Laser Technology, Inc.

Universal Laser Sensor

User's Manual

LASER TECHNOLOGY INC
Measurably Superior®

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LTI Contact Information:

Laser Technology, Inc.
6912 S. Quentin Street
Centennial, CO 80112

Phone: 1-303-649-1000
1-877-OWN-A-LIT (USA and Canada)
Fax: 1-303-649-9710
Web Site: www.lasertech.com
Email: service@lasertech.com

LTI Universal Laser Sensor User's Manual (p/n 0144745) Change Log

- **3rd Edition** November 2015
  - Added LTI-brand cover page with hex design and updated LTI contact information. Pages i-ii
  - Added the Change Log. Page 1
  - Updated cable drawing 4824689 Cable, Power PSG-6M-*/S90 S618 Turck. Page 33
  - Updated 4-20 mA Analog Output Mode Settings screen shot. Page 34
  - Updated "ULS Interface Program Requirements - Operating Systems". Page 64
- **2nd Edition** August 2006
  - Added Last Target Mode. Throughout
  - Changed Look Down Mode to Detection Mode. Throughout
  - Updated all screen shots of the ULS Interface Program. Throughout
  - Updated descriptions of the control buttons and added the terminal window. Page 8
  - Added "More Averaging Parameters" section. Page 15
  - Added "Output Processing" section. Page 18
  - Major revisions to entire "Section 3: Measurement Modes". Pages 20-31
  - The 1 meter long, 4-pin Turck to DB9 RS232 cable was changed to an available accessory. Page 33
  - Added note about the 4-20mA current loop factory calibration. Page 36
  - Added "Section 8: ULS Terminal Window". Page 38
  - Major revisions throughout the "ULS Commands" section. Pages 44-63
  - Updated specifications. Page 64
  - Updated Error Numbers. Pages 69-71
- **1st Edition** March 2005

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Safety Precautions

Internal 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 IIm.
  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 ULS 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.

- If using the optional sighting scope, never attempt to view the sun through the scope. Looking at sun through the scope may permanently damage your eyes.

- 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: Introduction

The ULS is a user-configurable product, which lets you adjust settings to optimize measurement performance in a variety of applications. The primary tool for controlling the operation of the ULS is the ULS Interface Program. This configuration software developed by Laser Technology Inc. (LTI) 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 ULS's internal memory so that each time you turn on the ULS, it will use these same settings.

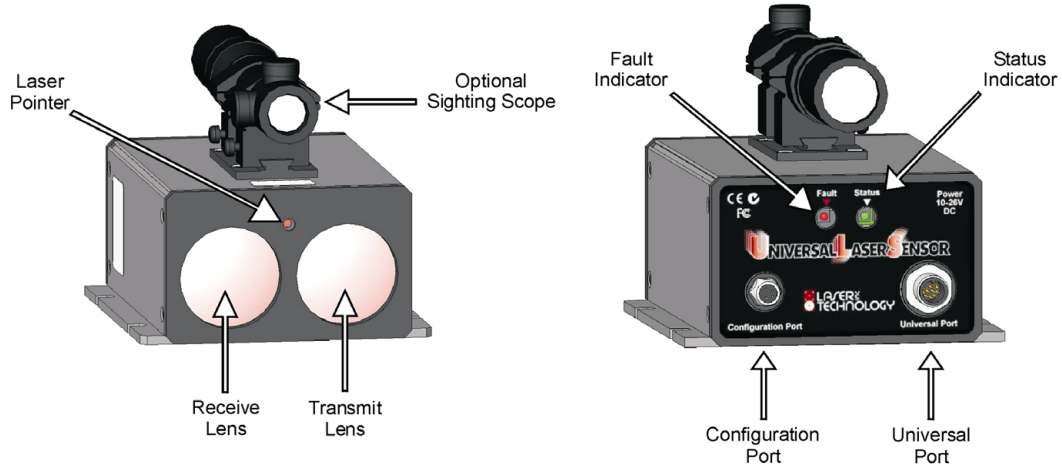
The ULS has four primary measurement modes: Averaging, Last Target, Binning, and Detection.

- **Averaging Mode**: the ULS takes a specified number of individual distance measurements and averages them into a single output result.
- **Last Target Mode:** used in poor environments to a achieve a measurement to the last object the laser hits.
- **Binning Mode:** allows the ULS to acquire a single specific target in the presence of multiple intervening unwanted targets (or system noise, in the case of an extremely weak target) by taking a 'burst' of individual measurements and determining the prominent target in the aggregate data set.
- **Detection Mode:** a dedicated, rapid update, proximity detection configuration used to detect the presence of fast moving objects.

This manual is intended to be used with:

- ULS version 5.x and any previous ULS version (Page 59).
- ULS Interface version 2.x. This version number is displayed when you select the About option located at the top of the ULS Interface screen.

The figures below show front and rear views of the ULS.



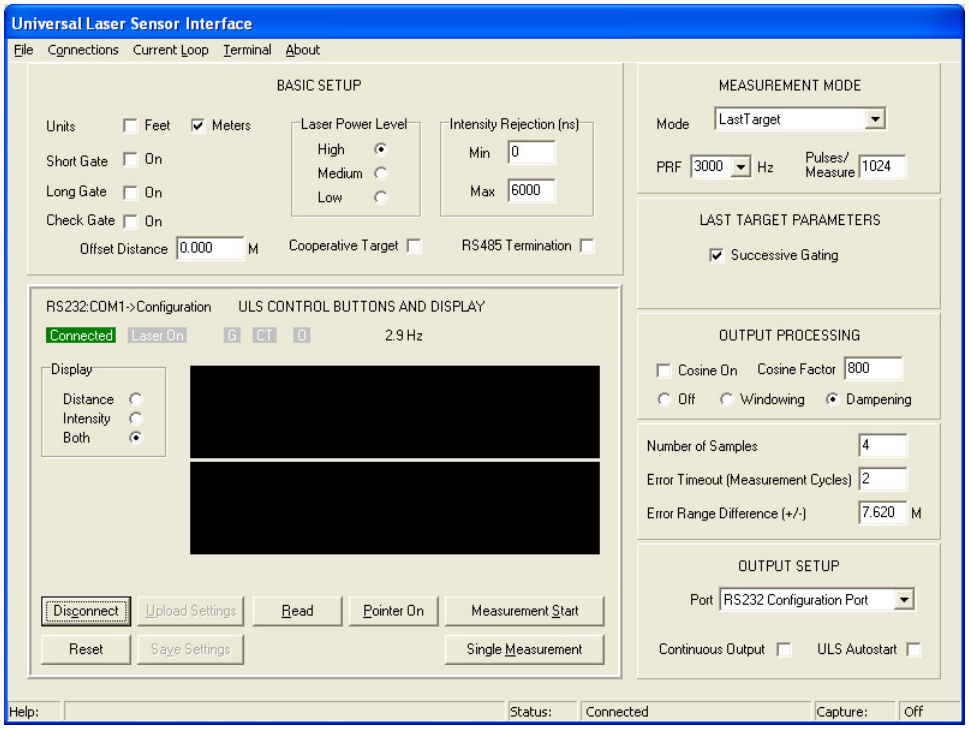
(Front) (Rear)

The ULS has two connection ports: a universal output port and an RS232 configuration port. In this interface configuration, the universal port provides RS232 and/or RS485 digital serial output data, as well as an RS232 / RS485 level "trip signal" output in the Detection Mode. The configuration port provides for RS232 input and output communications, allowing for sensor setup via the ULS Interface Program (or discrete serial data command strings), and the output of digital serial measurement data. Both of these ports provide a power input connection (V+ and ground) for the ULS. The two data port power inputs are wired together with series diodes. This allows power to be applied on either port or just one.

Section 2: ULS Interface Program

The ULS Interface Program is used to (1) set specific operating parameters within the ULS, (2) control the sensor's operation, and (3) view output data from the device. Each function/feature of the ULS Interface Program has a corresponding serial data communication message to/from the ULS that invokes the appropriate function in the sensor. If you connect the ULS into a system with a dedicated controller and/or CPU that cannot use the Windows-based Interface Program, you can communicate with and control the ULS directly using the appropriate serial communication messages. To accommodate this possible interface approach, the definition of each function's communication message to the ULS is provided in the ASCII Protocol section (Page 43-62).

The screen capture below shows the ULS Interface Program's main operating screen.

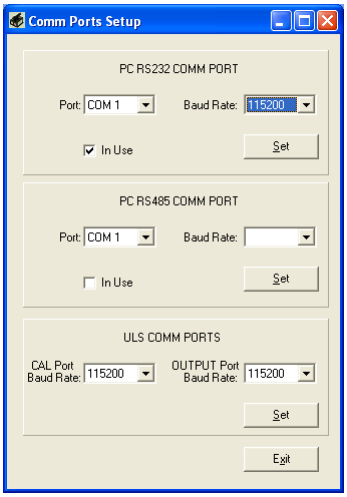


Getting Started

The ULS interface program is supplied on a CD-ROM. To install the program, insert the CD-ROM into the computer's CD-ROM drive and navigate to the ULS_Interface_Setup.exe file. An ULS Interface icon will be added to the computer's desktop during the installation process.

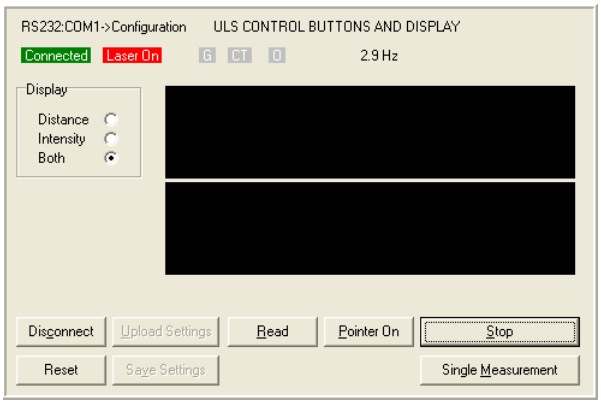
When you're ready to start the ULS interface program, make sure that the ULS is powered correctly and connected to the computer. When power is applied, the green STATUS indicator will light, noting that the unit has powered up properly.

The default port is Com 1, but that can be changed by selecting Connections > Comm Port Setup from the pull-down menus at the top of the screen and choosing the appropriate setting. Select the appropriate PC com port and baud rate (the default baud rate is 115200), and then press the Set button to configure the ULS program to the correct PC com port. Press Exit to close this window.



You can now click on Connect to see the complete screen (see figure above).

ULS Control Buttons and Display



System Configuration: Data output format and selected ULS output data are displayed in the upper left corner. In this example the configuration is displayed as *RS232:COM1*.

Measurement Output Rate: Value expressed in Hz. In this example, the measurement output rate = 2.9 Hz.

Connect/Disconnect
Connect: Activates the communication between the computer and the ULS.

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

Upload Settings: This button is highlighted when any parameter in the ULS Interface is changed. The highlighting signifies that changed settings need to be uploaded to the ULS. Press this button to upload all pending settings to the ULS. Once the settings have been uploaded, this button will no longer be highlighted. The ULS 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 show that the ULS has new settings that have not been saved. This allows you to run the ULS with new settings without saving them permanently into the unit. Once the changed settings have been verified to your satisfaction, press the Save Settings button to permanently save these changes to the ULS.

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.

Note: After defining specific operating parameters, the File Menu includes options that allow you to store this information as a configuration file (*.uls). The default file location is (C:\Program Files\LTI\ULS Interface\). Whenever you open a stored configuration file, always remember to Upload Settings.

Reset: Resets the ULS CPU to a power on reset state. This can be used to revert to ULS back to the instrument's stored settings. Any unsaved settings will be discarded, and the unit will start up with the current ULS saved settings.

Read: If you are not sure whether a parameter has been uploaded, the Read button downloads the current ULS settings. You can use the ULS Terminal Window to view the downloaded settings (see below). For more detailed information about the ULS Terminal Window, see Page 37.

Opening the Terminal Window

The ULS interface program has a terminal serial communication window that displays all ULS communications on the serial bus. To open this window, click on the Terminal menu or press Alt+T when the interface is active. The terminal window will appear immediately. The terminal may not appear in view on low resolution PC screens.

1. Press Alt + space bar to select the terminal window resize menu.
2. Press ↓ key once to select Move and then press Enter.
3. Use the ← key to move the terminal into view.

Once in view, click the terminal window bar with the mouse and move it to a good location on the desktop.

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.

- See Page 56 for information about the Pointer On/Off serial command.

Caution:This visible laser is not considered Class I eye safe. It is Class IIm. 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 measurements.

- See Page 54 for information about the Measurement Start serial command.

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

- See Page 53 for information about the Measurement serial command.

Display/Target Selection: Depending upon the measurement mode, this parameter affects the information displayed in the black measurement box and the serial output data string. In Averaging Mode and Last Target Mode, you have the option to display the measurement only, the signal intensity only or both at the same time. 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.

- See Page 49 for information about the Display Mode in Averaging serial command.

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

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

File Menu

The File Menu includes options for user-defined system configurations, measurement data capture, and closing the interface program.

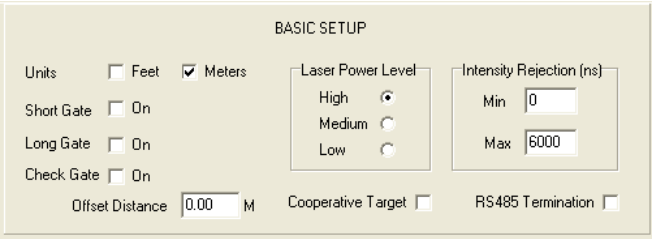
- **Open Setup:** Displays an Open dialog box that you can use to navigate to a previously saved configuration. The *.uls file extension is used for ULS configuration files.
- **Save Setup:** Displays a Save dialog box that you can use to store the current configuration. The *.uls file extension is used for ULS configuration files.
- **Save Setup As:** Displays a Save As dialog box that you can use to store the ULS current settings configuration. Be sure the upload settings button is not highlighted before saving the setup. Otherwise, the incorrect setup may be saved. The *.uls file extension is used for ULS configuration files.
- **Capture All:** Normally, only measurement data is captured and errors are excluded from the*.log file. When this option is selected, a check mark appears to the left of the option, and the *.log files includes both measurement data and errors. A time stamp is also added to each measurement logged.
- **Start Capture:** Displays a Capture Filename dialog box. The *.log file extension is used for ULS capture files and the default file location is the folder where the interface program resides, the default location is C:\Program Files\LTI\ULS Interface.
- **Stop Capture:** Ends the measurement data capture process and closes the capture file.

- **View Capture:** Displays a View Capture File dialog box. The *.log file extension is used for ULS capture files and the default file location is the folder where the interface program resides, the default location is C:\Program Files\LTI\ULS Interface. Select the log file that you want to view and click the Open button.
  The content of the capture file varies depending upon the measurement mode:
  - Averaging Mode: Time (H:M:S:mS), Distance, Distance Units, Intensity.
  - Last Target: Time (H:M:S:mS), Distance, Distance Units, Intensity.
  - Binning Mode: Time (H:M:S:mS), Index value in array, Number of Targets, Distance, Intensity, Distance Units.
  - Detection Mode: (H:M:S:mS), ON/OFF, Time, Time Units.

The capture file will be displayed in a separate window. The *.log file may be opened using a program such as Microsoft Word, Word Pad or Note Pad. The capture file can also be imported as a comma delimited text file into a spreadsheet program for data analysis.

- **Exit:** Closes the interface program

Basic Setup



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 (mm).

- See Page 54 for information about the Measurement Units serial command.

Short Gate: When this function is used, the laser 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 will not output a distance to that target.

All laser pulses are corrected for signal intensity, however, 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, as long as it greater than 2.4-3.0 meters (8-10 feet) beyond the first target.

- See Page 58 for information about the Short Gate serial command.

Long Gate: When this function is used, the laser 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. Also 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.

- See Page 52 for information about the Long Gate serial command.

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

- See Page 46 for information about the Check Gate serial command.

Offset Distance: This distance (can be 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 ULS.

- See Page 61 for information about the User Offset serial command.

Laser Power Level

The Laser Power Level only affects the maximum range capabilities of the ULS. If you are measuring to close targets, you can reduce the power level in order to potentially run the laser at a higher pulse frequency, yet stay below FDA Class I limits. If you are operating in dusty or dirty environments, we recommend using lower power setting.

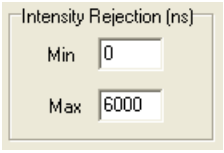
- See Page 56 for information about the Power Level serial command.

Cooperative Target

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

- See Page 46 for information about the Cooperative Filter (Target) serial command.

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.

- See Page 55 for information about the Minimum Pulse Width Rejection serial command.

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

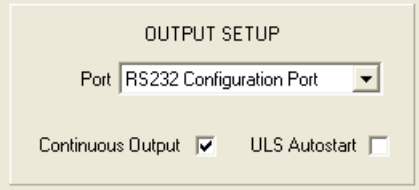
- See Page 52 for information about the Maximum Pulse Width Rejection serial command.

RS485 Termination

This function controls the termination resistor internal to the ULS on the RS485 port. The 100 ohm termination resistor should only be used on the last unit in the multi-unit configuration.

- See Page 58 for information about the RS485 Bus Termination On/Off serial command.

Output Setup



Port: Defines which port you want the output measurement data to be sent to.

The default setting is the RS232 Configuration Port since that is the port (4-pin connector) you are connected to when using the ULS Interface Program. The ULS Interface program may also be connected by the Universal Port (12-pin connector) by selecting either of the RS232 or RS485 port interfaces. If you change the measurement output to a different port, the measurement data will be directed to that port for output. Only one digital output mode is allowed at one time on the Universal port. Either RS232 or RS485, but not both at the same time. The RS232 configuration port is always active as an input.

- See Page 54 for information about the Measurement Output Port serial command.

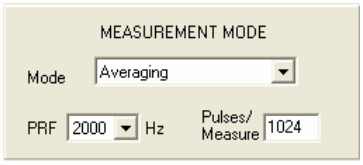
Continuous Output: When this function is on, the ULS downloads and displays each measurement completed. When this function is off, the ULS completes measurements, but the serial output data and display are not updated. You must select Single Measurement to display the last completed measurement. The continuous output data rate is the Pulses/Measure divided by the PRF (laser firing rate per second) in seconds.

- See Page 46 for information about the Continuous Measurement Output Mode serial command.

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

- See Page 53 for information about the Measurement Autostart On/Off serial command.

Measurement Mode



Mode: This parameter depends upon your application. Select Averaging if accuracy is critical. Select Last Target in poor environments to achieve a measurement to the last target the ULS sees. Select Binning if the environment is dusty, multiple targets are present, or very weak returns are expected. Select Detection Mode if you want to use the ULS as a look-down sensor for presence detection. For more information on these measurement modes, please refer to the Measurement Modes Section (Page 19). The corresponding parameter windows will appear for each measurement mode.

When changing the measurement mode, the Upload Settings button in the Interface Program for this change is done automatically. This change happens automatically 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 actually upload parameter changes.

- See Page 53 for information about the Measurement Mode serial command.

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 to 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

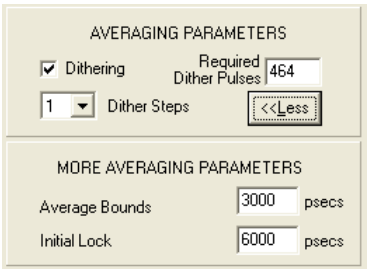
- See Page 56 for information about the PRF serial command.

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. Using the above screen as an example, with Pulses/Measure = 1024 and PRF = 2000, we would expect a measurement every 512 ms. As the PPM increases the measurement output update time will also increase.

- See Page 57 for information about the Pulses/Measure serial command.

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 is 32, 64, 96, or 128 then the dither step size should be 1. The smaller the dither step size, the more accurate the measurement.

- See Page 49 for information about the Dither On/Off serial command.

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 then one are used when the required dither return pulses is 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.

- See Page 44 for information about the Averaging Weight serial command.

More Averaging Parameters

The ULS 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 to targets. Locking is only done in Averaging Mode and is done for all average weights (Minimum Good Pulses, or Required Dither Pulses) greater then 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 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 ULS actually 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.

- See Page 43 for information about the Average Bounds serial command.

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 ULS 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 ULS is approximately 110 psecs (slightly oven 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 then 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 lowing the average weight to below 4 (no locking is done), and still no measurements are seen means nothing is being seen by the ULS 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 is moving that the ULS is trying to measure, the wider the locking criteria needs to be adjusted.

- See Page 51 for information about the Initial Lock serial command.

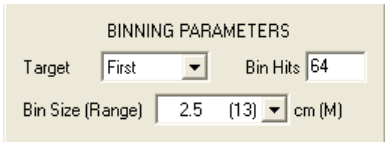
Last Target Parameters

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. It is the single longest range seen in the PPM block fired

Successive Gating: When this function is on, the ULS 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 ULS can see determines how many 10-pulse blocks the ULS must go though 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 ULS 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.

- See Page 50 for information about the Enable Gates serial command.

Binning Parameters



Target: Select your desired target from the drop down menu. In general, the 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.

- See Page 51 for information about the First, Last, Most, and All serial command.

Bin Hits: Establishes how many pulses must land in a bin in order 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 maybe 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. These values will be random each measurement. Targets beyond the 8 targets reported will be ignored. If this value is set too high, no targets will be found.

- See Page 45 for information about the Bin Threshold serial command.

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.

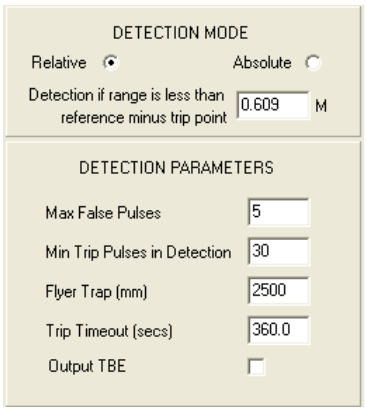
- See Page 45 for information about the Bin Size serial command.

Detection Parameters

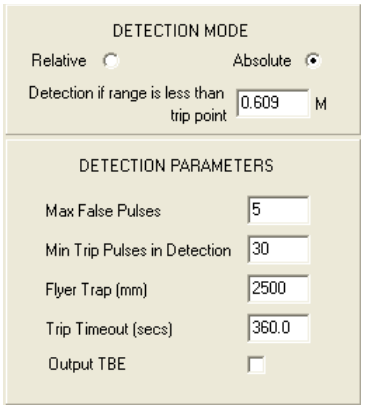
The Detection Mode may be run in two different configurations depending upon your specific application: Relative or Absolute.

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

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



(Relative)



(Absolute)

- See Page 48 for information about the Detection Mode Absolute vs. Relative Operation serial command.

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.

- See Page 52 for information about the Maximum False Pulses serial command.

Min Trip Pulses in Detection: Specifies the number of pulses required to start or finish a trip.

- See Page 47 for information about the Current Trip Threshold serial command.

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. Default value is 2500 mm.

- See Page 51 for information about the Flyer Trap serial command.

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

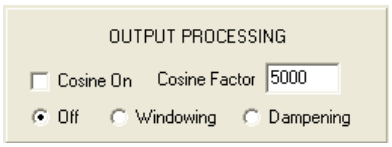
- See Page 60 for information about the Trip Timeout serial command.

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, or 485 output lines. The hexidecimal value of the number of fire pulses between events is output on the configuration port. Knowing the firing rate of the ULS, the time between events can be calculated.

- See Page 59 for information about the Time between Events serial command.

Output Processing

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.

For example, if the measurement value equals 10.000 meters and the specified Cosine Factor equals 5000, the measurement displayed and output will equal 50.000 meters.

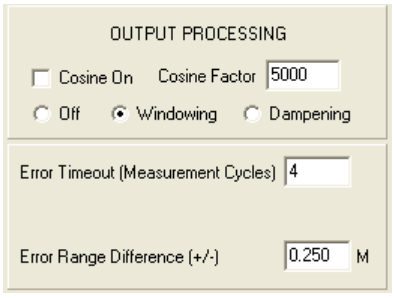
- See Page 47 for information about the Cosine Enable serial command.

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

- See Page 47 for information about the Cosine Value serial command.

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

- See Page 55 for information about the Minimum Pulse Width Rejection serial command.



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

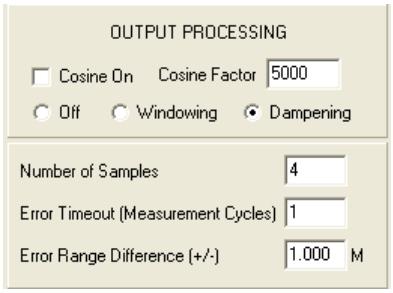
- See Page 55 for information about the Minimum Pulse Width Rejection serial command.

Error Timeout (Measurement Cycles): The number of measurement errors required before an error is output from the ULS. Measurement errors could be laser errors (ERR04) or measurements outside of the window.

- See Page 62 for information about the Windowing Time Out serial command.

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.

- See Page 61 for information about the Windowing Error Range Value serial command.



Dampening: Similar to the Windowing feature, except that 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 reported by the ULS.

- See Page 55 for information about the Minimum Pulse Width Rejection serial command.

Number of Samples: This parameter is a feature of Dampening. It is used to specified the number of readings that are used when calculating the dynamic average. A maximum of 10 samples is allowed.

- See Page 48 for information about the Dampening Samples serial command.

Error Timeout (Measurement Cycles): The number of measurement errors required before an error is output from the ULS. When 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 you set.

- See Page 48 for information about the Dampening Error Timeout and Error Range Difference serial command.

Section 3: Measurement Modes

The ULS has four distinct measurement modes that have unique pro and cons. When selecting a mode, you will need to consider your specific situation and application. The table below describes the pros and cons of each mode.

Measurement Mode	Pros	Cons
Averaging	• Highest accuracy possible. • Highest data rate possible. • Adjustable return shot criteria.	• Susceptible to intermittent airborne particulates (fog, dust). • First target measurement past an adjustable dead zone.
Last Target	• Good airborne particulate penetration (fog, dust). • Automatic intermediate target discrimination.	• Compared to Averaging Mode, accuracy is reduced an additional +2 cm, ±2 cm.
Binning	• Enhanced measurement range capability. • Dynamically tracks multiple targets. • Adjustable target definition criteria.	• 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	• 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.	• There is no range output in this mode, only an RS-232 confirmation that there is detection or a simple two wire pair going from low state to high.

ULS Processing Structure

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

Stage	Description	Notes
Pulse Width Rejection	• Allows you to set the minimum and maximum limits on the pulse intensity used for measurements.	• This works in all measurement modes, but does not need to be set.
Range Gate Rejection	• Allows you to set short and long gates to block out any pulses that are outside the area of interest.	• This works in all modes except Detection Mode using the Relative option. • Gates do not need to be set.
Measurement Calculation	• This is dependent on which measurement mode is being used. Essentially we are telling the ULS how to process the return pulses. • The process produces a measurement.	• The ULS has to be set to Averaging, Last Target, Binning or Detection Mode.

Stage	Description	Notes
Check Gate	• 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 makes sure that the final measurement does not violate the gate integrity.	• Gating is a very powerful tool in a Time of Flight (TOF) laser such as the ULS. However, TOF lasers complex to understand in certain situations. For this reason, more detailed information is provided in the detailed application sections for each mode.
Offset	• Allows you to add or subtract a fixed constant to the measurement. • This can be used to compensate for the ULS being in a different location from the desired zero point of a monitored object.	• This can be used in all measurement modes, except Detection mode. • All processing stages after Offset use the modified measurement.
Cosine	• This is simply a factor, which is typically used to convert a slope distance to either a vertical or horizontal measurement.	• This can be used in all measurement modes, except Detection mode.
Windowing or Dampening	• Windowing is a filter that makes sure that a 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.	• 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	• Final measurement.	

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 ULS 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 ULS 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 ULS 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 at long distances.

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

Averaging Mode: Measuring Through Windows

The ULS 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 ULS 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 10º from perpendicular to the measurement axis. The transmit side of the ULS 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 ULS. Tipping the window to the left will actually 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 a 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 ULS can only see a target 2.4-3.0 meters (8-10 feet) beyond the window. In fact, in any measurement mode, the ULS 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.

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 would 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 to water using the ULS, 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 maybe required to get accurate results. When setting the ULS 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 ULS 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.

Averaging Mode: Limiting Parallax Effects

What is parallax error? It is the optical effect on the laser due to the transmit and receiver optical paths being parallel. In the ULS, 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 it closest point.

If the laser cannot physically be moved back, you can create a look up table in software to compensate for the error. If the target is always the same object (same color), the correction table will work well. One ULS customer uses a correction table for every 3 inches for targets inside of 20 feet.

Averaging Mode: Accuracy vs. Data Rate

The ULS 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 ULS 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 the 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 ULS 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 ULS 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).

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 ULS 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 a low as possible to maintain the highest accuracies.

Without dithering, the ULS 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.

Averaging Mode: Possible Setups

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

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 exit 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 ULS can not 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 ULS interface. 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.

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 to it. In Last Target Mode, the ULS 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 is no events logged in all of 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 were 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 maybe 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.

Using Successive Gating

This is an additional feature within Last Target Mode. If it is turned on, the ULS 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 ULS 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 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.

Last Target Mode: Measuring Through Windows

This subject is covered in detail on Page 21. 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.

Last Target Mode: Using Cooperative Targets

Again, this is covered in detail on Page 21. In this mode, with a poor environment, cooperatives targets can be very powerful when used with objects that travel in a straight line.

Binning Mode Applications

As mentioned in the Summary table on Page 19, 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. The reason being that 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 ULS.

Binning Mode works right down in the system noise and uses statistics to isolate a target. First of all 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.

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. Sometimes it is handy to 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 head lights in fog, sometimes it doesn't help you see farther because you are blinded.

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 our 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.

Binning Mode: Selecting Targets

As discussed before, the ULS is capable of identifying multiple targets. You can select the target that want to display 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 ULS interface 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 actually 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 amount of Bin Hits. Then start increasing the Bin Hits by one, until the noise goes away. You will notice that the hard target remains.

Binning Mode: Using Gates

The Short Gate can also be used to block out targets within a certain distance to 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. For more information on gating out a window, see Page 21.

Binning Mode: Possible Setups

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

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 ULS 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 is increased. When using a bin length of 20.4 cm; a minimum bin hit value of 8 should be used, other wise 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.

Detection Mode Applications

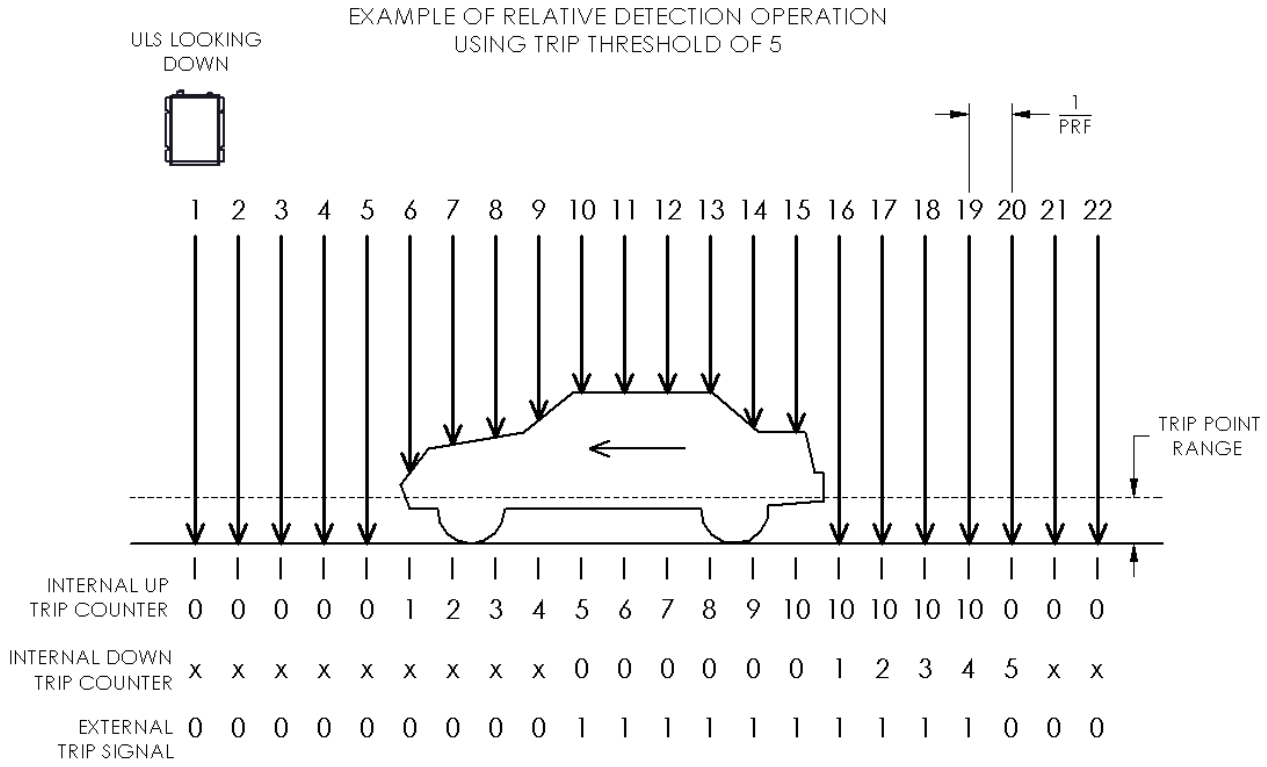
This mode is very powerful as it is extremely quick and accurate to detect an object in the optical path of the laser. As pointed out in the summary table on Page 19, this mode does not output a constant measurement. Detection Mode can be run in two different configurations, Relative or Absolute, which allows the ULS 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.

Example Showing Relative Detection Mode

The figure below shows a car coming into and out of the optical path of the ULS. The numbered points across the top of the graph are the sequential laser pulse fires. There is a return range associated with each laser pulse fire. One over the PRF (laser firing rate in Hz) is the time between laser fires.



- 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 considered to be a trip signal. In the figure, this range would be any range less than or above the dotted line to the laser.

- Referring to the figure on the previous page, Pulses #1 - #5 are all reference range readings.
    - 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.

- Referring to the figure on the previous page, Pulse #6 is the first reported range shorter then the dotted line and starts the Internal Up Trip Counter.
    - In this example, the Trip Threshold is set to 5. Since the five consecutive ranges from Pulse #6 - Pulse #10 are less than the reference minus the trip point range, the External Trip Signal will go from a low (0) to a high (1) at Pulse #10 as shown.
    - At this same time, the Internal down Counter is initialized to 0 to start watching for the trip to go away. At Pulse #16, the first range greater than the reference range minus the trip point range is seen, and starts the trip sequence back down.
    - The Internal Down Counter is incremented by Pulse #16 - Pulse #20 and the trip threshold of 5 is again reached causing the External Trip Signal to go from a high (1) to a low (0).

- 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.

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.

Other parameters (not shown in the figure):

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 then 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 then 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.
    - Obviously, 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 shinny 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 then 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.

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. If the figure on Page 27 was showing Absolute Detection Mode, the range to the road minus 0.61 meters (2 feet) would be the Trip Point Range.
    - If the range to the road was 10 meters then the trip point range would be set to 9.39 meters to get the same output response on the triggered output as when using Relative Detection Mode with a trip point of 0.61 meters.
    - 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 a AOR appears, the false counter will be incremented and the trip will still be incremented to its next state. As long as 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 then the programmed max false value the trip will internally reset and no trip level change will be seen at the output.

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 ULS 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. In the example figure on Page 27, this would be the range detected at Pulse #10. The interface program will also display On in the measurement window. When the object has cleared the path or the original target has moved back within the tolerance of the trip distance from the reference distance, the serial output will be $BM,0 and will display OFF on the interface program. The trip distance (in millimeters) is also displayed.

When Time between Events (TBE) is turned on ($TB,1), the ULS 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 then 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 ULS 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 programed 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 as long as the max false pulses programed is not exceeded. If enough AOR's are present, a trip will be stopped if the programed value of max falses is exceeded.

This configuration has been chiefly designed for a traffic lookdown 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.

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 ULS 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 programed 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 ULS 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.

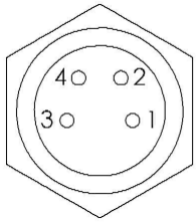
Section 4: ULS Connection Ports

The ULS has two interface ports, a 4-pin, RS232 configuration port and a 12-pin, RS232/RS485/4-20mA universal output port.

Configuration Port

The configuration port for the ULS provides RS232 input and output communications to the sensor. This port is used for system configuration via the ULS Interface Program. When the ULS is in RS232 output mode, the configuration port is used for system setup and can be configured to output measurement data. In the RS485 mode, this port is used for system setup, and all output measurement data is sent via the universal output port. When the ULS is in Detection Mode, the configuration port is used for system setup only.

Configuration Port Connector Diagram - rear panel view:

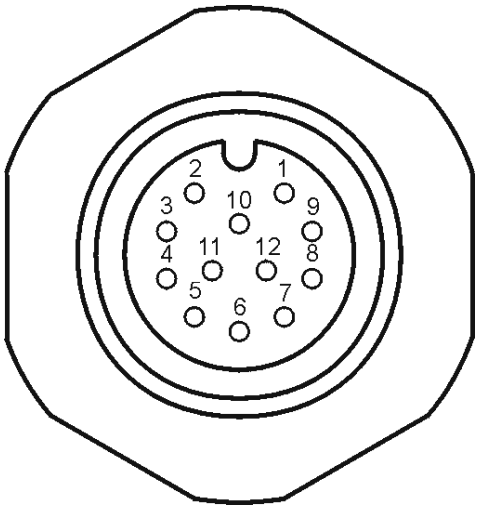


Configuration Port Signal Definition:

1 = GND
2 = POWER (+10 to +28VDC)
3 = RS232 RECEIVE DATA (RXD) INPUT TO THE ULS
4 = RS232 TRANSMIT DATA (TXD) OUTPUT FROM THE ULS

Universal Output Port

The universal port is strictly for measurement data output (or in Detection Mode, the trip signal output). In all ULS output modes (RS232, RS485 and Detection), this port provides measurement output data. Note that in RS232 mode, output data can be provided through either the universal output port or the configuration port, but not both at the same time.



Universal Output Port Signal Definition:

1 = GND
2 = POWER (+10 to +28VDC)
3 = RS232 TRANSMIT DATA (TXD)
OUTPUT FROM THE ULS
4 = RS232 RECEIVER DATA (RXD) INPUT TO THE ULS
5 = RS232 CTS INPUT TO ULS
(Serial Interrupt - not currently implemented)
6 = GND
7 = RS485 Differential (-)
8 = RS485 Differential (+)
9 = GND
10 = 4-20 milliamp (Sink)
11 = 4-20 milliamp (Source)
12 = 4-20 milliamp GND (Isolated)

Section 5: Cabling

The ULS package includes Universal Port Cable.

- 2 meter long, with a 12-pin Turck connector on one end, and un-terminated flying leads on the other end. This cable is intended to be connected to the ULS universal port, and gives you the ability to terminate the other end of the cable as needed for your specific installation/application.

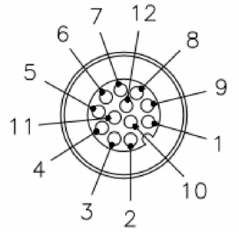
  It is intended that power for the ULS is supplied via the 12-pin universal port cable. A well-regulated DC voltage between +10 to +26 volts should be applied to pin 2 of the universal port (the brown wire from the un-terminated end of the 2 meter cable), with the power ground connection being made to pin 1 (the white wire from the cable). The ULS does have internal reverse polarity and transient over-voltage protection for the incoming supply voltage.

  See Page 33 for a drawing for the Universal Port Cable.

The following cable is available from LTI:

- 1 meter long, 4-pin Turck to DB9 RS232 cable. This cable connects the ULS configuration port to a computer RS232 serial port, for use with the ULS Interface Program. Note that this cable is not intended to supply power to the ULS.

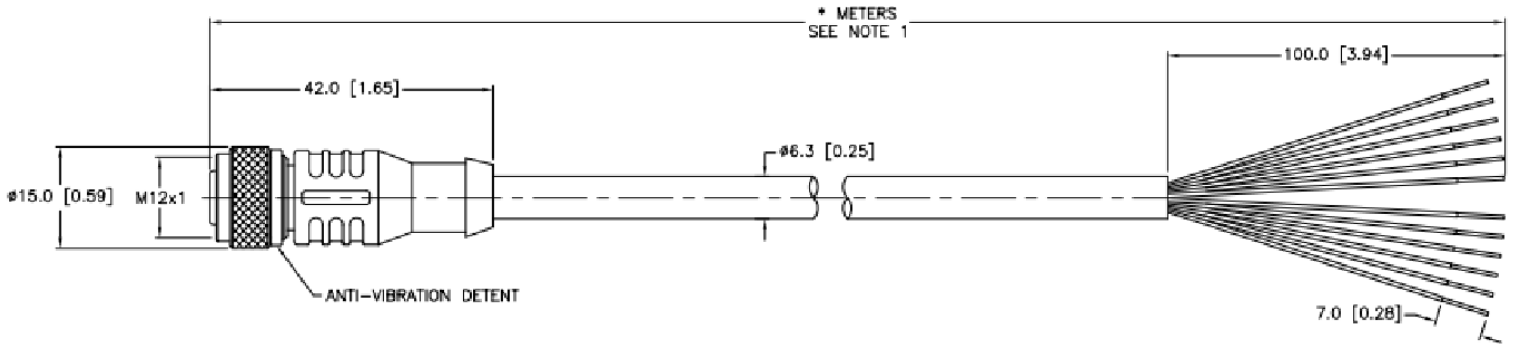
FEMALE END VIEW



1 = WHITE
2 = BROWN
3 = GREEN
4 = YELLOW
5 = GRAY
6 = PINK
7 = BLUE
8 = RED
9 = ORANGE
10 = TAN
11 = BLACK
12 = VIOLET

GND	1	WHITE
POWER (+10 TO +28VDC)	2	BROWN
RS232 TRANSMIT DATA (TXD) OUTPUT FROM THE ULS	3	GREEN
RS232 RECEIVER DATA (RXD) INPUT TO THE ULS	4	YELLOW
RS232 CTS INPUT TO ULS	5	GREY
GND	6	PINK
RS485 DIFFERENTIAL (-)	7	BLUE
RS485 DIFFERENTIAL (+)	8	RED
GND	9	ORANGE
4-20 MILLIAMP (SINK)	10	TAN
4-20 MILLIAMP (SOURCE)	11	BLACK
4-20 MILLIAMP GND (ISOLATED)	12	VIOLET

N/C



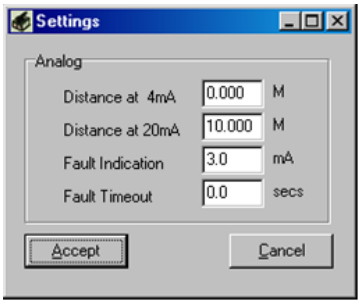
NOTES: UNLESS OTHERWISE SPECIFIED.

1. NOTES

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: ANGLES: ± 1/2° DECIMALS: .X ± .025 .XX ± .010 FINISH: 125 .XXX ± .005 .XXXX ± .001	DRAWN S. STOECKEL	DATE 03/17/15	LASER TECHNOLOGY 6912 South Quentin St. Centennial, CO 80112		
	CHECKED W. RHTT	DATE 03/17/15	TITLE CABLE, POWER ULS		
	APPROVED	DATE			
MATERIAL			SIZE A	PART NUMBER 4824689	REV 1
PROTECTIVE/DECORATIVE FINISH			REF FILE NAME XXX	SCALE 1:1	SHEET 1 OF 1

PART NUMBER 4824689 | SHEET 1 OF 1 | REV 1

Section 6: 4-20 mA Analog Output Mode



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

In this example screen capture, *Distance at 4 mA* is defined as 0 meters. *Distance at 20 mA* is defined as 10 meters. *Fault Indication* is set to 3mA and *Fault Timeout* is set to 0 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 output 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.

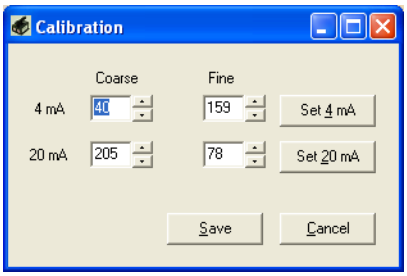
The actual current for the example current loop setup can be calculated by taking the 16 mA full-scale current range ÷ (20 mA range value - the 4 mA range value) = 1.6 mA per meter. So a 5 meter reading: 5 x 1.6 mA = 8 mA + 4 mA offset at zero = 12 mA.

Initially designed to provide an industrial standard 4-20 mA output, this improved design can be configured, with an external power source, to more than double the range of voltage compliance of the ULS analog output.

-See Page 57 for information about the Range at 4 mA serial command.
See Page 57 for information about the Range at 20 mA serial command.
See Page 43 for information about the 4-20 mA Fault Current Value serial command.
See Page 43 for information about the 4-20 mA Current Loop On/Off serial command.

Calibrating the Current Loop

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



Note: The 4-20mA current loop of every ULS 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 there 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 ULS.

In the standard, internally-powered configuration, you would provide a current sense resistor between pins 10 and 11 of the universal output port, with pin 11 being the (+) or current source and pin 10 being 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 the termination resistor that can be used in the current loop. Example: 9 volts ÷ 20 mA = a maximum sense resistor of 450 ohms.

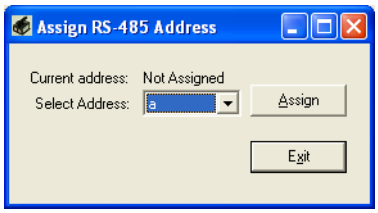
In the optional, externally-powered configuration, you would provide a current sense resistor between pin 12 of the universal output port, isolated GND, and the GND terminal of the external power source. The positive output voltage of the external power source would be connected to pin 10 of the universal output port.

Cautionary Note: The user configuration of externally provided power and choice of sense resistor must not exceed 400 milliwatts between pin 10 and pin 12 of the universal output port.

Section 7: RS485 Network Interface

Networking several ULS units can be done using the RS485 Network Interface. This is a half-duplex system which allows all units to be tied together on one RS485 set of differential lines. A unique address must be assigned to each unit.

Assigning an Address

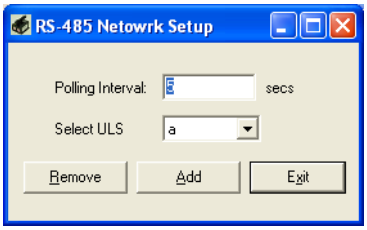


The Connections Menu includes an option that allows you to assign an address to a unit. When you select the Assign ULS Address option, a window will open showing the address that is currently assigned to the connected unit. If no value is assigned or if you want to change the value of the address, use the drop-down menu to display and select the address you want to assign to the unit. The selected address will only be assigned, once you press the Assign button.

Note: Values with an asterisk have already been assigned in the network using the ULS Interface Program. The RS485 system will not function correctly with the same address assigned to 2 or more units. You may use a value with an asterisk if that address is being replaced in the network.

- See Page 60 for information about the Unit Address serial command.

Modifying the RS485 Network

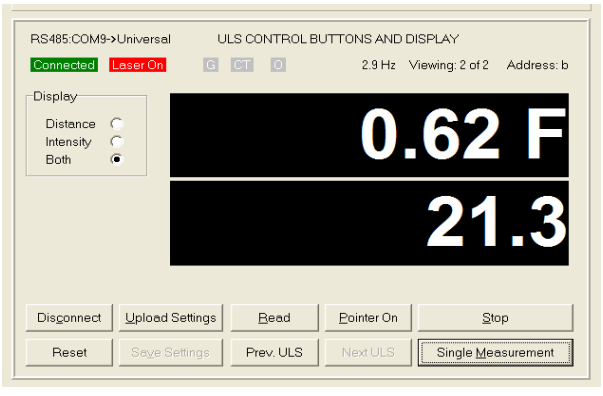


The Connections Menu also includes an option that allows you to modify the RS485 network. This option is used to tell the ULS Interface Program what ULS units are in the network. This option also allows you to add or remove units from the network.

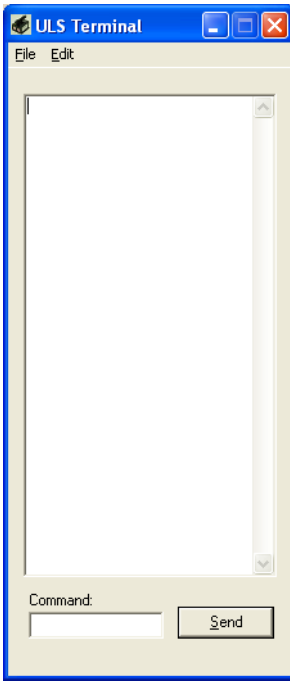
The ULS Interface Program periodically polls the units for status, and checks that the units are functioning. If the interface does not know the unit address, it cannot talk with the unit.

Notes:

- The Continuous Output setting must be turned off since the units only talk on the bus when addressed.
- The unit furthest from the network computer should have the Termination option set to Terminated.
- Only one unit (the last unit) on the bus should be terminated.
- Once the units are setup, the output selection should be changed to RS485. Now the system can be placed on the networked RS485 bus.
    - Make sure to select the correct comm port setup for the RS485 port on your computer.
    - To enable the ULS interface in RS485 networking mode, close the ULS Interface Program and then reopen it.
    - Select the Connections Menu > RS485 Network. The ULS Interface Program will show you the number of units connected and the unit that is being displayed in the interface.
    - If a new unit is to be assigned to the network, use the Connections menu and the Modify ULS Network option to add or remove unit to the network. Once this is done, the Interface Program must be closed and reopened for the Interface Program to see newly added units.
    - Use the Next and Previous ULS button to see all units on the network.



Section 8: ULS Terminal Window



A Serial terminal window has been added to the ULS Interface Program. The terminal window shows all of the serial communication protocol sent or received by the ULS while under the ULS Interface control. Click on the Terminal menu option to open the terminal window, and the terminal window should open. The terminal may not appear in view on low resolution PC screens.

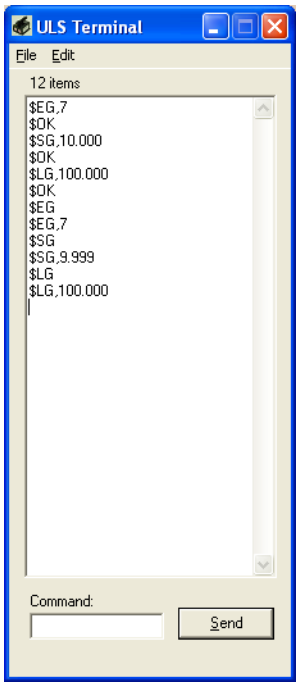
Follow the steps below, if the terminal window does not appear on your screen.

1. Press Alt + space bar to select the terminal window resize menu.
2. Press ↓ key once to select Move and then press Enter.
3. Use the ← key to move the terminal into view.
4. Once in view, click the terminal window bar with the mouse and move it to a good location on the desktop.

The serial data communication messages are covered in detail in the ULS ASCII Protocol section (Page 39 - 62).

The Menu bar located at to the top of the Terminal Window includes two menus:

- File Menu
  - **Save:** Select to save the items contained within the Terminal Window as a *.log file. The Save As dialogue box will be displayed. Enter the file name that you want to assign to the log file and click on the Save button.
  - **Quit:** Select to close the Terminal Window.
- Edit Menu
  - **Delete:** Select to clear the Terminal Window.
  - **Select All:** Select to select all items contained within the Terminal Window.
  - **Copy:** After selecting all items, select this option to copy all items to the clipboard. Once items have been copied to the clip board, they can be pasted into virtually any windows-based program.



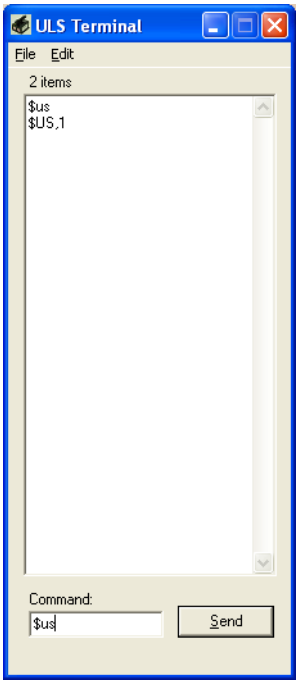
The top portion of the Terminal Window displays all serial data communication messages from/to the ULS and the computer.

As you modify parameters in the ULS Interface program, the Terminal Window displays the corresponding serial data communication. As an example, the figure to the left shows the Enable Gates command. (1) the Short Gate was changed to 10.000 and (2) the Long Gate was changed to 100.00.

The number of items currently contained in the display window appears between the Menu bar and the display window. In the example to the left, the display window includes 12 items. If the window contains more items than can be displayed at one time, the scroll bar to the right of the terminal window will be active.

The terminal window will buffer up to 500 readings. At 500 items, the buffer will remove the 500th item each time it inserts a new item.

Using the Command Field



The bottom portion of the Terminal Window includes the Command data entry field. This field allows you enter and send serial data communication messages to the ULS. Click To send a message, type the appropriate command, and select the Send button. In the example to the left, the command to Get Unit Status (non-addressable protocol) was entered and sent to the ULS.

The window displays the message sent to and the response received from the ULS. In this example the:

- Message sent to ULS = $us = Get Unit Status.
- Message received from ULS = $US,1 = unit ready, not firing.

Note: The ULS Interface Program is blind to these commands, so the ULS Interface should always be updated by pressing the Read button if the terminal command window is used.

Section 9: ULS ASCII Protocol

General Information

The ULS uses two formats of ASCII protocol (non-addressable and addressable). This allows you to control the ULS with the any terminal software (like HyperTerminal, TeraTerm etc.).

- Addressable protocol has to be used in RS485 multi-drop environment - multiple ULSs on single twisted-pair of wires.
- Non-addressable protocol can be used in any other environment.

RS232 or RS485 comm port settings: 115200 baud**, 8 bits, 1 stop, no parity, RS485 bus termination OFF. Addressable protocol messages start with '#' character, while non-addressable protocol messages start with '$' character.

***Note:*The baud rate may be changed using the interface program or a serial command (Page 44).
Interface program: maximum baud is 115200. Serial command: maximum baud is 230400.

RS485 Protocol

Maximum number of ULSs on a single bus is 64. Allowable address range is from 0x30 to 0xef

Address range 0xf0 to 0xff is reserved for broadcast type messages - send to all units at once and not requiring a reply from each unit.

Each ULS unit is shipped from the factory with its address set to 0. Unit with address 0 will not respond to any messages. Each unit has to be programmed during installation with an address from the allowable range.

The main controller will poll each ULS and get the status from each unit and measurement from the unit (or units) specified by the user.

Message Format: Non-Addressable Protocol

Set Command:

$CCCC,*values***<CR>**
ex. $MM,*1*<CR> Set ULS to Averaging Mode

Reply:

$OK<CR> if command accepted
$ER,*n***<CR>** if error encountered

Get Command:

$CCCC<CR>
ex. $MM Get Measurement Mode

Reply:

$CCCC,*values***<CR>** if command accepted
ex. $MM,1<CR> Averaging Mode is active
$ER,*n***<CR>** if error encountered

where: **$** = non-addressable protocol message identifier
CCCC = 2 to 4-letter mnemonic
OK = mnemonic for set value accepted
ER = mnemonic for error encountered
values = 0 to n comma separated parameter values
n = error number (see Error Codes, Page 68 for possible values)
<CR> = carriage return

Message Format: Addressable Protocol

Set Command:

#*a***CCCC,***values***<CR>**

ex. #ZMM,1<CR> Set ULS with address 0x5a ('Z') to Averaging Mode

Reply:

#*a***OK<CR>** if command accepted
#*a***ER,***n***<CR>** if error encountered

Get Command:

#*a***CCCC<CR>**

ex. #ZMM ULS with address 0x5a ('Z'), Averaging Mode is selected

Reply:

#*a***CCCC,***values***<CR>** if command accepted
ex. #ZMM,1<CR> ULS with address 0x5a ('Z'), Averaging Mode is active
#*a***ER,***n***<CR>** if error encountered

where: **#** = addressable protocol message identifier
a = one byte hexadecimal unit address 0x30 to 0xff (ASCII single character)
CCCC = 2 to 4-letter mnemonic
OK = mnemonic for set value accepted
ER = mnemonic for error encountered
values = 0 to n comma separated parameter values
n = error number (see Page 68 for possible values)
<CR> - carriage return

Measurement Data Output Formats from the ULS

- Averaging Mode

$BM,*n***<CR>** or **#***a***BM,***n***<CR>**
$BM,*p***<CR>** or **#***a***BM,***p***<CR>**
$BM,*n,p***<CR>** or **#***a***BM,***n,p***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
BM = mnemonic for Basic Measurement
n = measurement, in meters or in decimal feet
p = received pulse width in nanoseconds
<CR> = carriage return

Output from ULS depends on selected display output mode: Range, Pulse Width or Both.

- Last Target Mode

  $BM,*n***<CR>** or **#***a***BM,***n***<CR>**
  $BM,*p***<CR>** or **#***a***BM,***p***<CR>**
  $BM,*n,p***<CR>** or **#***a***BM,***n,p***<CR>**

  where: **$** = non-addressable protocol message identifier
  # = addressable protocol message identifier
  a = unit address
  BM = mnemonic for Basic Measurement
  n = measurement (in meters or in decimal feet)
  p = received pulse width in nanoseconds
  <CR> = carriage return

  Output from ULS depends on selected display output mode: Range, Pulse Width or Both.

- Binning Mode:

  $BM,*i,m,n,s***<CR>** or **#***a***BM,***i,m,n,s***<CR>**

  where: **$** = non-addressable protocol message identifier
  # = addressable protocol message identifier
  a = unit address
  BM = mnemonic for Basic Measurement
  i = index of Target Array
  m = number of targets in Target Array
  n = measurement, in millimeters (if meters selected)
  or in decimal inches (if inches selected)
  s = target strength
  <CR> = carriage return

  Note: If there is more than one target, the ULS will send information for all targets in the Target Array consecutively, always starting with index 0.

- Detection Mode (Configuration Port only!):
  - When Time between Events is not turned on:

    $BM,*n*<CR> or **#*a*BM,*n*<CR>**

    where: **$** = non-addressable protocol message identifier
    # = addressable protocol message identifier
    a = unit address
    BM = mnemonic for Basic Measurement
    n = 0 = OFF
    N = 1 = ON
    <CR> = carriage return

  - When Time between Events is turned on:

    $*n*<CR> or **#*an*<CR>** output at the start of no presence detected
    $XXXX**<CR>** or **#**aXXXX**<CR>** output at the start of presence detected

    where: $ = non-addressable protocol message identifier
    # = addressable protocol message identifier
    a = unit address
    n = 0 = OFF = No Presence detected
    n = XXXX = Time between no presence and presence detected in hex (number of pulse counts)
    <CR> = carriage return

    Note: A maximum value of FFFF hex can be output. If time exceeds this value, the output will be set to OOOO hex signifying maximum time occurred (approximately 22 seconds at 3000 PRF).

    See Page 16 for information about Time between Events.
    See Page 59 for information about the Time between Events serial command.

ULS Commands

4-20 mA Current Loop On/Off

Set:	**$CL,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***CL,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$CL<CR>**		**$CL,***n***<CR>**		
	#*a***CL<CR>**		**#***a***CL,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
CL = mnemonic for 4-20mA Current Loop
n = 0 = Current Loop Off
n = 1 = Current Loop On
<CR> = carriage return

- For more information about 4-20 mA Current Loop, see Page 34.

4-20 mA Fault Current Value

Set:	**$AF,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***AF,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$AF<CR>**		**$AF,***n***<CR>**		
	#*a***AF<CR>**		**#***a***AF,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
AF = mnemonic for Fault Current Indicator
n = Fault Current Indicator (in mA)
<CR> = carriage return

- For more information about the 4-20 mA Output Mode, see Page 34.

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.

Set:	**$AB,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***AB,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$AB<CR>**		**$AB,***n***<CR>**		
	#*a***AB<CR>**		**#***a***AB,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
AB = mnemonic for Average Bounds
n = = Average Bounds in picoseconds
<CR> = carriage return

- For more information about Average Bounds, see Page 14.

Averaging Weight

Used in Averaging Mode. This value is either (1) Number of Good Pulses or (2) Number of Required Dither Pulses.

Set:	**$AW,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***AW,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$AW<CR>**		**$AW,***n***<CR>**		
	#*a***AW<CR>**		**#***a***AW,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
AW = mnemonic for Averaging Weight
n = Averaging Weight. If dithering is enabled, the averaging weight should be a multiple of 32. The product of the dither step size and the Averaging Weight should always be a multiple of 32.
<CR> = carriage return

- For more information about Averaging Weight, see Page 13.

Baud Rate

Set:	**$BR,***p,n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***BR,***p,n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$BR,***p***<CR>**		**$BR,***p,n***<CR>**		
	#*a***BR,***p***<CR>**		**#***a***BR,***p,n***<CR>**		

Baud Rate Choices
1200
2400
4800
9600
14400
19200
38400
57600
115200
230400 (command)

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
BR = mnemonic for Baud Rate
p = 0 = Configuration port
p = 1 = Output port
n = Baud Rate (bauds)
<CR> = carriage return

- For more information about Baud Rate, see Page 7.

Bin Size

Set:	**$BS,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*BS,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$BS<CR>**		**$BS,*n*<CR>**		
	#*a*BS<CR>		**#*a*BS,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
BS = mnemonic for Bin Size
n = 0 = 1 inch (or metric equivalent)
n = 1 = 2 inches (or metric equivalent)
n = 2 = 4 inches (or metric equivalent)
n = 3 = 8 inches (or metric equivalent)
n = 4 = 16 inches (or metric equivalent)
n = 5 = 32 inches (or metric equivalent)
n = 6 = 64 inches (or metric equivalent)
n = 7 = 128 inches (or metric equivalent)
n = 8 = 256 inches (or metric equivalent)
<CR> = carriage return

- For more information about Bin Size, see Page 15.

Bin Threshold

Set:	**$BH,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*BH,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$BH<CR>**		**$BH,*n*<CR>**		
	#*a*BH<CR>		**#*a*BH,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
BH = mnemonic for Bin Threshold
n = minimum number of hits per target
<CR> = carriage return

- For more information about Bin Hits, see Page 15.

Check Gate

Check Gate used to gate ranges out that violate the current gate settings. For example, if the Short Gate is set to 10 meters and the ULS measures a range of 9.9 meters, if Check Gate is enabled then the 9.9 meters range will not be allowed out the serial interface. Check Gate should be disabled when moving the gates and watching to see if the target was gated out or not. Once this correct range for the gate is found, then the Check Gate feature can be re-enabled.

Set: $CG, n<CR> Reply: $OK<CR> or $ER, n<CR>
aCG, n<CR> # aOK<CR> or # aER, n<CR>
Get: $CG<CR> $CG, n<CR>
aCG<CR> # aCG, n<CR>

where: $ = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
CG = mnemonic for Check Gate
n = 0 = Check Gate disabled
n = 1 = Check Gate enabled
<CR> = carriage return

- For more information about Check Gate, see Page 11.

Continuous Measurement Output Mode

Set:	**$CO,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*CO,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$CO<CR>**		**$CO,*n*<CR>**		
	#*a*CO<CR>		**#*a*CO,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
CO = mnemonic for Continuous Measurement Output
n = 0 = Continuous Mode Off (polled mode)
n = 1 = Continuous Mode On
<CR> = carriage return

- For more information about Continuous Output, see Page 12.

Cooperative Filter (Target)

Set:	**$FL,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*FL,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$FL<CR>**		**$FL,*n*<CR>**		
	#*a*FL<CR>		**#*a*FL,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
FL = mnemonic for Cooperative Filter
n = 0 = Filter Off (non-cooperative target)
n = 1 = Filter On (cooperative target)
<CR> = carriage return

- For more information about Cooperative Target, see Page 11.

Cosine Enable

Enables the Cosine Enable multiplication output range processing.

Set:	**$CE,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*CE,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$CE<CR>**		**$CE,*n*<CR>**		
	#*a*CE<CR>		**#*a*CE,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
CE = mnemonic for Cosine Enable
n = 0 = Cosine Function OFF
n = 1 = Cosine Function ON
<CR> = carriage return

- For more information about the Cosine Enable, see Page 17.

Cosine Value

Specifies the value to be used in the Cosine Factor.

Set:	**$CV,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*CV,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$CV<CR>**		**$CV,*n*<CR>**		
	#*a*CV<CR>		**#*a*CV,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
CV = mnemonic for Cosine Value
n = Cosine value times the range divided by 1000. Example if cosine value equals 800 and internal range reading equals 10. The output reading will equal 10 x 800/1000 = 8.00. Default value = 800.
<CR> = carriage return

- For more information about Cosine Factor, see Page 17.

Current Trip Threshold

Used in Detection Mode. This is the number of valid trip pulses that must be seen before a trip signal change can occur.

Set:	**$CT,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*CT,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$CT<CR>**		**$CT,*n*<CR>**		
	#*a*CT<CR>		**#*a*CT,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
CT = mnemonic for Current Trip Threshold
n = Current Trip Threshold. Default value = 30.
<CR> = carriage return

- For more information about Current Trip Threshold, see Page 16.

Dampening Error Timeout and Error Range Difference

Set:	**$DR,***n,n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***DR,***n,n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$DR<CR>**		**$DR,***n,n***,<CR>**		
	#*a***DR<CR>**		**#***a***DR,***n,n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
DR = mnemonic for Dampening Error Range Value
n,n = Dampening Error Timeout (Measurement Cycles), Dampening Error Range Difference (distance in meters).
<CR> = carriage return

- For more information about Dampening Error Timeout and Error Range Difference, see Page 18.

Dampening Samples

Set:	**$DS,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***DS,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$DS<CR>**		**$DS,***n***<CR>**		
	#*a***DS<CR>**		**#***a***DS,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
DS = mnemonic for Dampening Samples
n = specifies number of dampening samples. Default value = 4 (maximum = 10).
<CR> = carriage return

- For more information about Dampening Samples, see Page 18.

Detection Mode Absolute vs. Relative Operation

Set:	**$LA,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***LA,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$LA<CR>**		**$LA,***n***<CR>**		
	#*a***LA<CR>**		**#***a***LA,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
LA = mnemonic for Detection Mode Absolute vs. Relative Operation
n = 0 = Detection Mode Relative Operation
n = 1 = Detection Mode Absolute Resolution
<CR> = carriage return

- For more information about Detection Mode Absolute vs. Relative Operation, see Page 16.

Display Mode in Averaging

Set:	**$DM,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*DM,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$DM<CR>**		**$DM,*n*<CR>**		
	#*a*DM<CR>		**#*a*DM,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
DM = mnemonic for Display Mode in Averaging
n = 1 = Distance
n = 2 = Distance and Intensity
n = 3 = Intensity
<CR> = carriage return

- For more information about Display in Averaging Mode, see Page 9.

Dither On/Off

Set:	**$DD,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*DD,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$DD<CR>**		**$DD,*n*<CR>**		
	#*a*DD<CR>		**#*a*DD,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
DD = mnemonic for Dithering
n = 0 = Dither Off
n = 1 = Dither On
<CR> = carriage return

- For more information about dithering, see Page 13.

Enable Gates

This command is used to enable the Short Gate, Long Gate, and Successive Gating features.

Set:	**$EG,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*EG,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$EG<CR>**		**$EG,*n*<CR>**		
	#*a*EG<CR>		**#*a*EG,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
EG = mnemonic for Enable Gates
n = decimal value (see table below)
<CR> = carriage return

Decimal Value	bit 0 **Short Gate**	bit 1 **Long Gate**	bit 2 **Successive Gating**
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

Note: 0 = gate is OFF, 1 = gates is ON

Fault Timeout for 4-20 mA Current Loop

Set:	**$AT,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*AT,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$AT<CR>**		**$AT,*n*<CR>**		
	#*a*AT<CR>		**#*a*AT,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
AT = mnemonic for Fault Timeout
n = Fault Timeout (in seconds, timeout allowed before 4-20mA goes to the fault current indication)
<CR> = carriage return

- For more information about the 4-20 mA Output Mode, see Page 34.

First, Last, Most, and All

Used in the Binning Mode to select the binning output format.

Set:	**$FA,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*FA,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$FA<CR>**		**$FA,*n*<CR>**		
	#*a*FA<CR>		**#*a*FA,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
FA = mnemonic for First, Last, Most, and All
n = 0 = First target
n = 1 = Last target
n = 2 = Most target (most Bin Hits)
n = 3 = All targets
<CR> = carriage return

- For more information about First, Last, Most and All, see Page 15.

Flyer Trap

Used in Detection Mode.

Set:	**$FT,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*FT,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$FT<CR>**		**$FT,*n*<CR>**		
	#*a*FT<CR>		**#*a*FT,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
FT = mnemonic for Flyer Trap
n = Flyer Trap distance in mm (default value = 2500)
<CR> = carriage return

- For more information about Flyer Trap, see Page 16.

Initial Lock

Initial Lock variable used in Averaging Mode in picoseconds.

Set:	**$IL,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*IL,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$IL<CR>**		**$IL,*n*<CR>**		
	#*a*IL<CR>		**#*a*IL,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
IL = mnemonic for Initial Lock
n = Initial Lock in picoseconds
<CR> = carriage return

- For more information about Initial Lock, see Page 14.

Long Gate

Set:	**$LG,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***LG,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$LG<CR>**		**$LG,***n***<CR>**		
	#*a***LG<CR>**		**#***a***LG,***n***<CR**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
LG = mnemonic for Long Gate
n = Long Gate Setting in measurement units
<CR> = carriage return

- For more information about the Long Gate, see Page 10.

Maximum False Pulses

Detection Mode. There are two types of false pulses:
(1) Absence of Return (AOR): Relative configuration only. A pulse was fired, but nothing came back.
(2) Flyer Trap Reading.

Set:	**$MX,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***MX,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$MX<CR>**		**$MX,***n***<CR>**		
	#*a***MX<CR>**		**#***a***MX,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
MX = mnemonic for Maximum False Pulses
n = Maximum False Pulses. (Default value = 5)
<CR> = carriage return

- For more information about Maximum False Pulses, see Page 16.

Maximum Pulse Width Rejection

All return pulses width intensities greater than XP will be rejected and not used in the measurement.

Set:	**$XP,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***XP,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$XP<CR>**		**$XP,***n***<CR>**		
	#*a***XP<CR>**		**#***a***XP,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
XP = mnemonic for Maximum Pulse Width Rejection
n = Maximum Pulse Width Rejection
<CR> = carriage return

- For more information about Maximum Pulse Width Rejection, see Page 11.

Measurement

Get: **$BM<CR>** Reply: Varies with measurement mode (Page 40-42).
#*a*BM<CR> Varies with measurement mode (Page 40-42).

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
BM = mnemonic for Basic Measurement
<CR> = carriage return

Measurement Autostart On/Off

Set: **$MA,*n*<CR>** Reply: **$OK<CR>** or **$ER,*n*<CR>**
#*a*MA,*n*<CR> **#*a*OK<CR>** or **#*a*ER,*n*<CR>**
Get: **$MA<CR>** **$MA,*n*<CR>**
#*a*MA<CR> **#*a*MA,*n*<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
MA = mnemonic for Measurement Autostart
n = 0 = ULS idle on power up
n = 1 = ULS measuring on power up
<CR> = carriage return

- For more information about ULS Autostart, see Page 12.

Measurement Mode

Set: **$MM,*n*<CR>** Reply: **$OK<CR>** or **$ER,*n*<CR>**
#*a*MM,*n*<CR> **#*a*OK<CR>** or **#*a*ER,*n*<CR>**
Get: **$MM<CR>** **$MM,*n*<CR>**
#*a*MM<CR> **#*a*MM,*n*<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
MM = mnemonic for Measurement Mode
n = 1 = Averaging with Noise Filtering
n = 2 = Binning
n = 3 = Detection Mode
n = 4 = Last Target
<CR> = carriage return

- For more information about selecting a Measurement Mode, see Page 12.

Measurement Output Port

Set:	**$MO,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*MO,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$MO<CR>**		**$MO,*n*<CR>**		
	#*a*MO<CR>		**#*a*MO,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
MO = mnemonic for Measurement Output Port
n = 0 = RS232 Configuration port
n = 1 = RS232 Universal port
n = 2 = RS485 Universal port
<CR> = carriage return

- For more information about Output Setup, see Page 12.

Measurement Start

Set:	**$GO<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*GO<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
GO = mnemonic for Measurement Start
<CR> = carriage return

Measurement Stop

Set:	**$ST<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*ST<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
ST = mnemonic for Measurement Stop
<CR> = carriage return

Measurement Units

Set:	**$MU,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*MU,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$MU<CR>**		**$MU,*n*<CR>**		
	#*a*MU<CR>		**#*a*MU,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
MU = mnemonic for Measurement Units
n = 0 = feet
n = 1 = meters
<CR> = carriage return

- For more information about Units, see Page 10.

Minimum Pulse Width Rejection

All return pulses width intensities less than MP will be rejected and not used in the measurement.

Set:	**$MP,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***MP,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$MP<CR>**		**$MP,***n***<CR>**		
	#*a***MP<CR>**		**#***a***MP,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
MP = mnemonic for Minimum Pulse Width Rejection
n = Minimum Pulse Width Rejection
<CR> = carriage return

- For more information about Minimum Pulse Width Rejection, see Page 11.

Output Processing Enable for Either Windowing or Dampening

Set:	**$OP,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***OP,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$OP<CR>**		**$OP,***n***<CR>**		
	#*a***OP<CR>**		**#***a***OP,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
OP = mnemonic for Output Processing Enable for Either Windowing or Dampening
n = 0 = Output Windowing and Dampening Functions OFF.
n = 1 = Output Windowing Enabled.
n = 2 = Output Dampening Enabled.
<CR> = carriage return

- For more information about Windowing and Dampening, see Page 17-18.

Pointer Autostart On/Off

Set:	**$PA,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***PA,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$PA<CR>**		**$PA,***n***<CR>**		
	#*a***PA<CR>**		**#***a***PA,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
PA = mnemonic for Pointer Autostart
n = 0 = Pointer Off at power up
n = 1 = Pointer On at power up
<CR> = carriage return

Pointer On/Off

Set: **$PT,***n***<CR>** Reply: **$OK<CR>** or **$ER,***n***<CR>**
#*a***PT,***n***<CR>** **#***a***OK<CR>** or **#***a***ER,***n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
PT = mnemonic for Pointer
n = 0 = Pointer Off
n = 1 = Pointer On
<CR> = carriage return

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

- For more information about Pointer On/OFF, see Page 9.

Power Level

Set: **$PL,***n***<CR>** Reply: **$OK<CR>** or **$ER,***n***<CR>**
#*a***PL,***n***<CR>** **#***a***OK<CR>** or **#***a***ER,***n***<CR>**
Get: **$PL<CR>** **$PL,***n***<CR>**
#*a***PL<CR>** **#***a***PL,***n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
PL = mnemonic for Power Level
n = 0 = High
n = 1 = Medium
n = 2 = Low
<CR> = carriage return

- For more information about Power Level, see Page 11.

PRF

Set: **$PF,***n***<CR>** or **$PF,***n,n,n***<CR>** Reply: **$OK<CR>** or **$ER,***n***<CR>**
#*a***PF,***n***<CR>** or **#***a***PF,***n,n,n***<CR>** **#***a***OK<CR>** or **#***a***ER,***n***<CR>**
Get: **$PF<CR>** **$PF,***n,n,n***<CR>**
#*a***PF<CR>** **#***a***PF,***n,n,n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
PF = mnemonic for PRF
n = Pulse Repetition Frequency (in Hz)
<CR> = carriage return

Notes: **$PF,***n,n,n* where *n,n,n* is Averaging or Last Target,Binning,Detection.
$PF,*n***<CR>** and **#***a***PF,***n***<CR>** change the PRF in the mode that is currently active.

- For more information about PRF, see Page 13.

Pulses/Measure

Set:	**$PO,***n***<CR>** or **$PO,***n,n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***PO,***n***<CR>** or **#***a***PO,***n,n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$PO<CR>**		**$PO,***n,n***<CR>**		
	#*a***PO<CR>**		**#***a***PO,***n,n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
PO = mnemonic for Pulses/Measure
n = Pulses per Output
<CR> = carriage return

Notes: **$PO,***n,n* where *n,n* is Averaging and Last Target,Binning.
$PO,*n***<CR>** and **#***a***PO,***n***<CR>** change the PPM in the mode that is currently active.

- For more information about Pulses/Measure, see Page 13.

Range at 4 mA

Set:	**$AL,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***AL,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$AL<CR>**		**$AL,***n***<CR>**		
	#*a***AL<CR>**		**#***a***AL,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
AL = mnemonic for Range at 4 mA
n = Range at 4 mA in user units (decimal feet or meters)
<CR> = carriage return

- For more information about Range at 4 mA, see Page 34.

Range at 20 mA

Set:	**$AH,***n***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a* **AH,***n***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$AH<CR>**		**$AH,***n***<CR>**		
	#*a* **AH<CR>**		**#***a* **AH,***n***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
AH = mnemonic for Range at 20 mA
n = Range at 20 mA in user units (decimal feet or meters)
<CR> = carriage return

- For more information about Range at 20 mA, see Page 34.

RS485 Bus Termination On/Off

Set:	**$TE,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*TE,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$TE<CR>**		**$TE,*n*<CR>**		
	#*a*TE<CR>		**#*a*TE,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
BT = mnemonic for RS485 Bus Termination
n = 0 = Bus Termination Off
n = 1 = Bus Termination On
<CR> = carriage return

- For more information about RS485 Termination, see Page 11.
- For more information about the RS485 Network Interface, see Page 36.

Save User Settings into Non-Volatile Memory

This command must be done when the unit is stopped. If the unit is firing when the $SU command is issued, the unit will respond with error 78 and not save the user setting.

Set:	**$SU<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*SU<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
SU = mnemonic for Save User Settings into Non-Volatile Memory
<CR> = carriage return

For more information about Save Settings, see Page 8.

Short Gate

Set:	**$SG,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*SG,n<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$SG<CR>**		**$SG,*n*<CR>**		
	#*a*SG<CR>		**#*a*SG,n<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
SG = mnemonic for Short Gate
n = Short Gate Setting in measurement units
<CR> = carriage return

- For more information about the Short Gate, see Page 10.

Software Version

Get: **$ID<CR>** Reply: **$ID,ULS** *version number date*
#*a***ID<CR>** **$***a***ID,ULS** *version number date*

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
ID = mnemonic for ULS Software Version
<CR> = carriage return

- Note: This manual is intended to be used with ULS version 5.x and any previous ULS version. There is also a software version number associated with the ULS Interface Program. For more information about the ULS Interface Program software version number, see Page 6.

Time between Events

Set: **$TB,***n***<CR>** Reply: **$OK<CR>** or **$ER,***n***<CR>**
#*a***TB,***n***<CR>** **#***a***OK<CR>** or **#***a***ER,***n***<CR>**
Get: **$TB<CR>** **$TB,***n***<CR>**
#*a***TB<CR>** **#***a***TB,***n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
TB = mnemonic for Time between Events
n = 0 = Time between Events Off
n = 1 = Time between Events On
<CR> = carriage return

- For more information about Time between Events (TBE), see Page 16.

Trip Point

Set: **$TP,***n***<CR>** Reply: **$OK<CR>** or **$ER,***n***<CR>**
#*a***TP,***n***<CR>** **#***a***OK<CR>** or **#***a***ER,***n***<CR>**
Get: **$TP<CR>** **$TP,***n***<CR>**
#*a***TP<CR>** **#***a***TP,***n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
TP = mnemonic for Trip Point
n = Trip Distance in measurement units
<CR> = carriage return

- For more information about Trip Point, see Page 16.

Trip Timeout

Set:	**$TT,***h***<CR>**	Reply:	**$OK<CR>**	or	**$ER,***n***<CR>**
	#*a***TT,***h***<CR>**		**#***a***OK<CR>**	or	**#***a***ER,***n***<CR>**
Get:	**$TT<CR>**		**$TT,***h***<CR>**		
	#*a***TT<CR>**		**#***a***TT,***h***<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
TT = mnemonic for Trip Timeout
h = Trip Timeout ((seconds * 3000) in hexadecimal notation)
<CR> = carriage return

- For more information about Trip Timeout, see Page 16.

Unit Address

Set:	**$UA,***aa***<CR>**	Reply:	**$OK<CR>**
	#*a***UA,***aa***<CR>**		**#***a***OK<CR>**
Get:	**$UA<CR>**		**$UA,***ad***<CR>**
	#*a***UA<CR>**		**#***a***UA,***ad***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address (Ascii single character = a-z, A-Z, or 0-9)
UA = mnemonic for Unit New Address
aa = unit Address (Ascii single character = a-z, A-Z, or 0-9)
ad = unit Address (Decimal Value)
<CR> = carriage return

Note: Equivalent values for *aa* and *ad*:

a = 97	n = 110	A = 65	N = 78	0 = 48
b = 98	o = 111	B = 66	O = 79	1 = 49
c = 99	p = 112	C = 67	P = 80	2 = 50
d = 100	q = 113	D = 68	Q = 81	3 = 51
e = 101	r = 114	E = 69	R = 82	4 = 52
f = 102	s = 115	F = 70	S = 83	5 = 53
g = 103	t = 116	G = 71	T = 84	6 = 54
h = 104	u = 117	H = 72	U = 85	7 = 55
i = 105	v = 118	I = 73	V = 86	8 = 56
j = 106	w = 119	J = 74	W = 87	9 = 57
k = 107	x = 120	K = 75	X = 88	
l = 108	y = 122	L = 76	Y = 89	
m = 109	z = 123	M = 77	Z = 90	

For more information about Assigning an Address, see Page 36.

Unit Status

Get: **$US<CR>** Reply: **$US,***n***<CR>**
#*a***US<CR>** **#***a***US,***n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
US = mnemonic for Unit Status
n = 0 = error condition, unit fails to complete initialization
n = 1 = unit ready, not measuring
n = 3 = laser firing and Detection Mode or measurement setup mode
n = 7 = laser firing and Averaging Mode or Last Target Mode
n = 11 = laser firing and Binning Mode
<CR> = carriage return

Note:
```
#define ULS_INACTIVE       0x00 \\ Bit 1
#define ULS_ACTIVE         0x01 \\ Bit 1
#define LASER_FIRING       0x02 \\ Bit 2
#define AVERAGING_CALC     0x04 \\ Bit 3
#define BINNING_CALC       0x08 \\ Bit 4
```

User Offset

Set: **$OF,***n***<CR>** Reply: **$OK<CR>** or **$ER,***n***<CR>**
#*a***OF,***n***<CR>** **#***a***OK<CR>** or **#***a***ER,***n***<CR>**
Get: **$OF<CR>** **$OF,***n***<CR>**
#*a***OF<CR>** **#***a***OF,***n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
OF = mnemonic for User Offset
n = User Offset in measurement units
<CR> = carriage return

- For more information about Offset Distance, see Page 11.

Windowing Error Range Value

Set: **$WV,***n***<CR>** Reply: **$OK<CR>** or **$ER,***n***<CR>**
#*a***WV,***n***<CR>** **#***a***OK<CR>** or **#***a***ER,***n***<CR>**
Get: **$WV<CR>** **$WV,***n***<CR>**
#*a***WV<CR>** **#***a***WV,***n***<CR>**

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
WV = mnemonic for Windowing Error Range Value
n = Windowing Error Range Value (distance in feet or meters)
<CR> = carriage return

- For more information about Windowing Error Range Value, see Page 17.

Windowing Time Out

Set:	**$WT,*n*<CR>**	Reply:	**$OK<CR>**	or	**$ER,*n*<CR>**
	#*a*WT,*n*<CR>		**#*a*OK<CR>**	or	**#*a*ER,*n*<CR>**
Get:	**$WT<CR>**		**$WT,*n*<CR>**		
	#*a*WT<CR>		**#*a*WT,*n*<CR>**		

where: **$** = non-addressable protocol message identifier
# = addressable protocol message identifier
a = unit address
WT = mnemonic for Windowing Time Out
n = Number of measurement cycles before errors are reported on the output. (Default value = 2)
<CR> = carriage return

- For more information about Windowing Time Out, see Page 17.

Section 10: Specifications

Units:	Feet or Meters
Resolution:	0.01 foot or 1 mm

Pulsed Laser

Beam Divergence:	3 milliradians nominal (~0.3m @ 100 m)
Exit Aperture:	42 mm
Wavelength:	905 nm (infrared)
High Power:	400 nJ per pulse
Medium Power:	200 nJ per pulse
Low Power:	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)

Internal Laser Pointer

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

Optical Sighting Scope (optional)

Zoom:	1.5-4 x 16

Input Power

Absolute Minimum:	10V DC minimum
Absolute Maximum:	30V DC maximum
	Nominal 12-24V DC @ 170 mA typical

Communications

Configuration Port		
RS232:	Minimum Baud Rate:	1200
	Interface Program Maximum Baud Rate:	115200
	Serial Command Maximum Baud Rate:	230400
Universal Port		
RS232:	Minimum Baud Rate:	1200
	Interface Program Maximum Baud Rate:	115200
	Serial Command Maximum Baud Rate:	230400
RS485:	Minimum Baud Rate:	1200
	Interface Program Maximum Baud Rate:	115200
	Serial Command Maximum Baud Rate:	230400
4-20 mA:	Analog Current:	4-20 mA isolated
	Voltage Compliance:	9V maximum

Physical

Dimensions:	5.3 inches L x 4.75 inches W x 2.5 inches H (13.5 cm L x 12 cm W x 6.3 cm H)
Weight:	1.75 lbs (0.8 kg)
Enclosure:	Anodized Aluminum
Mounting:	75 mm hole spacing front/back and 110 mm spacing side/side (four hole pattern)

Environmental

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

User Interface (Universal Port 12-pin)

Interface:	RS232 (cable supplied)
Cable:	24-pin cable with RS232 DB9 port for computer and wires for input power, RS485 and 4-20 mA output
User Port:	All interfaces are made via a 12-pin port (cable supplied)

Calibration Interface (Configuration Port)

Interface:	RS232
Cable:	4 pin cable, RS232 and input power

ULS Interface Program Requirements

Operating System:	Windows XP, Windows Vista, Windows 7, Windows 8 and Windows 10
Media:	CD-ROM

Averaging Mode

	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)

Last Target Mode

Compared to Averaging Mode, accuracy is reduced an additional +2 cm, ±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 μs per character at 115200 baud rate. This time is inversely proportional to the baud rate so the time per character will double to 200 μs at a baud rate setting of 57600.

This main limiting factors of output data rate are the output data type selection and measurement range. These settings effect 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)
yyyyyyy	= intensity (picoseconds)
<CR>	= carriage return

Example: Unit running at 115200 baud rate, range output only.
12 characters x 100 μs = 1.2 mS. Fastest output data rate = 1/1.2 ms = 833 Hz.

Example: Unit running at 115200 baud rate, range and intensity.
21 characters x 100 μs = 2.1 mS. Fastest output data rate = 1/2.1 ms = 476 Hz.

Binning Mode

	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 due to the fact that 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 μs 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 μs 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 μs 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

Section 11: Error Numbers

This section lists all possible error numbers. While using your ULS if you experience an error, you may be able to resolve it yourself. You will notice that some errors are flagged with ⌦; these errors must be resolved by LTI. If you experience an error that is flagged as needing to be resolved by LTI, please contact LTI Service for technical support.

- Phone: 1-800-790-7364 (USA and Canada) or 1-303-649-1000
- Email: service@lasertech.com
- Fax: 1-303-649-9710

Error Number	Explanation	ULS Interface Display
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

Error Number	Explanation	ULS Interface Display
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
88	Invalid Temperature Compensation Range	ER 088
89	Invalid Dither Step Size	Invalid Dither Step Size

Interrupt Error Numbers

Error Number	Explanation	ULS Interface Display
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

Table Checksum Error Numbers

Error Number	Explanation	ULS Interface Display
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

RS485 Error Numbers

Error Number	Explanation	ULS Interface Display
82	Unit Address Not Assigned	Unit Address Not Assigned

4-20 Error Numbers

Error Number	Explanation	ULS Interface Display
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

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