Figure 2.1) press the Connect Button located in the bottom left-hand corner of the screen.
- Figure 2.3 will now be displayed.

Figure 2.3



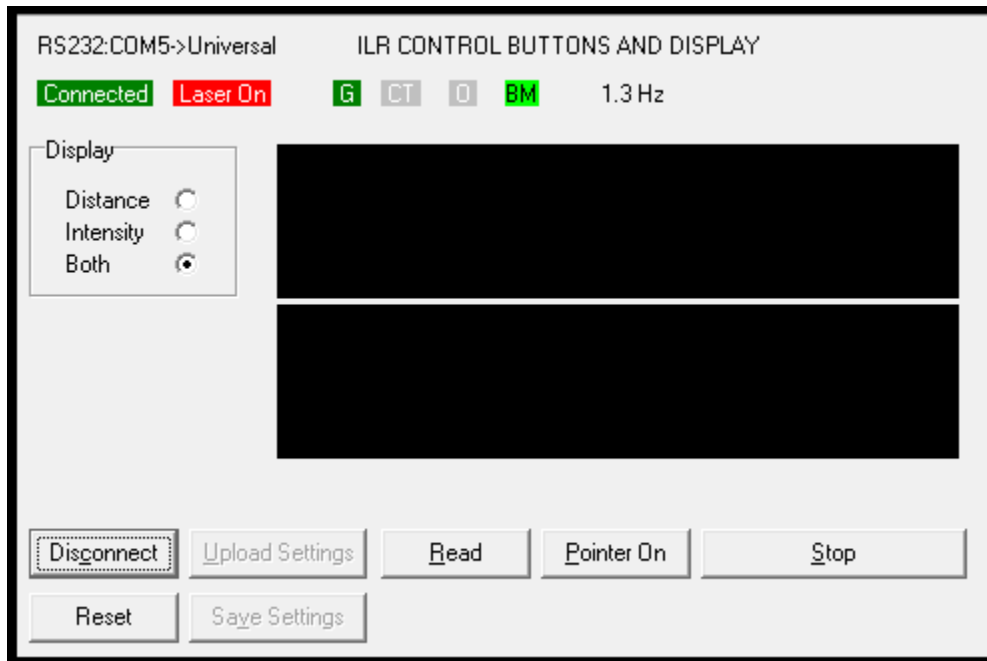
- The Laser Rangefinders measurements will now be displayed.

Section 3.0: ILR Interface Advanced Description

3.1 ILR Control Buttons and Display:

The following sections will go into detail about the various sections located on the Software Interface and how to use the various sections to setup the Laser Rangefinder for proper working conditions.

Figure 3.0



System Configuration: Data output format and selected ILR output data are displayed in the upper left corner. In this example the configuration is displayed as RS232:COM5.

Measurement Output Rate: Value expressed in Hz. In this example, the measurement output rate = 2.0 Hz.

Connect: Activates the communication between the computer and the Laser Rangefinder.

Disconnect: Terminates the communication between the computer and the Laser Rangefinder. As an alternative to this button, you may select Connections menu > Disconnect.

Upload Settings: This button is highlighted when any parameter in the ILR interface program is changed. The highlighting signifies that changed settings need to be uploaded to the Laser Rangefinder. Once the settings have been uploaded, this button will no longer be highlighted. The Laser Rangefinder uses the uploaded settings until additional changes are uploaded or the unit is powered OFF. A warning message will be displayed if you attempt to exit the interface program without saving the current settings.

Note: Once all pending settings have been uploaded, the Save Settings button will be highlighted to indicate that the Laser Rangefinder has new settings that have not been saved. This allows the user to run the Laser Rangefinder with new settings without saving them permanently. Once the changed settings have been verified to the user's satisfaction, press the Save Settings button to permanently save these changes.

Save Settings: After settings have been uploaded, the Save Settings command stores the settings in non-volatile memory. If the unit is powered OFF, stored settings will be used the next time the unit is powered ON.

Pointer On/Off: Toggles the laser pointer on and off. We recommend using the pointer for alignment during setup and installation only and turning it off during regular use.

Caution: This visible laser is not considered Class I eye safe. It is Class II_m. Care should be taken when using any laser pointing device. Do not stare directly into the visible laser beam.

Measurement Start/Stop: Starts or stops the Laser Rangefinder measurements.

Single Measurement: Available when the Continuous Output option is off. The ILR interface program downloads and displays the most recent measurement.

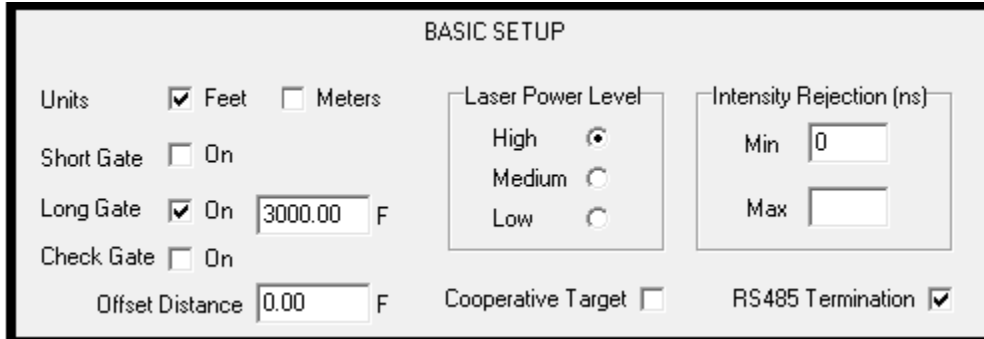
Display/Target Selection: Depending upon the measurement mode, this parameter affects the information displayed in the black measurement window and the serial output data string. In Averaging and Last Target Mode, the user has the option to display the measurement only, the signal intensity only or both. In Binning Mode, the number of targets detected appears to the left of the display box. In Detection Mode the on/off condition of the trip signal (i.e., target detected or not) is displayed.

Icons: Displayed above the black measurement window, show measurements and the main parameters.

- **Connected:** The Laser Rangefinder is connected to the PC.
- **Laser On:** The Laser Rangefinder is firing.
- **G:** Gates are set.
- **CT:** Cooperative Target is set.
- **O:** An Offset value is being applied to measurements.
- **BM:** Basic Measurement, the Laser Rangefinder is producing valid measurements more than once every two seconds.

3.2 Basic Setup:

Figure 3.1



The screenshot shows the 'BASIC SETUP' menu with the following settings:

- Units: Feet, Meters
- Short Gate: On
- Long Gate: On, 3000.00 F
- Check Gate: On
- Offset Distance: 0.00 F
- Laser Power Level: High , Medium , Low
- Intensity Rejection (ns): Min 0, Max []
- Cooperative Target:
- RS485 Termination:

Units: Sets the desired units of measurement. Once this parameter is set, most other distance parameters use these units. One exception is the Flyer Trap parameter in the Detection Mode which is always millimeters.

Short Gate: When this function is used, the Laser Rangefinder will not measure to a target within this distance. For example: if we set this parameter to 10 meters and a target is between 0 and 10 meters, the Laser Rangefinder will not output a distance to that target. All laser pulses are corrected for signal intensity, the gating process works on the raw measurement before the correction; therefore, the gate distance is approximate. If you want to eliminate a consistent target such as a window, deselect the Check Gate option, and increase the Short Gate value until the window target disappears. The laser should see the next target beyond the first target, if it is greater than 2.4-3.0 meters (8-10 feet) beyond the first target.

Long Gate: When this function is used, the Laser Rangefinder will not measure to a target beyond this distance. For example, if we set this parameter to 100 meters and a target is further than 100 meters away, the laser will not output a distance to that target. In most cases this function is not required in Averaging Mode because it is a first target system. Caution should be used when trying to use the long gate (or close gate). The long gate should be set in front of the target needing blocked when long returns need to be rejected. Move the long gate out until the long target reappears to find the correct distance for the application. This may be helpful in Binning Mode where multiple targets are output and far targets are not wanted at the output. As with the short gate, the exact distance will vary considerably depending on modes and whether dithering is on or off.

Check Gate: When function is used, the measurement value is checked to ensure that it does not violate the gate integrity (within a couple of millimeters of the gate value). If the range being reported by the Laser Rangefinder is outside the enabled gate range, the output will not be allowed to be output by the unit. Removing this selection allows all readings to be reported out of the unit on the serial interface regardless of the gate settings.

Offset Distance: This distance (can be a positive or negative value) modifies the actual measurement distance accordingly. The actual distance is used for the purpose of gate distance; where the Offset Distance merely affects the distance reported out of the Laser Rangefinder.

Laser Power Level: The Laser Power Level only affects the maximum range capabilities of the Laser Rangefinder. If the user is measuring close targets, the power level can be reduced in order to potentially run the Laser Rangefinder at a higher pulse frequency, and still stay below FDA Class I limits. If operating in dusty or dirty environments, we recommend using a lower power setting.

Cooperative Target: When this function is used, the Laser Rangefinder will only measure to a target that has reflective properties (reflective tape, plastic reflector, or glass prism); the Laser Rangefinder may not measure to a natural target (i.e., non-cooperative) in this mode. Cooperative target selection gives the best accuracy possible if you can see the target.

Intensity Rejection: This function is used to reject returned receive pulses that are either less than the minimum (Min) value or greater than the maximum (Max) value specified in nanoseconds. These values are not exact but should correspond closely to the nanoseconds of the pulse width return intensity.

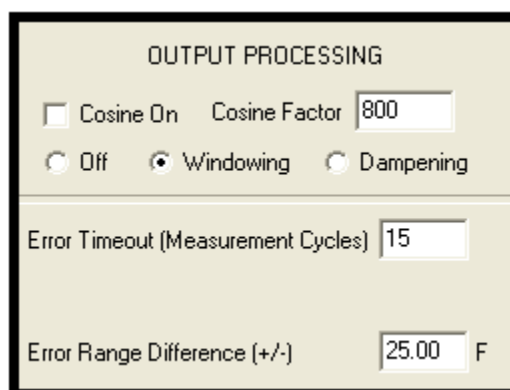
Note: Rejected values are also thrown out of the average so a smaller average weight may be needed to avoid average not filled errors.

- **Min:** If a known weak pulse return is present, this value can be increased until the small return stops.
- **Max:** If a known strong pulse return is present, this value can be decreased until the large return stops.

ILR AutoStart: When this function is on, the unit will automatically start measuring when powered on. When this function is off, the unit will initialize when powered on, but will not start measuring without a go command being issued (Start Measurement or Get Measurement).

3.3 Output Processing:

Figure 3.2



Note: The Output Processing parameters are not available in the Detection Mode.

Cosine On: When this function is used, the measurement value is multiplied by the specified Cosine Factor (see below). The result of the multiplication is displayed in the measurement window and output from the serial port.

Cosine Factor: A factor, which is typically used to convert a slope distance to either a vertical or horizontal measurement.

Off: When this option is selected, both Windowing and Dampening are off.

Windowing: When this feature is on, a filter is applied to ensure that the following measurement is within a certain distance of a previous measurement.

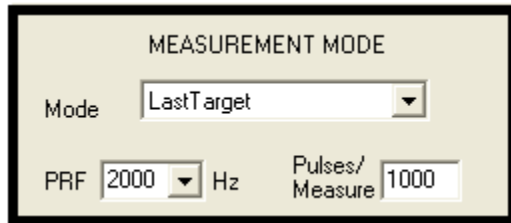
- **Error Timeout (Measurement Cycles):** The number of measurement errors required before an error is output from the Laser Rangefinder. Measurement errors could be laser errors (ERR04) or measurements outside of the window.
- **Error Range Difference (+/-):** The amount of range difference required to be flagged as an error. This can be used to signal when a range measurement goes outside the error measurement window that you set.

Dampening: When this feature is on, up to 10 readings can be dynamically averaged (current reading with previous readings). This is a running average of the ranges being measured by the Laser Rangefinder.

- **Number of Samples:** This parameter is a feature of Dampening. It is used to specify the number of readings that are used when calculating the dynamic average. A maximum of 10 samples is allowed.
- **Error Timeout (Measurement Cycles):** The number of measurement errors required before an error is output from the Laser Rangefinder. When the unit times out, a new running average is started.
- **Error Range Difference (+/-):** The amount of range difference required to be flagged as an error. This can be used to signal when a range measurement goes outside the error measurement window that the user sets.

3.4 Measurement Mode:

Figure 3.3



Mode: This parameter depends upon the application. Select Averaging if accuracy is critical. Select Last Target in poor environments to achieve a measurement to the last target the Laser Rangefinder sees. Select Binning if the environment is dusty, multiple targets are present, or very weak returns are expected. Select Detection Mode if the Laser Rangefinder is to be used to look-down for presence detection. For more information on these measurement modes, please refer to the Measurement Modes Section (Section 3: Measurement Modes). The corresponding parameter windows will appear for each measurement mode.

When changing the measurement mode, the settings are uploaded in the ILR Interface Program automatically. This change happens since all measurement mode related items must also be changed when the measurement mode is changed. All other parameter changes require you to select the Upload Settings button to upload parameter changes.

PRF: Sets the laser firing Pulse Rate Frequency. Select a value from the drop-down menu. Possible values vary, depending upon the measurement mode. If you want to use a value that does not appear on the drop-down menu, you can manually enter the value.

Separate PRF values are stored in the unit for Averaging, Binning, and Detection Modes. Last Target mode shares the Averaging Mode PRF and PPM values.

PRF values that are too high will result in an Error 32 - Invalid PRF Rate.

Max values:	Averaging Mode:	4000
	Last target Mode:	4000
	Binning Mode:	1000
	Detection Mode:	4500
Minimum value all modes:		10

Pulses/Measure: The number of laser pulses fired per output measurement (PPM). You should note that this option is not available in the Detection Mode.

Note: The Pulses/Measure divided by the PRF establishes the measurement output or update data rate.

3.5 Averaging Parameters:

Dithering: During Averaging Mode, dithering allows for finer resolution over the average. If less than 256 returns are to be averaged per output, dithering is recommended. The unit is calibrated with dithering on and will be more accurate if dithering is used. The dither cycle is 32 pulses. This means that the product of the Dither Step size and the Required Dither Pulses should always be a multiple of 32. If the Required Dither Pulses (number of averaged readings) is 8, then the dither step size needs to be 4 to make the product equal 32. If the required dither pulses are 32, 64, 96, or 128 then the dither step size should be 1. The smaller the dither step size, the more accurate the measurement.

- **Dither Steps:** Sets the number of dither steps. Select a value from the drop-down menu. Possible Values = 1, 2, 4, 8, 16 (all of which are factors of 32). Step sizes larger than one are used when the required dither return pulses are less than 32. The product of the step size and the required dither pulses must be a multiple of 32.
- **Required Dither Pulses:** The number of good returns required to produce an average output reading. If set to 32, 32 good returns from each PPM block must be returned and in lock to fill the average reading. As the minimum required pulses or minimum dither pulses increases, the averaging increases which improves the accuracy of the measurement.

Minimum Good Pulses: This option is available when dithering is off. This value is the number of good returns required to average as an output result. As the minimum good pulses increases, the averaging increases which improves accuracy of the measurement. This value must be less than the PPM or an error will be generated.

Note: If dithering is ON, Required Dither Pulses represents the Averaging Weight.
If Dithering is OFF, Minimum Good Pulses represents the Averaging Weight.

The laser uses locking criteria internally to keep from mixing multiple return ranges into its average. A brief description of how locking is done is given to allow the user a few different possibilities when locking targets. Locking is only done in Averaging Mode and is done for all average weights (Minimum Good Pulses or Required Dither Pulses) greater than 3. If no locking is required, then only three average weights can be used 1,2 or 3. All average weights 4 and above will use locking criteria for each returned measurement. Using average weights of 2 and 3 can be misleading because 2 or 3 different return measurement ranges could appear on each PPM block, and they would be averaged and sent out being an incorrect range. Using an average weight of one is not a problem because each range reported will be a range the laser measured.

Two different programmable locking parameters are given to control how tight the locking criteria should be.

- **Average Bounds:** The amount of separation in time (distance) allowed between each return measurement and the last average lock value found in the last good average output measurement. The default value is 3000 psecs.

- **Initial Lock:** This value is used when starting a measurement before an average lock value has been found or if any out of lock condition exists for any reason the initial locking will be repeated on the next measurement block. Both locking values are entered in picoseconds. A good rule of thumb is that 1000 picoseconds equals a foot of distance. With dithering turned on an extra 2000 psecs of locking room should be added to the lock values to cover the dither cycle plus the locking distances needed. The default value is 3000 psecs. The unit will output error 4 if locking criteria is not met. If an error 5 is output (average not filled) then the initial lock criteria was met, but not enough good returns were either in lock or present to fill the average weight (Minimum Good Pulses or Required Dither Pulses).

Example of how locking is done from the start of the \$Go command:

The first return measurement seen by the laser receiver system is used to compare to the next good return measurement seen. These range values are compared to the Initial lock value programmed. If the difference in range between the two samples is within the initial lock value, then a third and a fourth return will also be looked for. Once four values are seen inside the initial lock range the initial lock is complete. Now each return measurement is compared to the initial lock range value and compared to average bounds lock value until a complete PPM block is done. If both processes are successful, then the average range value will be output and used in the next PPM block as the average lock range to compare with along with the average bounds value. Without averaging the single shot resolution of the Laser Rangefinder is approximately 110 psecs (slightly over an inch). Because the initial lock is always done on the first four return pulses seen and the average bounds value is used during the complete PPM block the average bounds values should usually be larger than the initial lock value.

If problems are occurring with many error 4 or 5's being output, then the average bounds and initial lock values can be raised to see if locking problems are causing the errors. If lowering the average weight to below 4 (no locking is done), and still no measurements are seen means nothing is being seen by the Laser Rangefinder receiver system. If there are measurements with no locking enabled, then the locking criteria needs to be raised to allow more readings into the average. The faster the object moves that the Laser Rangefinder is trying to measure, the wider the locking criteria needs to be adjusted.

Last Target Parameters: Last Target Mode and Averaging Mode share some parameters. The PRF and the PPM values are the same variables as used for Averaging Mode. The Average Weight (Required Dither Pulses, or Minimum Good Pulses) used in Averaging Mode is not used in Last Target Mode as last target measurements are not an average value.

Successive Gating: When this function is on, the Laser Rangefinder looks for the last event in a series of 10 pulses. Then it automatically places a short gate on that target to look beyond that target. The number of pulses in the PPM block and the number of targets that the Laser Rangefinder can see determines how many 10-pulse blocks the Laser Rangefinder must go through each PPM block to find the last target. If the PPM block is below 40, successive gating should be turned off. When this function

is off, the Laser Rangefinder looks at the last event of each shot and saves the longest one. When all the pulses for that measurement have been processed, the longest last event is the measurement.

3.6 Binning Parameters:

Target: Select your desired target from the drop-down menu. In general, the data for the selected target is output and displayed in the measurement window.

- **First:** When multiple targets are identified, the closest returned target is displayed in the measurement window.
- **Last:** When multiple targets are identified, the furthest returned target is displayed in the measurement window.
- **Most:** The returned target with the most amount of bin hits is displayed in the measurement window.
- **All:** Every returned target with more than the specified amount of bin hits. The value displayed in the measurement window is the last target.

Targets are displayed in bar graph format just below the measurement window and the total number of targets is displayed to the left of this area. All targets are only displayed and or output when the All selection is made. First, Last, and Most selections always output only a single target.

Bin Hits: Establishes how many pulses must land in a Bin for it to be considered a target. This value should be changed to acquire or remove targets when in the All Targets Mode. The \$FA command may be used to select the First, Last, Most and All selection without stopping the unit. This allows you to check for multiple or strong targets without having to wait for the unit to stop and restart. Moving the Bin Hits value up will drop weak targets, while moving this value down will find weaker targets. This value needs to be adjusted for each Bin Size setting shown below. As the bin sizes increase, the more the possibility of noise falling into the bin. This says that the bin hits must be increased for larger bin sizes and dropped for lower bin sizes. Note the maximum targets logged in Binning Mode is 8. If the bin hits value is set too low, bins with just noise in them will be displayed as targets. Each measurement value will be random. Targets beyond the 8 targets reported will be ignored. If this value is set too high, no targets will be found.

Bin Size (Range): Establishes the resolution and the maximum range of the binning measurement. However, a smaller resolution also has a limited maximum measurement range. Once you select a Bin Size, the number in parenthesis is the maximum acquisition distance for the given Bin Size setting. Refer to the pull-down menu for acceptable Bin Size values.

Output measurement rate in binning is the PRF divided by the Pulses/Measure in seconds. The maximum PRF in Binning Mode is 1000 because of the multiple target processing time required.

Detection Parameters: The Detection Mode may be run in two different configurations depending upon your specific application: Relative or Absolute

Relative: In this configuration, the Laser Rangefinder looks for a change in distance. Detection if range is less than the reference distance minus the trip point.

Absolute: In this configuration, the Laser Rangefinder looks for an object inside a desired range. Detection if range is less than the trip point.

Max False Pulses: Specifies the maximum number of false pulses. There are two types of false pulses.

- Absence of Return (AOR): Relative configuration only. A pulse was fired, but nothing came back.
- Flyer Trap Reading: See Flyer Trap below.

Flyer Trap (mm): Specifies the allowable difference between two consecutive readings. This value is always specified in millimeters, even when you have selected feet as the distance measurement unit. The default value is 2500 mm.

Trip Timeout (secs): The amount of time required at a trip level before the Laser Rangefinder will re-reference to that level as its reference. If a reference appears that is longer in range, then the current reference the Laser Rangefinder will quickly move to that reference distance. This is only used in the Relative Detection Mode.

Output TBE: Output Time between Events. Measures the time from the end of a trip event to the beginning of the next trip event. This configuration can be used in either relative or Absolute Detection Mode. Normal trip signals are present on the universal port RS232. The hexadecimal value of the number of fire pulses between events is output on the configuration port. Knowing the firing rate of the Laser Rangefinder, the time between events can be calculated.

Section 4.0: Measurement Modes

4.1 Advantages and Disadvantages:

The Laser Rangefinder has four distinct measurement modes that have unique pros and cons. When selecting a mode, you will need to consider your specific situation and application.

Table 4.0

Measurement Mode	Pros	Cons
Averaging	<ul style="list-style-type: none"> • Highest accuracy possible. • Highest data rate possible. • Adjustable return shot criteria. 	<ul style="list-style-type: none"> • Susceptible to intermittent airborne particulates (fog, dust). • First target measurement past an adjustable dead zone.
Last Target	<ul style="list-style-type: none"> • Good airborne particulate penetration (fog, dust). • Automatic intermediate target discrimination. 	<ul style="list-style-type: none"> • Compared to Averaging Mode, accuracy is reduced an additional ± 2 cm.
Binning	<ul style="list-style-type: none"> • Enhanced measurement range capability. • Dynamically tracks multiple targets. • Adjustable target definition criteria. 	<ul style="list-style-type: none"> • Maximum effective data rate is 32 Hz. • Best measurement resolution is 2.5 cm (1 inch) and it increases as maximum range for the application increases. Resolution is 20.32 cm at 91.4 meters (8 inches at 300 feet).
Detection	<ul style="list-style-type: none"> • Ultra quick detection with precision timing signals that are output to control precision time measurement equipment. • Two modes of detection, one looks for a change in distance, the other looks for an object inside a desired range. 	

4.2 Laser Rangefinder Processing Structure

The Laser Rangefinder has extensive programming capabilities. The table below lists the stages in the process and a brief description of each parameter.

Table 4.1

Stage	Description	Notes
Pulse Width Rejection	<ul style="list-style-type: none"> Allows user to set the minimum and maximum limits on the pulse intensity used for measurements. 	<ul style="list-style-type: none"> This works in all measurement modes but does not need to be set.
Range Gate Rejection	<ul style="list-style-type: none"> Allows user to set short and long gates to block out any pulses that are outside the area of interest. 	<ul style="list-style-type: none"> This works in all modes except Detection Mode using the Relative option. Gates do not need to be set.
Measurement Calculation	<ul style="list-style-type: none"> This is dependent on which measurement mode is being used. This tells the Laser Rangefinder how to process the return pulses. The process produces a measurement. 	<ul style="list-style-type: none"> The Laser Rangefinder must be set to Averaging, Last Target, Binning or Detection Mode.
Check Gate	<ul style="list-style-type: none"> During the range gate procedure, the gate distances are not exact as the pulse intensity affects the gate distances. For this reason, it is possible to get a measurement slightly inside a short gate or slightly beyond a long gate. Check Gates ensures that the final measurement does not violate the gate integrity. 	<ul style="list-style-type: none"> Gating is a very powerful tool in a Time of Flight (TOF) laser such as the Laser Rangefinder. However, TOF lasers are complex to understand in certain situations. For this reason, more detailed information is provided in the detailed application sections for each mode (section 4).
Offset	<ul style="list-style-type: none"> Allows user to add or subtract a fixed constant to the measurement. This can be used to compensate for the Laser Rangefinder being in a different location from the desired zero point of a monitored object. 	<ul style="list-style-type: none"> This can be used in all measurement modes, except Detection mode. All processing stages after Offset use the modified measurement.
Cosine	<ul style="list-style-type: none"> This is simply a factor, which is typically used to convert a slope distance to either a vertical or horizontal measurement. 	<ul style="list-style-type: none"> This can be used in all measurement modes, except Detection mode.
Windowing or Dampening	<ul style="list-style-type: none"> Windowing is a filter that makes sure that the following measurement is within a certain distance of a previous measurement. Dampening is a running or dynamic average of the current reading plus previous readings. 	<ul style="list-style-type: none"> Windowing and Dampening cannot run simultaneously, or they can both be turned off. The result of using either parameter is a more stable reading; however, neither should be used in very fast, dynamic applications.
Output	<ul style="list-style-type: none"> Final Measurement 	

Section 5.0: Detailed Mode Applications

5.1 Averaging Mode Applications

Averaging Mode is the most commonly used mode because it has the greatest accuracy and data rate potential. In Averaging Mode, the Laser Rangefinder uses a series of pulses to produce a measurement. The first part of the measurement is to find a stable target. Once this target is found, then it looks for measurements within a certain distance of that target and averages them to produce a measurement. If the first part of the measurement fails to lock onto a target, then the display will show "Target not found" or ERR04 on the serial line. If a target is found, but the process cannot find the required minimum good shots or required dither pulses (average weight), then it will display "Average not found" or ERR05 on the serial line. If the average weight is less than 4, the target locking function is disabled and any returned shots are averaged unless the Minimum Good Shots is set to 1.

Another concept that is important to understand is how the unit uses a threshold during averaging. After the Laser Rangefinder converts light energy from the target to electrical pulses, it is impossible to determine whether a pulse is received from the target or some electronic noise inside the laser. Since the pulse derived from the target is larger in amplitude than intermittent noise, we use a threshold to make the Laser Rangefinder blind to small signals commonly associated with system noise. This also has the effect of reducing the maximum ranging capability of the laser, but the integrity of data is maintained. If you are only interested in strong targets, an additional threshold, called Cooperative Target, can be used. This will certainly eliminate any system noise as well as weak optical targets such as dark targets or natural targets over long distances.

Lastly, when the timing mechanism processes a laser shot, it maps multiple events for that single shot. Therefore, the timing device can report the first target, an intermediate target, or the last target. In Averaging Mode, the laser is looking at first target returns.

5.2 Averaging Mode: Measuring Through Windows

The Laser Rangefinder is a very sensitive device thus it is normal that it can get a measurement from a window even if the window is clean. Given that Averaging Mode is the most accurate mode possible, you do not want to switch modes just because the Laser Rangefinder is measuring off the window. There are techniques and tools available to "see past" the window.

There are two manual techniques that can be used that do not involve changing the laser's software configuration. If the window is very close to the laser, you can manually prevent measurements off the window by inserting a piece of rubber foam between the lenses. This works well if the foam stripping is slightly compressed between the front face (between the lenses) of the laser and the window. The second, if possible, is to angle the window by more than 10° from perpendicular to the measurement axis. The transmit side of the Laser Rangefinder is the left lens so the window should be tipped to the right with the closest part of the window to the right side of the Laser Rangefinder. Tipping the window to the left will point the reflection from the window directly back at the receiver lens on the right. If neither manual method proves useful, or if the window is too far from the laser, then you can use the Short Gate feature.

The Short Gate works very well in Averaging Mode with two exceptions. If the window is giving measurement signal strength of greater than 30 ns, then the receiver gets saturated, and it is difficult to see anything past the window for some distance. Angling the window or lowering the output laser power can decrease this window signal. Another drawback of using a Short Gate is that the Laser

Range finder can only see a target 2.4-3.0 meters (8-10 feet) beyond the window. In fact, in any measurement mode, the Laser Range finder cannot ever recognize a second target if the first target is within 2.4-3.0 meters (8-10 feet). This is because the pulses from both targets are overlaid and appear to be one pulse.

Setting the Short Gate is not as straightforward as it seems. We are trying to gate out a pulse from an object at a known distance. However, the range from that pulse has not yet been corrected for intensity, thus it can still be inaccurate at that point. Therefore, for a window 3 meters (10 feet) away from the laser, you should start with a gate of 3 meters (10 feet), and keep increasing the gate, until the window distance disappears. Make sure the Check Gate option is turned off. What we are trying to do is prevent the front edge of the window pulse from being seen by the timing device. It can see the back edge and determine that the whole pulse is invalid. At that point it is ready to see the next target. It should also be noted that for another 3 meters (10 feet) past the dead zone or up to 6 meters (20 feet) from the first target, there might be some accuracy degradation as a result of the tail of the first target running into the leading edge of the second target.

5.3 Averaging Mode: Using Cooperative Targets

What is a cooperative target? There are two classifications of targets in the Time-of-Flight world, natural and cooperative. Natural targets are any natural surface, while a cooperative target is highly reflective such as reflective tape or a reflector.

Cooperative targets can be extremely useful when measuring to objects that travel in a straight line because the reflective material stays in the path of the laser at all times. If you want to measure to a target on rails in moderate dust through a window, the cooperative target will allow you to reduce the laser power, and possibly turn on Cooperative Target feature as well. There would still be enough signal to measure to the cooperative target, but not enough signal to see the window reflection or spurious reflections from the dust. If the window reflection or dust does not produce a big enough signal to be detected, the signal does not get to the timing device, and the window reflection or dust are not seen as targets. Averaging Mode: Measuring to Water

If you want to accurately measure the distance to water using the Laser Range finder, the Averaging Mode should be used. Because water surfaces vary from glassy to very diffused, and because the water surface angles are always moving, measurements vary greatly. Because of this, several validation techniques may be required to get accurate results. When setting the Laser Range finder up to see the water, use a fast update rate of 10 Hz or more with a low average weight. This will allow you to aim the Laser Range finder until decent returns are found. Once the aiming has been completed, the PPM block and the average weight can be made larger to average the measurement to a more accurate value.

5.4 Averaging Mode: Limiting Parallax Effects

What is parallax error? It is the optical effect on the laser due to the transmit and receive optical paths being parallel. In the Laser Range finder, parallax has an effect within the first 9.1 meters (30 feet) from the laser, but the main effects are within 1.5 meters (5 feet). Therefore, to minimize the effect, you can back the laser away from an area of interest by 5-10' so that the laser is more accurate when the object is at its closest point.

5.5 Averaging Mode: Accuracy vs. Data Rate

The Laser Range finder is a Time-of-Flight laser device, which sends out a series of pulses to produce a measurement. The more laser shots that are used, the more accurate and stable the measurement. If

more shots are being used for each measurement, the measurement rate is slower. Therefore, there is an inverse relationship between data rate and accuracy.

The Laser Rangefinder has very good single shot accuracy, meaning that, without averaging, it can produce a measurement that is accurate to within 5.1-10.2 cm (2-4 inches). Averaging individual laser shots or pulses can bring accuracy below 2.5 cm (1 inch) or better depending on the consistency of the target reflectance, the quality of target visibility and the maximum range it is measuring. It is important to note that TOF technology is not as accurate as triangulation or phase techniques, but it is much more robust as far range and environment than the other two methods. TOF lasers would produce a very poor measurement if the measurement was not corrected for signal intensity. The Laser Rangefinder has a signal intensity correction table for each output power level (3) at natural or cooperative target setting (x2), which totals six tables. They are automatically loaded depending on your configuration.

Before using the Laser Rangefinder in a difficult application or as a sensor in a system, experiment with different PRF settings, Pulse/Measurement setting and the Average Weight (Minimum Good Pulses or Required Dither Pulses).

5.6 Averaging Mode: Using Dithering

Dithering can be a powerful tool if used in the right circumstances. Dithering is a method of making the measurement more accurate than the single discreet resolution of the ILR unit. The single shot resolution in Averaging Mode is 2.5-5.1 cm (1-2 inches). With dithering ON, this measurement accuracy could be made 3 to 4 times better with the correct dithering setup. Therefore, you could realize a more accurate measurement at a higher data rate by using Dithering.

Dithering greatly helps the accuracy of the measurements when the Average Weight of the measurement cycle is between 4 and 256. With Average Weights above 256, very little change will be seen with dithering removed. Remember the dither cycle is 32, so the product of the dither step size and the average weight (Required dither pulses) should always equal a multiple of 32. If the Average Weight is below 32, the dither step size must be larger than one to make the 32-step dither cycle. The dither step size should always be made as low as possible to maintain the highest accuracies.

Without dithering, the ILR can be made more accurate by averaging more pulses or shots. This is because individual pulses can land in various timing bins. These bins are fixed in length so, for example, you may get 65 shots at 20.08 feet, 28 shots at 19.95 feet and 7 shots at 20.19 feet. When they are averaged together, the reading would be 20.05. Dithering could probably achieve the same result using 32 shots, as the timing bins are constantly shifted to help find the point at which the proper measurement lies.

5.7 Averaging Mode: Possible Setups

The table below lists possible settings for the output rates listed. Output Update Rate equals PRF/PPM per second.

Table 5.0

Output Update Rate (Hz)	PRF	PPM	AW	<PPM, multiple of 32 if dithering is enabled
0.1/sec	1000	10000	8000	dither step is 1 if enabled
1/sec	1000	1000	512	dither step is 1 if enabled
10/sec	2000	200	160	dither step is 1 if enabled
100/sec	4000	40	32	dither step is 1 if enabled
1000/sec	4000	4	4	dither step is 8 if enabled

The above settings will produce the output rates listed. Several other possibilities exist in some cases. If targeting errors are seen, lowering the Average Weight (AW) values should make it easier to get a range at the expense of range noise variation. If the unit responds with No Target Found or Error 4, try lowering AW below 4 to inhibit the unit from using locking criteria. If the unit still reports ranging errors and no ranges are being reported, the Laser Rangefinder cannot see any return signals. If ranges are reported at lower AW values, try increasing the locking parameter values seen in the more screen in averaging mode in the ILR interface program. Using PRF rates above 3000 should only be done in display mode 1 or range only. Intensity output should be turned off by using display mode 1 (output range only) if PRF is above 3000. Using display mode 2 (range and intensity output) above 3000 PRF will cause 1 lost range value, every Pulse per Measurement (PPM) block. Dithering should be used when the AW is 128 or less. The product of the AW and the dither step size should be an even multiple of 32.

5.8 Last Target Mode Applications

This mode is used in poorer measurement conditions such as fog or dust. If the light energy cannot make it from the laser to the target and back, then a measurement is not possible. The best rule of thumb is to shine a flashlight at your target and if you can see the footprint of the flashlight on the target, then you can probably measure it. In Last Target Mode, the Laser Rangefinder still uses a series of pulses to produce a measurement; however, only one pulse is used in the final measurement.

As discussed in the Averaging Mode section, the timing system can produce a first target, an intermediate target or last target. Averaging Mode uses the first target and Last Target Mode obviously uses the last target or last event. There are no minimum good shots in this mode. The Average Weight is assumed to be 1; as no averaging is done in Last Target Mode. Simply put, you select how many shots will be used for each measurement (PPM). The timing mechanism looks at the last event of each shot and saves the longest one. When all the measurements from that measurement block are completed, the longest range reported will be output. When all the pulses for that measurement have been processed, the longest last event is the measurement. If there are no events logged in all the shots, then "Average not filled" is displayed and ERR05 is sent out on the serial line.

Last Target Mode can be used with Averaging Mode to validate the averaging measurement is staying near the last target range. This is helpful in bad environments where dust and/or particulate measurements are corrupting the average measurement. The Measurement mode can be switched from Averaging Mode to Last Target Mode without stopping the unit. This is because Averaging Mode and Last Target Mode share the same PRF and PPM values. When switching from Averaging Mode to

Last Target Mode, the current measurement will be dropped, and the output measurement timing should be maintained. When switching from Last Target Mode to Averaging Mode the unit will have to re-lock to the target. This should give one out of lock error measurement and then resume normal Averaging Mode measurements. A faulty measurement may be produced when switching from Last Target Mode to Averaging Mode if Successive Gating is enabled. For this reason, either Successive Gating should be turned off when switching between these modes when the unit is firing, or you will have to disregard the first few measurements when switching to Averaging Mode.

5.9 Using Successive Gating

This is an additional feature within Last Target Mode. If it is turned on, the Laser Rangefinder will look for the last event in a series of ten pulses. Then it will automatically place a short gate on that target to look for additional last targets. This process will repeat until no further targets can be seen, and the unit will then move the gate back in position to measure the Last Target. Because Successive Gating requires multiple groups of ten shots to complete the function, Pulses/Measure blocks of 40 or larger should be used. If this is not possible, Successive Gating should be disabled.

Without gating, the minimum target separation needs to be around 12 meters (40 feet). When the first target is gated out, the Laser Rangefinder can identify a new target within 2.4-3.0 meters (8-10 feet) of that target. The process works as follows:

- a. Use 10 shots to find the longest last event.
- b. Place a gate on that target.
- c. Use 10 more shots to find a target past that target.
- d. If another target is found, repeat 'b' above, otherwise there are no more targets.
- e. Place a gate in front of the last known target and shoot the remaining shots to find the longest last event.

When using Successive Gating, the minimum shots/measurement should be 40. This would permit more than one target to be found and enough shots to verify that the last event is achieved. The bigger you make the shots/measurement, the better stability you have to a target in poor conditions.

5.10 Last Target Mode: Measuring Through Windows

This subject is covered in detail on Page 5.2 Averaging Mode: **M**. The major difference is that, in Last Target Mode with Successive Gating enabled, the unit will automatically see beyond the window. If your target is within 3 meters (10 feet) from the window, make every effort to prevent the window from being seen as a target. This would involve angling the window or the laser to the window, lowering the output power of the laser and/or decreasing the sensitivity of the receiver by using the Cooperative Target feature.

5.11 Last Target Mode: Using Cooperative Targets

Again, this is covered in detail on Page 5.3 Averaging Mode: Using Cooperative **Targets**. In this mode, with a poor environment, cooperatives targets can be very powerful when used with objects that travel in a straight line.

5.12 Binning Mode Applications

As mentioned in the Summary table on Page Section 4.0: Measurement Modes, Binning Mode is best used for longer ranges with possible multiple targets. In Averaging Mode and Last Target Mode, we talked about using a threshold. This is because we didn't want to confuse electrical pulses that were

generated from optical pulses from the target with electronic noise inside the laser. Since the target pulse is usually higher in amplitude than system noise, we impose a threshold to eliminate the spurious system noise pulses. By using a threshold, however, we do reduce the maximum ranging capability of the Laser Rangefinder.

Binning Mode works right down in the system noise and uses statistics to isolate a target. It is important to understand that Binning Mode uses 512 bins to look for a range. You can adjust his bin size, but the smaller the bin size (measurement resolution), the smaller the maximum range that you can see with the unit. For example, if we set the bin size to 1 meter, the maximum range that we can look for a target or targets is 512 meters. If we use a bin size of 2.5 cm, then the maximum target detection is up to 13 meters.

The table below lists Bin Size and maximum range capabilities.

Table 5.1

Bin Size		Maximum Range	
CM	Inches	Meters	Feet
2.5	1	13	42
5.1	2	26	84
10.2	4	52	168
20.4	8	104	336
40.8	16	208	672
81.6	32	416	1344
163.2	64	832	2688
325.1	128	1664	5376

Now that we have identified the bins and maximum range potential, it is time to explain how we can measure to a target with electronic noise present. We know two things: targets will return results constantly to bins representing their actual range from the laser and system noise is random and will not accumulate too much in a certain bin. Therefore, we send out a series of pulses and set the criteria of how many pulses need to be in a bin before we call it a target. The number of pulses in a bin is called "Bin Hits". Statistically, if we send out 32 pulses, we can expect 4 or more hits to a certain bin to generate a target measurement. As we increase our maximum range, we must increase the Bin Hit criteria because we are observing more noise since the observation period is longer. Try to keep the ratio of 1 hit per 8 pulses sent out. For maximum performance, you may need to adjust this ratio for specific applications. Lower the laser output power so that spurious returns from dust and fog are ignored. It is analogous to using your car's high beam headlights in fog, sometimes it doesn't help you see farther because you are blinded.

5.13 Binning Mode: Using Proper Binning Parameters

Assuming that we have decided to use Binning Mode because we need the maximum range or we want to track multiple targets, we need to enter the parameters that will make the application successful. The first question that needs to be addressed is what the maximum range of the application. That will help set up the bin size. Now we have established the resolution of the measurement and the maximum

range with one parameter. The next parameter is the desired measurement output data rate. Binning Mode generally works best with a minimum of 32 pulses to be sent out for each measurement. Given that the maximum pulse repetition frequency (PRF) or maximum pulses the laser diode can sent out per second is 1000, then the maximum data rate will usually be around 30 Hz. Please bear in mind, a TOF laser system has more accurate and stable readings when measuring at slower data rates because it is using more laser shots to achieve the measurement. If you do not need a large data rate, use more shots in your measurement block (Shots/measurement). After you have defined that number, try using about 1/8 of the number for the Bin Hits criteria.

5.14 Binning Mode: Selecting Targets

As discussed before, the Laser Rangefinder can identify multiple targets. You can select the target that is desired to be displayed on the screen and to output. You can choose between First target, Last target, Most and All.

First and Last target is straight forward, but Most is the returned target with the most amount of bin hits, but Most is the returned target with the most amount of Bin Hits above the programmed Bin Hit value. Lastly, if you select All, then all the targets are displayed on the screen at the same time, and all output is sent from the serial port each measurement cycle. The value in the measurement window is the Last target and it is also the target range being output. The range displayed in the ILR interface program window will be the Last target in each group of measurements. In the All Targets Binning Mode the 4-20 mA system will also be driven by the Last target.

All Target Mode is the only Binning Mode that outputs multiple targets. All other Binning Modes (First, Last, and Most) only output a single target. The binning system is processing multiple targets and chooses the Last, First, or Most target to output at the end of each measurement block.

As a training exercise, select All Targets and reduce the Bin Hits criteria to 1. This will let you graphically see the multiple targets, as well as the random system noise. Notice that the hard target remains solid all the time. The graph also scales the targets by the number of Bin Hits. Then start increasing the Bin Hits by one, until the noise goes away. You will notice that the hard target remains.

5.15 Binning Mode: Using Gates

The Short Gate can also be used to block out targets within a certain distance of the laser. This is typically referred to as a dead zone. The use of Short Gates is very effective in this mode especially if measuring through a window.

When long range measurements are being made in Binning Mode, a Short Gate should be employed to gate early noise returns out of the system so that targets further away can be seen. Example, if you want to measure a target at 1000 meters, and you know that there are not any targets before 500 meters, you should set the Short Gate to 500 meters. This will remove all noise pulse to 500 meters in the flight line. Each noise pulse seen is considered a target, and the maximum number of targets is eight. If the laser system sees 8 noise pulses during a return, it will look no further for more targets. This is why a Short Gate can improve long range performance in Binning Mode.

5.16 Binning Mode: Possible Setups

The table below lists possible settings for the output rates listed. Output Update Rate equals PRF/PPM per second.

Table 5.2

Output Update Rate (Hz)	PRF	PPM	Bin Hits (<PPM)
0.2/sec	100	500	30 (or less)
2/sec	1000	500	30 (or less)
20/sec	1000	50	20 (or less)
40/sec	1000	25	10 (or less)

The above settings will produce the output rates listed. Several other possibilities exist in some cases. If targeting errors are seen, lowering the Bin Hits value should make it easier to get a valid range at the expense of range noise variation. Lower the bin hits value slowly until a target appears. If only random, non-repeating targets appear, noise is all that is being seen by the Laser Rangefinder receiver system. Because Binning Mode is running in the noise, the Bin Hits value should be raised for longer bin sizes. This is because as the bin lengths increase, the possibility of noise landing in that bin increases. When using a bin length of 20.4 cm; a minimum bin hit value of 8 should be used; otherwise, noise targets could appear and be random in range and occurrences. At the bin size of 5.1 cm, a minimum value of 4 could possibly be used without noise showing up as a target. If random low hit value targets are being seen, raise the Bin Hits number. Note only in All target mode will multiple targets be seen and displayed (maximum of 8). All other binning modes output only a single target (Last, First, or Most). Always use All target mode when adjusting PPM or Bin Hits values to see all changes that result from the adjustments.

5.17 Detection Mode Applications

This mode is very powerful as it is extremely quick and accurate to detect an object in the optical path of the laser. Referring to the summary table in the summary table in section 3, this mode does not output a constant measurement. Detection Mode can be run in two different configurations, Relative or Absolute, which allows the Laser Rangefinder to perform to the maximum level depending on the application.

Detection Mode does not utilize shot averaging, last events or statistical presence to determine distances like the previous modes. The purpose of this mode is to detect objects with very accurate timing properties. The primary output is two lines from the Universal Port, which transition from a low state to high state when the object is detected. The configuration RS-232 port also provides a serial description of the event although it is not nearly as synchronous to the event as the two-wire output.

Since this is a quick response mode and because we are not averaging any readings, we can run the Pulse Repetition Frequency (PRF) faster than the other modes. In fact, this mode can be run with a PRF as fast as 4500, which means that the laser can fire up to 4500 pulses per second.

5.18 Relative Detection Mode

In Relative Detection Mode, the programmable Trip Point is the distance from the reference distance (ground) to the range point that you want to use as a trip signal. In the case of a car, this distance should be approximately 0.61 meters (2 feet) shorter than the reference distance.

- Any range less than the reference distance minus the trip point is a trip signal.
 - In Relative Detection Mode, the reference distance is internally generated at the start of the laser measurement.

- Invalid ranges for the reference during startup will cause erroneous results until the laser has seen the reference range for at least 20 to 30 consecutive pulses.
- The External Trip Signal is delayed by the Trip Threshold value at both the start and the end of the object passing through the lasers path.
 - This is done with the accuracy of 0 to +1 fire pulse at the beginning of a trip and the same accuracy at the end. the higher the PRF rate, the smaller the 0 to +1 pulse error becomes.

5.19 Measuring Speed

Two of these systems are separated by a constant distance with external timing gear watching the time difference between the two units' rising edges.

- The recommended minimum distance between the two lasers is two meters. This makes the 1-pulse measurement errors small enough to maintain good speed accuracy. This minimum distance also lowers the possibility of one laser seeing pulses fired from the other laser.

5.20 Other Parameters

1. Max False Pulses

- The Max False value is the number of false pulses allowed in a trip sequence. Two things can cause a false return, the Absence of Return (AOR) or a flyer return.
 - An AOR is no return was seen at all for a given fire pulse.
 - A flyer return is a range that changes more than the set Flyer Trap value from one range to the next consecutive range. If the Flyer Trap value is set to 2,000 mm and the change between two consecutive range readings is greater than 2,000 mm, then that pulse is considered a flyer.
- As an example, let's say the Flyer Trap is set to 2000 mm. If Pulse #6 in the figure measured more than 2,000 mm shorter than the reference, the False Pulse counter would be incremented to 1.
 - If the Max False value is set to 1, then the internal start of trip counter would be reset back to 0.
 - If the Max False value is set to 2, then this pulse would be allowed as a valid pulse and the system would trip as shown.
 - If an AOR occurred at Pulse #7 after having a flyer at Pulse #6, then the false counter would be incremented to 2.
 - If the Max False value is set to 2, the system would again invalidate the internal trip counters and the counters would all be set back to 0.
 - The Max False counter can be set from 0 false pulses allowed to values greater than the trip threshold.
 - If the Max False value is set to 0, then no AORs or Flyers are allowed. Any start trip sequence will be reset if any false pulse occurs.
- If the Max False value is made larger than the trip threshold, the consecutive number or AOR returns greater than the Trip Threshold will also cause a trip. This is OK, if the AORs are caused by a very shiny black car, but if this is caused by rain, you would not want the laser to trip.

2. Trip Timeout

- The Trip Timeout is the amount of time (in seconds) required in a high trip state before the unit will re-reference to that range.
 - If the car in the figure stopped under the laser for longer than the programmed Trip Timeout, the laser will re-reference to the top of the car and the trip condition will be removed. When the car pulls away, the laser will quickly re-reference back to the ground. The Trip Timeout occurs in Relative Detection Mode only. The Trip Timeout period is not used in Absolute Detection Mode, since it does not use a reference distance.
3. Maximum Detection Range
- In Relative Detection Mode, maximum detection range is 65 meters. This means the maximum reference range to the laser must be less than 65 meters. This also means the largest trip point possible must be less than 65 meters.

5.21 Absolute Detection Mode

In Absolute Detection Mode, the system acts very similar to Relative Detection Mode. The difference is that the Trip Point is absolute instead of relative to the reference. The unit will trip on detected ranges that are less than the Trip Point and will reset the trip signal when the laser sees ranges that are greater than the Trip Point.

- As in Relative Detection Mode, the programmable Trip Threshold count value criteria must be met to set the trip.
 - In Absolute Detection Mode, AOR's are not allowed to start a trip. This is because no reference is being used or may not even be present. AOR is considered a max range in Absolute Detection Mode and is input into the trip system as 152.4 meters (500 feet).
 - In Absolute Detection Mode, the maximum range is 152.4 meters (500 feet). Because of this, the largest trip point must be less than 152.4 meters (500 feet).
 - Max False value is used as before which means that flyer readings will cause a false counter increment. Since AORs are input as max range values in absolute mode, if a trip is started by seeing a valid range less than the trip point and then an AOR appears, the false counter will be incremented, and the trip will still be incremented to its next state. If the number of false returns is less than the programmed Max False value, the trip will still occur. If the number of false returns is larger than the programmed max false value, the trip will internally reset, and no trip level change will be seen at the output.

5.22 Detection Mode: Relative Operation

In this configuration, the laser automatically searches out to find a constant target. It then establishes this as the reference target. If the distance to that target or the distance to a different object in the path of the laser gets shorter than the user defined Trip Distance relative to the reference distance established, then the Laser Rangefinder will signify a detection. As discussed before, a detection primarily means that the two-wire pair will move from a low state to a high state, but more information is available from the configuration serial port.

In the standard operation, the serial configuration port output will issue a \$BM,n when it is "tripped" where the n is the distance in mm of the last valid distance that caused the trip.

When Time between Events (TBE) is turned on (\$TB,1), the Laser Rangefinder will still trip the two wires the same, but the serial configuration port output is modified. When there is a trip condition for the first time will display \$0000 then when the detection is off, the system will issue a \$0. The next detection will display a \$XXXX where XXXX is the hex value of the amount of laser pulses that transpired between the end of one object and the beginning of the other. The number of laser pulses is divided by the PRF to find the exact TBE. This is a powerful tool as it produces an actual TBE without knowing the speed of the objects.

In this mode, it is possible to have the reference target obstructed for a certain period of time. If the target stays tripped longer than the trip time out variable, then it will re-establish the new reference. The trip time out can be adjusted using the interface to shorten or lengthen the trip time out period. Also stopping and then starting the unit when in relative Detection Mode will cause the unit to also re-reference to the distance the unit finds at startup.

To avoid any spurious detection, the Laser Rangefinder requires a Trip Threshold number of pulses to be seen inside the trip zone to constitute a trip. It also needs to see the reference level for this same trip threshold number of pulses before the unit will go back to not tripped. This delays the output trigger by the trip threshold count programmed for both the beginning of the trip and the end of the trip. For very fast objects moving in the optical path of the laser, getting 30 trips can be difficult, as the surface is shiny so there is an Absence of Detection algorithm that will count missed shots as long as there are real trips to start the process. Essentially, a missed shot means that the reference target is not being seen thus there is something there. For this reason, Short Gates will not work in this configuration.

Absence of return (AOR) will be logged as a false trip signal, but it is a valid trip pulse if the max false pulses programmed is not exceeded. If enough AOR's are present, a trip will be stopped if the programmed value of max falses is exceeded.

This configuration has been chiefly designed for a traffic lockdown sensor. It can be used to give vehicle counts (two wire output) and time between events with one sensor. Two sensors with a fixed offset can be used to create a system that can provide very accurate speed information as well as vehicle counting and TBE. The main criteria for this configuration is that it can constantly detect a reference target when there is no obstacle to detect.

5.23 Detection Mode: Absolute Operation

In this configuration, the laser continuously sends out laser pulses. This configuration does not care whether is getting a return distance as opposed to the relative configuration. If a target is detected within the Trip Distance, then the Laser Rangefinder will signify a detection. As discussed before, a detection primarily means that the two-wire pair will move from a low state to a high state, but more information is available from the serial port.

In the standard operation, the serial configuration port output will issue a \$BM,n when it is "tripped" where the n is the distance in mm of the last valid trip distance range that caused the trip. The interface program will also display On in the measurement window. When the object has cleared the path or the original target has moved within the tolerance of the programmed trip point, the serial configuration port output will be \$BM,0 and will display OFF on the interface program.

When TBE is turned on (API only), the Laser Rangefinder will still trip the two wires the same, but the serial output is modified. When there is a trip condition for the first time it will display \$0000. Then when the detection is off, the system will issue a \$0. The next detection will display a \$XXXX, where XXXX is the hex value of the amount of laser pulses that transpired between the end of the first object

and the beginning of the next object. The number of laser pulses is divided by the PRF to find the exact TBE. This is a powerful tool as it produces an actual TBE without knowing the speed of the objects.

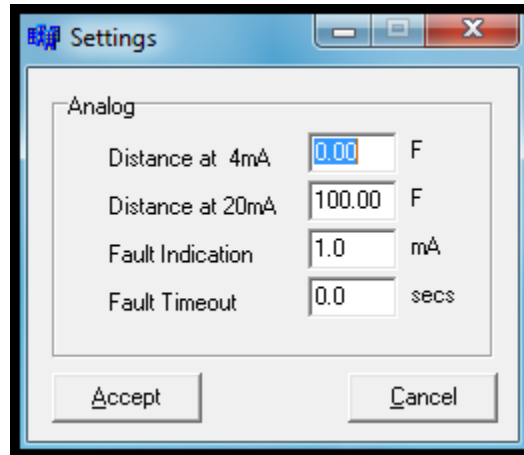
This configuration does not employ trip timeout, as it is an absolute measuring tool, and it can be used for processing line detection where high-speed handling equipment needs to prepare for a new batch of material. It can also be used for an obstacle avoidance alarm or a proximity curtain.

Section 6.0: 4-20 mA Analog Output Mode

6.1 Configuring Current Loop:

The Laser Rangefinder provides a 4-20mA analog output current loop. You may configure this output for current for the ranges specified in the main menu under Current Loop.

Figure 6.0



In Figure 6.0 above, *Distance at 4 mA* is defined as 0 feet. *Distance at 20 mA* is defined as 100 feet. *Fault Indication* is set to 1 mA and *Fault Timeout* is set to 2 seconds. Fault current will be output when Error 4 or 5 exists, that is *No Target Found* or *Average Not Filled*.

Note: When the 4 to 20 mA loop is enabled and the unit is not measuring, very close to zero current will be output.

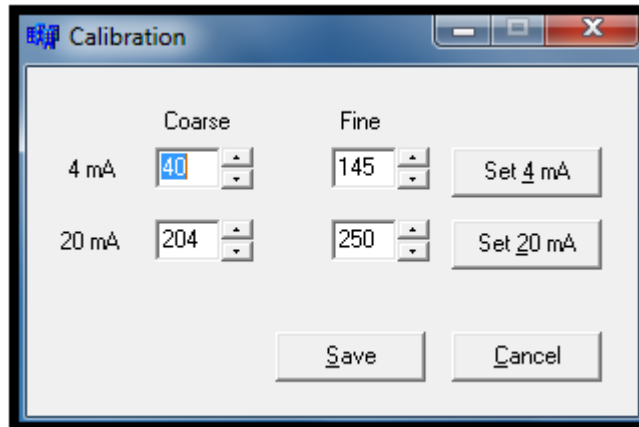
Enabling the 4-20mA loop without setting the distance at 4mA and 20mA will result in an error because the current loop ranges have not been set. Set the ranges then errors during the enable will be removed.

The actual current for the example current loop setup can be calculated by taking the 16 mA full-scale current range / (20 mA range value - the 4 mA range value) = 1.6 mA per meter. So a 5 meter reading: $5 \times 1.6 \text{ mA} = 8 \text{ mA} + 4 \text{ mA offset at zero} = 12 \text{ mA}$.

6.2 Calibrating the Current Loop:

The Current Menu includes an option that allows you to calibrate the 4-20 mA current loop.

Figure 6.1



Note: The 4-20mA current loop of every Laser Rangefinder is calibrated at the factory using precision test equipment. This procedure is given for customers that need to either verify or calibrate the current system to their requirements. Typically, the factory calibration is within 0.1% and should not need re-calibration.

1. Stop the unit.
2. Verify that the Current Loop (4-20 mA) selection is checked in the output setup box. This selection enables the 4-20mA system.

You must be able to measure the output current to find the set points. The system is very accurate with very fine resolution. This will require a precision DC voltmeter or current meter. The output of the system must be terminated with a suitable resistance before this calibration can be performed. As seen in the calibration box both the 4 mA and 20 mA set points can be calibrated. The coarse and fine digital/analog converter (dac) setting for both the 4 mA and 20 mA set point are displayed. By pressing either the Set 4 mA or Set 20 mA button the dac values displayed will be output to the current loop.

3. Adjust the dac values up or down.
4. Press the appropriate set button to output the result to the current loop.
5. Once both the 4 mA and 20 mA dac values are correct press the SAVE button. This will save these calibration points to non-volatile memory in the Laser Rangefinder.

The standard, internally powered configuration, you would provide a current sense resistor between the (+) or current source and the (-) or current sink terminal. This configuration will provide approximately 9 volts of compliance, or span, across the sense resistor.

Note: This voltage compliance value will limit the maximum size of the termination resistor that can be used in the current loop. Example: 9 volts / 20 mA = a maximum sense resistor of 450 ohms.

Section 8.0: Specifications

Performance:

Max range (reflective/ non-reflective) 1600 m / 500 m (5249 ft / 1640 ft)
 Accuracy +/- 2 cm (0.70 inches)
 See Targeting modes for more detail.

Pulsed Laser:

Beam Divergence: 3 milliradians nominal
 30cm beam diameter @ 100m / 1 ft @ 328 ft
 Exit Aperture: 42 mm
 Wavelength: 905 nm (near infrared)
 High / medium / low power: 400 / 200 / 100 nJ per pulse
 Average Power: Proportional to PRF (pulse firing rate)
 Eye Safety: Class I, 7 mm (FDA CFR 21)
 Class I M (IEC 60825-1:2001)

Visible Laser Pointer:

Wavelength: 650 nm (red)
 Eye Safety: Class II m (FDA CFR 21)
 Switch: Software Controlled
 Average output power: 1 mW

Input Power:

ACCL-LAS-24V-01, nominal: 16 - 30VDC @ 170 mA typical
 ACCL-LAS-120V-01, nominal: 100 - 240 VAC, 50 - 60Hz

Communications:

RS232 Port: Default Baud Rate: 19200
 Supported Baud Rate: 1200 to 115200
 4-20 mA: Analog Current: 4-20 mA
 Voltage Compliance: 9V maximum
 Maximum Loop Resistance: 450 Ohms

User Interface (RS232 Port):

Units: Feet or Meters
 Data Interface: RS232 (custom cable needed)
 Cable: M23 9-pin cable to RS232 DB9 port for PC
 Cable Lengths p/n:
 25feet: ACCL-PROG-CABLE-25
 50feet: ACCL-PROG-CABLE-50
 100feet: ACCL-PROG-CABLE-100
 150feet: ACCL-PROG-CABLE-150

Environmental:

Weather: IP 67 and NEMA 4
 Temperature: -22°F to +140° F (-30°C to +60°C)

NOTE: All specifications are subject to change without notice.

8.1 Averaging Mode Specifications

Table 8.0

	Laser Output Power		
	Maximum	Medium	Minimum
Non-Cooperative Target	±4 cm typical	±4 cm typical	±4 cm typical
Cooperative Target	±2 cm typical	±2 cm typical	±2 cm typical
Resolution	1 mm or 0.01 ft	1 mm or 0.01 ft	1 mm or 0.01 ft
Minimum Range	15 cm	15 cm	15 cm
Maximum Non-Cooperative Range	500 m to white wall (90% diffuse)	400 m to white wall (90% diffuse)	300 m to white wall (90% diffuse)
	250 m to gray wall (20% diffuse)	200 m to gray wall (20% diffuse)	150 m to gray wall (20% diffuse)
Maximum Cooperative Range	1700 m or 5577 ft (High-intensity Reflective Sheet)	1700 m or 5577 ft (High-intensity Reflective Sheet)	1700 m or 5577 ft (High-intensity Reflective Sheet)

8.2 Last Target Mode Specifications

Compared to Averaging Mode, accuracy is reduced an additional ± 2 cm. Depending on conditions (dust, vapor, etc.). Refer to the table above.

Output Data Rate

Output data rate depends on baud rate of the serial port, the PRF of the unit, the number of pulses per measure, the measurement mode, and the type of output data that has been selected. The ULS is designed to output a measurement every time the number of Pulses Per Measure (PPM) is reached. The time it takes for each PPM depends on the firing rate of the laser (the PRF). This data rate output time is within 0.01% typical. At the high end of the data rate spectrum other factors such as baud rate and the number of characters to be output will limit the output rate.

Example: Unit running at 3000 PRF and 300 PPM. Output data rate: $3000/300$ Hz or 10 Hz.

Baud Rate: Approximately $100 \mu\text{s}$ per character at 115200 baud rate. This time is inversely proportional to the baud rate so the time per character will double to $200 \mu\text{s}$ at a baud rate setting of 57600.

These main limiting factors of output data rate are the output data type selection and measurement range. These settings affect the number of characters sent out per measurement. With only range selected, approximately 10 characters will be sent out per measurement. If both range and intensity are selected, approximately 20 characters will be sent out per measurement.

Output Serial Data Stream

Range only: \$BM,xxxx.xxx<CR> 12 characters max
Range and Intensity: \$BM,xxxx.xxx,yyyyyyy<CR> 21 characters max,
where: \$ = non-addressable protocol message identifier
 BM = mnemonic for Basic Measurement
 xxxx.xxx = range (meters)
 xxxx.xx = range (feet)
 yyyyyyyy = intensity (picoseconds)
 <CR> = carriage return

Example: Unit running at 115200 baud rate, range output only.

$12 \text{ characters} \times 100 \mu\text{s} = 1.2 \text{ mS}$. Fastest output data rate = $1/1.2 \text{ ms} = 833 \text{ Hz}$.

Example: Unit running at 115200 baud rate, range and intensity.

$21 \text{ characters} \times 100 \mu\text{s} = 2.1 \text{ mS}$. Fastest output data rate = $1/2.1 \text{ ms} = 476 \text{ Hz}$.

8.3 Binning Mode Specifications

Table 8.1

	Laser Output Power		
	Maximum	Medium	Minimum
Accuracy and Maximum Range	± 2.5 cm typical at 13 m max. range	± 2.5 cm typical at 13 m max. range	± 2.5 cm typical at 13 m max. range
	± 5.1 cm typical at 26 m max. range	± 5.1 cm typical at 26 m max. range	± 5.1 cm typical at 26 m max. range
	± 10.2 cm typical at 52 m max. range	± 10.2 cm typical at 52 m max. range	± 10.2 cm typical at 52 m max. range
	± 20.4 cm typical at 104 m max. range	± 20.4 cm typical at 104 m max. range	± 20.4 cm typical at 104 m max. range
	± 40.8 cm typical at 208 m max. range	± 40.8 cm typical at 208 m max. range	± 40.8 cm typical at 208 m max. range
	± 81.6 cm typical at 416 m max. range	± 81.6 cm typical at 416 m max. range	± 81.6 cm typical at 416 m max. range
	± 163.2 cm typical at 832 m max. range	± 163.2 cm typical at 832 m max. range	± 163.2 cm typical at 832 m max. range
	± 326.4 cm typical at 1664 m max. range	± 326.4 cm typical at 1664 m max. range	± 326.4 cm typical at 1664 m max. range
Resolution	Same as Accuracy and Maximum Range above.	Same as Accuracy and Maximum Range above.	Same as Accuracy and Maximum Range above.
Minimum Range	15 cm	15 cm	15 cm
Maximum Range	450 m to white wall 90% diffuse	300 m to white wall 90% diffuse	250 m to white wall 90% diffuse
	225 m to gray wall 20% diffuse	150 m to gray wall 20% diffuse	125 m to gray wall 20% diffuse
	1664 m or 5459 ft (High-intensity Reflective Sheet)	1664 m or 5459 ft (High-intensity Reflective Sheet)	1664 m or 5459 ft (High-intensity Reflective Sheet)

Output Data Rate

As in Averaging Mode, the output data rate equals the PRF/PPM in Hz. In Binning Mode, the max PRF should not exceed approximately 1 KHz. This is because the unit has to download and process every laser pulse fired. The Pulses Per Measure (PPM) number is used to fill the bins, so a reasonable number of 25 to 100 PPM must be used. Using values less than 25 will not fill the bins with enough information to find the targets. With these two factors in mind the highest approximate output data rate is 1000/25 or 40 Hz. Output data rate depends on baud rate of the serial port, the PRF of the unit, and the PPM. The ULS is designed to output a measurement every time the number of Pulses Per Measure (PPM) is reached. The time it takes for each PPM depends on the firing rate of the laser (the PRF). This data rate output time is within 0.01% typical. At the high end of the data rate spectrum, other factors such as baud rates and the number of characters to be output will limit the output rate.

Example: Unit running at 1000 PRF and 100 PPM. Output data rate: 1000/100 Hz or 10 Hz. Baud Rate: It takes approximately 100 μ s to output one character at 115200 baud rate. This time is inversely proportional to the baud rate, so the time per character will double to 200 μ s at a baud rate setting of 57600.

In Binning Mode, multiple targets are output if found. The maximum number of targets is fifteen. The maximum number of characters per target will be approximately 18. The number of range and intensity characters will vary per application and measurement. The number of targets will also vary. As the worst case, the number of characters that must be considered is 20 characters per target and 15 targets or 300 characters per measurement. At approximately 100 μ s per character, the total time would be 30 ms per output measurement. This equates to a maximum output data rate of 33 Hz.

Output Serial Data Stream

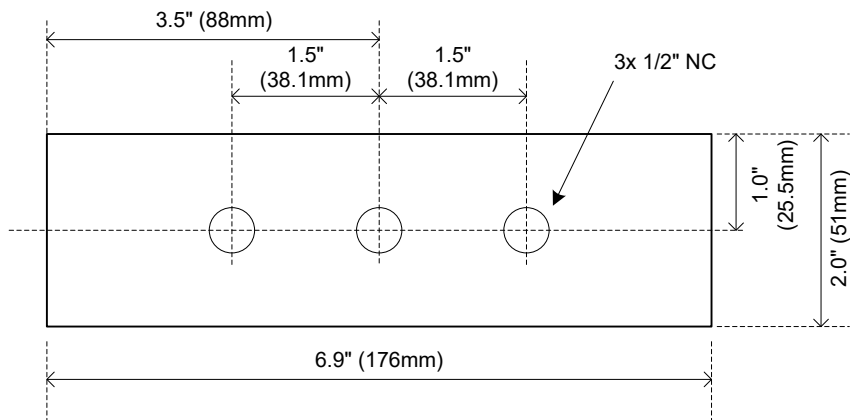
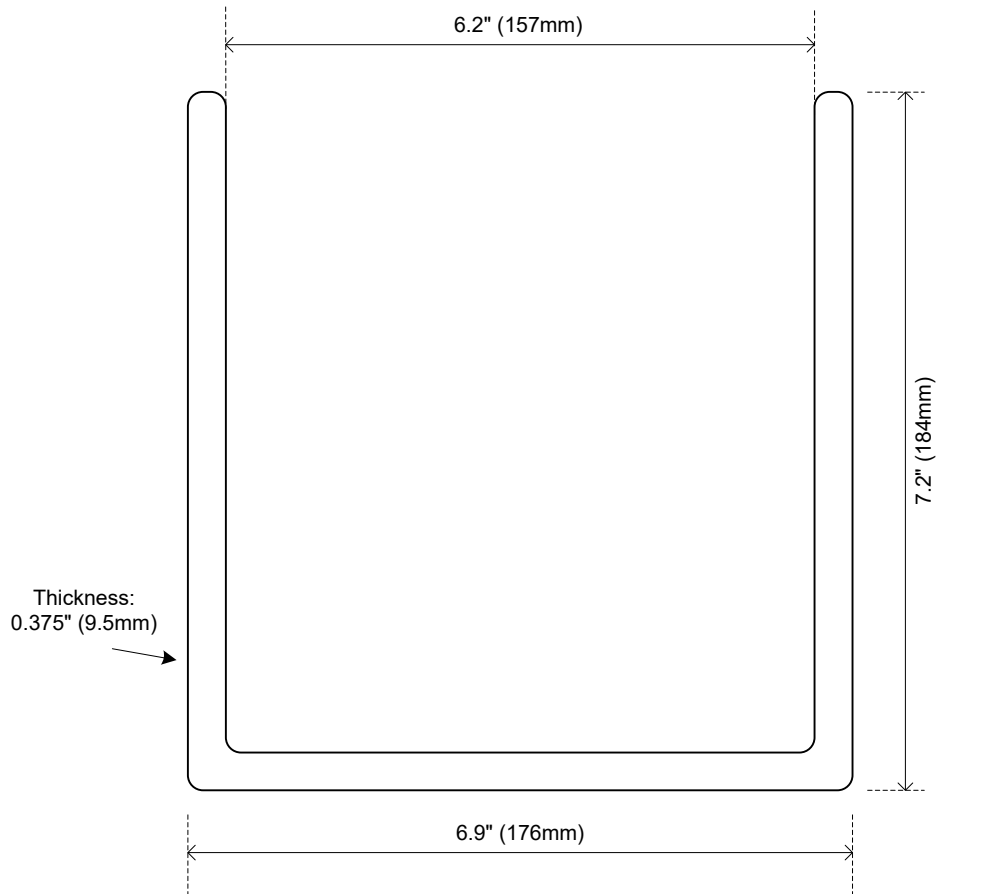
`$BM,I,A,xxxx.xxx,SSS<CR>` is 20 characters max (single target output stream)

Up to 15 targets maximum or 15 lines maximum per measurement

where:

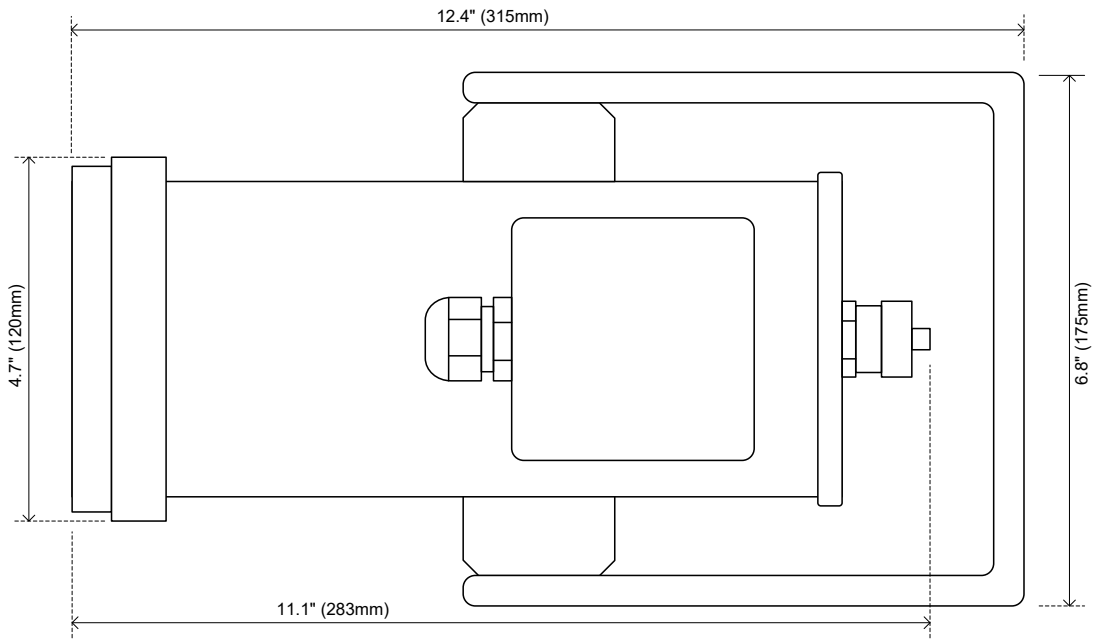
- \$ = non-addressable protocol message identifier
- BM = mnemonic for Basic Measurement
- I = index value in array
- A = number of targets in the array
- xxxx.xxx = range value for that particular target
- SSS = strength for that particular target
- <CR> = carriage return

8.4 Accutron Laser Rangefinder Mounting Bracket

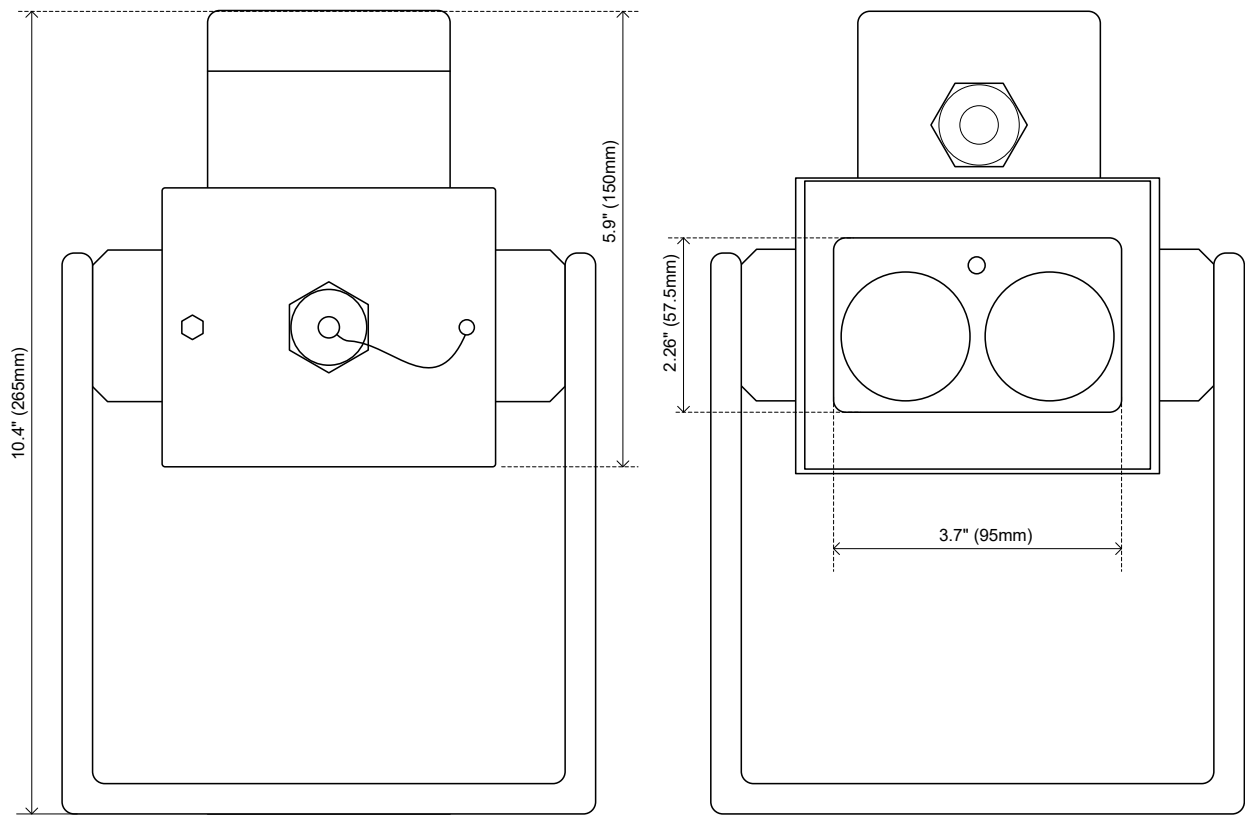


Mounting Footprint

8.5 Accutron Laser Rangefinder Housing Dimensions



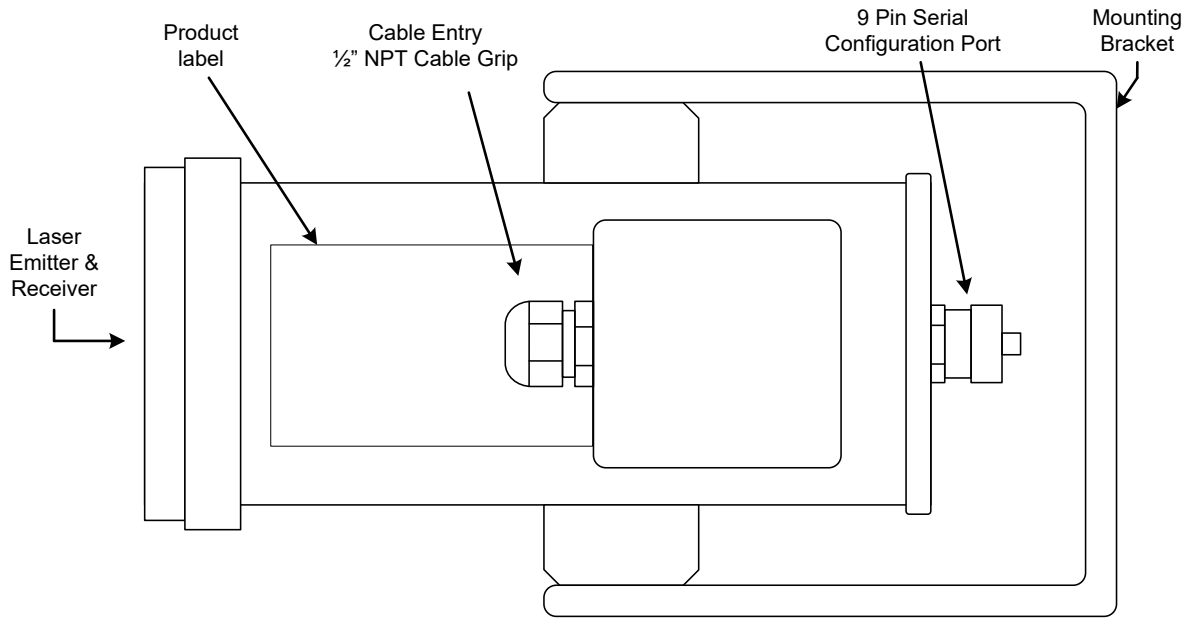
Top View



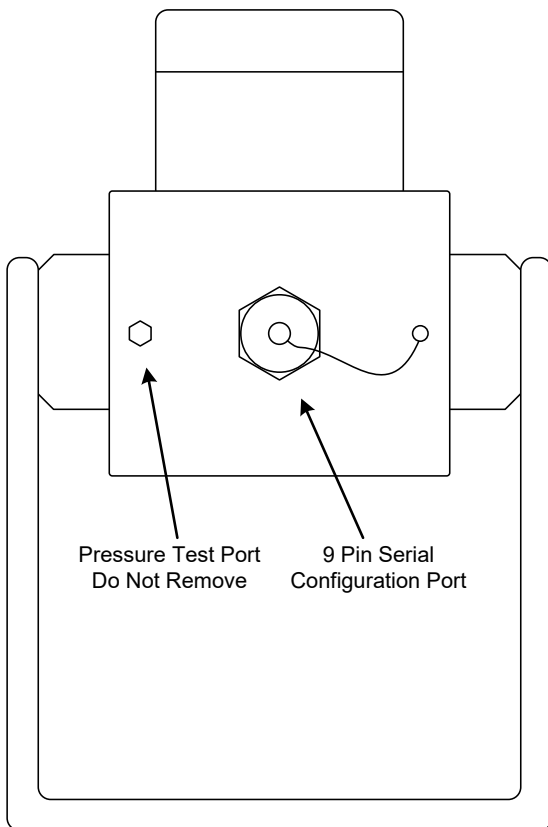
Back View

Front View

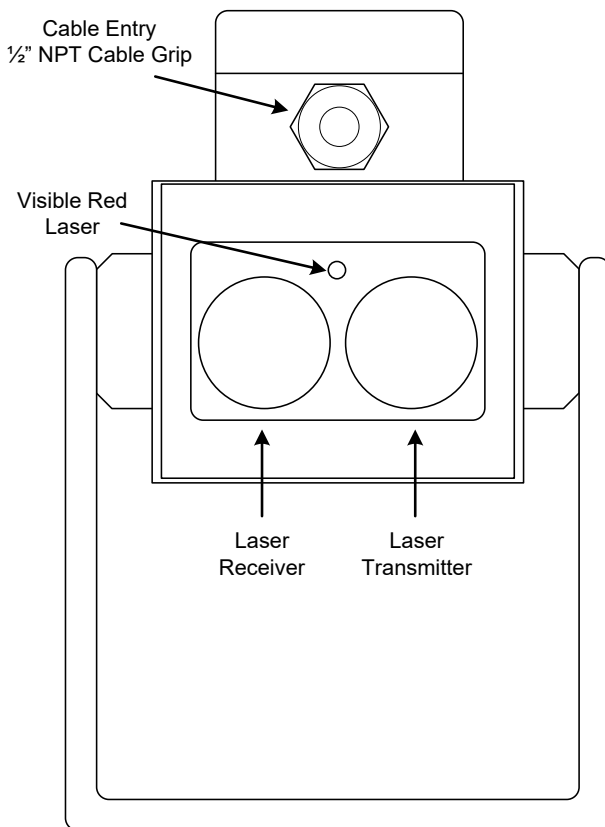
8.6 Accutron Laser Rangefinder General Layout



Top View

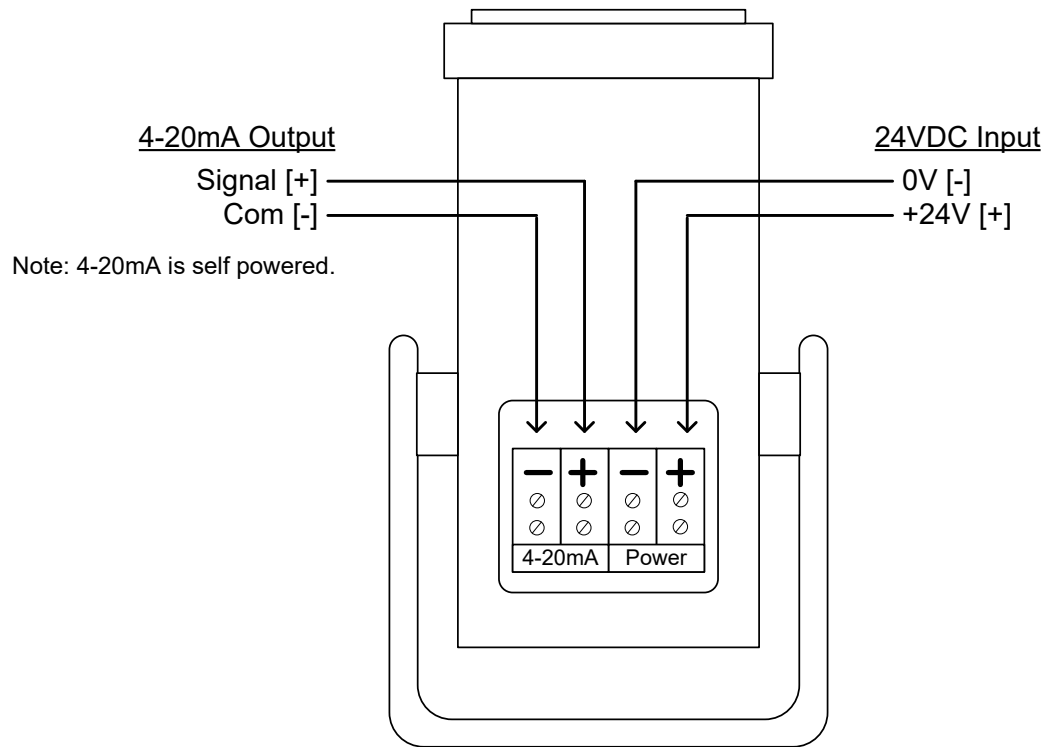


Back View

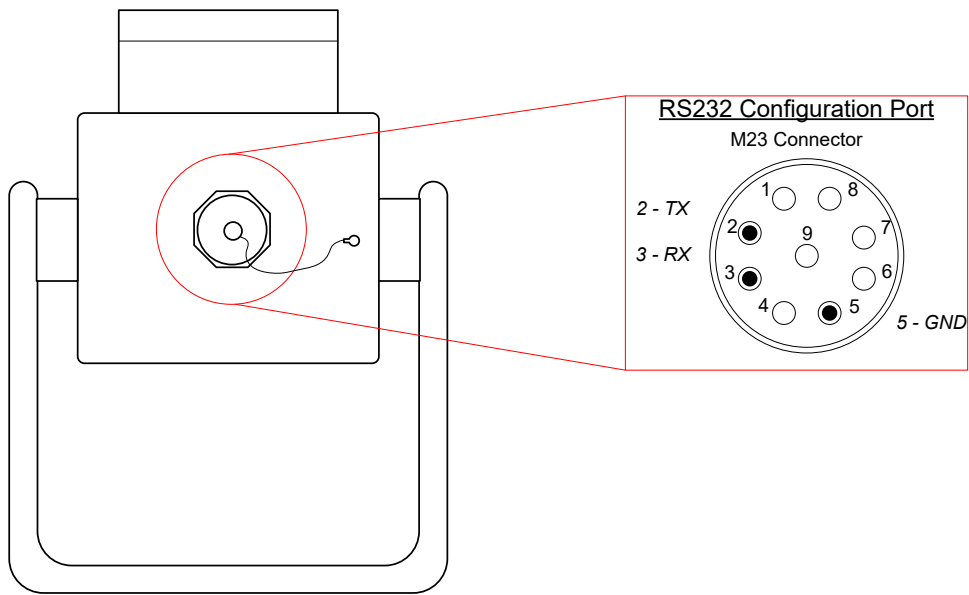


Front View

8.7 Connections Diagram – ACCL-LAS-24V-01

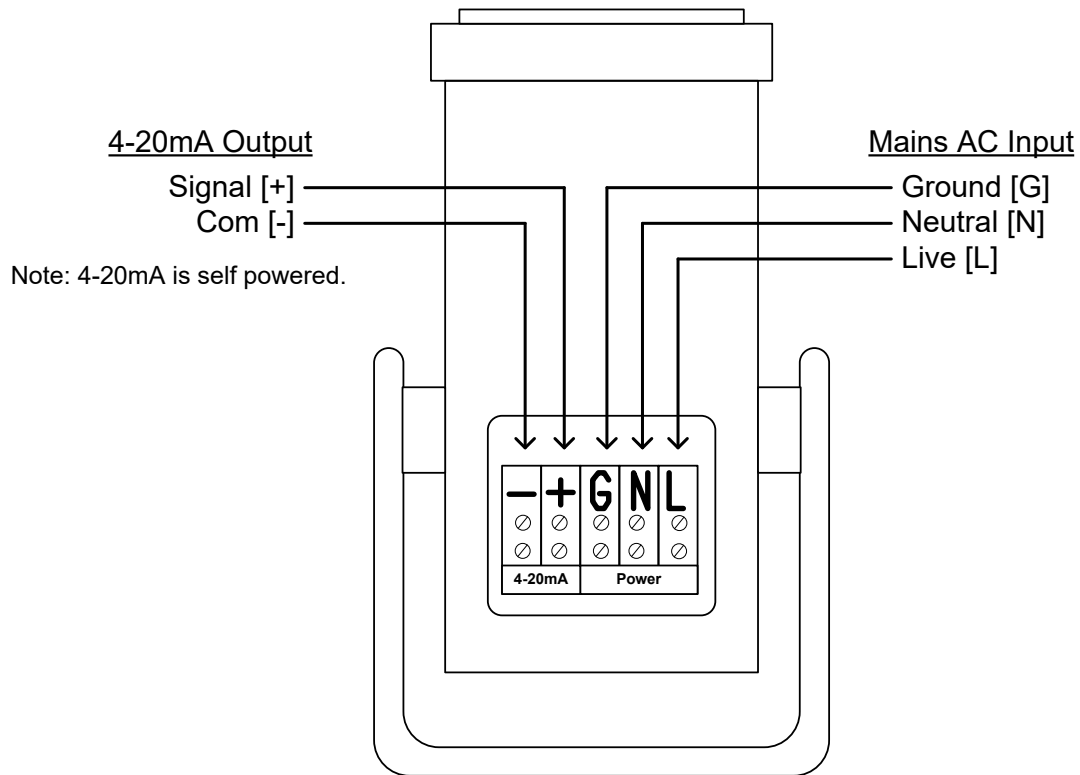


Top View

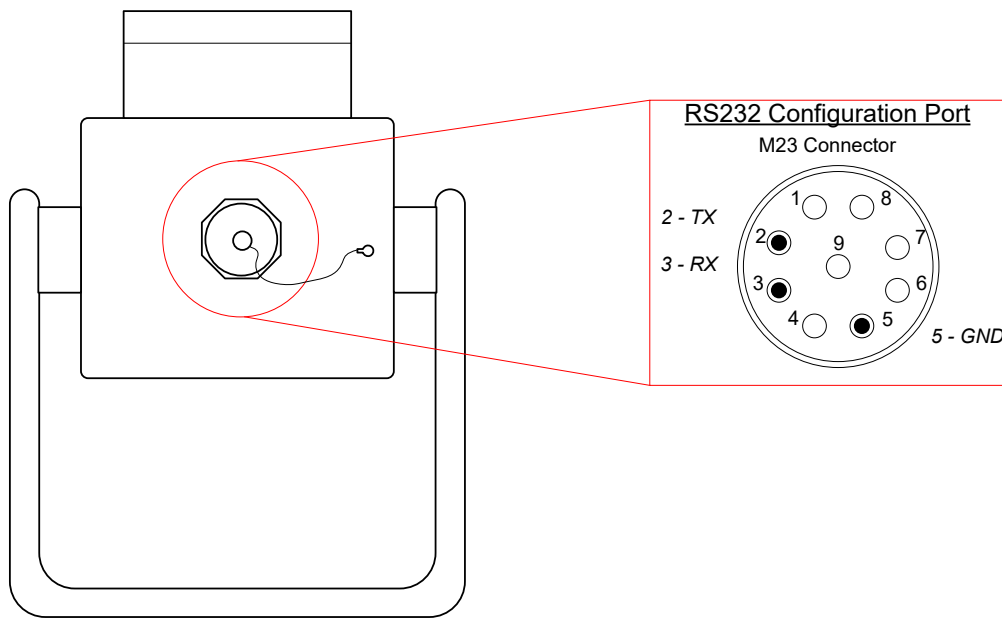


Rear View

8.8 Connections Diagram - ACCL-LAS-120V-01



Top View



Rear View

Section 9.0: Error Numbers

While using the Rangefinder Laser software, any errors that can occur are listed below.

Note: Errors that are flagged with (*) must be resolved by Accutron Instruments Inc. If that is the case Accutron technical support needs to be informed.

<u>Error Number</u>	<u>Explanation</u>	<u>ILR Interface Display</u>
1	General Command Interface Error	Invalid Command
4	Lock Not Found	Target Not Found
5	Average Weight Not Filled	Average Not Filled
6	Measurement Start Error	Measurement Start Error
7	Measurement Read Error	Measurement Read Error
8	Measurement Stop Error	Measurement Stop Error
9	*PTFCAL Bad Status Error	ER 009
10	*ADC Error	ER 010
11	*Memory Write Error	Memory Write Error
12	*Averaging Error	Averaging Error
13	*General ASIC Error	General ASIC Error
14	*General Laser CPU Error	General Laser CPU Error
15	*User Settings Checksum Error	User Settings Checksum Error
16	*Bad Password Error	Bad Password
17	*No Measuring Data Available Error	ER 017
18	*Measurement Data Not OK Error	ER 018
19	*Cannot Write To Flash Error	ER 019
20	*Cannot Reset Asic Done Bit	ER 020
21	*ASIC BIST Test Timeout	ER 021
22	*ASIC Failed RAM Test	ER 022
23	*Laser CPU Failed RAM Test	Laser CPU Failed RAM Test
24	*Serial EEPROM Write Protect Jumper in Place	ER 024

25	*RX Buffer Overrun	RX Buffer Overrun
26	*Incorrect ADC Address Error	ER 026
27	*General Ring Frequency Cal Error	ER 027
28	*HV CLK Frequency Too High Error	ER 028
29	Unsafe DAC Setting Error	ER 029
30	*PTFCAL Zero Events	ER 030
31	No Serial While Measuring Error	Instrument Is Already Measuring
32	Invalid Rep Rate	Invalid PRF
33	Invalid Input Base	ER 033
34	Invalid Baud Rate	Invalid Baud Rate
35	Invalid Average Weight	Invalid Average Weight
36	Invalid Noise Zone Error	ER 036
37	Factory Defaults Checksum Error	Bad Factory Defaults Checksum
38	Code Checksum Error	Bad Code Checksum
39	*Too Many EEPROM Writes Error	ER 039
40	*Broken EEPROM Error	ER 040
41	*Unverifiable Image Checksum Error	ER 041
42	*Bad User Settings Defaults Checksum	Bad User Settings Defaults Checksum
43	*Bad User Settings Checksum	Bad User Settings Checksum
44	*Bad Factory Defaults Checksum	Bad Factory Defaults Checksum
45	*No Factory Defaults Present Error	No Factory Defaults
46	*EEPROM Not Finished Yet Error	ER 046
47	*SPI Busy	ER 047
48	*Serial Checksum Error	ER 048
49	Pulse Per Output Must Be Greater Than Average Weight	PPO Must Be Greater Than Average Weight

9.1 Interrupt Error Numbers

<u>Error Number</u>	<u>Explanation</u>	<u>ILR Interface Display</u>
50	Dropped Pulse	ER 050
51	Measurement Bad Status	Measurement Bad Status
52	NEG PW	ER 052
53	*RFC Fail Bad Status Error	ER 053
54	PW Too Long Or Too Short	ER 054
55	*RFC Fail Zero Event Count Error	ER 055
56	*Insufficient Cal Data for CALC Error	ER 056
57	*RXC Fail Bad Status Error	ER 057
58	*RXC Fail Insufficient Events Error	ER 058

9.2 Table Checksum Error Numbers

<u>Error Number</u>	<u>Explanation</u>	<u>ILR Interface Display</u>
59	*BAD PTF Table Checksum	BAD PTF Table Checksum
60	*Bad Power Table1 Checksum	ER 060
61	*Bad Power Table2 Checksum	ER 061
62	*Bad Power Table3 Checksum	ER 062
63	*Bad Power Table4 Checksum	ER 063
64	*Bad Power Table5 Checksum	ER 064
65	*Bad Power Table6 Checksum	ER 065
66	*Bad Power Table7 Checksum	ER 066
67	*Bad Power Table8 Checksum	ER 067
68	*Gate Open Cal Invalid	ER 068
69	*Gate Close Cal Invalid	ER 069
70	Incorrect Bootloader Password	ER 070
71	Invalid Power Table Selection	ER 071
72	Invalid HV1 Table Selection	ER 072
73	HV1 Not Set	HV1 Not Set
74	Invalid HV1 Sense Table Selection	ER 074

75	Unsafe HV1 Sense Setting	ER 075
76	HV1 Sense Not Set	ER 076
77	HV1 Sense Error	ER 077
78	Invalid Command for Measurement Mode	ER 078
79	Instrument Not Ready	Instrument Not Ready
80	*Gate Open Fail Bad Status	ER 080
81	*Gate Close Fail Bad Status	ER 081

9.3 4-20 Error Numbers

<u>Error Number</u>	<u>Explanation</u>	<u>ILR Interface Display</u>
83	Invalid MA420 Range	Invalid Current Loop Range
84	Invalid Port	Invalid Port
85	Invalid Measurement Mode	Invalid Measurement Mode
86	Instrument Not Measuring	Instrument Not Measuring
87	Invalid Minimum Pulse Width	Invalid Minimum Pulse Width
88	Invalid Temperature Compensation Range	Invalid Temperature Compensation Range
89	Invalid Dither Step Size	Invalid Dither Step Size



REV 2023.06.15

For ACCL-LAS-24V-01
and ACCL-LAS-120V-01

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