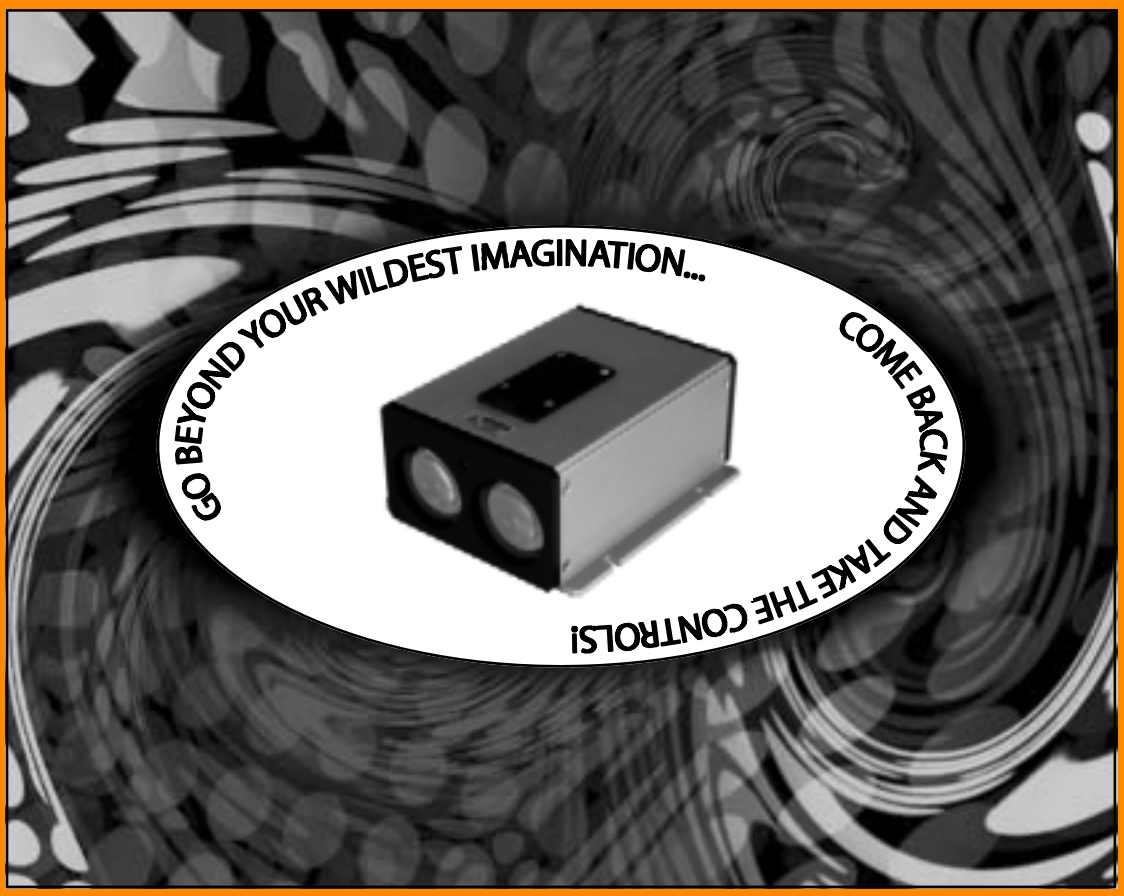
LASER TECHNOLOGY, INC.

UNIVERSAL LASER SENSOR

HARDWARE / SOFTWARE INTERFACE SPECIFICATION



LASER TECHNOLOGY INC
Redefining Measurement

Universal Laser Sensor (ULS)
Hardware/Software Interface Specification
First Edition Part Number 0144745

Copyright Notice:
Information in this document is subject to change without notice and does not represent a commitment on the part of Laser Technology Inc. No part of this manual may be reproduced in any form or by any means, electronic or mechanical, including photocopying, recording, or information storage and retrieval systems, for any purpose other than the purchaser's personal use, without the express written consent of Laser Technology, Inc.

Copyright © Laser Technology, Inc., 2004 - 2005. All rights reserved.

First Edition: March 2005

Patents:
Patent pending.

LTI Contact Information:

Laser Technology, Inc.
7070 S. Tucson Way
Centennial, CO 80112 USA

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

Table of Contents

Safety Precautions 3

Section 1 - Introduction 5

Section 2 - ULS Interface Program 6
Getting Started 6
ULS Control Buttons and Display 7
Basic Setup 8
Laser Power Setup 9
Output Setup 9
Measurement Mode 10
Averaging Parameters 10
Binning Parameters 11
Look Down Parameters 11

Section 3 - Measurement Modes 12
Overview 12
Averaging Mode 12
Binning Mode 13
Look Down Mode 14
Time between Events 15

Section 4 - ULS Connection Ports 16
Configuration Port 16
Universal Output Port 16

Section 5 - Cabling 17
Universal Port Cable 18

Section 6 - 4-20 mA Analog Output Mode 19
Calibrating the Current Loop 19

Section 7 - RS485 Network Interface 21
Assigning an Address 21
Modifying the RS485 Network 21

Section 8 - ULS Protocol - ver 0.97 22
General Information 22
RS485 Protocol 22
Message Format: Non-Addressable Protocol 22
Message Format: Addressable Protocol 23
Measurement Data Output Formats from the ULS 23
ULS Commands 25
Dither On/Off 25
Get Measurement 25
Get Software Version 25
Get Unit Status 26
Measurement Autostart On/Off 26
Measurement Start 26
Measurement Stop 27
Pointer Autostart On/Off 27
Pointer On/Off 27
Save User Settings into Non-Volatile Memory 27
Set/Get 4-20 mA Current Loop On/Off 28
Set/Get Averaging Weight (Number of Good Pulses) 28

Set/Get Baud Rate . . . 28
Set/Get Bin Size . . . 29
Set/Get Bin Threshold . . . 29
Set/Get Continuous Measurement Output Mode . . . 29
Set/Get Cooperative Filter . . . 30
Set/Get Display Mode in Averaging . . . 30
Set/Get 4-20 mA Fault Current Value . . . 30
Set/Get Fault Timeout for 4-20 mA Current Loop . . . 31
Set/Get Long Gate . . . 31
Set/Get Measurement Mode . . . 31
Set/Get Measurement Output Port . . . 32
Set/Get Measurement Units . . . 32
Set/Get Power Level . . . 32
Set/Get PRF . . . 33
Set/Get Pulses Per Measurement . . . 33
Set/Get Range at 20 mA . . . 33
Set/Get Range at 4 mA . . . 34
Set/Get RS485 Bus Termination On/Off . . . 34
Set/Get Short Gate . . . 34
Set/Get Time between Events . . . 35
Set/Get Trip Point . . . 35
Set/Get Trip Point Timeout . . . 35
Set/Get Unit Address . . . 36
Set/Get User Offset . . . 36

Section 9 - Specifications . . . 37
Pulsed Laser . . . 37
Internal Laser Pointer . . . 37
Optical Sighting Scope (optional) . . . 37
Input Power . . . 37
Communications . . . 37
Physical . . . 37
Environmental . . . 38
User Interface (Universal Port 12-pin) . . . 38
Calibration Interface (Configuration Port) . . . 38
ULS Interface Program Requirements . . . 38
Averaging Mode . . . 38
Output Data Rate . . . 39
Output Serial Data Stream . . . 39
Binning Mode . . . 40
Output Data Rate . . . 40
Output Serial Data Stream . . . 41

Section 10 - Error Numbers . . . 42
Interrupt Error Codes . . . 43
Table Checksums Error Codes . . . 44
RS485 Error Codes . . . 44
4-20 Error Codes . . . 44

Index . . . 45

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.

Pulsed Laser:

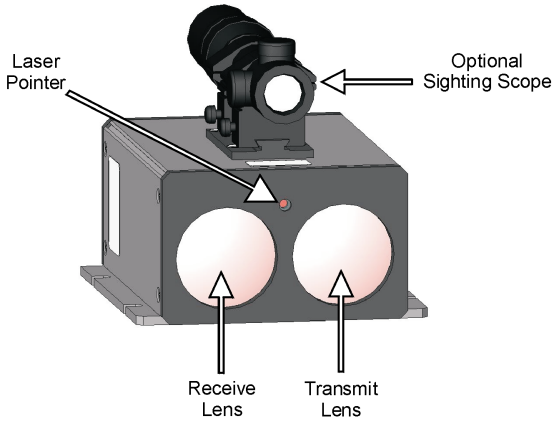
- Avoid staring directly at the laser beam for prolonged periods. The ULS is designed to meet FDA eye safety requirements and is classified as eye-safe to FDA (CFR21) Class I 7 mm limits, which means that virtually no hazard is associated with directly viewing the laser output under normal conditions.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

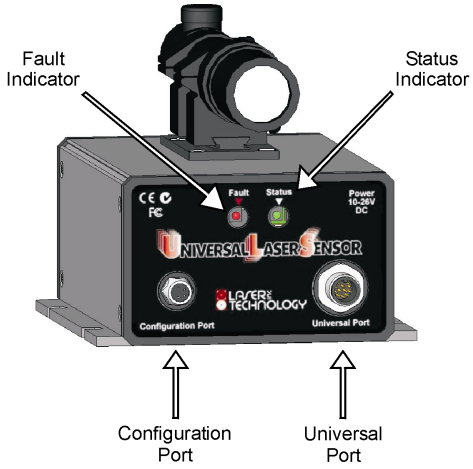
The ULS is a user-configurable product, which lets you adjust settings to optimize measurement performance in a variety of applications. The primary tool for controlling the operation of the ULS is the ULS Interface Program. This configuration software developed by Laser Technology Inc. (LTI) allows 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 three primary measurement modes: Averaging, Binning, and Look Down. In Averaging Mode, the ULS takes a specified number of individual distance measurements and averages them into a single output result. 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. Look Down Mode is a dedicated, rapid update, proximity detection configuration used to detect the presence of fast moving objects.

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



(Front)



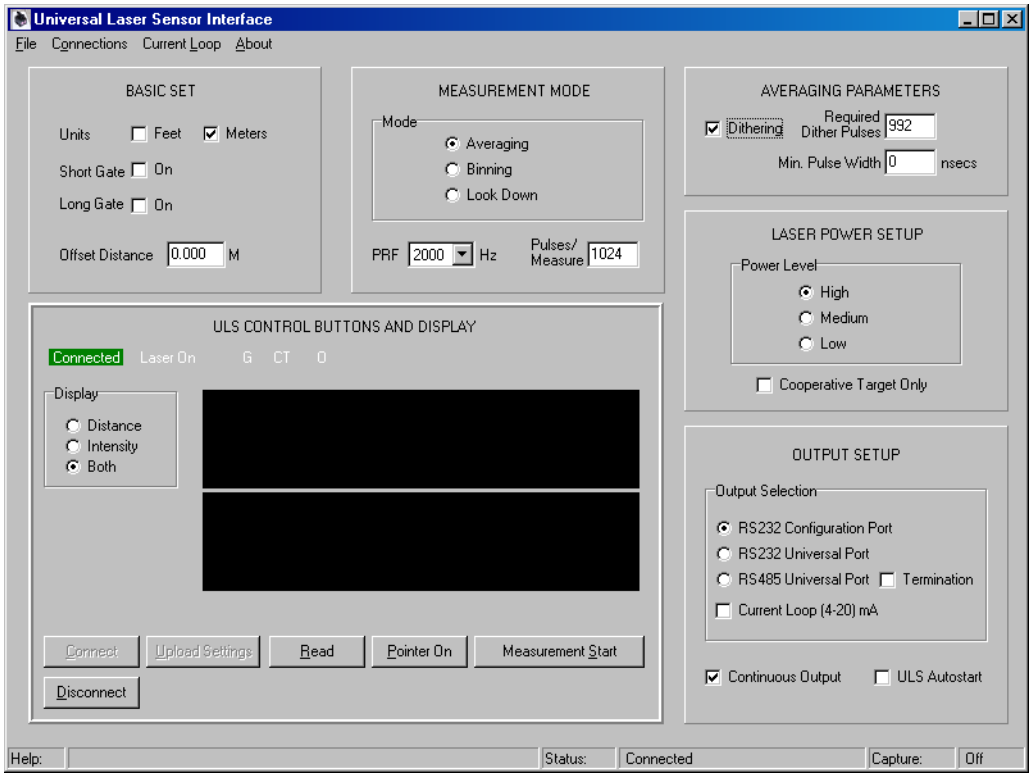
(Rear)

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 Look Down 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 tied together internally (paralleled) within the ULS.

Section 2 - ULS Interface Program

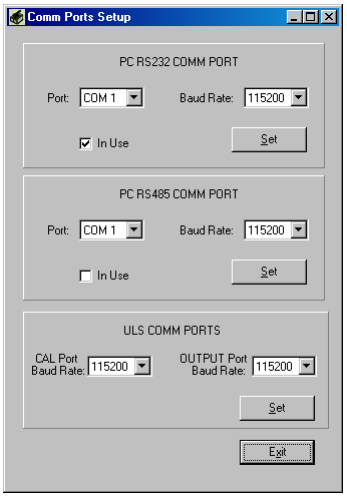
The ULS Interface Program is used to set specific operating parameters within the ULS, to control the sensor's operation, and to view output data from the device. Each function/feature of the ULS Interface Program has a corresponding serial data communication message to/from the ULS that invokes the 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 online, you may communicate 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 Protocol section (see pages 22-36).

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



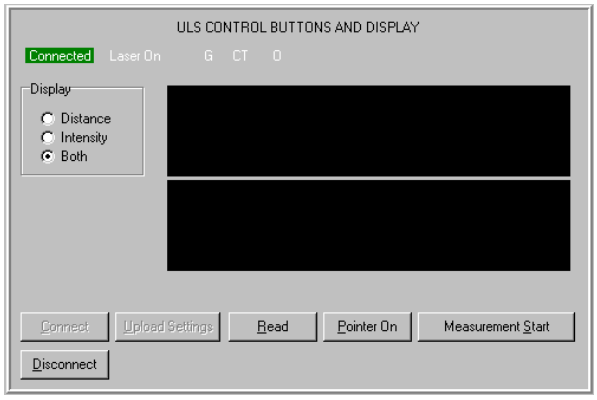
Getting Started

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 choose the appropriate setting. You can now click on Connect to see the complete screen as above. To take measurements see the following "ULS Control Buttons and Display" Section. Later sections explain other parameter windows.

ULS Control Buttons and Display



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

Disconnect: Terminates the communication between the computer and the ULS.

Upload Settings: After any parameter in any other window is changed, the Upload Settings command issues the change or changes to the ULS. Parameters within this window are all automatically updated and do not need to be manually uploaded.

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 File\LTI\ULS Interface\). Whenever you open a stored configuration file, always remember to Upload Settings.

Read: If you are not sure whether a parameter has been uploaded, Read downloads the current ULS settings.

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 27 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 the laser measurements. When you want to stop the measurements, toggle this selection again.

See Page 26 for information about the Measurement Start serial command.
See Page 27 for information about the Measurement Stop serial command.

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

See Page 25 for information about the Get Measurement serial command.

Note: The File Menu includes options (Start Capture and Stop Capture) that allow you to capture data during the any one of the measurement modes. The View Capture option allows you open the capture file (*.log). The default file location is (C:\Program File\LTI\ULS Interface\).

The content of the capture file varies depending upon the measurement mode:

- Averaging Mode: Time (H:M:S:mS), Distance, Units, Intensity.
- Binning Mode: Time (H:M:S:mS), Index value in array, Number of Targets, Distance, Units.
- Look Down Mode: (H:M:S:mS), ON/OFF.

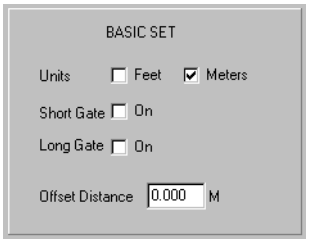
Display/Target Selection: Depending upon the measurement mode, this parameter affects the information displayed in the black measurement box. In Averaging Mode, you have the option to display the measurement only, the signal intensity only or both at the same time. In Binning Mode you can choose to display the first target the laser sees or the last target. In Look Down Mode the on/off condition of the trip signal (i.e. target detected or not) is displayed.

See Page 30 for information about the Set/Get Display Mode in Averaging serial command.

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

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

Basic Setup



Units: Sets the desired units of measurement. Once this parameter is set, all other distance parameters use these units.

See Page 32 for information about the Set/Get 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 m and a target is between 0 and 10 m, the laser will not output a distance to that target.

This function has deliberately been set to occur sooner then the set point. This guarantees opening of gating sooner then actually specified. To actually find the distance needed, first find the target at the range you want blocked, then move the short gate (or open gate) distance up until the display reports no target found. This set point is not to be assumed exact, and in most cases will have at least a 10-foot offset. The system has been designed to be very linear and is calibrated on an on-going basis when the instrument is firing and measuring.

See Page 34 for information about the Set/Get 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 m and a target is further than 100 m away, the laser will not output a distance to that target.

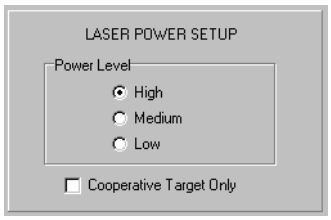
In most cases this function is not required in Averaging Mode because it is a first target system. Also caution should be used when trying to use the long gate (or close gate). The long gate should be set in front of the target needing blocked when long returns need to be rejected. Move the long gate 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 31 for information about the Set/Get Long Gate serial command.

Offset Distance: This distance (can be positive or negative) modifies the actual measurement distance accordingly. It should be noted that the actual distance is used for the purposes of Gate distances where the Offset Distance merely affects the distance reported out of the ULS.

See Page 36 for information about the Set/Get serial command.

Laser Power Setup



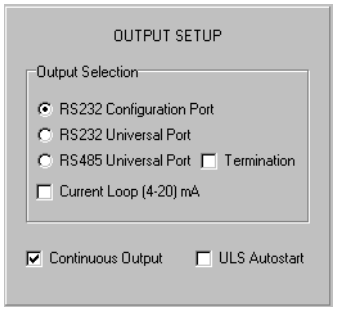
Power Level: The laser power level only affects the maximum range capabilities of the ULS. If you are measuring to close targets, you can reduce the power level in order to potentially run the laser at a higher pulse frequency, yet stay below FDA Class I limits. If you are operating in dusty or dirty environments, we recommend using high power; otherwise, use the lowest power possible to measure to your desired target.

See Page 32 for information about the Set/Get Power Level serial command.

Cooperative Target Only: When this function is used, the ULS will only measure to a target with 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.

See Page 30 for information about the Set/Get Cooperative Filter serial command.

Output Setup



Output Selection: Defines how you want to export the measurement data from the ULS.

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 output setup to a different port, the measurement data and control will then 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 32 for information about the Set/Get Measurement Output Port serial command.

The 4 to 20 mA current loop is provided on the Universal port output. It can be used at anytime regardless of the settings of the other output setups. If not in use, this should be left not checked to save power consumption internal to the ULS. See Page 19 for details on 4-20 mA current loop. See Page 16 for the wiring diagrams for the ports described above.

See Page 30 for information about the Set/Get 4-20 mA Fault Current Value serial command.

Termination: 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 34 for information about the Set/Get RS485 Bus Termination On/Off serial command.

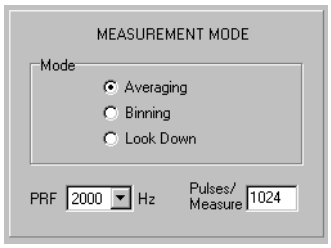
Continuous Output: When this function is on, the ULS downloads and displays each measurement completed. When this function is off, the ULS completes measurements, but the display is not updated. You must select Single Measurement to display the last completed measurement. The continuous output data rate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

See Page 29 for information about the Set/Get Continuous Measurement Output Mode serial command.

ULS Autostart: When 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 26 for information about the Measurement Autostart On/Off serial command.

Measurement Mode



Mode: This parameter depends upon your application. If accuracy is critical, select Averaging. If the environment is dusty, multiple targets are present, or very weak returns are expected, select Binning. If you want to use the ULS as a look-down sensor for presence detection, select Look Down. For more information on these measurement modes, please refer to the Measurement Modes Section (Page 12). The corresponding parameter windows will appear for each measurement mode.

See Page 31 for information about the Set/Get Measurement Mode serial command.

PRF: Sets the laser firing pulse rate frequency. Select a value from the drop down menu. Values range from 10 to 5000.

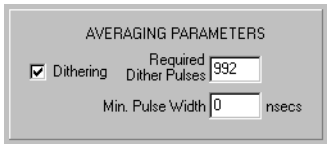
See Page 33 for information about the Set/Get PRF serial command.

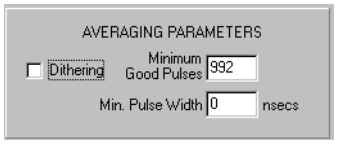
Pulses/Measure: The number of laser pulses fired per output measurement (PPM). You should note that this option is not available in the Look Down Mode.

Note: The Pulses/Measurement 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 33 for information about the Set/Get Pulses Per Measurement serial command.

Averaging Parameters





Dithering: When this option is used, more accurate results are produced when using smaller number of required dither pulses.

See Page 25 for information about the Dither On/Off serial command.

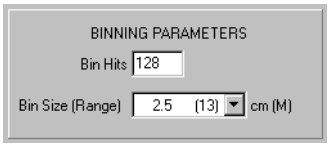
Required Dither Pulses: This value should be a multiple of 32, which is a complete dither cycle. As the minimum required pulses or minimum dither pulses increases, the averaging increases which improves accuracy of the measurement.

See Page 28 for information about the Set/Get Averaging Weight (Number of Good Pulses) serial command.

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 then the PPM or an error will be generated.

Minimum Pulse Width: This value is used to reject returned receive pulses less then the value specified, in nano-seconds. This allows you to reject weak return measurements. This value is not exact, but should correspond closely to the intensity value shown in averaging mode. If a known weak pulse return is present, this value can be increased until the small return stops.

Binning Parameters



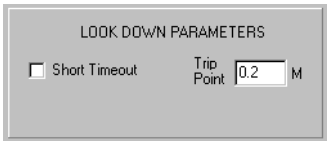
Bin Hits: Establishes how many pulses must land in a bin in order for it to be considered a target. This value should be changed to acquire or remove targets. Moving the value up will drop weak targets, while moving this value down will find weaker targets. This value needs to be adjusted for each Bin 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 15. 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 15 targets reported will be ignored. If this value is set too high, no targets will be found.

See Page 29 for information about the Set/Get Continuous Measurement Output Mode serial command.

Bin Size: 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.

See Page 29 for information about the Set/Get Continuous Measurement Output Mode serial command.

Look Down Parameters



Trip Point: Establishes the reference distance. This presence detection mode simply shoots the laser very quickly without averaging, and looks for a single pulse distance difference shorter than the trip point. When this distance is shorter then the trip point, an output line is toggled high. The display will display Off if no presence is detected and ON if a presence is detected.

See Page 35 for information about the Set/Get Trip Point serial command.

Short Timeout: This option is used mainly when setting up the sensor. In Look Down Mode, the sensor references itself when the laser is started. The sensor will re-reference after a specified timeout period. The default timeout is approximately 6 minutes at 3000 PRF. The timeout period is inversely proportional to the PRF. Since the timeout period is typically several minutes, the Short Timeout option allows you to setup the sensor quicker.

Note: Leaving this option selected will cause incorrect results if presence detection exceeds the Short Timeout period. The Short Timeout period is approximately 3 seconds at 3000 PRF. The timeout period is inversely proportional to the PRF.

Section 3 - Measurement Modes

Overview

The ULS is unique in that it can operate in any of the three following modes:

Averaging: This conventional mode averages multiple pulses or shots. In this mode, the ULS measures quicker and is more accurate. This is a result of LTI's proprietary ASIC and use of high-speed CPU processing on-board.

Binning: The other distance-measuring mode is the Binning Mode. This method is possible, again, because of the capabilities of the ASIC. This proprietary method has the laser send out a predefined number of pulses and records their arrival back to the laser by placing them in a contiguous series of bins, each bin represents a certain distance. Multiple accumulated return pulses sitting in a single bin signify that a target exists at that distance.

Look Down: This mode is used for high-speed presence/proximity detection. A distance is not produced, but a hardware communication line is toggled high when something interrupts the laser's detection beam (above the user-defined trip point). A high-speed time between events can also be output in this mode.

Averaging Mode

The ULS pulsed rangefinder sends a single pulse of light, typically 8 ns in duration, to a target. It measures the time it takes for the pulse to return to the rangefinder. Given that the speed of light is relatively constant in all barometric atmospheres, the distance to the target can be calculated. One individual pulse would not provide a very accurate measurement since we are dealing with picoseconds (i.e. 10^{-12} seconds). The rangefinder uses a series of pulses and averages them for a more accurate measurement result. Since the ULS is fully programmable, you can choose if you need a fast measurement rate with lower accuracy or a slower measurement rate with higher accuracy.

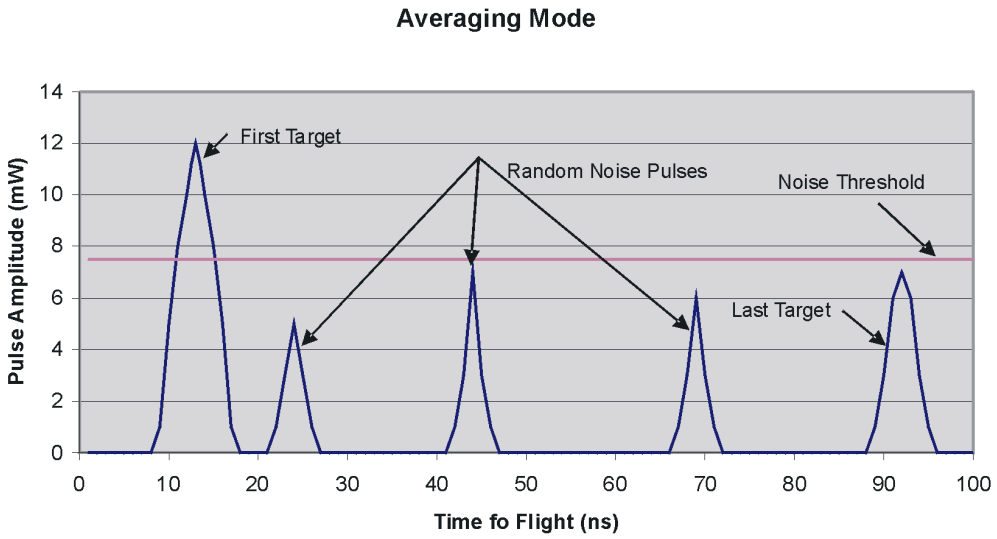
The output data update rate is defined by the Pulses/Measurement (PPM) value divided by the PRF in seconds. The amount of averaging between updates is the Minimum Good Pulses or Required Dither Pulses value set in the averaging parameter box (page 10). An error will be generated if the Minimum Good Pulses or Required Dither Pulses are not less than the PPM parameter. Also, an error will be generated if not enough good pulses are returned to meet the averaging of the Minimum Good or Required Dither Pulses. The ULS Interface program will display an error message *Average Not Filled*. Lowering the value of the averaging parameter will lower the accuracy of the measurement, but will allow validation of any returned targets. If zero return targets are seen an error will be displayed *Target Not Found*. Lowing the value of the averaging parameter will not remove this error.

The Averaging Mode includes an advanced feature called dithering, which can dramatically increase the accuracy of the measurement without using more pulses per measurement. We recommend using this feature when higher accuracy is required. The dithering cycle is 32 good receive pulses. For best accuracy, the Required Dither Pulses should always be a multiple of 32.

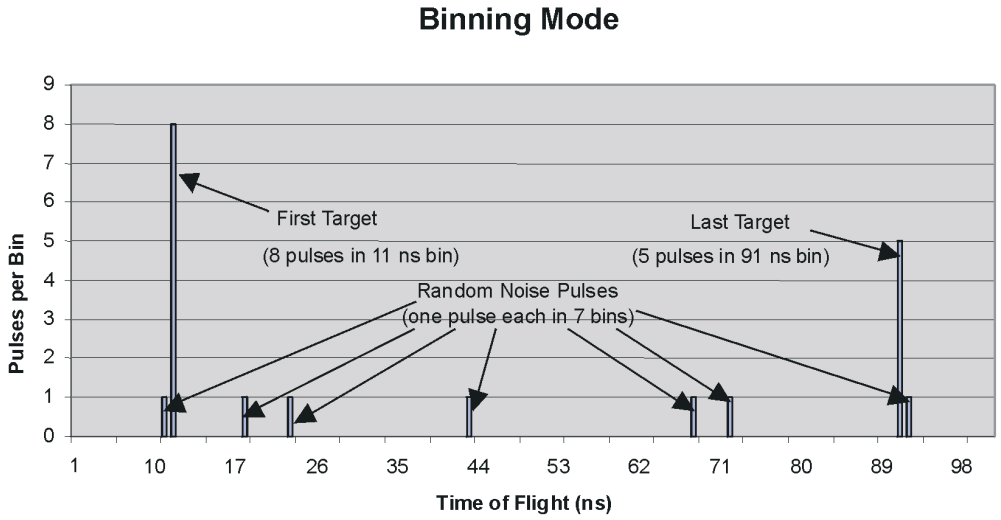
Binning Mode

Multiple targets can be tracked simultaneously. This method of reporting is extremely useful when there are several targets in the path of the laser, the laser is being used in a dusty environment, or the return signals are very weak (can't see the target in Averaging Mode). In this case, you may want to track the "last pulse" (farthest target) or the "first pulse" (first target).

The ULS's ranging ability is enhanced because conventional lasers must operate using an electronic threshold that prevents internal electronic noise from interfering with the return optical pulse of light, which is converted to an electrical pulse as well. The Binning Mode runs without a threshold because noise pulses are randomly distributed in the bins, where as the pulses from the target land in one specific bin. The maximum acquisition range of the ULS is increased in this mode because weaker targets are not eliminated by a given detection threshold setting (pulse amplitude diminishes as a function of longer range). To illustrate how greater distances can be measured in the Binning Mode, the following diagrams use the same targets in each mode.



Averaging Mode: Two targets are encountered, but the last target cannot be measured because it is below the noise threshold.



Binning Mode: The random noise pulses are not statistically stable, two targets are identified and measured.

The Binning Mode is not as accurate as Averaging Mode since the pulse's individual flight times are not being averaged. A pulse is recorded as a hit inside a bin (a given range of distances) and a target is identified as having multiple, accumulated hits within a given bin. You can establish how many pulses in a bin constitute a target. Binning is only as accurate as the bin size, which is determined by the maximum distance needed (i.e. a tradeoff between distance accuracy and maximum distance acquisition). Because the bin size is variable, the number of bin hits must be changed to optimize target detection.
The basic rule of thumb is the larger the bin size, the larger the bin hits needed. The maximum PRF should be about 1000 for binning. This is due to the fact that in Binning Mode all return pulses are processed before the next pulse is fired. The pulses per measure should be high enough to allow for multiple target outputting between each measurement. Each target found results in a measurement output reading. The higher the number of targets, the higher the number of messages that must be sent out each measurement period (PPM/PRF in seconds).

The maximum number of targets allowed in Binning Mode is 15. If the Bin Hits value is set low at long ranges, 15 targets can easily be found before the total range is checked. If 15 targets appear during binning, the unit restarts the firing sequence and will not find targets beyond the last one detected. In this case the Bin Hits value should be raised so that only two or three targets appear. If these are not real targets, the range values will be random. Again the Bin Hits value should be raised until a non-random target (real target) is found. If no targets are found, the Bin Hits value should be lowered until targets start appearing. Again if only random targets are found, no real target exists.

Look Down Mode

The Look Down Mode is intended to be used in a proximity or presence detection application whereby the ULS is mounted above a desired monitoring area and aimed to "look down" at passing targets that move through the measurement beam (i.e. vehicles). In this mode, the sensor continuously fires pulses and looks for a specific change in distance (i.e. a shorter distance) above a reference distance (i.e. the ground).

In the Look Down Mode, the ULS is turned on and targeted at the reference surface with no targets present. This distance establishes the reference distance (the longest possible distance) for the given setup. The sensor will then look for a specific change in distance above (i.e. shorter than) the reference distance, and will send out a signal when this trip distance is detected. You can set the exact trip distance using the ULS Interface Program. The state of the look down system is displayed in the ULS Interface Program. OFF is displayed when only the reference is detected; ON is displayed when the system is tripped by presence detected.

Note: The display will remain blank when the system is first started and the reference is detected. When one detection of presence is found, the display will toggle ON or OFF depending on presence or no presence detected respectively.

The Look Down trip signal is available on a single output line of the universal output port, and can be selected as either an RS232 or an RS485 level signal. In RS232 mode, the Look Down output is provided on pin 3 (TxD) of the port and is referenced to pin 6 (GND). In RS485 mode, the output is provided on pin 8 (differential +) and referenced to pin 7 (differential -). Note that the RS232 Look Down output signal is always available at the universal port, but the RS485 signal must be manually turned on or off using the ULS Interface Program. The 'no target detected', or reference distance output signal will be a low state (RS232: approximately -5V; RS485: approximately -3V differential voltage), and the 'target detected', or trip distance output signal will be at a high state (RS232: approximately +5V; RS485; approximately +3V differential).

Note: The RS485 output signals are a balanced, differential pair, so how you connect them into the communications interface defines the exact state (high or low).

The Look Down trip signal will stay active (high/ON) for as long as an object is within the measurement beam, and will return to the inactive (low/OFF) state when the object exits the beam. Note that the sensor continuously monitors the reference distance for any significant changes.

- If the trip signal is in its active state, and the ULS registers a target distance that does not change for prolonged time (1,080,000 laser pulses or approximately 6 minutes), it will establish this distance as the new reference distance.
- If the short timeout period is selected in the ULS interface, the unit will re-reference in 8,000 laser pulses or approximately 3 seconds.
- If the trip signal is in its inactive state, and the ULS registers a target distance that is longer than the reference distance, the sensor will establish the longer distance as the new reference distance over an adjustment period of a few seconds.

While in Look Down Mode, the response time and timing uncertainty of the trip signal depends on the selected ULS laser pulse rate. A faster pulse rate results in a faster response time, and vice-versa for a slower pulse rate. The response time of the Look Down output signal is based upon the fact that the sensor uses 30 laser pulses to determine if the trip distance has been exceeded. At a pulse rate of 3 kHz, this computes to a time latency of 10 milliseconds for a state change of the output signal. The timing uncertainty of the Look Down signal is equal to plus or minus the time of one laser pulse, or $\pm {}^{1}/_{\text{Pulse Rate}}$ At a pulse rate of 3 kHz, the timing uncertainty is ±330 µs.

See Page 35 for information about the Set/Get Trip Point serial command.
See Page 35 for information about the Set/Get Trip Point Timeout serial command.

Time between Events

Time between events can be logged using the configuration port only; it cannot be logged using the ULS Interface program. The time between events is output by setting the Time Between Events serial command. The unit outputs the number of fire pulses between *not present* and *present* events. The output is 4 hex characters that must be converted into pulse fires to be converted back to time depending on the PRF. 3000 pulses at 3kHz PRF takes one second, so a value of 0BB8 hex (3000 decimal) would be output if the time between not present edge to present edge was detected that equaled 1 second. The maximum time between events is 65535 PRF counts. At a PRF of 3KHz the maximum time between events is approximately 22 seconds. Time between events that exceed 22 seconds will result in output of 0000 signifying that the maximum time between events was larger then the maximum.

See Page 24 for information about Measurement Data Output when Time between Events is turned on.
See Page 35 for information about the Set/Get Time between Events serial command.

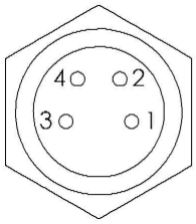
Section 4 - ULS Connection Ports

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 Look Down Mode, the configuration port is used for system setup only.

Configuration Port Connector Diagram - rear panel view:



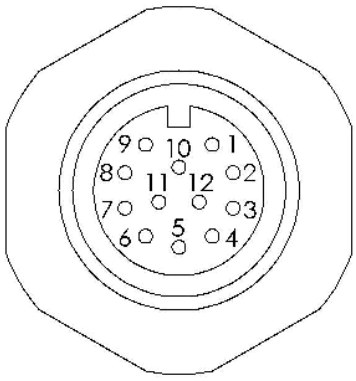
Configuration Port Signal Definition:

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 Look Down Mode, the trip signal output). In all ULS output modes (RS232, RS485 and Look Down), 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 Connector Diagram - rear panel view:



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

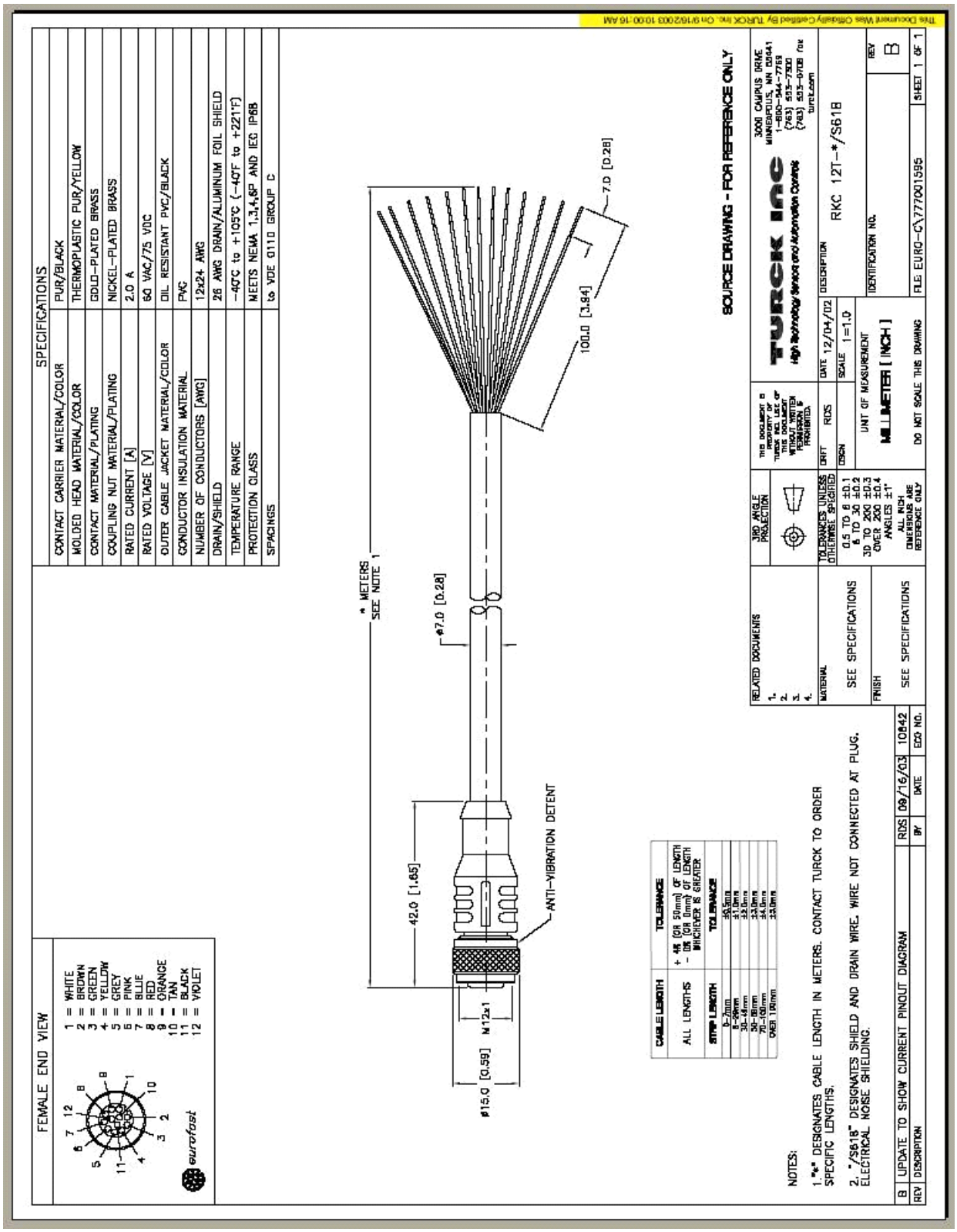
The ULS package includes two interface cables.

- 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.
- 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.

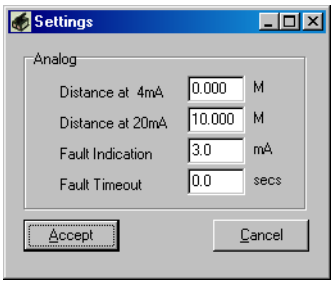
It is intended that power for the ULS is supplied via the 12-pin universal port cable. A well-regulated DC voltage between +10 to +26 volts should be applied to pin 2 of the universal port (the brown wire from the un-terminated end of the 2 meter cable), with the power ground connection being made to 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.

A drawing for the Universal Port Cable is on Page 18.

Universal Port Cable



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.

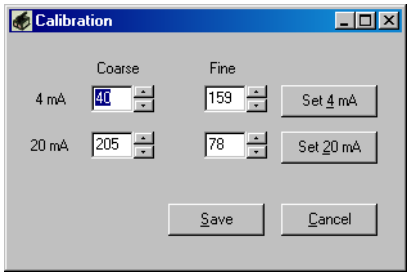
The actual current for the example current loop setup can be calculated by taking the 16 mA full-scale current range ÷ (20 mA range value - the 4 mA range value) = 1.6 mA per meter. So a 5 meter reading: 5 x 1.6 mA = 8 mA + 4 mA offset at zero = 12 mA.

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 34 for information about the Set/Get Range at 4 mA serial command.
See Page 33 for information about the Set/Get Range at 20 mA serial command.
See Page 30 for information about the Set/Get 4-20 mA Fault Current Value serial command.
See Page 31 for information about the Set/Get Fault Timeout for 4-20 mA Current Loop serial command.

Calibrating the Current Loop

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



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 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.

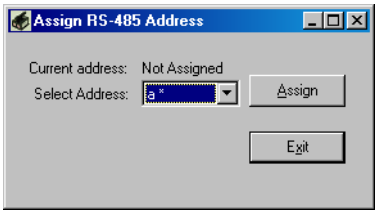
In the optional, externally-powered configuration, you would provide a current sense resistor between pin 12 of the universal output port, isolated GND, and the GND terminal of the external power source. The positive output voltage of the external power source would be connected to pin 10 of the universal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

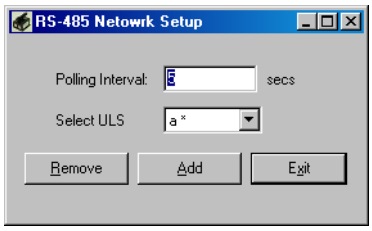


The Connections Menu includes an option that allows you to assign an address to a unit. When you select the Assign ULS Address option, a window will open showing the address that is currently assigned to the connected unit. If no value is assigned or if you want to change the value of the address, use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

Note: Values with an asterisk have already been assigned in the network using the ULS program. The RS485 system will not function correctly with 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 36 for information about the Set/Get Unit Address serial command.

Modifying the RS485 Network

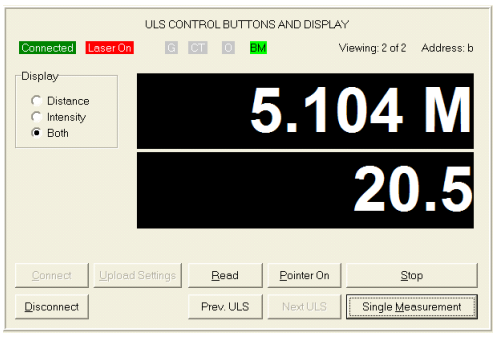


The Connections Menu also includes an option that allows you to modify the RS485 network. This option is used to tell the ULS Interface Program what ULS units are in the network. This option allows you to add or remove units from the network.

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 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 tab to add or remove unit to the network. Once this is done the 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 Protocol - ver 0.97

General Information

The ULS uses two formats of ASCII protocol (non-addressable and addressable). This allows you to control the ULS with 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 28). 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 42 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 42 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.

- 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 Target Array consecutively, always starting with index 0.

- Look Down Mode:
  - 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 15 for information about Time between Events.
    See Page 35 for information about the Set/Get Time between Events serial command.

ULS Commands

The following commands are presented in alphabetical order.

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

Note: For more information about dithering, see Pages 10 and 12.

Get Measurement

Get:	**$BM<CR>**	Reply:	Varies with measurement mode. See pages 23-24.
	#*a***BM<CR>**		Varies with measurement mode. See pages 23-24.

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

Get 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 Software Version
<CR> = carriage return

Get 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 Look Down Mode
n = 7 = laser firing and Averaging 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
```

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

Note: For more information about Autostart, see Page 9.

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

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 on power up
n = 1 = Pointer On on 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.**

Note: For more information about Pointer On/OFF, see Page 7.

Save User Settings into Non-Volatile Memory

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

Set/Get 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

Note: For more information about 4-20 mA Current Loop, see Pages 9 and 19.

Set/Get Averaging Weight (Number of Good 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 (in multiples of 32)
<CR> = carriage return

Note: For more information about Required Good Pulses or Minimum Good Pulses, see Page 10.

Set/Get 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>**		

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

Set/Get 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

Note: For more information about Bin Size, see Page 11.

Set/Get 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

Note: For more information about Bin Hits, see Pages 11 and 14.

Set/Get 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

Note: For more information about Continuous Output, see Page 9.

Set/Get Cooperative Filter

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

Note: For more information about Cooperative Target Only, see Page 9.

Set/Get 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 = Range
n = 2 = Range and Intensity
n = 3 = Intensity
<CR> = carriage return

Set/Get 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

Note: For more information about the 4-20 mA Output Mode, see Page 19.

Set/Get 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

Note: For more information about the 4-20 mA Output Mode, see Page 19.

Set/Get 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

Note: For more information about the Long Gate, see Page 8.

Set/Get 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 = Look Down Sensor
<CR> = carriage return

Note: For more information about selecting a Measurement Mode, see Page 10.

Set/Get 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 User port
n = 2 = RS485 User port
<CR> = carriage return

Note: For more information about Output Setup, see Page 9.

Set/Get 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

Note: For more information about Units, see Page 8.

Set/Get 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

Note: For more information about Power Level, see Page 9.

Set/Get 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 Hertz)
<CR> = carriage return

Note: **$PF,***n,n,n* where *n,n,n* is Averaging,Binning,Look Down.
For more information about PRF, see Page 10.

Set/Get Pulses Per Measurement

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 Per Measurement
n = Pulses per Output
<CR> = carriage return

Note: **$PF,***n,n* where *n,n* is Averaging,Binning.
For more information about Pulses/Measure, see Page 10.

Set/Get 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 20mA
n = Range at 20mA in user units (decimal feet or meters)
<CR> = carriage return

Note: For more information about Range at 20 mA, see Page 19.

Set/Get 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 4mA
n = Range at 4mA in user units (decimal feet or meters)
<CR> = carriage return

Note: For more information about Range at 4 mA, see Page 19.

Set/Get 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

Note: For more information about Termination, see Page 9.
For more information about the RS485 Network Interface, see Page 21.

Set/Get 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

Note: For more information about the Short Gate, see Page 8.

Set/Get 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

Note: *For more information about Time between Events, see Page 15.*

Set/Get 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

Note: For more information about Trip Point, see Page 11.

Set/Get Trip Point 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 Point Timeout
h = Trip Point Timeout ((seconds * 3000) in hexadecimal notation)
<CR> = carriage return

Set/Get 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 21.

Set/Get 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

Note: For more information about Offset Distance, see Page 8.

Section 9 - Specifications

Units: Feet or Meters

Resolution: 0.01 ft or 1 mm

Pulsed Laser

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:	FDA CFR 21 Class I 7 millimeter

Internal Laser Pointer

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

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 max

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	

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

Physical

Dimensions:	5.3" L x 4.75" W x 2.5" H (13.5 cm L x 12 cm W x 6.3 cm H)
Weight:	1.75 lbs or 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 54
Temperature: -30° C to +60° C (-22° F to +140° F)

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 supplied)
Cable: 4 pin cable, RS232 and input power

ULS Interface Program Requirements

Operating System: Windows 95, 98, 2000, NT, and XP
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	266 m to white wall (90% diffuse)	228 m to white wall (90% diffuse)	188 m to white wall (90% diffuse)
	133 m to gray wall (20% diffuse)	114 m to gray wall (20% diffuse)	94 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)

Output Data Rate

Output data rate depends on baud rate of the serial port, the PRF of the unit, the number of pulses per measurement, 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 measurement (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 (pico seconds)
<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 measurement (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 measurement (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 10 - 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

Error Number	Explanation	ULS Interface Display
35	Invalid Average Weight	Invalid Average Weight
36	Invalid Noise Zone Error	ER 036
37	Factory Defaults Checksum Error	Bad Factory Defaults Checksum
38	Code Checksum Error	Bad Code Checksum
39	⌦ Too Many EEPROM Writes Error	ER 039
40	⌦ Broken EEPROM Error	ER 040
41	⌦ Unverifiable Image Checksum Error	ER 041
42	⌦ Bad User Settings Defaults Checksum	Bad User Settings Defaults Checksum
43	⌦ Bad User Settings Checksum	Bad User Settings Checksum
44	⌦ Bad Factory Defaults Checksum	Bad Factory Defaults Checksum
45	⌦ No Factory Defaults Present Error	No Factory Defaults
46	⌦ EEPROM Not Finished Yet Error	ER 046
47	⌦ SPI Busy	ER 047
48	⌦ Serial Checksum Error	ER 048
49	Pulse Per Output Must Be Greater Than Average Weight	PPO Must Be Greater Than Average Weight

Interrupt Error Codes

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 Checksums Error Codes

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 Codes

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

4-20 Error Codes

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

Index

Numerics

4-20 mA Analog Output Mode 19
4-20 mA Fault Current Value
    command 30

A

address
    assigning 21
Addressable Protocol 23
ASCII protocols 22
Averaging Mode 12, 38
    output format 23
Averaging Parameters 10
Averaging Weight
    command 28

B

baud rate
    choices 37
    command 28
Bin Hits 11
Bin Size 11
    command 29
Bin Threshold
    command 29
Binning Mode 13, 40
    output format 24
Binning Parameters 11
BM icon 8

C

cabling 17
Calibrating the Current Loop 19
capture file 7
Comm Port Setup 6
commands
    serial.See specific command
configuration file
    storing 7
configuration port 5, 16
Connect 7
connection ports 16
Connections Menu 21
Continuous Output 9
    command 29
Cooperative Filter
    command 30
Cooperative Target Only 9
CT icon 8

D

Disconnect 7
Display Mode in Averaging
    command 30
Dither On/Off
    command 25
Dithering 10

E

error numbers 42

F

fault indicator 5
Fault Timeout for 4-20 mA Current Loop
    command 31
front panel 5

G

G icon 8
gates 8
Get Measurement
    command 25
Get Software Version
    command 25
Get Unit Status
    command 26

I

icons 8
interface program
    installing 6

L

Laser On icon 8
laser pointer 5
Laser Power Setup 9
Long Gate 8
    command 31
Look Down Mode 14
    output format 24
Look Down Parameters 11
LTI
    contact information 42

M

Measurement
command 25
Measurement Autostart On/Off
command 26
measurement data
output formats 23
Measurement Mode
command 31
Measurement Output Port
command 32
Measurement Start
command 26
Measurement Start/Stop
control button 7
Measurement Stop 27
Measurement Units
command 32
Minimum Good Pulses 10
Minimum Pulse Width 10
Mode 10

N

Non-Addressable Protocol 22
Number of Good Pulses
command 28

O

O icon 8
Offset Distance 8
Output Data Rate
Averaging Mode 39
Binning Mode 40
output formats
measurement data 23
Output Selection 9
Output Serial Data Stream
Averaging Mode 39
Binning Mode 41

P

Pointer Autostart On/Off
command 27
Pointer On/Off
command 27
control button 7
Power Level 9
command 32
precautions 3
PRF 10
command 33
protocol
Addressable 23
Non-Addressable 22
Pulses Per Measurement
command 33
Pulses/Measure 10

R

Range at 20 mA
command 33
Range at 4 mA
command 34
rear panel 5
receive lens 5
Required Dither Pulses 10
RS485 Bus Termination On/Off
command 34
RS485 Network
modifying 21
RS485 Network Interface 21
RS485 Protocol 22

S

safety 3
Save User Settings
command 27
serial commands 25
serial data formats 22
Set/Get 4-20 mA Current Loop On/Off
command 28
Set/Get 4-20 mA Fault Current Value
command 30
Set/Get Averaging Weight
command 28
Set/Get Baud Rate
command 28
Set/Get Bin Size
command 29
Set/Get Bin Threshold
command 29
Set/Get Continuous Measurement Output Mode 29
command 29
Set/Get Cooperative Filter
command 30
Set/Get Display Mode in Averaging
command 30
Set/Get Fault Timeout for 4-20 mA Current Loop
command 31
Set/Get Long Gate
command 31
Set/Get Measurement Mode
command 31
Set/Get Measurement Output Port
command 32
Set/Get Measurement Units
command 32
Set/Get Power Level
command 32
Set/Get PRF
command 33
Set/Get Pulses Per Measurement
command 33
Set/Get Range at 20 mA
command 33

Set/Get Range at 4 mA
command 34
Set/Get RS485 Bus Termination On/Off
command 34
Set/Get Short Gate
command 34
Set/Get Time between Events
commands 35
Set/Get Trip Point
command 35
Set/Get Trip Point Timeout
command 35
Set/Get Unit Address
command 36
Set/Get User Offset
command 36
Short Gate 8
command 34
Short Timeout 11
signal definition
connection ports 16
Single Measurement
control button 7
specifications 37
Start Capture 7
Status
command 26
status indicator 5
Stop Capture 7

T

Termination 9
Time between Events 15
command 35
transmit lens 5
Trip Point 11
command 35
Trip Point Timeout
command 35

U

ULS Autostart 9
Unit Address
command 36
Units 8
command 32
universal port 5, 16
Upload Settings 7
User Offset
command 36

V

View Capture 7
views of the ULS 5