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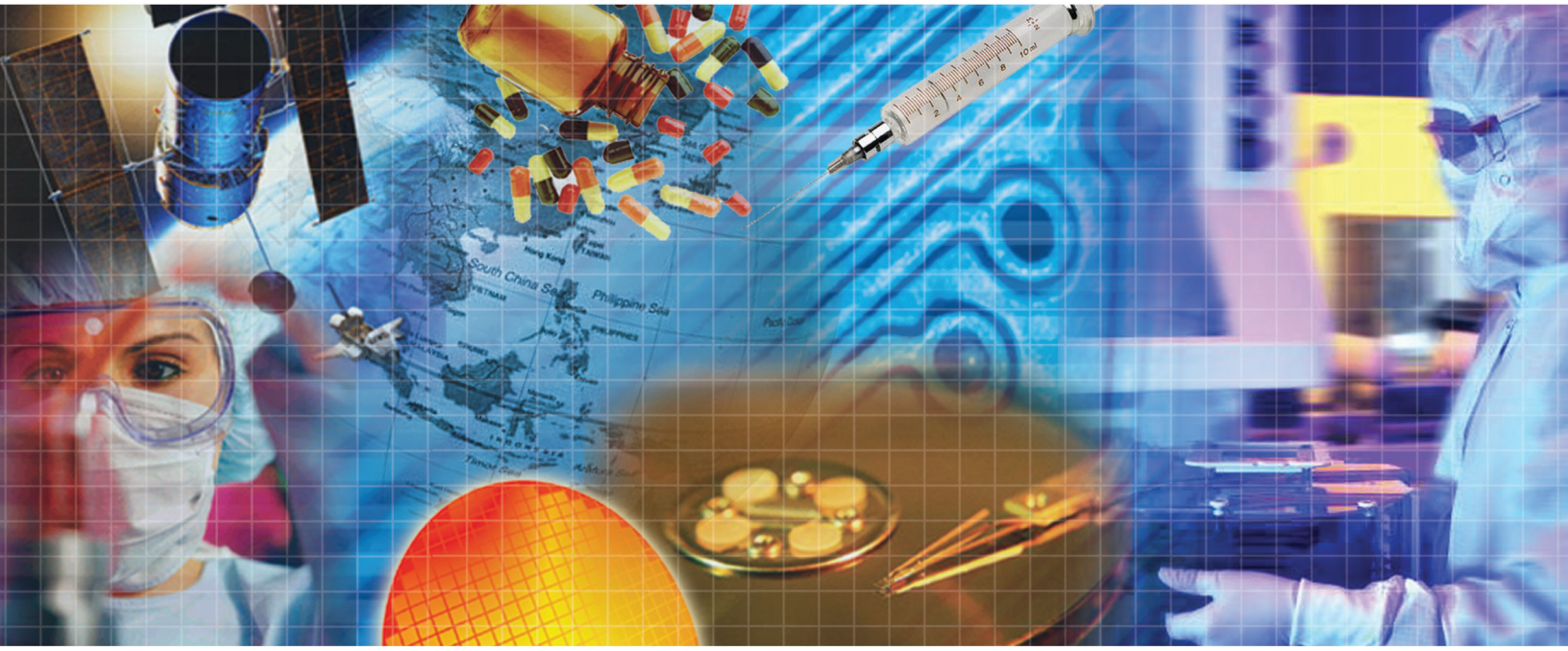
USER GUIDE

Remote liquid particle counters (LPC)

Lighthouse

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LIGHTHOUSE
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REMOTE

LPC LE

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Operating Manual

Lighthouse Worldwide Solutions

REMOTE LPC LE

Operating Manual

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Manufactured by:

Lighthouse Worldwide Solutions

1221 Disk Drive

Medford, Oregon 97501

LWS Part Number 248083425-1 Rev 3

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About This Manual

This manual describes the detailed operation and use of the Lighthouse REMOTE Liquid Particle Counter LE (referred to as RLPC LE) with MODBUS/4-20mA output.

Text Conventions

The following typefaces have the following meanings:

Note: *A note appears in the sidebar to give extra information regarding a feature or suggestion*

WARNING: ***A warning appears in a paragraph like this and warns that doing something incorrectly could result in personal injury, damage to the instrument or loss and/or improper storage of data.***

italics	Represents information not to be typed or interpreted literally. For example, *file* represents a file name. Manual titles are also displayed in italics.
boldface	Introduces or emphasizes a term.
`Courier font`	Indicates command syntax or text displayed by the diagnostic terminal.
`Bold Courier`	Indicates commands and information to be typed. Uppercase or lowercase may be used; in this manual, commands are shown in uppercase.
Helvetica Italics	Indicates a comment on a command or text output.

Additional Help

For more information about Lighthouse RLPC LE, contact Lighthouse Worldwide Solutions.

Service and Support:

Tel: 1-800-945-5905 (Toll Free USA)
Tel: 1-541-770-5905 (Outside of USA)
techsupport@golighthouse.com

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1 General Safety

Safety Considerations

Warnings and cautions are used throughout this manual. It is the responsibilty of the the user to familiarize themselves with the meaning of a warning before operating the particle sensor. Warnings may appear in the left margin of the page next to the subject or step to which it applies or within the step itself. Take extreme care when performing any procedures preceded by or containing a warning.

There are several classifications of warnings defined as follows:

WARNING: ***There are no user-serviceable components inside the particle counter.***

- LASER - pertaining to exposure to visible or invisible laser radiation
- Electrostatic - pertaining to electrostatic discharge
- Network Connect - pertaining to communication ports and instrument damage

LASER Safety Information

This product is considered to be a Class 1 LASER product (as defined by FDA 21 CFR, §1040.10) when used under normal operation and maintenance. Service procedures on the sensor can result in exposure to invisible radiation. Service should be performed only by factory-authorized personnel.

The particle counter has been evaluated and tested in accordance with EN 61010-1:2012, “Safety Requirements For Electrical Equipment for Measurement, Control and Laboratory Use” and IEC 60825-1:2007, “Safety of LASER Products”.

WARNING: ***The use of controls, adjustments or procedures other than those specified within this manual may result in personal injury and/or damage to this instrument.***

For further technical assistance, contact our Technical Support Team at 1-800-945-5905 (Toll Free USA) or 1-541-770-5905 (Outside of USA).

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Electrostatic Safety Information

Electrostatic discharge (ESD) can damage or destroy electronic components. Therefore, all service or maintenance work should be done at a static-safe work station. A static-safe work station can be created by doing the following:

WARNING: ***Using a wrist-strap without an isolation resistor will increase the severity of an electrical shock. Use of control or adjustment or performance of procedure other than specified here may result in hazardous radiation exposure.***

- Use a grounded conductive table mat and resistor-isolated wrist-strap combination
- Earth-ground all test instruments to prevent a buildup of static charge

2 Introduction

Overview

This operating manual introduces the Lighthouse REMOTE Liquid Particle Counter model RLPC LE. Included in this manual are instructions for operation, communications and maintenance.

Description

The RLPC LE has a range of 1.0 - 50µm or 1.0 - 200µm with eight user selectable sizes using MODBUS.

With a user-controlled flow rate of 30 or 50 ml/min, ± 5%, the RLPC LE sensor is designed to accurately measure 8 channels of simultaneous particle count data.

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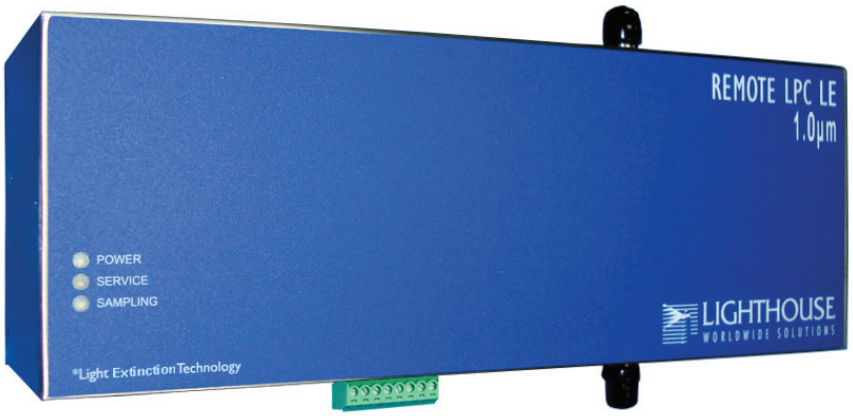


Figure 2-1 RLPC LE

The instrument uses a laser diode light source and collection optics for particle detection. Particles suspended in a liquid block light from a focused laser beam.

The result is a voltage pulse each time a particle crosses the laser beam. The width of the pulse is proportional to the time it takes the particle to cross the laser beam and the pulse's amplitude is proportional to the size of the particle.

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The voltage pulses created by the particles are processed by additional electronics to quantify the pulses by the size of each particle. The quantities of the various sized particles are processed and stored in the sensor's buffers or transferred via the 4-20mA interface.

The RLPC LE counter was created for continuous, 24 hours per day, 7 days per week operation. The instrument provides versatile mounting options allowing installation where space is at a premium. The RLPC LE integrates seamlessly with many large facility monitoring or management systems.

Accessories

several accessories can be ordered to tailor the instrument to specific needs. These accessories are listed below.

Included:

- **Operating Manual on CD**
- **2 each 10-foot Teflon® sample tubes**
- **USB to RJ45 Serial Cable**
- **Power Supply**

Optional:

- **Flowmeter (Teflon® PFA or aluminum)**
- **Additional Sample Tubing**
- **REMOTE Mounting Plate**
- **RLPC Stand with Flowmeter mounting**
- **RS232 Communications Kit**
- **RS485 Adapter Cable**

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RLPC LE Specifications

Table 2-1 RLPC LE Specifications

Size Range	1.0 - 50µm 1.0 - 200µm
Channel Sizes	1-50µm: 1.0, 3.0, 5.0, 10.0, 15.0, 20.0, 25.0, 50.0 micron 1-200µm: 1.0, 5.0, 10.0, 15.0, 20.0, 25.0, 50.0, 200.0 micron
Flow Rate	50 ml/min for 1-50µm 30 ml/min for 1-200µm
Laser Source	Laser Diode
Calibration	NIST Traceable
Data Storage	Rotating buffer, 1,000 Records
Communication Modes	RS485/MODBUS via RJ45 to PC, 4-20mA or ASCII
LED Indicators	Power, Service, Sampling
Supporting Software	LMS Express RT and LMS Pharma
Concentration Limit	1 - 50µm Max Concentration = 40,000 P/mL 1 - 200µm Max Concentration = 50,000 P/mL
Power Input Requirements	24VDC@ 150mA
Enclosure	Stainless Steel
Sample Inlet/Outlet Connection	1/4” Compression
Sample Temperature	32 - 158^{o}F (0 - 70^{o}C)
Sample Pressure	150 PSI
Wetted Surface Material	SS316L, Quartz, Kalrez
Dimensions	9.75"(L) x 3.57"(W) x 3.8"(H) [24.7 x 9.0 x 9.6 cm]
Weight	4.3 lbs. (1.95 kg)
Operating Temp/RH	50° F to 104° F (10° C to 40° C) / 20% to 95% non-condensing
Storage Temp/RH	14° F to 122° F (-10° C to 50° C) / Up to 98% non-condensing

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3 Get Started

Initial Inspection

The instrument is thoroughly inspected and tested at the factory and is ready for use upon receipt.

When received, inspect the shipping carton for damage. If the carton is damaged, notify the carrier and save the carton for carrier inspection. Inspect the unit for broken parts, scratches, dents or other damage.

If the carton is not damaged, keep it for reshipping the instrument for its annual factory calibration. ***RETAIN THE INLET AND OUTLET SHIPPING CAPS!***

Annual Calibration

The manufacturer recommends that the Lighthouse instrument be calibrated annually by a Certified Lighthouse Service Provider to ensure that it continues to perform within specifications.

Shipping Instructions

Should it become necessary to return the unit to the factory for any reason, be sure to contact Customer Service and obtain a Return Material Authorization (RMA) number. Reference this number on all shipping documentation and purchase orders. After receipt of the RMA, follow the instructions below:

WARNING: ***If the sensor must be returned for service or when it is returned for calibration, the Flow Cell must be flushed with DI water or reagent grade isopropyl alcohol and blown dry with clean air and the nozzles capped. If the Flow Cell is not clean and dry prior to shipping, it may be damaged (freeze-fracture, dried contaminants) and require replacement during servicing or calibration.***

1. After the conditions in the above warning are met, use the original container or carton and packing materials whenever possible.

Note: *Contact Lighthouse to purchase a replacement shipping container and nozzle caps.*

2. If the original container and packing materials are not available, wrap the unit in “bubble pack” plastic; surround with shock-absorbent material and place in a double-wall carton.

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3. Seal container or carton securely. Mark “FRAGILE” and write the RMA number in any unmarked corner.

4. Return to the address instructed by the Lighthouse representative.

LEDs

Understanding the LEDs

The front-panel LEDs have specific meanings when illuminated. Figure 3-1 shows the location of the LEDs and gives a brief description of their meaning.



Figure 3-1 Detail of Front Panel LEDs

- The green POWER LED turns on when the instrument is powered on.

- The yellow SERVICE LED will turn on when the instrument reaches its calibration date.

  In the event that the SERVICE LED turns on, contact Lighthouse Technical Support at 1-800-945-5905 (Toll Free USA) or 1-541-770-5905 (Outside of USA).

- The blue SAMPLING LED indicates that the instrument is in the sampling state.

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Instrument Overview

Outlet Nozzle

The Outlet Nozzle on the top of the instrument uses 1/4” tubing and allows the liquid sample to flow back to the system being sampled.



Figure 3-2 Unit’s Top Connection

The connector on the bottom of the unit is the Inlet Nozzle and needs to be connected to the system being sampled. See Figure 3-3.

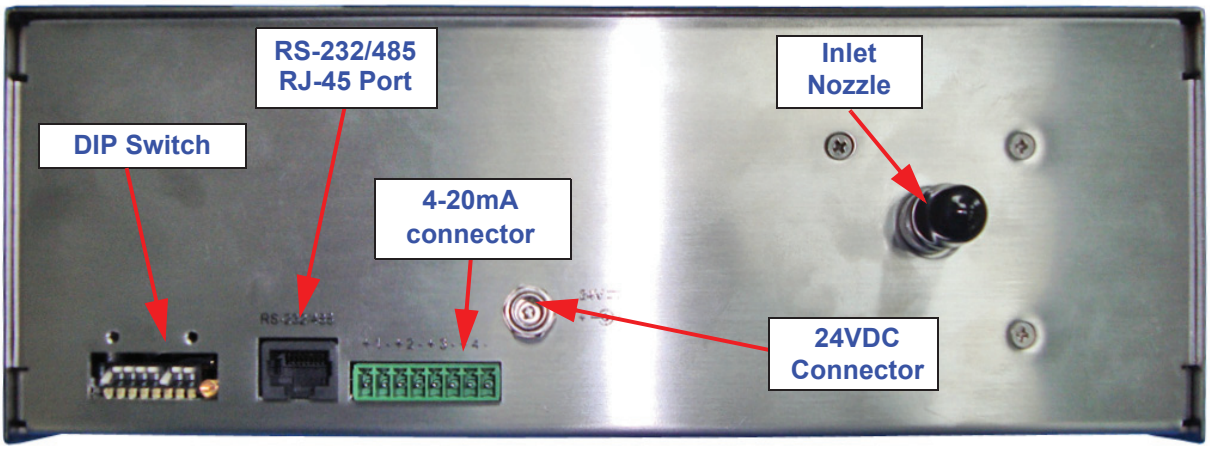


Figure 3-3 Unit’s Bottom Connections

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Communication Ports

The RJ45 port incorporates Serial communications to allow short distance point-to-point RS232/RS485.

Table 3-1 RJ-45 Pinouts

Pin	Signal Name
1	RS-232 - TX
2	RS-232 - RX
3	RESERVED for future use
4	RS-485B
5	RS-485A
6	RESERVED for future use
7	RESERVED for future use
8	GND

The J1 connector provides standard 4-20mA communications.

Table 3-2 J1 Pinouts

CH Pin #	Signal Assigned
1	CH1+
2	CH1-
3	CH2+
4	CH2-
5	CH3+
6	CH3-
7	CH4+
8	CH4-

The RS232 protocol is provided for quick simple cable connections to a standard PC COM port and is used for single-unit communications only.

DIP Switches

Note: *The DIP switches must be set before the unit is powered on.*

The DIP switches set the address of the instrument for RS232 configurations and the communications mode.

Addressing (DIP 1-5)

Note: *To change the DIP switches, use a small Phillips screwdriver to remove the cover plate and use a small pointed tool, such as a stylus or the end of a paper clip, to move the DIP switch.*

Note: *Since Address "0" is reserved for RS-485 broadcast, whenever all of the DIP switches are OFF or when DIP switch 1 is ON, the instrument address is set to "1".*

Table 3-3 details the addresses set by DIP switches 1 - 5.

- DIP switch 6: ON is for MODBUS. OFF is for DDTP (ASCII).

Table 3-3 DIP Switch Addressing

DIP SWITCHES 1 2 3 4 5	ADDRESS	DIP SWITCHES 1 2 3 4 5	ADDRESS
1 0 0 0 0	1	1 0 0 0 1	17
0 1 0 0 0	2	0 1 0 0 1	18
1 1 0 0 0	3	1 1 0 0 1	19
0 0 1 0 0	4	0 0 1 0 1	20
1 0 1 0 0	5	1 0 1 0 1	21
0 1 1 0 0	6	0 1 1 0 1	22
1 1 1 0 0	7	1 1 1 0 1	23
0 0 0 1 0	8	0 0 0 1 1	24
1 0 0 1 0	9	1 0 0 1 1	25
0 1 0 1 0	10	0 1 0 1 1	26
1 1 0 1 0	11	1 1 0 1 1	27
0 0 1 1 0	12	0 0 1 1 1	28
1 0 1 1 0	13	1 0 1 1 1	29
0 1 1 1 0	14	0 1 1 1 1	30
1 1 1 1 0	15	1 1 1 1 1	31
0 0 0 0 1	16		

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Power

This REMOTE instrument uses an external 24VDC power supply. The power input is 100-240 VAC, 50-60Hz, 0.4A and output is 24VDC, 0.62A.

Inlet Nozzle

Note: ***The user is responsible for maintaining a nominal flow rate of 20 ml/min ± 5% through the sensor.***

The sample source is attached using 1/4" tubing to the Inlet Nozzle. The user is responsible for maintaining a nominal flow rate of 20 ml/min ± 5% through the sensor to insure the accuracy of the data. See Figure 3-4 for a diagram showing the RLPC installation and direction of flow.

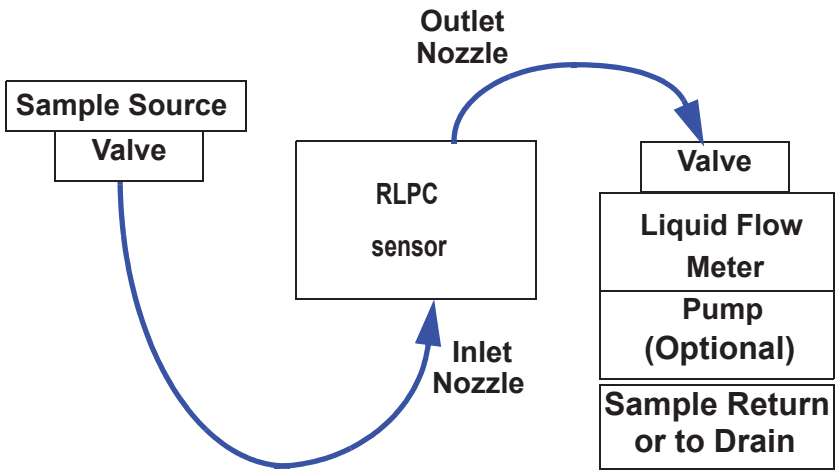


Figure 3-4 Example of an RLPC Installation

If there are any questions or problems during system setup, please contact Lighthouse Worldwide Solutions' Technical Support at techsupport@golighthouse.com.

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Attach Sensor

This section describes how to attach sample tubing and wiring and start using the RLPC.

WARNING: ***Please adhere to standard work precautions for handling liquids and electronics.***

Use of safety measures when working with liquids around electronics cannot be stressed enough. Make sure the RLPC is physically secure before connecting any tubing or electrical cables.

1. Verify that there is no flow of liquid in the system and power is removed from the RLPC.

Note: *When connecting compression fittings to the RLPC, do* ***NOT*** *swage the fittings on the instrument. Follow the Swagelok Installation Instructions.*

When swaging the tubing to the fitting, follow the Swagelok installation instructions.

2. Connect the liquid source to the RLPC's Inlet using the provided tubing. Verify the tubing is inserted firmly into the inlet port. Attach the compression nut until snug and then tighten a 1/4-turn with an adjustable wrench.

3. Connect the liquid drain to the RLPC's Outlet using the provided tubing. Verify the tubing is inserted firmly into the outlet port. Attach the compression nut until snug and then tighten a 1/4-turn with an adjustable wrench.

4. Turn the liquid system on and allow liquid to flow through the RLPC, verifying that there are no leaks at the sensor's inlet or outlet or any other connections.

WARNING: ***If a leak occurs anywhere within the system, immediately stop the flow of liquid and repair the leak!***

5. If leaks occur, immediately stop the flow of liquid. Disconnect and clear the compression fittings and connectors of debris or burrs. Repair any other leak(s), then return to Step 1 of this section.

6. If no leaks occur, connect power the RLPC.

7. Verify the sample liquid is bubble-free - bubbles will be counted as particles and in large amounts may cause sensor errors.

8. Allow liquid to flow through the sensor for 10 minutes or until there are no bubbles and the Service LED is OFF. If the Service LED comes on and remains on, the flow cell should be cleaned (see *Appendix B,* "Maintenance" on page B-1 for cleaning instructions).

9. If there are no leaks and the service LED is off, the instrument is ready to configure the communications - refer to *Chapter 4, "Programming"*.

10. Adding devices or additional connections between the sample source and the sensor will increase the chances for leaks and bubbles - keep connections to a minimum.

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4-20mA Wiring

Data Port

The 8-pin terminal connector on the bottom of the instrument is used to communicate with a 4-20mA monitoring system. Signals at this port include four 4-20mA data channels.

Table 3-4 J1 Data Connector Pinouts

CH Pin #	Signal Assigned
1	CH1+
2	CH1-
3	CH2+
4	CH2-
5	CH3+
6	CH3-
7	CH4+
8	CH4-

Included with the instrument is a plug to connect the J1connector. The plug allows the user to wire the channels to a 4-20mA monitoring system.

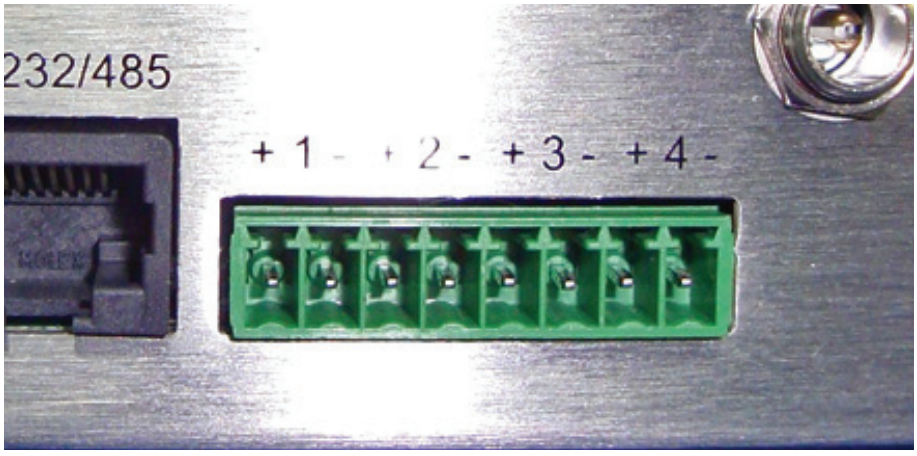


Figure 3-5 J1 Connector, Showing Pinout

4 Programming

General

The RLPC LE can only be programmed one way if using 4-20mA communications. If an ASCII terminal is connected to the instrument, it can program the unit's 4-20mA range.

This chapter contains the information needed to program the instrument to meet manufacturing or facility monitoring needs.

DIP Switches

The DIP switches are located behind a removable panel next to the RS232/RS485 connector.



Figure 4-1 Panel Covering the DIP Switches

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Remove the two Phillips head screws to expose the DIP switches.

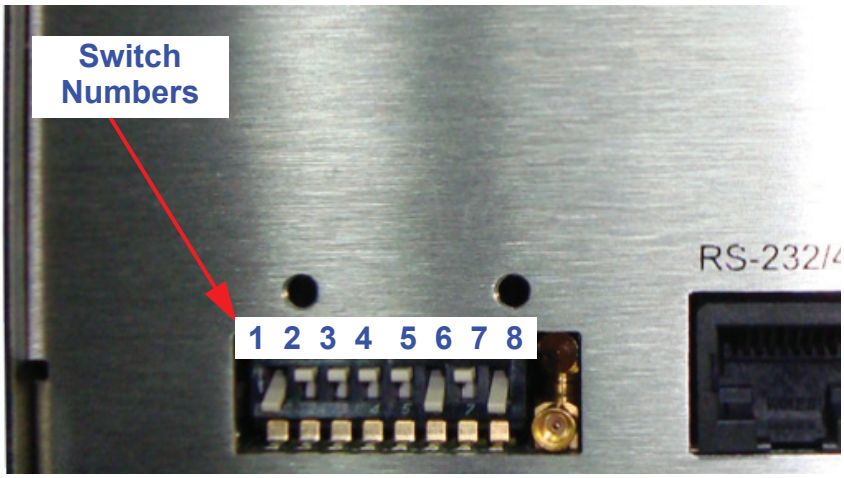


Figure 4-2 Panel Removed, Switches Exposed

DIP Switch Settings

GENERAL DEFINITIONS

OFF (UP) = 0, ON (DOWN) = 1

Table 4-1 DIP Switch Settings

Position #	Description	Setting
1	Binary Bit 0	OFF = 0, ON = 1
2	Binary Bit 1	OFF = 0, ON = 1
3	Binary Bit 2	OFF = 0, ON = 1
4	Binary Bit 3	OFF = 0, ON = 1
5	Binary Bit 4	OFF = 0, ON = 1
6	Communication Mode	OFF: ASCII Mode ON: MODBUS Mode
7		
8	Fast Transfer (Data Save) Mode	ASCII Mode: Reserved MODBUS Mode: OFF: Data Saved ON: No Data Saved

Note: *The DIP switches must be set before the unit is powered on.*

Communications Mode (DIP #8)

DIP Switch 8 is for MODBUS protocol only. ON activates Fast Transfer. OFF allows writing to the buffer.

Addressing (DIP 1-5)

Note: *To change the DIP switches, use a small Phillips screwdriver to remove the cover plate and use a small pointed tool, such as a stylus or the end of a paper clip, to move the DIP switch.*

Note: *Since Address "0" is reserved for RS-485 broadcast, whenever all of the DIP switches are OFF or when DIP switch 1 is ON, the instrument address is set to "1".*

Table 4-2 details the addresses set by DIP switches 1 - 5.

- DIP switch 6: ON is for MODBUS. OFF is for DDTP (ASCII).

Table 4-2 DIP Switch Addressing

DIP SWITCHES 1 2 3 4 5	ADDRESS	DIP SWITCHES 1 2 3 4 5	ADDRESS
1 0 0 0 0	1	1 0 0 0 1	17
0 1 0 0 0	2	0 1 0 0 1	18
1 1 0 0 0	3	1 1 0 0 1	19
0 0 1 0 0	4	0 0 1 0 1	20
1 0 1 0 0	5	1 0 1 0 1	21
0 1 1 0 0	6	0 1 1 0 1	22
1 1 1 0 0	7	1 1 1 0 1	23
0 0 0 1 0	8	0 0 0 1 1	24
1 0 0 1 0	9	1 0 0 1 1	25
0 1 0 1 0	10	0 1 0 1 1	26
1 1 0 1 0	11	1 1 0 1 1	27
0 0 1 1 0	12	0 0 1 1 1	28
1 0 1 1 0	13	1 0 1 1 1	29
0 1 1 1 0	14	0 1 1 1 1	30
1 1 1 1 0	15	1 1 1 1 1	31
0 0 0 0 1	16		

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Connecting to a Terminal

The RJ-45 connector on the instrument (marked “RS-232/485” in Figure 4-3) is used to connect the RLPC LE with a COM port on a desktop or laptop PC. Once connected and set up as an ASCII terminal, the PC can be used to program the instrument settings.

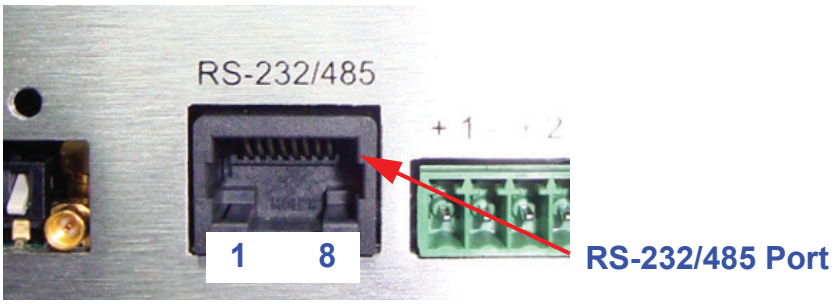


Figure 4-3 The Programming Port, Showing Pin Numbers

RS232/RS485 Pinouts

Table 4-3 RJ-45 Pinouts

Pin	Signal Name
1	RS-232 - TX
2	RS-232 - RX
3	RESERVED for future use
4	RS-485B
5	RS-485A
6	RESERVED for future use
7	RESERVED for future use
8	GND

Using the RS485 Port to Connect to a PC

To connect to the instrument using the RS232/RS485 port and protocol, use the RS485 to USB Converter Cable. Verify that a USB driver has been installed first. Connecting the instrument to the PC and applying power before the driver has been installed will be problematic.

To connect the instrument to a computer using RS485 Protocol:

1. Remove power from the instrument.
2. Connect the RJ-45 end of the converter cable to the RS485 port on the instrument.
3. Connect the USB end of the converter cable to a USB Port on the PC.

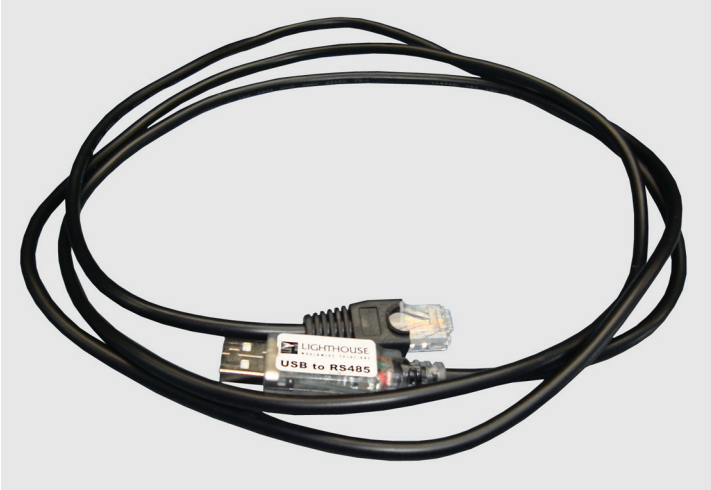


Figure 4-4 LWS RS485 to USB Converter Cable

4. Apply power to the instrument.
5. Windows will recognize that a new hardware device has been attached and will finalize the installation as needed. This is a routine “registering” of components that should take only a moment. An additional COM port will be added to the PC.
6. Identify the computer port that has been added to the PC by using the “Properties” of My Computer and examining the COM ports. USB ports are generally added to the bottom of the list and named USB COM port “x”. Refer to Figure 4-5 for screen examples (Windows XP).

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Table 4-4 EIA Industry Standards for RS485 Communications

SPECIFICATIONS	RS485
Mode of Operation	Differential
Total Number of Drivers and Receivers on One Line (One driver active at a time for RS485 networks)	32 Drivers 32 Receivers
Maximum Cable Length	4000 ft. (1,219.2 m)
Maximum Data Rate (40 ft. - 4000 ft. for RS422/RS485)	10Mb/s - 100Kb/s
Maximum Driver Output Voltage	-7V to +12V
Driver Output Signal Level (Loaded Min.): LOADED	+/-1.5V
Driver Output Signal Level (Loaded Max.): UNLOADED	+/-6V
Driver Load Impedance (Ohms)	54
Max Driver Current in High Z State (POWER ON)	+/-100µA
Max Driver Current in High Z State (POWER OFF)	+/-100µA
Receiver Input Voltage Range	-7V to +12V
Receiver Input Sensitivity	+/-200mV
Receiver Input Resistance (Ohms), (1 Standard Load for RS485)	≥12k

USB Communications

The SOLAIR provides point-to-point communications via the USB Port.

If not previously done, install the USB driver provided on the product CD. Once it has been installed and the instrument is connected, the driver will be used to establish communications using a virtual COM port on the PC.

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Using the USB Port to connect to a PC

To connect the instrument to a computer using the USB port, make sure that the driver has been installed first. Connecting the instrument to the PC and applying power before the driver has been installed will be problematic. Refer to the following:

Note: *Verify that the USB driver has been installed on the PC before connecting and applying power to the instrument.*

1. Remove power from the instrument.
2. Connect Side B of a standard “A to B” USB cable to the instrument (only Side B will fit).
3. Connect Side A to any available USB port on the PC.
4. Apply power to the instrument.
5. Windows will recognize that a new hardware device has been attached and will finalize the installation as needed. This is a routine “registering” of components that should take only a moment. An additional COM port will be added to the PC.
6. Identify the computer port that has been added to the PC by using the “Properties” of My Computer and examining the COM ports. USB ports are generally added to the bottom of the list and named USB COM port “x”. Refer to Figure 4-5 for screen examples (Windows XP).

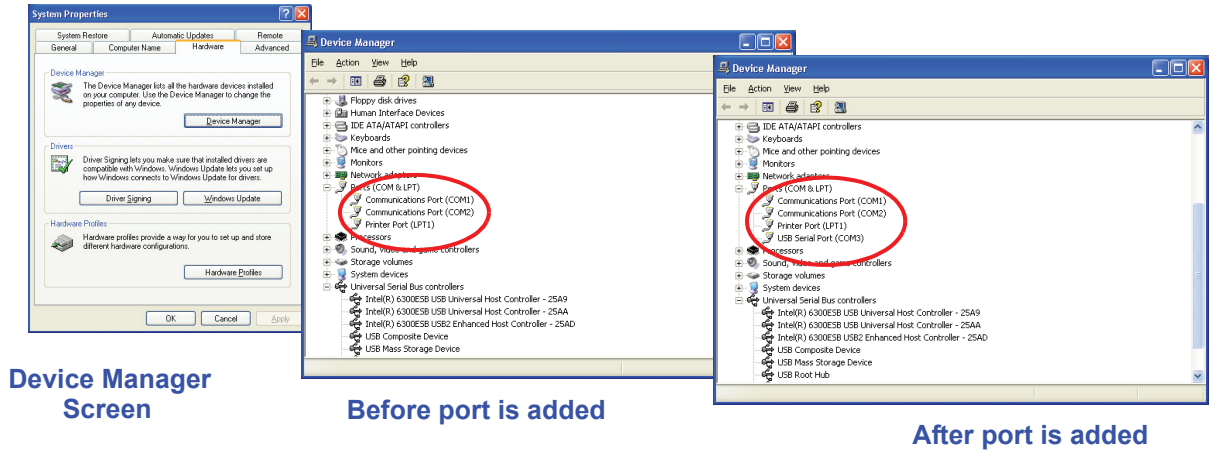


Figure 4-5 Example Device Manager Screens

Use LMS XChange or one of the LMS Express products to connect to the instrument and retrieve data from it. Use the port assignment determined above.

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Communicating through HyperTerminal (ASCII Mode)

To communicate using ASCII mode:

1. Remove power from the instrument.
2. Connect the RS485 to USB converter cable to a computer USB port.
3. Open Hyperterminal on computer.
4. Configure the COM Port settings as follows. Any available COM Port may be used:

Note: *Verify that the USB driver has been installed on the PC before connecting and applying power to the instrument.*

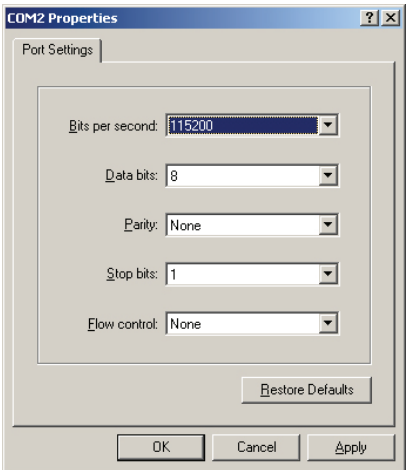


Figure 4-6 COM Port Properties

5. Configure the ASCII settings as follows:

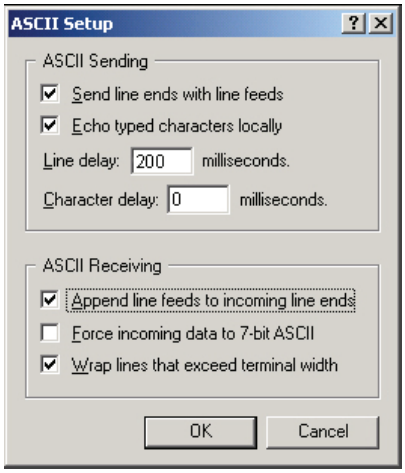


Figure 4-7 ASCII Settings

6. Ensure that all DIP Switches are set to 0 (OFF).

ASCII Programming Syntax

Using a simple ASCII protocol, the RLPC LE can be programmed from an ASCII terminal (i.e. Hyper Terminal). The protocol format is based on a start character followed by a command, which is then followed by a terminating character. Any characters before the start character or after the terminating character are ignored. White spaces between command character and command parameter are ignored.

Command Structure

The commands are defined as single case-sensitive ASCII characters. Format is defined as:

Note: *The < and > characters are part of the command and must be typed.*

<xy#*>**

where:

< = Start Character

Note: *All command characters are lower case.*

x = Command Character

y = Command Subset

= Index if needed

*** = Value

> = Terminating Character

Protocol

Protocol is defined through an RS-232 interface. The hardware protocol is defined as:

Baud Rate: 115200

Data Bits: 8

Stop Bits: 1

Parity: None

Flow Control: None

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SET CHANNEL RANGES

`<chi###>`

`<` = Start Character

`ch` = Channel

`i` = index 0-3 tied to channel number

`###` = High Threshold

`>` = Terminating Character

High Threshold is 20mA. The default range is set at 1000 counts and can be changed using the `<chi###>` command. The current value can be polled using `<ch?>`. The Low Threshold is 0, which equals 4mA.

For example, to change the CH1 threshold to 100, type the following:

```
<ch0 100>
```

The new threshold will need to be saved by typing the following:

```
<Ms 1>
```

For single count resolution the count threshold must be less than 3000. The instrument will begin to lose resolution over 3000 counts as threshold.

Configuring with MODBUS Protocol

Alternatively, the instrument can be configured using the MODBUS protocol.

To start sampling, send the command **11** to command register 40002. The instrument will begin sampling using the default configuration.

- Location = 0
- Sample Time = 60 seconds
- Hold Time = 0 seconds
- Initial Delay = 0 seconds

Note: *For the full MODBUS register map, please refer to Appendix A.*

To stop the sampling, send the command **12** to command register 40002.

Note: *The automatic starting of the sampling accommodates systems that do not send a START command, but just polls the instrument for data.*

Setting the Real Time Clock

The Real Time Clock (RTC) can be read in registers 40027 and 40028.

Table 4-5 Real Time Clock Registers

Register	Data Type	Description
40027	signed integer	Real Time Clock (RTC) [high]. Works in conjunction with 40028. Displays date and time, in number of seconds since midnight, 1/1/1970.
40028	signed integer	Real Time Clock [low]

To change the RTC to the current local date/time, enter the high and low values as unsigned integers to registers 40035 and 40036 respectively, which are the Data Set registers.

Table 4-6 Data Set Registers

Register	Data Type	Description
40035	unsigned integer	Data Set [high]. Works in conjunction with 40036. Data entered here is applied to the device through the command register.
40036	unsigned integer	Data Set [low]

Then write the command 13 to the command register 40002. This will write the values in the Data Set registers (40035 and 40036) to the RTC registers (40027 and 40028).

Changing the Default Instrument Parameters

The main instrument parameters involved with the operation of the RLPC LE are Location, Sample Time, Hold Time and Initial Delay.

The Location is set by writing an unsigned integer to register 40026. The range of values is from 0 to 999.

Sample Time, Hold Time and Initial Delay all use 2 registers, a high word and a low word. If the desired value for any of these parameters is less than 9 hours 6 minutes 8 seconds, then only the low word register needs to be written (in seconds).

The low word register for Sample Time is 40034.

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The low word register for Hold Time is 40032.

The low word register for Initial Delay is 40030.

Table 4-7 Instrument Parameters

Register	Data Type	Description
40026	unsigned integer	Location number; Specifies location of Particle Counter
40029	unsigned integer	Initial Delay [high]. Works in conjunction with 40030. Number of seconds to wait before starting the first sample. Max value is 359,999, which equals 99h 59m 59s.
40030	unsigned integer	Initial Delay [low]
40031	unsigned integer	Hold Time [high]. Works in conjunction with 40032. Number of seconds to wait between samples periods. Max value is 359,999, which equals 99h 59m 59s.
40032	unsigned integer	Hold Time [low]
40033	unsigned integer	Sample Time [high]. Works in conjunction with 40034. Number of seconds to sample. Max value is 86,399, which equals 23h 59m 59s.
40034	unsigned integer	Sample Time [low]

Running the Instrument

Action commands for running the RLPC LE are displayed in Table 4-8.

Table 4-8 Action Commands

Value	Action
1	Saves all writable 4xxxx register values to the EEPROM.
3	Clears the Data Buffer. Record count is set to zero.
4	Saves the instrument parameters in the 40xxx registers to the EEPROM. Parameters include Sample Time, Hold Time, Initial Delay and Location.
5	Enable Remote Control. Locks out the instrument's user interface. Can only change instrument parameters via MODBUS.

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Table 4-8 Action Commands

Value	Action
6	Enable Local Control. Unlocks the instrument's user interface. Instrument changes can be made at the device itself or though MODBUS.
7	Start Pump.
8	Stop Pump.
9	External Start Counter. The instrument samples continuously until it receives an External Stop Counter command. Does not turn on the pump. Ignores local timing parameters.
10	External Stop Counter. Records counts since External Start.
11	Instrument Start. Uses defined Initial Delay, Hold Time, Sample Interval and counting mode. Instrument executes samples and holds until an Instrument Stop command is issued. This command will start the pump.
12	Instrument Stop. Aborts current sample. Stops pump. Stops data collection.

There are 2 basic modes of operation: Manual counting and Automatic counting. Write each of the described action commands to the command register (40002).

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MANUAL Counting Mode

In Manual counting mode, the sample time is based on when the counter is instructed to stop counting. At that point, a data record is recorded and the sample time is the interval between the command to start counting and the command to stop counting.

7 *Start Pump*

9 *Start Manual Count*

10 *Stop Manual Count*; writes a data record, uses the time interval as the sample time.

In MANUAL counting mode, the "**hold**" time is the time between a *Stop Manual Count* and a *Start Manual Count* command.

After the last desired sample is taken, send the following to stop the pump:

8 *Stop Pump*

AUTOMATIC Counting Mode

In Automatic counting mode, the instrument uses the configured sample time, hold time and initial sample delay to record samples.

The instrument will continue running samples until it receives a stop command. If sampling is stopped before the instrument has completed the sampling cycle, that cycle's data will not be recorded to the buffer.

After setting all the instrument parameters, run the following commands:

11 *Start Instrument*; to start sampling

12 *Stop Instrument*; to stop sampling

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A MODBUS Register Map v1.48

COMM Settings

Lighthouse particle counters using MODBUS require the following communications settings:

Table A-1 MODBUS Communications Settings

Baud Rate	19200
Data Bits	8
Stop Bits	1
Parity	None
Hardware Protocol	RS485, USB and Ethernet
Software Protocol	MODBUS ASCII (supports upper/lower case) MODBUS TCP

The MODBUS slave address is set on the particle counter.

Supported MODBUS Commands

Table A-2 MODBUS Registers

Hex Command	Description
03	Read Holding Registers
04	Read Input Registers
06	Write Single Holding Register

See www.modbus.org for documentation on how to use these commands.

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Register Map

Sensor Settings Registers

Instrument settings are stored in holding registers (the 4xxxx series), which are mostly read/writable. Not all holding registers are writable. Table A-3 describes the contents of these registers.

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40001	unsigned integer	MODBUS register map version. Matches the version number of this document. Major version digits are hundreds. Minor version digits are tens and ones. For example, v1.35 = 135d = 0087h.
40002	unsigned integer	Command register. Makes the counter execute a command. See the description of this register in the table below.
40003	unsigned integer	Device Status. [bit 0=RUNNING, bit 1=SAMPLING, bit 2=NEW DATA, bit 3=DEVICE ERROR]
40004	unsigned integer	Firmware version. Major version digits are hundreds. Minor version digits are tens and ones. For example, 210 = v2.10.
40005	unsigned integer	Serial Number [high]
40006	unsigned integer	Serial Number [low]
40007	ASCII string	Product Name char[0], char [1] (NULL terminated string)
40008	ASCII string	Product Name char[2], char [3]
40009	ASCII string	Product Name char[4], char [5]
40010	ASCII string	Product Name char[6], char [7]
40011	ASCII string	Product Name char[8], char [9]
40012	ASCII string	Product Name char[10], char [11]
40013	ASCII string	Product Name char[12], char [13]
40014	ASCII string	Product Name char[14], char [15]
40015	ASCII string	Model Name char[0], char [1] (NULL terminated string)
40016	ASCII string	Model Name char[2], char [3]
40017	ASCII string	Model Name char[4], char [5]
40018	ASCII string	Model Name char[6], char [7]
40019	ASCII string	Model Name char[8], char [9]

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40020	ASCII string	Model Name char[10], char [11]
40021	ASCII string	Model Name char[12], char [13]
40022	ASCII string	Model Name char[14], char [15]
40023	unsigned integer	Flow Rate. Divide by 100 to get rate in CFM. For example, 100 = 1CFM.
40024	unsigned integer	Record Count. Total number of records stored in the counter.
40025	unsigned integer	Record Index. Zero based index to data in 30xxx register series. Must be lower than the record count (register 40024). Set this index to expose a counter's record in the 30xxx registers. Set to -1 to retrieve last record stored in the counter.
40026	unsigned integer	Location number. Particle Counters: Specifies location of Particle Counter. Must be 1 to 200 (maps to location names associated with registers 40200 - 40999). Manifold Controller: Specifies Manifold position. Values 1-32 for the Universal Manifold and values 1-6 for the MiniManifold Controller moves the arm to that position on the manifold. Value 0 moves arm to Home position.
40027	signed integer	Real Time Clock (RTC) [high]. Updates instrument's real-time clock. Works in conjunction with 40028. Displays date and time, in number of seconds since midnight, 1/1/1970. Can be generated by ANSI C/C++ time() function.
40028	signed integer	Real Time Clock [low]
40029	unsigned integer	Initial Delay [high]. Works in conjunction with 40030. Number of seconds to wait before starting the first sample. Max value is 359,999, which equals 99h 59m 59s.
40030	unsigned integer	Initial Delay [low]
40031	unsigned integer	Hold Time [high]. Works in conjunction with 40032. Number of seconds to wait between sample periods. Max value is 359,999, which equals 99h 59m 59s.
40032	unsigned integer	Hold Time [low]
40033	unsigned integer	Sample Time [high]. Works in conjunction with 40034. Number of seconds to sample. Max value is 86,399, which equals 23h 59m 59s.

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Table A-3 Sensor Settings Registers

Register	Data Type	Description
40034	unsigned integer	Sample Time [low]
40035	unsigned integer	Data Set [high]. Works in conjunction with 40036. Data entered here is applied to the device through the command register.
40036	unsigned integer	Data Set [low]
40037	unsigned integer	Alarm Mode. Type of alarming performed
40038	unsigned integer	Alarm Parameter. Control parameter for given alarm mode.
40039	unsigned integer	Laser Reference Voltage (millivolts)
40040	unsigned integer	View Volume. Divide by 100 to get percentage. For example: 6550d = 65.50%
40041	ASCII string	Flow Unit. Defines unit as cfm, lpm, mlpm char[0], char[1] (NULL terminated string).
40042	ASCII string	Flow Unit. char[2], char[3]
40043	unsigned integer	Calibration Reference Voltage (millivolts)
...		
40049	signed integer	Printer Options
40050	signed integer	Device Options
...		
40199	unsigned integer	Number of available alphanumeric location names (0 means alphanumeric names are not supported).
40200	ASCII string	Location_1_char[0], char[1] (NULL terminated string)
40201	ASCII string	Location_1_char[2], char[3]
40202	ASCII string	Location_1_char[4], char[5]
40203	ASCII string	Location_1_char[6], char[7]
...		
40996	ASCII string	Location_200_char[0], char[1] (NULL terminated string)
40997	ASCII string	Location_200_char[2], char[3]
40998	ASCII string	Location_200_char[4], char[5]
40999	ASCII string	Location_200_char[6], char[7]

Alarm Mode (40037) defines the type of calculation performed to define an alarm condition. Alarm Mode = 0 corresponds to conventional threshold alarming; channel bit set if threshold exceeded for that given channel.

Alarm Parameter (40038) defines additional parameters that may be needed in defining an alarm mode.

Printer Options (40049) displays the configuration of the instrument's printer function.

Table A-4 Printer Options

Bit	Description
0	Unused - non-writable
1	Print on Sample (1=Enabled, 0=Disabled)
2-15	Reserved

If Bit-1 of Register 40049 is set, the instrument will print the last recorded data at the end of each sample. This feature cannot be enabled if the *One Second Data Update* feature is enabled.

Device Options (40050) displays the instrument's device configuration.

Table A-5 Device Options

Bit	Description
0	Fast Download (1=Enabled, 0=Disabled) non-writable
1	One Second Data Update (1=Enabled, 0=Disabled)
2-15	Reserved

If bit 0 of Register 40050 is set, it indicates that the instrument is capable of Fast Download.

If Bit 1 of Register 40050 is set, the instrument will display and update the data registers every second. No data will be recorded in the data buffer. Enabling this feature disables the Print on Sample feature.

Registers 40200-40999 are reserved for eight character names associated with location index values. Thus the name for location =3 would be located at registers 40208-40211. Up to two hundred locations can be specified.

Register 40199 indicates the number of location names supported on

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this device.

Device Status

The Device Status register (40003) displays the current status of the device.

Table A-6 Device Status

Bit	Description
0	**RUNNING:** Set when a start command is executed remotely via Command 9 (manual start) or Command 11 (instrument start) or through the user interface. The flag will remained set until a stop command is executed.
1	**SAMPLING:** This is set only when the instrument is actually sampling data that is to be recorded. Caution must be used in sending a command during this time that may invalidate current sample.
2	**NEW DATA:** Set to 1 to indicate that a new data record has been recorded and it hasn't been read via modbus yet. When a data record has been read via modbus (registers 30001 to 30999), then this flag is reset to zero.

Command Register

The Command Register (40002) is used to make the device perform an action. The register performs an action when an integer value is written to it. The action is completed when the device sends a MODBUS response. When this register is read, it always returns a zero.

Table A-7 Command Register

Value	Action
1	Saves all writable 4xxxx register values to the EEPROM.
2	Reserved for future use.
3	Clears the Data Buffer. Record count is set to zero.
4	Saves the instrument parameters in the 40xxx registers to the EEPROM. Parameters include Sample Time, Hold Time, Initial Delay, and Location.
5	Enable Remote Control. Locks out the instrument's user interface. Can only change instrument parameters via MODBUS.

Table A-7 Command Register

Value	Action
6	Enable Local Control. Unlocks the instrument's user interface. Instrument changes can be made at the device itself or through MODBUS.
7	Start local pump, if applicable - perform before 9 below.
8	Stop pump, if applicable - perform after 10 below.
9	Manual Start. The instrument samples continuously until it receives a Manual Stop command. Ignores local timing parameters. Sets Sample Time for data record to equal the time interval between the Manual Start and Manual Stop command. If applicable to device, does not start pump.
10	Manual Stop. Stops sampling. Records counts since Manual Start.
11	Instrument Start (Automatic Counting). Particle Counters: Uses defined Initial Delay, Hold Time, Sample Interval and counting mode. Instrument executes samples and holds until an Instrument Stop command is issued. For instruments with pumps, this command will start the pump. Manifold Controller: Uses defined Manifold Sequence. Stops counting and changing position when Instrument Stop command is issued.
12	Instrument Stop. Aborts current sample. Stops pump, if applicable. Stops data collection.
13	Set Real Time Clock. Writes "Data Set" values (from Registers 40035 & 40036) to the local Real Time Clock. New time value is saved.
14	Manifold Controller: Clear data register bank. Bank is reset and remains 0 until ne data is available or index registers are changed.
192	Changes instrument baud rate to 19200K upon command execution.
576	Changes instrument baud rate to 57600K upon command execution.
1152	Changes instrument baud rate to 115200K upon command execution.

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Data Registers

Data is stored in the input registers (30xxx series), which are read-only. All data items are four bytes long and are stored across two registers. Byte and word order for integer data is big-endian. Thus, data items are formed by placing the high bytes in front of the low bytes.

Example:

<High Bytes><Low Bytes> = <4 Byte Data Item>

IEEE floating point has big-endian byte order and little-endian word order. Thus, analog data items are formed by placing the low bytes in front of the high bytes.

Example:

<Low Bytes><High Bytes> = <4 Byte Data Item>

Not all particle and analog channels are necessarily active. Retrieving data from an inactive channel returns garbage. See the Data Enable Registers section of this document for details on how to record data from active channels.

This entire series of registers represents one data record in the device. The Record Index Register (40025) must be changed to index other records here.

The first record in the data buffer is located at Index=0. The most recently saved value is at Index=-1.

Table A-8 Data Registers

Register	Data Type	Description
30001	signed integer	Timestamp [high] (# of seconds since midnight, 1/1/1970)
30002	signed integer	Timestamp [low]
30003	unsigned integer	Sample Time [high] (In seconds)
30004	unsigned integer	Sample Time [low]
30005	signed integer	Location [high] (Place where data was recorded)
30006	signed integer	Location [low]
30007	unsigned integer	Data Status [high]
30008	unsigned integer	Data Status [low]

Table A-8 Data Registers

Register	Data Type	Description
30009	unsigned integer	Particle Channel 1 [high]
30010	unsigned integer	Particle Channel 1 [low]
30011	unsigned integer	Particle Channel 2 [high]
30012	unsigned integer	Particle Channel 2 [low]
30013	unsigned integer	Particle Channel 3 [high]
30014	unsigned integer	Particle Channel 3 [low]
30015	unsigned integer	Particle Channel 4 [high]
30016	unsigned integer	Particle Channel 4 [low]
30017	unsigned integer	Particle Channel 5 [high]
30018	unsigned integer	Particle Channel 5 [low]
30019	unsigned integer	Particle Channel 6 [high]
30020	unsigned integer	Particle Channel 6 [low]
30021	unsigned integer	Particle Channel 7 [high]
30022	unsigned integer	Particle Channel 7 [low]
30023	unsigned integer	Particle Channel 8 [high]
30024	unsigned integer	Particle Channel 8 [low]
...		
30074	unsigned int	Valid particle channels
30076	unsigned int	Alarm Flags - Particle Channels

Note: *Particle data is always a cumulative raw count regardless of the instrument's settings.*

The timestamp field indicates when the data record was recorded. Timestamps are stored as the number of seconds since 1/1/1970, the Unix time epoch. This value can be written directly into a C/C++ time_t data type to be used by ANSI C time functions.

Data Status Byte (30007 - 30008)

Note: *Although MODBUS sends 4 bytes of status information, Lighthouse instruments only use the first (least significant) byte.*

The registers used for the Data Status Byte are 30007 and 30008.

The bit order of the Data Status Byte is 7 to 0, where bit 7 is the most significant bit and bit 0 is the least significant bit.

The bits within the Data Status Byte are flagged to indicate particular

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conditions of the currently indexed data record.

If multiple states occur, the bits are added together. For example, a Flow Alert and a Particle Overflow would return a value of 6 in register 30008 (bits 1 and 2 are set TRUE).

Table A-9 Data Status Byte

Bit	Description
0	Laser Alert Status 0 = Laser is OK 1 = Laser Alert
1	Flow Alert Status 0 = Flow Rate is OK 1 = Flow Rate Alert
2	Particle Overflow Status 0 = No overflow 1 = Overflow occurred
3	Instrument Service Status 0 = Working correctly 1 = Malfunction detected.
4	Threshold High Status 0 = Threshold not exceeded 1 = Threshold exceeded
5	Threshold Low Status 0 = Threshold not exceeded 1 = Threshold exceeded
6	Instrument Sampler Status 0 = Nominal Operation 1 = Sampler Error

Bits 7 to 31 are currently unused.

Valid Data in Channels (30074)

Register 30074 represents the flag bits corresponding to valid data present in the particle register range.

Alarm Flags in Channels (30076)

Register 30076 represents the flag bits corresponding to particle channels that have exceeded the threshold [Threshold High Registers (45xxx series)] based on alarm mode

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Data Type Registers

Note: *All data records have the same data types assigned to them. The user does not have to read the data type registers for every record.*

The 41xxx register series is used to identify the type of data items in the 30xxx series. The Data Type registers run in parallel with the Data Registers. For example, Data Register 30041's Data Type register is 41041.

Data Types are assigned 4 ASCII characters across 2 registers. If a Data Type string contains less than 4 characters, then the rest of the string is padded with NULL characters. Note that a Data Type using all four characters will not end with a NULL character.

Table A-10 Data Types

String	Description
TIME	Timestamp
STIM	Sample Time
SVOL	Sample Volume
LOC	Location
STAT	Status
TEMP	Temperature
RH	Relative Humidity
AIRV	Air Velocity
DPRS	Differential Pressure
ESD	Electrostatic Discharge
FLOW	Flow Rate
LASV	Laser Voltage
VOLT	Voltage
PRES	Pressure

Note: *Only Particle data types have numbers in their strings.*

Particle data items are typed specially. They contain numbers, sometimes a space and sometimes a period used as a decimal point. These entries are used to identify particle channel sizes and are always

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expressed in microns. These types represent raw counts only.

Table A-11 Examples of Particle Data Items

String	Description
0.3	Particle type of size 0.3 micron
1.0	Particle type of size 1.0 micron
20.0	Particle type of size 20.0 micron
.015	Particle type of size 0.015 micron or 15 nanometer

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Data Units Registers

The 42xxx register series identifies the units used by data items in the 30xxx series. These registers run in parallel with the Data Registers. For example, Data Register 30010's Units Register is 42010.

Note: *Not all data types have units.*

LWS Particle Counters may use units not on the table.

Units are stored as 4 character ASCII strings across 2 registers. If the Units string contains less than 4 characters or no characters at all, the rest of the string is padded with NULLs.

The table below shows units that may be sent by the device. Some of these units are not currently used but are reserved for future use.

Table A-12 Data Units

Units	Description	Units	Description
#	Count (For Particles)	ft/m	Feet per minute
%	Percent	m/s	Meters per second
s	Seconds	"H2O	Inches of water
min	Minutes	"Hg	Inches of mercury
hour	Hours	mmWa	Millimeters of water
F	Fahrenheit	mmHg	Millimeters of mercury
C	Celsius	cmHg	Centimeters of mercury
K	Kelvin	Pa	Pascals
ft	Feet	kPa	Kilopascals
m	Meters	Bar	Bar
ft^2	Square feet	mBar	Milli-bar
m^2	Square meters	V	Volts
ft^3	Cubic feet	mV	Milli-volts
m^3	Cubic meters	A	Amperes
L	Liters	mA	Milli-amps
CFM	Cubic feet per minute	Ohm	Ohms
CMM	Cubic meters per minute	mOhm	Milli-ohm
L/m	Liters per minute	p/f3	Particles per cubic foot
p/m3	Particles per cubic meter	LPM	Liters per minute

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Table A-12 Data Units

Units	Description	Units	Description
PCT	Percent	MLPM	Milliliters per minute
SEC	Seconds	IHG	Inches of mercury
p/L	Particles per liter	p/ml	Particles per milliliter

Data and Alarm Registers

Data and Alarm Enable Registers

The Data and Alarm Enable input registers (43xxx series) are read/write. All enable data items are 4 bytes long and are stored across 2 registers. Byte and word ordering is big-endian. Thus, data items are formed by placing the high bytes in front of the low bytes. For example:

<High Bytes><Low Bytes> = <4 Byte Data Item>

The 43xxx register series is used to determine which particle data channel is ENABLED and which are set to ALARM ENABLE. These registers supersede the older Data Enable Registers (31xxx) which have been obsoleted.

Table A-13 Enable/Disable Bits

Bit	Description
0	DATA ENABLE (0=disable; 1=enable)
1	ALARM ENABLE (0=disable; 1=enable)

These registers run in parallel with the data registers (30xxx series). For example, data register 30010's enable register would be 43010. Data register 30016's enable register would be 43016.

Note: *Alarm Enable currently only works for Particle Channels.*

The user can enable multiple particle channels for alarming at the same time.

Particle data registers for the Enable setting start at 43009 for the high word and 43010 for the low word for particle channel 1.

Table A-14 Alarm Enable Registers

Register	Data Type	Description
43009	unsigned int	Enable for Particle Channel 1 [high] (smallest particle size starts here)

Table A-14 Alarm Enable Registers

Register	Data Type	Description
43010	unsigned int	Enable for Particle Channel 1 [low]
43011	unsigned int	Enable for Particle Channel 2 [high]
43012	unsigned int	Enable for Particle Channel 2 [low]
43013	unsigned int	Enable for Particle Channel 3 [high]
43014	unsigned int	Enable for Particle Channel 3 [low]
43015	unsigned int	Enable for Particle Channel 4 [high]
43016	unsigned int	Enable for Particle Channel 4 [low]
43017	unsigned int	Enable for Particle Channel 5 [high]
43018	unsigned int	Enable for Particle Channel 5 [low]
43019	unsigned int	Enable for Particle Channel 6 [high]
43020	unsigned int	Enable for Particle Channel 6 [low]
43021	unsigned int	Enable for Particle Channel 7 [high]
43022	unsigned int	Enable for Particle Channel 7 [low]
43023	unsigned int	Enable for Particle Channel 8 [high]
43024	unsigned int	Enable for Particle Channel 8 [low]
43041	unsigned int	Enable for Analog Channel 1 [high]
43042	unsigned int	Enable for Analog Channel 1 [low]
43043	unsigned int	Enable for Analog Channel 2 [high]
43044	unsigned int	Enable for Analog Channel 2 [low]
43045	unsigned int	Enable for Analog Channel 3 [high]
43046	unsigned int	Enable for Analog Channel 3 [low]
43047	unsigned int	Enable for Analog Channel 4 [high]
43048	unsigned int	Enable for Analog Channel 4 [low]

Enable Alarming for a Channel

To enable alarming on the third particle channel, the user would enable Bit 1 for register 43014.

To disable alarming on the third channel and enable alarming on the

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second channel, disable Bit 1 for register 43014 and enable Bit 1 for register 43012.

To disable alarming completely, disable Bit 1 for register 43012. Now, no channels are enabled for alarms.

Table A-15 Example of Alarming on Channel 2

Registers	Particle Channel	Bit 1 Enabled
43009 - 43010	1	0
43011 - 43012	2	1
43013 - 43014	3	0
43015 - 43016	4	0
43017 - 43018	5	0
43019 - 43020	6	0
43021 - 43022	7	0
43023 - 43024	8	0

Use the Threshold registers to set the alarm threshold value. This is described in the next section.

Threshold Setup Registers

Threshold data is stored in the input registers in the 45xxx series which are read/write. All threshold data items are 4 bytes long and are stored across 2 registers. Byte and word ordering is big-endian. Thus, data items are formed by placing the high bytes in front of the low bytes. For example:

<High Bytes><Low Bytes> = <4 Byte Data Item>

For particle channels, the threshold value is a 32-bit unsigned integer. If the data value exceeds the threshold value and the alarm is enabled for that channel, the threshold flag in the Data Status register (30007-30008, bit 4) is set.

Note: *The table below shows the registers for an 8 channel particle counter. Counters with fewer channels do not use the extra registers. The smallest particle channel starts at the xxx09 position.*

The threshold registers (45xxx series) run in parallel with the data registers (30xxx series). For example, data register 30010's corresponding threshold register would be 45010. Data register 30016's threshold register would be 45016.

Table A-16 Alarm Threshold Registers

Register	Data Type	Description
45009	unsigned int	Threshold for Particle Channel 1 [high] (smallest particle size starts here)
45010	unsigned int	Threshold for Particle Channel 1 [low]
45011	unsigned int	Threshold for Particle Channel 2 [high]
45012	unsigned int	Threshold for Particle Channel 2 [low]
45013	unsigned int	Threshold for Particle Channel 3 [high]
45014	unsigned int	Threshold for Particle Channel 3 [low]
45015	unsigned int	Threshold for Particle Channel 4 [high]
45016	unsigned int	Threshold for Particle Channel 4 [low]
45017	unsigned int	Threshold for Particle Channel 5 [high]
45018	unsigned int	Threshold for Particle Channel 5 [low]
45019	unsigned int	Threshold for Particle Channel 6 [high]
45020	unsigned int	Threshold for Particle Channel 6 [low]
45021	unsigned int	Threshold for Particle Channel 7 [high]
45022	unsigned int	Threshold for Particle Channel 7 [low]
45023	unsigned int	Threshold for Particle Channel 8 [high]
45024	unsigned int	Threshold for Particle Channel 8 [low]

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Setting the Alarm Threshold Value

The Alarm Threshold Value is set in the low register of the channels.

Table A-17 Alarm Threshold Registers set to default value

Registers	Particle Channel	Threshold Value
45009 - 45010	1	1000
45011 - 45012	2	1000
45013 - 45014	3	1000
45015 - 45016	4	1000
45017 - 45018	5	1000
45019 - 45020	6	1000
45021 - 45022	7	1000
45023 - 45024	8	1000

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B Maintenance

Cleaning the Sensor

The RLPC LE sensor may become dirty, contain foreign objects or be filled with bubbles. This may be indicated by unusually low or zero counts in the smaller channel sizes. If these indicators are verified during sampling, then the sensor may need to cleansed.

WARNING: **Do not use a cleaning brush and cleaning solution on the sensor as it may cause damage to the flow cell.**

WARNING: ***Please follow the standard precautions for working with liquids around electronic components. Use Personal Protection Equipment, such as face shields and gloves, when working with hazardous liquids.***

Flush Using Purified Water

1. Remove power to the instrument.
2. Flush the sensor with purified water for one minute. This liquid should NOT be allowed to re-enter the sampling system and should be safely discarded. Repeat the flush a second time.
3. Re-connect power to the instrument and run at least 3 samples to determine if the sensor was successfully cleansed.
4. If the samples still show unusually low or zero counts after flushing twice with purified water, then flush the sensor with purified salt water

Flush using Purified Salt Water

1. Remove power from the instrument.
2. Flush the sensor with purified water and a 20% salt mix for one minute. This liquid should NOT be allowed to re-enter the sampling system and should be safely discarded. Repeat the flush a second time.
3. Flush the sensor two times with purified water for one minute each.
4. Re-connect power to the instrument and run at least 3 samples to determine if the sensor was successfully cleansed.
5. If this process fails, contact Technical Support at 1-800-945-5905 (Toll Free USA) or 1-541-770-5905 (Outside of USA).

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C Limited Warranty

Limitation Of Warranties:

A. Lighthouse Worldwide Solutions (LWS) warrants that all equipment shall be free from defects in material and workmanship under normal use for a period of two years from date of shipment to Buyer except that LWS does not warrant that operation of the software will be completely uninterrupted or error free or that all program errors will be corrected. Buyer shall be responsible for determining that the equipment is suitable for Buyer's use and that such use complies with any applicable local, state, or federal law. Provided that Buyer notifies LWS in writing of any claimed defect in the equipment immediately upon discovery and any such equipment is returned to the original shipping point, transportation charges prepaid, within two years from date of shipment to Buyer and upon examination LWS determines to its satisfaction that such equipment is defective in material or workmanship, i.e. contains a defect arising out of the manufacture of the equipment and not a defect caused by other circumstances, including, but not limited to accident, misuse, unforeseeable use, neglect, alteration, improper installation, improper adjustment, improper repair, or improper testing, LWS shall, at its option, repair or replace the equipment, shipment to Buyer prepaid. LWS shall have reasonable time to make such repairs or to replace such equipment. Any repair or replacement of equipment shall not extend the period of warranty. If the Instrument is modified or in any way altered without the explicit written consent of LWS then the warranty is null and void. This warranty is limited to a period of two years, except as noted below, without regard to whether any claimed defects were discoverable or latent on the date of shipment. The length of warranty for pumps in hand held particle counters is one (1) year. Batteries and accessories with all products are warranted for one (1) year. Fuses and purge filters carry no warranty. If a third party battery is used in the product, the product warranty is null and void. If the battery is charged by a third party battery charger the battery warranty is null and void.

B. If Buyer shall fail to pay when due any portion of the purchase price or any other payment required from Buyer to LWS under this contract or otherwise, all warranties and remedies granted under this Section may, at LWS's option, be terminated.

C. THE FOREGOING WARRANTY IS EXCLUSIVE AND IN LIEU OF ALL OTHER REPRESENTATIONS, WARRANTIES AND COVENANTS, EXPRESS OR IMPLIED WITH RESPECT TO THE EQUIPMENT AND ANY DEFECTS THEREIN OF ANY NATURE WHATEVER, INCLUDING AND WITHOUT LIMITATION WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. LWS SHALL NOT BE LIABLE FOR, AND BUYER ASSUMES ALL RISK OF, ANY ADVICE OR FAILURE TO PROVIDE ADVICE BY LWS TO BUYER REGARDING THE EQUIPMENT OR BUYERS USE OF THE SAME. UNDER NO CIRCUMSTANCES SHALL LWS BE LIABLE TO BUYER UNDER ANY TORT, NEGLIGENCE, STRICT LIABILITY, OR PRODUCT LIABILITY CLAIM AND BUYER AGREES TO WAIVE SUCH CLAIMS. LWS's SOLE AND EXCLUSIVE LIABILITY AND BUYERS SOLE AND EXCLUSIVE REMEDY, FOR ANY NONCONFORMITY OR DEFECT IN THE PRODUCTS OR ANYTHING DONE IN CONNECTION WITH THIS CONTRACT, IN TORT, (INCLUDING NEGLIGENCE), CONTRACT, OR OTHERWISE, SHALL BE AS SET FORTH IN THE SUBSECTION A HEREOF AS LIMITED BY SUBSECTION B HEREOF. THIS EXCLUSIVE REMEDY SHALL NOT HAVE FAILED OF ITS ESSENTIAL PURPOSE (AS THAT TERM IS USED IN THE UNIFORM COMMERCIAL CODE) PROVIDED THAT THE SELLER REMAINS WILLING TO REPAIR OR REPLACE DEFECTIVE EQUIPMENT (AS DEFINED IN SUBSECTION A) WITH A COMMERCIALLY REASONABLE TIME AFTER RECEIVING SUCH EQUIPMENT. BUYER SPECIFICALLY ACKNOWLEDGES THAT SELLER'S PRICE FOR THE EQUIPMENT IS BASED UPON THE LIMITATIONS OF LWS'S LIABILITY AS SET FORTH IN THIS CONTRACT.

Warranty Of Repairs After Initial Two (2) Year Warranty:

A. Upon expiration of the initial two-year warranty, all parts and repairs completed by an authorized Lighthouse repair technician are subject to a six (6) month warranty.

B. Other than the above, LWS makes no warranty of any kind, expressed or implied, except that the products manufactured and sold by LWS shall be free from defects in materials and workmanship and shall conform to LWS's specifications; Buyer assumes all risk and liability resulting from use of the products whether used singly or in combination with other products. If instrument is modified or in any way altered without the explicit written consent of LWS, then the warranty is null and void.

C. WARRANTY REPAIRS SHALL BE COMPLETED AT THE FACTORY, BY AN AUTHORIZED SERVICE LOCATION, BY AN AUTHORIZED SERVICE TECHNICIAN, OR ON SITE AT BUYER'S FACILITY BY A LIGHTHOUSE AUTHORIZED EMPLOYEE. BUYER PAYS FREIGHT TO FACTORY; SELLER WILL PAY STANDARD RETURN FREIGHT DURING THE WARRANTY PERIOD. BUYER MAY SELECT A FASTER METHOD OF SHIPMENT AT ITS OWN EXPENSE.

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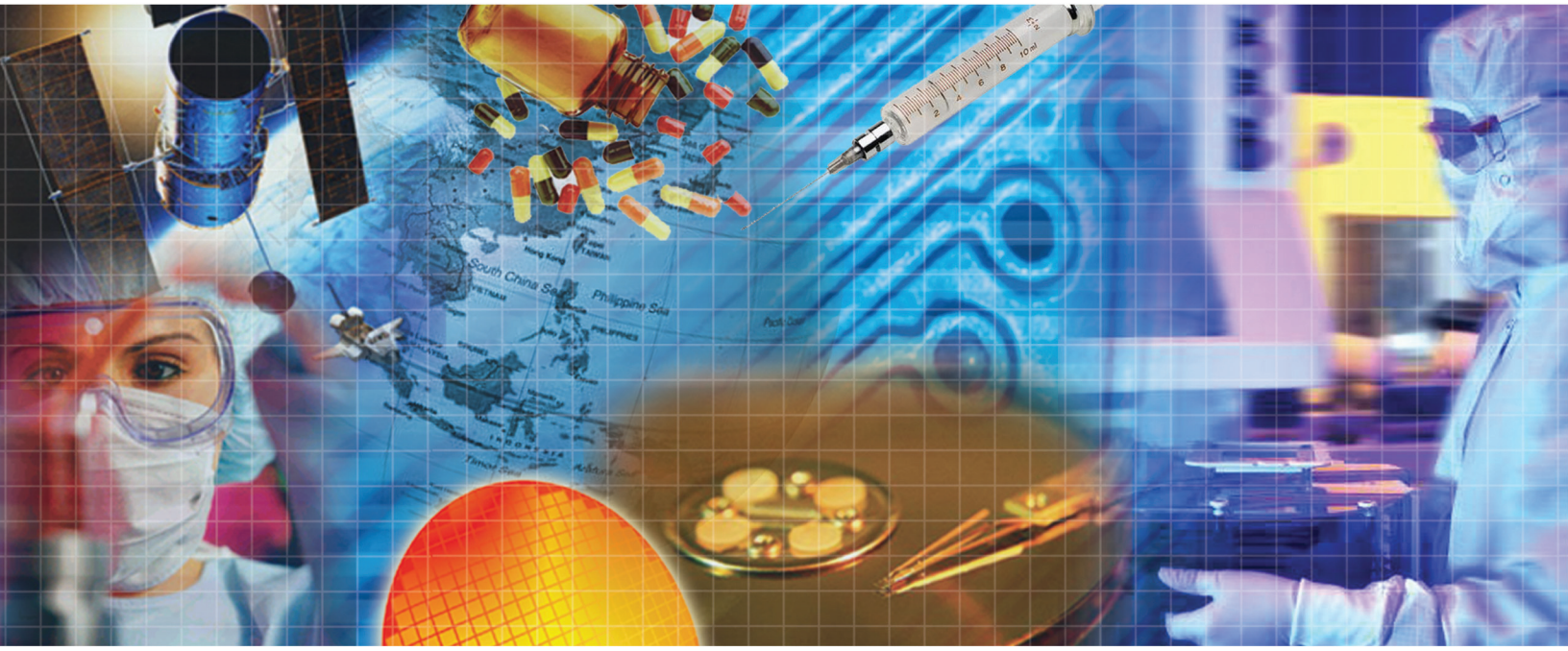
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