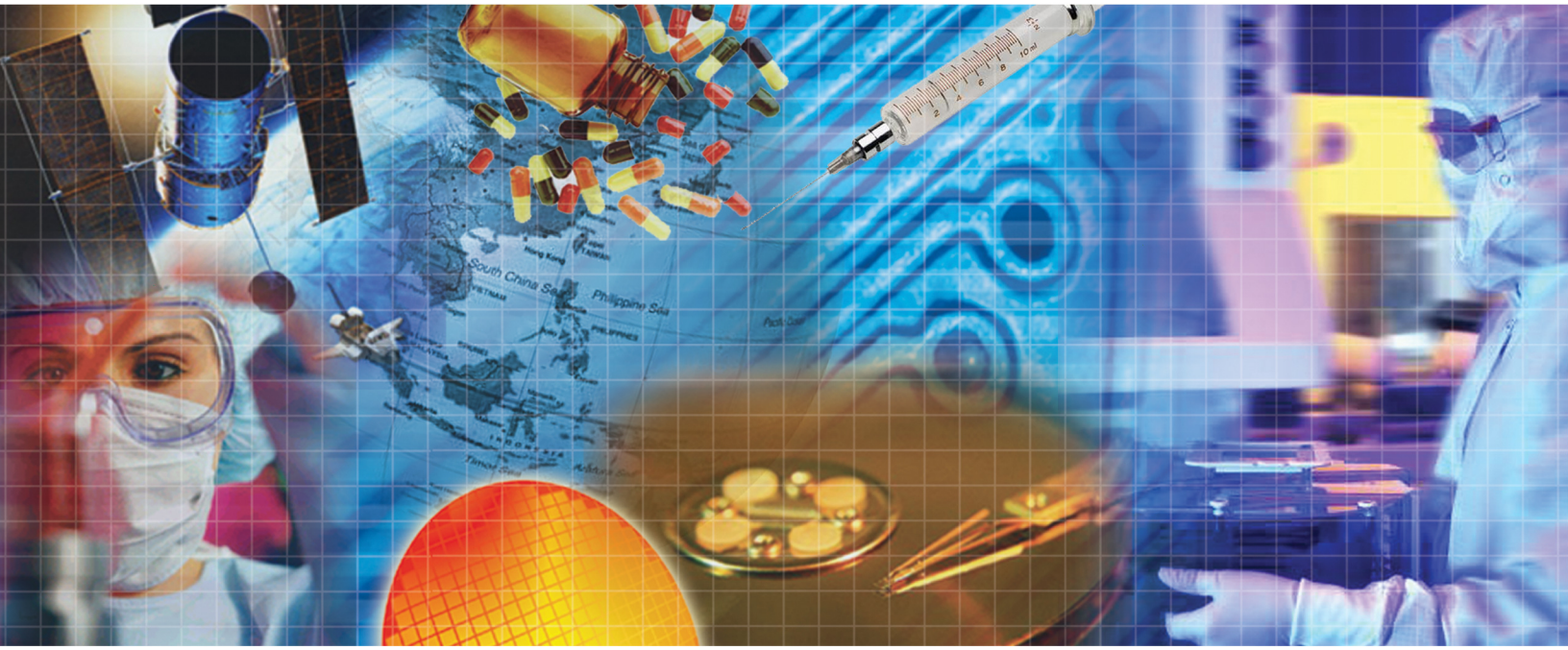


LIGHTHOUSE
WORLDWIDE SOLUTIONS
Technology That Counts!

REMOTE
5104V

Operating Manual

Lighthouse Worldwide Solutions

REMOTE 5104V Airborne Particle Counter

Operating Manual

LWS Part Number 248083293-1 Rev 7

EU DECLARATION OF CONFORMITY

Manufacturer's Name: Lighthouse Worldwide Solutions, Inc.

Manufacturer's Address: Lighthouse Worldwide Solutions, Inc.
1221 Disk Drive
Medford, OR 97501

Declares that the product:

Product Name: Remote Airborne Particle Counter

Model Number(s): REMOTE 2014V, 3014V, 5014V, 5104V

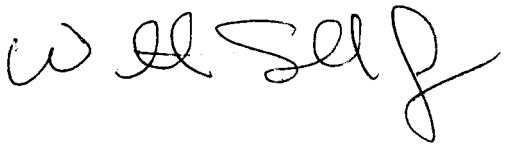
Conforms to the following Product Specifications:

SAFETY	EN61010-1:2001	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use Part I: General Requirements IEC 61010-1:2000
	CAN/CSA C22.2 No. 1010.1-1992	Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use, Part 1: General Requirements
	CSA-C22.2 No. 61010-1, 2nd Ed., July 2004	Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements
	ISA-82.02.01 2nd Ed., July 2004	Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements
	CSA-C22.2 No. 213-M1987 (R 1999)	Non-incendive Electrical Equipment for Use in Class 1, Division 2 Hazardous Locations
	ISA-12.12.01-2000	Non-incendive Electrical Equipment for Use in Class 1 and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations
LASER SAFETY	IEC 60825-1 Am. 2 IEC 60601-2-22 (Laser Notice 50)	Guidance on Laser Products: Conforms to FDA 21 CFR Chapter 1 Subchapter J

EMC	EN61326	Electrical Equipment for Measurement, Control and Laboratory Use EMC Requirements Part 1: General Requirements Includes Amendment A1:1998;IEC 61326:1997 + A1:1998
GMP	21CFR-Part 211	Guidance for industry Sterile Drug Products, Produced by Aseptic Processing Current Good Manufacturing Practice: Remote Particle Counting Probe

UL 61010A-1 – UL Standard for Safety Electrical Equipment for Laboratory Use; Part 1: General Requirements Replaces UL 3101-1

Supplementary information: The product herewith complies with the requirements of the Low Voltage Directive 73/23/EEC amended by Directive 93/68/EEC and the EMC Directive 89/336/EEC amended by Directive 93/68/EEC, and carries the CE marking accordingly.



Fremont, CA, May 15, 2007

William L. Shade – V.P. Engineering

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About this Manual

This manual describes the detailed operation and use of the Lighthouse REMOTE 5104V Airborne Particle Counter.

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 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 that you type.
Helvetica Italics	Indicates a comment on a command or text output.

Additional Help

For more information about Lighthouse REMOTE 5104V Airborne Particle Counters, contact Lighthouse Worldwide Solutions:

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

1 Safety

Safety Considerations

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

Warnings

There are several classifications of Warnings defined as follows:

- Laser - pertaining to exposure to visible or invisible Laser radiation;
- Explosion Hazard - pertaining to use of the instrument in explosive atmospheres;
- Electrostatic - pertaining to electrostatic discharge.

Suitability

Note: *THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C & D OR NON-HAZARDOUS LOCATIONS ONLY.*

Laser Safety Information

This product contains a Laser-based sensor that is a Class I 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. See Figure 1-1.

Figure 1-1 LASER Warning Label on Unit

The particle counter has been evaluated and tested in accordance with ISA-82.02.01 2nd Ed., July 2004, "Safety Requirements For Electrical Equipment for Measurement, Control, and Laboratory Use" and ANSI/ISA-12.12.01-2000, "Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations. See Figure 1-2.

WARNING: ***The use of controls, adjustments, or performance of procedures other than those specified within this manual may result in exposure to invisible (infrared) radiation that can quickly cause blindness.***

Figure 1-2 Explosion Hazard Label

WARNING: ***EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS THE AREA IS KNOWN TO BE NON-HAZARDOUS.***

AVERTISSEMENT - RISQUE D'EXPLOSION - NE PAS DÈBRANCHER TANT QUE LE CIRCUIT EST SOUS TENSION, A MOINS QU'IL NE S'ÀGISSE D'UN EMPLACEMENT NON DANGEREUX.

WARNING: ***EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR Class I, DIVISION 2.***

AVERTISSEMENT - RISQUE D'EXPLOSION - LA SUBSTITUTION DECOMPOSANTS PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS DE CLASSE 1, DIVISION 2.

WARNING: ***EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT UNLESS POWER HAS BEEN SWITCHED OFF OR THE AREA IS KNOWN TO BE NON-HAZARDOUS.***

AVERTISSEMENT - RISQUE D'EXPLOSION - AVANT DE DÉCONNECTER L'EQUIPMENT, COUPER LE COURANT OU S'ASSURER QUE L'EMPLACEMENT EST DÉSIGNÉ NON DANGEREUX.

Wherever the symbol to the left is found within this manual, it indicates that a hazardous or potentially hazardous condition or situation exists and that it is imperative that the accompanying text be read and any cautions be observed. The importance of this cannot be stressed enough.

Note: *Cautionary statements may be found in the Introduction, Getting Started and the Communication chapters, where the reader will find this symbol.*

Figure 1-3 illustrates use of the caution symbol on the REMOTE 5104V product overlay.

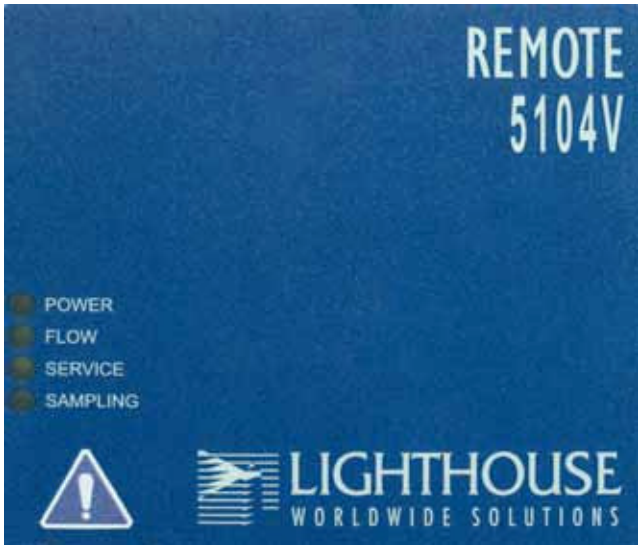

Figure 1-3 R5104V Label with Hazard Symbol

For further assistance, please contact Lighthouse Service and Support at 800-945-5905 (USA Toll Free) or 541-770-5905 (Outside of USA).

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

R5104V and Daisy Chaining

WARNING: ***The REMOTE 5104V is not designed for use in a daisy chain configuration. It is designed to communicate through a single RJ45 connector and must be used in a star (connected to a hub) or a single-point (i.e., connected to a single PC) configuration where the R5104V is always the terminating device on the data cable to which it is attached.***

WARNING: ***Defeating this design by using its data connector as a parallel connection to more than one instrument or as part of a daisy chain network of instruments may result in damage to the R5104V, which may void the R5104V's warranty.***

2 *Introduction*

Overview

This operating manual introduces the Lighthouse REMOTE 5104V family of Airborne Particle Counters. Also included in this manual are instructions for inspecting, using, and maintaining the instrument.

Description

The 5104V instrument has up to four particle-size channels starting at 0.5 microns with a flow of 1.0 CFM.

The model number signifies the minimum particle size measured by the instrument and the flow rate. For example, the number "5104" indicates a 0.5 µm channel size at 1.0 CFM.. See Figure 2-1.
.

Figure 2-1 REMOTE 5104V Airborne Particle Counter

The instrument uses a laser diode light source and laser beam shaping optics to illuminate a cross section of the air flow path with a laser beam. As particles move along the flow path, they cross the laser beam and scatter light. The light scattered is collected by an imaging optical system and imaged onto a photodiode. The photodiode converts the light imaged onto it into a current which is converted to a voltage and amplified by an electronic circuit.

The result is the electronic circuit outputs a voltage pulse each time a particle crosses the laser beam. The width of the voltage pulse is proportional to the time it takes the particle to cross the laser beam. The amplitude of the voltage pulse is proportional to the light scattered which in turn is proportional to the size of the particle.

The voltage pulses created by the particles are then processed by additional electronics that analyzes the height of each pulse and therefore the size of each corresponding particle. Thus the number of particles at various sizes is determined.

This instrument is effective in both ultra-clean areas (such as Class 1 or Class 10) and also in more traditional cleanzones rated as Class 100 or higher. Refer to Specifications in this manual for additional instrument information.

The REMOTE 5104V line of Airborne Particle counters was designed for continuous operation.

Using an external vacuum source, the instrument provides versatile mounting options and can be installed where minimal space is available. The REMOTE 5104V integrates seamlessly with large facility monitoring/management systems and transfers up to 4 channels of simultaneous particle count data using RS-485/MODBUS output.

Accessories

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

- **Isokinetic Sampling Probe 1.0 CFM**
- **Sample Tubing**
- **0.1 m Purge Filter Assembly 1.0 CFM Flow Rate with Tubing**
- **Vacuum tubing per foot**
- **Cable per foot**

REMOTE 5104V Specifications

Size Range	0.5 - 25.0 m
Channel Thresholds	Standard: 0.5, 5.0 µm
	Optional: 0.5, 1.0, 5.0, 10.0 µm Other sizes available; specify at time of order
Flow Rate	1 CFM (28.3 LPM)
Counting Efficiency	50% (per ISO 21501-4)
Laser Source	Laser diode
Zero Count Level	<1 count/5 minutes (per ISO 21501-4)
Calibration	NIST Traceable
Data Storage	Rotating buffer, 2000 Records
Communication Modes	RS-485 MODBUS Protocol
Supporting Software	Lighthouse Monitoring System, LMS XChange, LMS Express
Power Input Requirements	24VDC ±5% @ 100mA max
Enclosure	Stainless Steel
Dimensions	5.42"(l) x 5.12"(w) x 2"(h) [13.8 x 13 x 5 cm]
Weight	21.1 oz (0.6 kg)
Pollution Degree	2
Operating Altitude	0-2,000 meters
Operating Environment	Indoor Use
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

Table 2-1 REMOTE 5104V Specifications

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

When calibration is due, the Service LED will turn ON during sampling and remain on until calibration has been completed.

3 Getting 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 reshipment when returning the instrument for the annual factory calibration or a Return Merchandise Authorization for repair. Replacements are available for purchase.

Shipping Instructions

Should it become necessary to return the unit to the factory for any reason, contact Lighthouse Customer Service or visit our website, www.golighthouse.com/RMA, and obtain a Return Merchandise Authorization (RMA) number. Reference this number on all shipping documentation and purchase orders. After receipt of the RMA number, follow the shipping instructions below:

WARNING:
If the instrument is damaged during shipment due to inadequate user packing, the warranty may be voided and all repairs required will be at cost.

1. Use the original container, nozzle caps and packing materials whenever possible. If the instrument contains a battery, remove it before packing the instrument. If the battery needs to be shipped, package it separately and refer to www.golighthouse.com/rma for detailed instructions.
2. If the original container and packing materials are not available, wrap the unit in "bubble pack", surround with shock-absorbent material and place in a double-wall carton - the instrument should not rattle around when the carton is vigorously shaken. If the instrument is damaged during shipment due to inadequate user packing, the warranty may be voided and all repairs required will be at cost. Contact Lighthouse to purchase a replacement shipping container and nozzle caps.
3. Seal container or carton securely. Mark "FRAGILE" and enter the Return Merchandise Authorization (RMA) number in any unmarked corner.
4. Return to the address provided by a Lighthouse representative or the RMA website.

Cable Build

The REMOTE 5104V is not designed for use in a daisy chain configuration. It is designed to communicate through a single RJ45 connector and must be used in a star (connected to a hub) or a single-point (i.e., connected to a single PC) configuration where the R5104V is always the terminating device on the data cable to which it is attached.

Defeating this design by using its data connector as a parallel connection to more than one instrument or as part of a daisy chain network of instruments may result in damage to the R5104V, which may void the R5104V's warranty.

The specialized connector required to meet Class I Division 2 standards may be supplied with the instrument in kit form. The end of the network cable that attaches to the instrument must use this connector in order to meet this standard. This section of the manual will illustrate installing this connector.

Requirements

The following tools and materials are required to build / attach the sealed industrial RJ45 connection used on the REMOTE 5104V.

- Category 5e Unshielded Twisted-Pair 24AWG wire (CAT5e UTP), minimum
- CAT5e UTP plenum wire may be required for installation in ceiling plenum area
- Industrial RJ45 plug kit
- Wire strippers
- RJ45 crimp tool
- RS-485 hub that supplies 24VDC on pin 7 and Ground on pin 8 of all RJ45 receptacles

Site Preparation

WARNING: ***Both ends of the cable must be wired the same. References are made throughout this section to the EIA/TIA-568B standard for ethernet/RJ45 wiring that must be followed.***

Failure to wire both ends to this standard will cause failure of the instrument and may damage the instrument, the hub or both and void the respective warranties.

When all needed tools and materials are ready, proceed through the following steps:

1. Check with local regulatory agencies to determine installation restrictions and cable requirements for the application before starting cable runs.

2. Make the necessary cable "runs" and leave about two to three feet at each end as a "service loop". When pulling CAT5e cable, do NOT allow it to kink or the cable may break internally and cause failures. Typical installations use Unshielded Twisted Pair (UTP) but Shielded Twisted Pair (STP) may be required in areas of high electrical noise equipment, such as generators, fans and fluorescent lights. When cable has to be installed in the false ceilings or air space above a work area (plenum), plenum cable may be required.

3. Even though the RJ45 connectors used to build ethernet cables are typically the same for either end, the connector supplied in the kit should be used on the instrument end.

4. If STP wire is needed, the RJ45 required for wire termination is metal-jacketed. This special RJ45 provides a grounding point for the cable’s shield. Only one end of the each cable should be grounded. This provides the shield to block electrical noise from entering the wire. Because the RS-485 hub uses grounded connector housings, the hub end would be the best point for the ground connection.

Procedure

1. Strip 1-1/2-inch to two-inches of insulation from the end of the cable, taking extreme care to not nick or cut the individual wires. Do NOT strip the individual wires.

2. Remove the contents of the Industrial RJ45 connector from the package - do NOT dispose of or lose any pieces. Compare the contents with Figure 3-1. Contact Lighthouse Support if it appears that something is missing from the package.

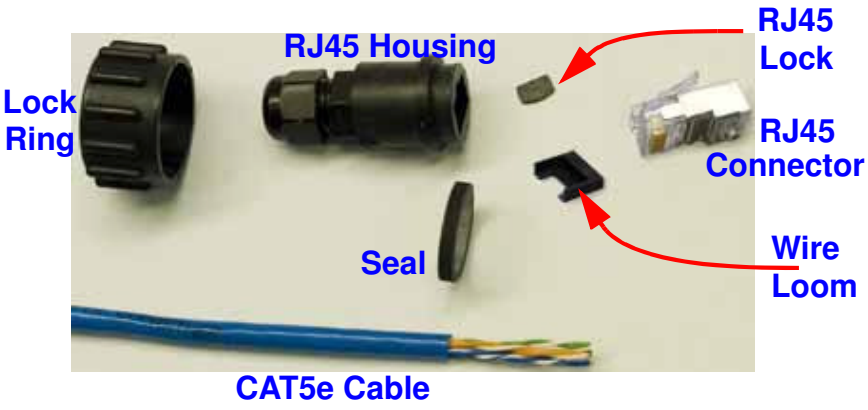

Figure 3-1 R5104V RJ45 Cable Parts

3. Remove the large lock ring from the housing if they are mated.

4. Loosen the smaller sealing nut to allow the CAT5e cable through.

5. On the instrument end of the cable, push the stripped end of the cable through the large Lock Ring and RJ-45 housing as illustrated in Figure 3-2. Make sure the ring is oriented as shown. If it is reversed, the cable may have to be cut, the RJ45 connector discarded and a new connector installed.

Figure 3-2 Housing with Cable Inserted

6. Separate the pairs of wires down to the cable's insulation. There will be an orange, a green, a blue and a brown pair of wires. Each pair will have a solid color wire and one striped wire of the pair color. Do not get them confused - the orange and brown pair may look alike in plenum cable and "swapping" these two pairs will cause failure of the cable.

7. Carefully untwist each pair and straighten the wire. The individual wires will be inserted into the Wire Loom shown in Figure 3-1 and Figure 3-3.

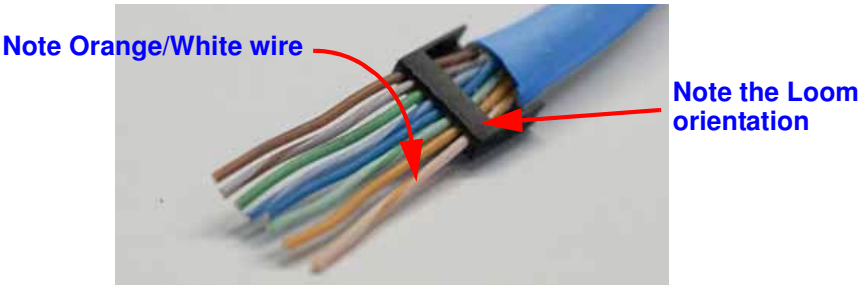

Figure 3-3 Close-up of Wire Loom

Note that the Loom has a flat tray shape. Insert the wire.

8. Separate the wires and insert them into the loom based on the EIA/TIA-568B standard as shown in Figure 3-3. Note that the green pair is split up and the blue pair is out of sequence (solid color then striped) and between the green-pair wires. When all of the wires are in the correct holes, push the loom onto the wires as far as it will go and verify that at least one-eighth-inch of each wire extends beyond the edge of the loom. This will allow for trimming the wires in a straight line parallel to the loom edge. The one-eighth-inch is required for crimping into the RJ-45 connector. Review the photos in Figure 3-4 to ensure accuracy.

Figure 3-4 EIA/TIA-568B Color Code Example

Note: *The "pairing" of wires in the loom changes at positions 4 through 6.*

9. Continue to push the cable into the loom and trim the ends of the wires in a straight line to one-eighth-inch as illustrated in the center panel of Figure 3-4.

10. Insert the wires and loom into the RJ-45 connector (lock tab facing down) and push inward until they fully butt against the end of the wire channels. See Figure 3-5. The loom helps to keep the wires positioned so they will go into the correct channels for crimping.

Figure 3-5 Loomed Wires Being Inserted into RJ-45

11. Insert the RJ-45 connector into a crimp tool similar to that shown in Figure 3-6. Maintain inward pressure while crimping the wires into their channels.

Figure 3-6 Typical RJ-45 Crimp Tool

12. Check the cable wire ends in the RJ-45 to make sure they have been crimped properly. Removing the connector at this point is a lot easier than after everything is installed and communication with the instrument is failing due to a poor crimp. Review Figure 3-7 for an illustration of how tightly the wire ends should be against the ends of each channel.

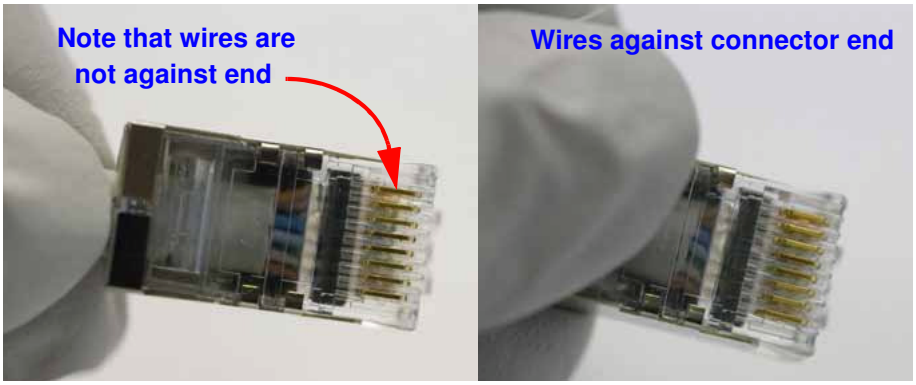

Figure 3-7 Close-up of RJ-45 Wire Detail

13. Pull on the cable to bring the RJ-45 into the connector housing. Make sure to squeeze the latch tab to allow it to enter the slot in the housing See Figure 3-8.

Figure 3-8 Close-up of RJ-45 Latch

14. Push the RJ-45 connector fully into the housing and insert the Lock Clip, round edge out, as illustrated in Figure 3-9.

Figure 3-9 Lock Clip Installation

15. Hand tighten the housing cable clamping nut until snug. See Figure 3-10.

Figure 3-10 Tighten Cable Clamp Nut

16. Install the sealing ring onto the front of the connector housing. This seal is held in place when the connector is locked onto the instrument. See Figure 3-11.

Figure 3-11 Install Connector Seal

17. Slide the large lock ring down the cable and over the cable housing body. It may need a twisting action to fully position it against its retainer ring. Verify that its larger opening is facing outward, away from the cable as shown in Figure 3-12.

Figure 3-12 Cable Connector Completed

18. The hub end of the cable run can now be terminated. The wire should be checked with an ethernet 100baseT cable tester (not just a continuity tester) to ensure that the signals, power and ground will be reliable. Steps 6 through 12 can be used as a reference for termination of the hub end.

19. Use the template shown in Figure 3-13 to locate and install the R5104V securely on a flat vertical surface in the area to be sampled.

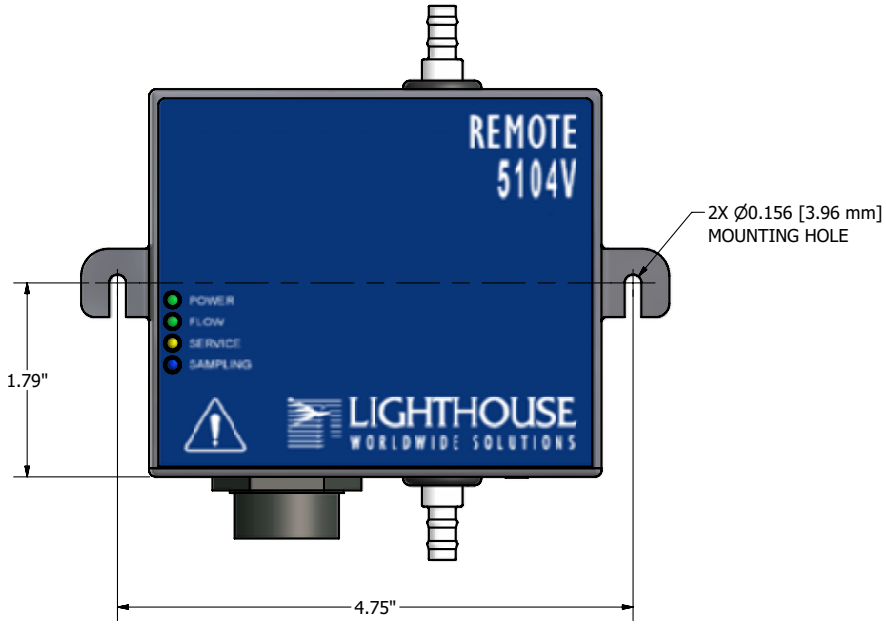

Figure 3-13 Mounting Template

20. Make sure the hub power is OFF or the hub end of the cable is disconnected from the hub before connecting the cable to the instrument.

Operation

Understanding the LEDs

The front-panel LEDs have specific meanings when illuminated. Figure 3-14 shows location of the LEDs and gives a brief description of their meaning

.

Figure 3-14 Front Panel LEDs

- The green POWER LED turns on when the instrument is powered on.
- The green FLOW LED turns on steady when the flow is within specification.
- The green FLOW LED will blink if the flow is out of specification.
- The yellow SERVICE LED will stay on steady if Laser power is out of range, the sensor optics are dirty or the view volume contains foreign objects.
- The blue SAMPLING LED indicates that the instrument is in a sampling state.

Connections

The top of the instrument has a connection for an isokinetic inlet probe. See Figure 3-15.

Figure 3-15 Instrument Top Connections

The sensor can be used with a direct-mount 1.0 CFM isokinetic probe or the probe can be attached via tubing to the inlet barb.

Figure 3-16 illustrates the connections found on the bottom side of the R5104V, which include the vacuum source fitting, Data connector and the DIP switch cover plate.

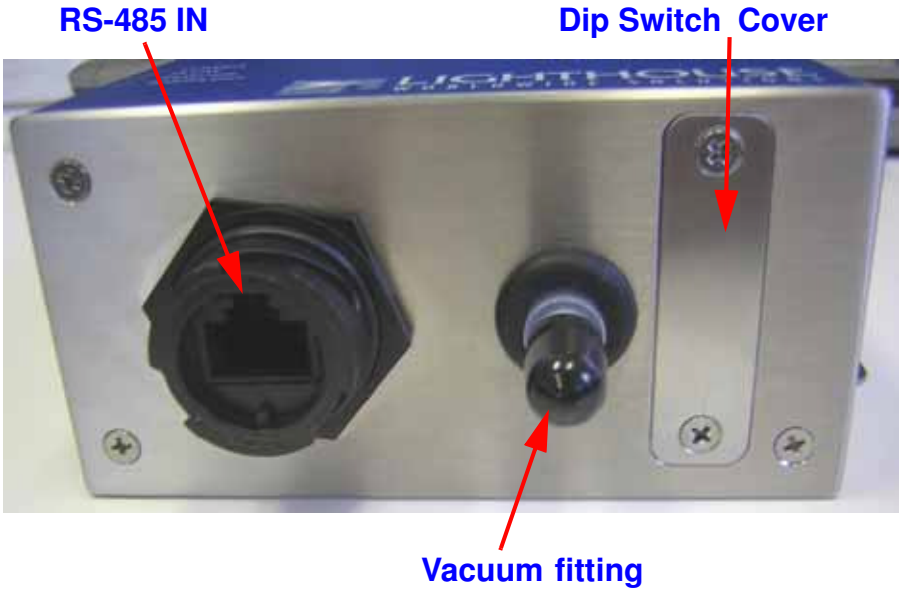

Figure 3-16 Instrument Bottom Connections

Vacuum supplied to the fitting must be 18" Hg or greater for the R5104V to operate properly and the RS-485 IN port (Data connector) must be used to connect the instrument to a 'star' or single-point communication. The R5104V is not designed for daisy chain configuration.

Attempting to defeat this design requirement by using it in a daisy chain network may damage the R5104V, which may void the instrument warranty. See "R5104V and Daisy Chaining" on page 1-4 for more information.

.Communication Ports

The communication port provides RS-485 MODBUS connection. RS-485 is provided for industrial applications with multiple devices on the same bus. The RS-485 connector allows easy connection using a Class I Division 2 cable to an RS-485 hub. Connecting the counter to a PC via RS-485 requires an RS-485 hub. Please contact a Lighthouse Sales Representative for the hub.

For more information, please see *"Communications" on page 4-1*.

Cabling Sensor

WARNING: ***EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS THE AREA IS KNOWN TO BE NON-HAZARDOUS.***

AVERTISSEMENT - RISQUE D'EXPLOSION - NE PAS DÈBRANCHER TANT QUE LE CIRCUIT EST SOUS TENSION, A MOINS QU'IL NE S'ÀGISSE D'UN EMPLACEMENT NON DANGEREUX.

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AVERTISSEMENT - RISQUE D'EXPLOSION - AVANT DE DÉCONNECTER L'EQUIPMENT, COUPER LE COURANT OU S'ASSURER QUE L'EMPLACEMENT EST DÉSIGNÉ NON DANGEREUX.

WARNING: ***Make sure the communication cable is NOT attached to the hub before it is connected to the sensor. Power to the hub should be OFF when connecting sensors. An explosion hazard exists if power is applied to the cable while it is being connected to the sensor.***

The required cable is designed specifically for Class I Division 2 use, incorporates an O-ring and provides a positive seal through its twist-lock design. Figures in this section illustrate how the cable is "mated" to the sensor.

Note that Figure 3-17 and Figure 3-18 show the orientation of the key is up. Make sure the cable is positioned with its key up.

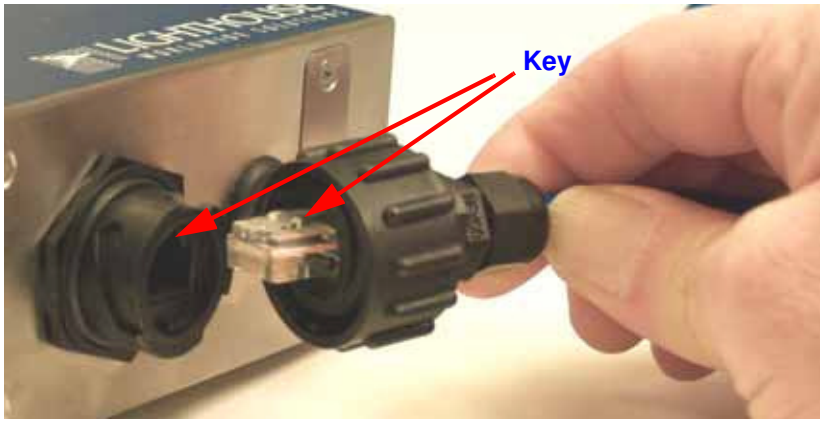

Figure 3-17 Readying Cable for Attachment

WARNING: ***The REMOTE 5104V is not designed for use in a daisy chain configuration. It is designed to communicate through a single RJ45 connector and must be used in a star (connected to a hub) or a single-point (i.e., connected to a single PC) configuration where the R5104V is always the terminating device on the data cable to which it is attached. Defeating this design by using its data connector as a parallel connection to more than one instrument or as part of a daisy chain network of instruments may result in damage to the R5104V, which may void the R5104V's warranty.***

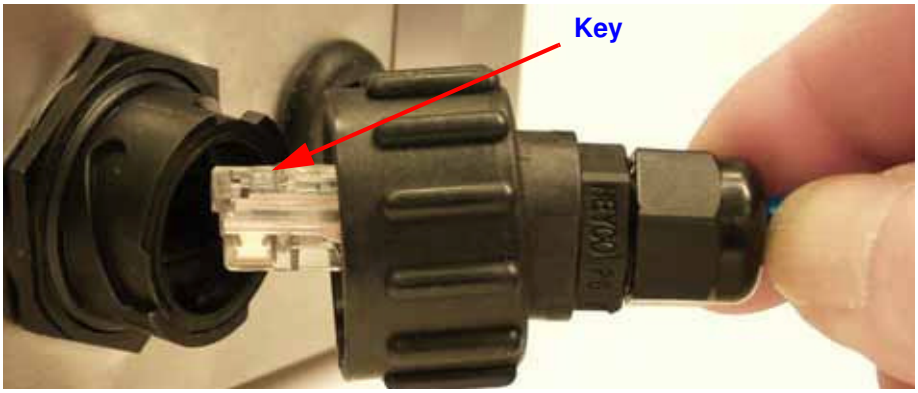

Figure 3-18 Cable Attachment Step 2

1. Insert the cable male connector into the sensor receptacle - make sure the cable fully seats into the receptacle.

2. Figure 3-19 shows the twist motion required to lock cable into place - make sure the lock groove and lock sleeve mate.

Figure 3-19 Cable Receptacle Lock Groove

3. Figure 3-20 illustrates the cable as fully attached to sensor. The free end of the cable may now be connected to the RS-485 hub, power applied to the hub and the sensor powered up.

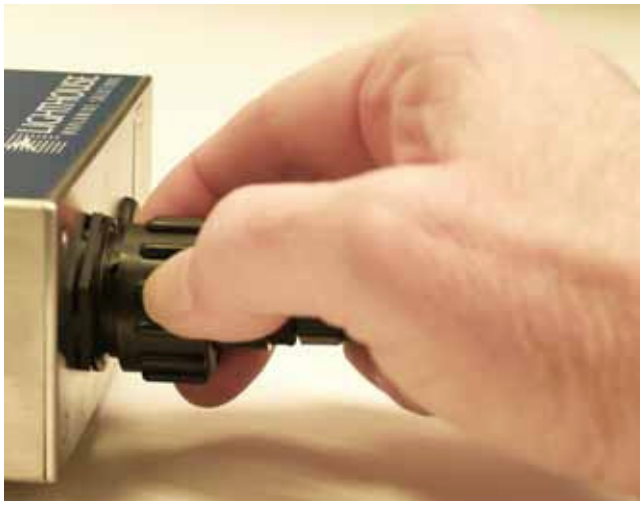

Figure 3-20 Cable Fully Attached

DIP Switches

The DIP switches are used for addressing the instrument for RS-485 daisy chain configurations and setting the communications mode. See “DIP Switch Communications Mode” on page 4-2 for details.

Positions 1-6 set the address of the instrument.

Position 7 and 8 set the communications mode.

The DIP Switches require a tool with a small, pointed tip in order to change. A very small screwdriver or multimeter probe can be used.

Instrument Mounting

The R5104V is designed with mounting tabs to assist with simple mounting to a wall or other flat, vertical surface. Make sure the instrument is oriented with the bottom of the instrument level and facing down. Figure 3-21 illustrates the dimensions required by the R5104V for proper mounting.

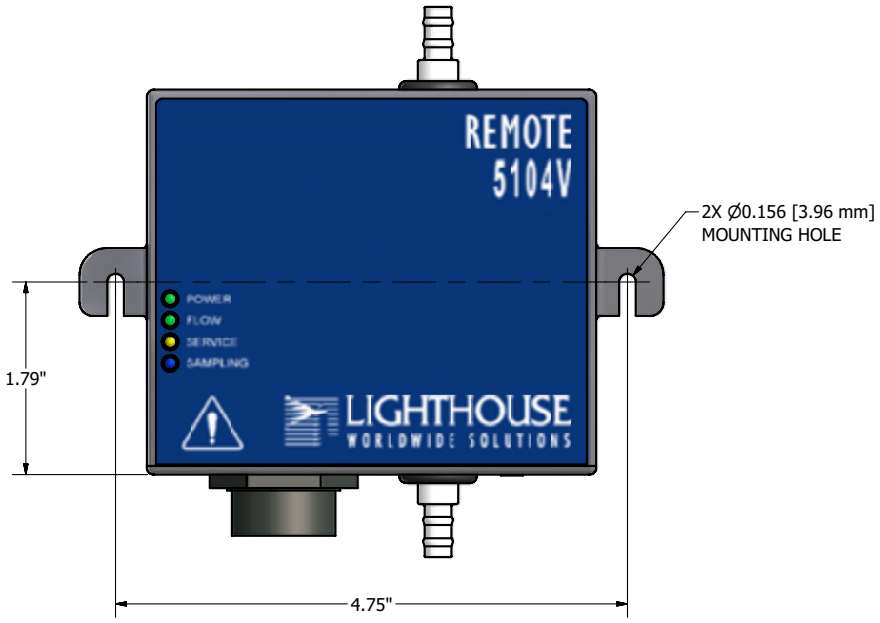

Figure 3-21 Mounting Details

Power

This REMOTE instrument receives +24VDC on pin 7 of the RJ45 connector and Ground on pin 8. The RS-485 hub supplies these. The power consumption is +24V, 100mA.

Vacuum Inlet

The Inlet (located on the top of the instrument) and Outlet (on bottom of instrument) nozzles use 1/4" ID tubing. Vacuum or airflow is from the top of the instrument to the bottom. The vacuum source must be connected to the bottom (Outlet nozzle). This maintains a downward flow to carry particles out of the instrument.

The Inlet nozzle can be attached to a length of hose and the other end of that hose can be attached to an Isokinetic probe to maintain a non-turbulent flow through the instrument.

The vacuum supplied must be at least 18" (45.7 cm) of Hg in order to pull 1.0 cfm through the sensor. The flow is controlled by an internal critical orifice.

If not enough vacuum is present to provide 1.0 CFM, the FLOW LED will blink. In this case, please contact Lighthouse Worldwide Solutions Technical Support at techsupport@golighthouse.com.

4 Communications

This chapter contains information regarding the communications hardware and how to configure the hardware to allow interfacing with the REMOTE instrument.

DIP Switches

The DIP switches are behind a panel to the right of the RS-485 port connector. See Figure 4-1.

Figure 4-1 DIP Switch Cover

Remove the two Phillips head screws to expose the DIP switches. See Figure 4-2.

Figure 4-2 DIP Switches Exposed

DIP Switch General Definitions

Table 4-1 displays the general DIP Switch settings. OFF (LEFT) = 0, ON (RIGHT) = 1.

Note: *Use a tool with a very small, pointed tip in order to change the DIP Switch positions.*

Table 4-1 DIP Switch settings

Position #	Description	Setting
1	Binary Bit 0	Addressing, OFF=0, ON=1
2	Binary Bit 1	Addressing, OFF=0, ON=1
3	Binary Bit 2	Addressing, OFF=0, ON=1
4	Binary Bit 3	Addressing, OFF=0, ON=1
5	Binary Bit 4	Addressing, OFF=0, ON=1
6	Binary Bit 5	Addressing, OFF=0, ON=1
7	Communication Mode	Used in conjunction with DIP switch 8 to set MODBUS mode
8	Communication Mode	Used in conjunction with DIP switch 7 to set MODBUS mode

Communication Modes

The communication mode used for the REMOTE 5104V is MODBUS protocol mode. See Table 4-2.

Table 4-2 DIP Switch Communications Mode

COMMUNICATIONS MODE	DIP SW 7	DIP SW 8
MODBUS protocol	OFF	OFF

OFF (LEFT) = 0, ON (RIGHT) = 1

The DIP Switches must be set before the unit is powered up. If the DIP Switches are changed, power cycle the instrument to implement the change.

DIP Switch Addressing

Note: *Because Address 0 is reserved for broadcasting in MODBUS RS-485 communications, Address 1 is set when all the DIP switches are OFF or when DIP switch1 is ON.*

Table 4-3 details the addresses set by the binary DIP switches 1-6.

Table 4-3 DIP Switch Addressing

DIP SWITCHES 1 2 3 4 5 6	ADDRESS	DIP SWITCHES 1 2 3 4 5 6	ADDRESS
0 0 0 0 0 0	0 or 1	0 0 0 0 0 1	32
1 0 0 0 0 0	1	1 0 0 0 0 1	33
0 1 0 0 0 0	2	0 1 0 0 0 1	34
1 1 0 0 0 0	3	1 1 0 0 0 1	35
0 0 1 0 0 0	4	0 0 1 0 0 1	36
1 0 1 0 0 0	5	1 0 1 0 0 1	37
0 1 1 0 0 0	6	0 1 1 0 0 1	38
1 1 1 0 0 0	7	1 1 1 0 0 1	39
0 0 0 1 0 0	8	0 0 0 1 0 1	40
1 0 0 1 0 0	9	1 0 0 1 0 1	41
0 1 0 1 0 0	10	0 1 0 1 0 1	42
1 1 0 1 0 0	11	1 1 0 1 0 1	43
0 0 1 1 0 0	12	0 0 1 1 0 1	44
1 0 1 1 0 0	13	1 0 1 1 0 1	45
0 1 1 1 0 0	14	0 1 1 1 0 1	46
1 1 1 1 0 0	15	1 1 1 1 0 1	47
0 0 0 0 1 0	16	0 0 0 0 1 1	48
1 0 0 0 1 0	17	1 0 0 0 1 1	49
0 1 0 0 1 0	18	0 1 0 0 1 1	50
1 1 0 0 1 0	19	1 1 0 0 1 1	51
0 0 1 0 1 0	20	0 0 1 0 1 1	52
1 0 1 0 1 0	21	1 0 1 0 1 1	53
0 1 1 0 1 0	22	0 1 1 0 1 1	54
1 1 1 0 1 0	23	1 1 1 0 1 1	55

Table 4-3 DIP Switch Addressing

DIP SWITCHES 1 2 3 4 5 6	ADDRESS	DIP SWITCHES 1 2 3 4 5 6	ADDRESS
0 0 0 1 1 0	24	0 0 0 1 1 1	56
1 0 0 1 1 0	25	1 0 0 1 1 1	57
0 1 0 1 1 0	26	0 1 0 1 1 1	58
1 1 0 1 1 0	27	1 1 0 1 1 1	59
0 0 1 1 1 0	28	0 0 1 1 1 1	60
1 0 1 1 1 0	29	1 0 1 1 1 1	61
0 1 1 1 1 0	30	0 1 1 1 1 1	62
1 1 1 1 1 0	31	1 1 1 1 1 1	63

Communicating with the Instrument

RS-485 Port

The RJ-45 connector on the instrument's RS-485 port has +24VDC power, ground and RS-485 lines. The pinouts and ratings are displayed in Table 4-4.

Table 4-4 RJ-45 Pinouts

RJ-45 Pin	Signal Name
1	N/A
2	N/A
3	RESERVED for future use
4	RS-485B (-7 to +12 VDC)
5	RS-485A (-7 to +12 VDC)
6	RESERVED for future use
7	+24VDC Maximum
8	GND

The instrument utilizes RS-485 communications in a multi-point star, or hub, configuration. To connect to the instrument using a computer, the computer must be configured to use a port on the RS-485 hub.

1. Remove power from the hub.
2. Connect one end of the RJ-45 cable to the RS-485 converter: pin 4 to ChB+ and pin 5 on ChA-.
3. Connect the other end of the RJ-45 cable to a port on the hub.
4. Connect the RS-232 DB9 side of the RS-485 converter to the DB9 COM port on the computer with a DB9 Male to DB9 Female straight through cable. Any available COM Port may be used.
5. Power on the hub, which will supply power to the instrument.

Table 4-5 displays the RS-485 standards for distances and number of devices on a chain. The Electronics Industry Association (EIA) has produced standards for RS-485 that deal with data communications.

Table 4-5 EIA RS-485 Communication Standards

SPECIFICATION	RS-485
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)	+/-100 A
Max Driver Current in High Z State (POWER OFF)	+/-100 A
Receiver Input Voltage Range	-7V to +12V
Receiver Input Sensitivity	+/-200mV
Receiver Input Resistance (Ohms), (1 Standard Load for RS485)	>=12k

5 Programming with MODBUS Protocol

The REMOTE 5104V family of instruments can be programmed using the MODBUS Protocol. The full protocol is detailed in "R5104V MODBUS Register Map v1.44" on page A-1.

This chapter contains the information needed to program the basic configuration for the instrument using the MODBUS protocol.

DIP Switches

During power-up and reset, the counter reads the DIP switches on the back panel.

Note: *When changing the DIP switch settings, the instrument power must be cycled on and off to save the settings.*

DIP Switches 7 and 8 must both be in the OFF position in order to use the MODBUS protocol.

Protocol Settings

The MODBUS Protocol is defined through an RS-485 interface with:

- Baud Rate: 19200
- Data Bits: 8
- Stop Bits: 1
- Parity: None
- Flow Control: None

Power On/ Auto Start

When powering up the instrument, it will begin sampling using the default configuration:

- Location = 0
- Sample Time = 60 seconds
- Hold Time = 0 seconds
- Alarm Channel = Enabled

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

To stop the sampling, send the command **10 or 12** to command register 40002.

Stopping the sampling will set the Device Status bit in Register 40003 to 0.

Running the Instrument Using MODBUS

The applicable action commands are displayed in Table 5-1.

Table 5-1 MODBUS 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, and Location.
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.
10	Manual Stop. Stops sampling. Records counts since Manual Start.
11	Instrument Start (Automatic Counting). Uses defined Hold Time and Sample Time. Instrument executes samples and holds until an Instrument Stop command is issued.
12	Instrument Stop. Aborts current sample. Stops data collection.

Each of the described action commands above are written to the command register (40002).

AUTOMATIC Counting Mode

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

The instrument will continue running samples at the configured sample time until it receives a stop command. When the stop command is given, the most current data will not record to the buffer.

After setting all the instrument parameters as described in “Changing the Default Instrument Parameters” on page 5-4, write these commands to the Command register (40002):

11 Start Instrument; to start recording

12 Stop Instrument; to stop recording

MANUAL Counting Mode

In Manual counting mode, the computer starts the sample and the instrument continues counting until a stop command is given. At that point, the sample time is listed at whatever the time interval was between the start command and the stop command.

Write these commands to the Command register (40002):

9 Start Instrument; to start recording.

10 Stop Instrument; to stop recording after desired sample time.

Configuring with the MODBUS Protocol

Setting the Real Time Clock

The Real Time Clock (RTC) can be read in registers 40027 and 40028 as shown in Table 5-2.

Register 40027 is the high word for the real time clock; 40028 is the low word. The date/time is calculated as the number of seconds since midnight of 1/1/1970.

The date & time is stored in a 4-byte unsigned integer or as a 32-bit unsigned integer.:

Table 5-2 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]

In order 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. See Table 5-3.

Table 5-3 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.

Table 5-3 Data Set Registers

Register	Data Type	Description
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 REMOTE counter are Location, Sample Time, and Hold Time as shown in Table 5-4.

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

Sample Time and Hold Time both use 2 registers, a high word and a low word. If the desired value for any of these parameters is less than or equal to 9 hours, 6 minutes and 7 seconds (32767 seconds), then only the low word register needs to be written with the value in seconds.

The low word register for Sample Time is 40034.

The low word register for Hold Time is 40032.

Table 5-4 Instrument Parameters

Register	Data Type	Description
40026	unsigned integer	**Location number** Specifies location of Particle Counter.
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.
40034	unsigned integer	**Sample Time [low]**

Using Sensor Setting Registers

Certain configuration settings can be sent to the counter through these registers.

Sensor Setting Registers 40001 and 40003 through 40023 are protected and should not be changed.

Location (Register 40026)

For Particle Counters, this value specifies at what location a sample was recorded.

For Manifold Controllers, this value specifies the manifold position. Writing a value from 1-32 to this register will move the manifold arm to that position on the manifold. Value 0 moves the arm to the Home position.

Hold Time (Registers 40031, 40032)

The Hold Time is used for pausing in between samples for multiple cycles. If Hold Time is greater than 1 minute, the pump will turn off.

This time is specified in seconds. The maximum value is 359,999 seconds (high word: 5, low word: 32319) which is 99 hours, 59 minutes, and 59 seconds. To set the Hold Time to a value less than 9 hours, 6 minutes, 7 seconds, enter the number of seconds in the *low register* (40032).

During Hold Time, the Device Status bit is 0 (Idle).

Sample Time (Registers 40033, 40034)

The Sample Time specifies the time period of each sample. This time is specified in seconds. The maximum value of the sample time is 86,399 seconds (high word: 1, low word: 20863) which is 23 hours, 59 minutes, 59 seconds.

To set the Sample Time to a value less than 9 hours, 6 minutes, 7 seconds, enter the number of seconds in the *low register* (40034).

During the Sample Time, the Device Status is 1 (Sampling).

Alarm and Threshold Registers

Alarm Enable Registers

The Alarm Enable input registers (43xxx series) shown in Table 5-5 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 channels are set to ALARM ENABLE.

Table 5-5 Alarm Enable/Disable Bits

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

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

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

Enabling the Alarm for a particle channel requires setting the bit in the low word of that channel. Any or all active particle channels can be enabled at a time and can set a different alarm threshold for each. See Table 5-6.

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

Table 5-6 Alarm Enable Registers

Register	Data Type	Description
43009	unsigned int	Alarm Enable for Particle Channel 1 [high] (smallest particle size starts here)
43010	unsigned int	Alarm Enable for Particle Channel 1 [low]
43011	unsigned int	Alarm Enable for Particle Channel 2 [high]
43012	unsigned int	Alarm Enable for Particle Channel 2 [low]
43013	unsigned int	Alarm Enable for Particle Channel 3 [high]
43014	unsigned int	Alarm Enable for Particle Channel 3 [low]

Table 5-6 Alarm Enable Registers

Register	Data Type	Description
43015	unsigned int	Alarm Enable for Particle Channel 4 [high]
43016	unsigned int	Alarm Enable for Particle Channel 4 [low]

Enable Alarming for a Channel

Alarm and threshold registers are independent of each other. Any one register's settings will not affect the others and any channel alarms may be enabled or disabled as the user requires. For example, to enable alarming on just the first particle channel, enable Bit 1 by writing the value of '3' to register 43010. To disable alarming on the first channel and enable alarming on the second channel, write a '1' to register 43010 and a '3' to register 43012. To enable all alarms, write a '3' to each of the registers 43010, 43012, 43014 and 43016. See Table 5-7.

To disable alarming completely, write a '1' to the enabled register or registers (43010, 43012, 43014 or 43016).

Table 5-7 Example of Alarming on only Channel 2

Registers	Particle Channel	Bit 1 Enabled	Bit 0 should always be:
43009 - 43010	1	0	1
43011 - 43012	2	1	1
43013 - 43014	3	0	1
43015 - 43016	4	0	1

Use the Threshold registers to set the alarm threshold value(s) as 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.

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.

The Data Status flag is set if any of the channels have a threshold exceeded state as true.

Note: *The REMOTE comes standard with 2 particle channels; Table 5-8 shows the optional 4 channels.*

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. See Table 5-8.

Table 5-8 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]

Setting the Alarm Threshold Value

The Alarm Threshold Value is set in the low register of the channels. Each channel has independent threshold value registers. Since any or all channels can be enabled for alarms at any given time, each threshold value applies to the corresponding channel. Setting a value for channel 1 as 100 will not affect channel 2 setting of, say, 500. See Table 5-9.

Table 5-9 Alarm Threshold Registers set to 1000

Registers	Particle Channel	Threshold Value
45009 - 45010	1	1000
45011 - 45012	2	1000
45013 - 45014	3	1000
45015 - 45016	4	1000

A R5104V MODBUS Register Map v1.44

COMM Settings

Lighthouse particle counters with MODBUS have the following communications settings:

Table A-1 MODBUS Communications Settings

Baud Rate	19200
Data Bits	8
Stop Bits	1
Parity	None
Hardware Protocol	RS-232-C or RS-485 standard
Software Protocol	MODBUS ASCII (supports upper/lower case)

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.

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-2 describes the content 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]
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	signed integer	Record Count. Total number of records stored in the counter
40025	signed integer	Record Index. Zero based index to data in 3xxxx register series. Must be lower than the record count (register 40024). Set this index to expose a counter's record in the 3xxxx registers. Set to -1 to retrieve last record stored in the counter.
40026	unsigned integer	Location number Particle Counters: Specifies location of Particle Counter. Manifold Controller: Specifies Manifold position. Setting this value moves to that position on the manifold.
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]
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.
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]

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40039	unsigned integer	Laser Reference Voltage (millivolts)
40041	ASCII string	Flow Unit - Defines the Unit that FlowRate value is based on. char[0], char[1]. (NULL-terminated string)
40042	ASCII string	Flow Unit. char[2], char[3]
40043	unsigned integer	Calibration Reference Voltage (millivolts)
40047	signed integer	Calibration Due Date [high]. Indicates when instrument is due for calibration. This number can be generated by the ANSI C/ C++ time() function.
40048	signed integer	Calibration Due Date [low].

Device Status

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

Table A-4 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-5 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.
6	Enable Local Control. Unlocks the instrument's user interface. Instrument changes can be made at the device itself or through MODBUS.
7	Turns local pump on, if applicable.
8	Stop pump, if applicable.
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.

Table A-5 Command Register

Value	Action
13	Set Real Time Clock. Writes "Data Set" values (from Registers 40035 & 40036) to the local Real Time Clock. New time value is saved.

Alarm and Threshold Registers

Alarm Enable Registers

The 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:

Note: *These registers currently apply only to ALARM enable/disable, **not** to Channel enable/ disable.*

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

The 43xxx register series is used to determine which particle data channels are set to ALARM ENABLE.

Table A-6 Alarm Enable/Disable Bits

Bit	Description
0	******RESERVED******
1	ALARM ENABLE (0=disable; 1=enable)
2	RESERVED

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

Note: *Alarm Enable currently only works for Particle Channels. Any or all channels and their alarm thresholds can be enabled and configured independently of each other.*

To enable the Alarm for a particle channel, set the bit in the low word of that channel. Because Bit-0 is reserved and must always be ON, only Bit-1 will change for any channel alarm setting and Bit-0 must always be written as a '1'. What this means is that these registers will receive a '3' to turn the setting ON and a '1' to turn it OFF.

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

Table A-7 Alarm Enable Registers

Register	Data Type	Description
43009	unsigned int	Alarm Enable for Particle Channel 1 [high] (smallest particle size starts here)
43010	unsigned int	Alarm Enable for Particle Channel 1 [low]
43011	unsigned int	Alarm Enable for Particle Channel 2 [high]
43012	unsigned int	Alarm Enable for Particle Channel 2 [low]
43013	unsigned int	Alarm Enable for Particle Channel 3 [high]
43014	unsigned int	Alarm Enable for Particle Channel 3 [low]
43015	unsigned int	Alarm Enable for Particle Channel 4 [high]
43016	unsigned int	Alarm Enable for Particle Channel 4 [low]

Enable Alarming for a Channel

To enable alarming on particle channel #1, write a ’3’ to register 43010, which enables its Bit 1 and maintains Bit 0 as ’1’. To disable alarming on channel 1 and enable it on channel 2, write a ’1’ to register 43010 and a ’3’ to register 43012. To enable all, write a ’3’ to 43010, 43012, 43014 and 43016.

To disable alarming completely, write a ’1’ to disable Bit 1 to registers 43010, 43012, 43014 and 43016.

Table A-8 Example of Alarming on only Channel 2

Registers	Particle Channel	Bit 1 Enabled	Bit 0 should always be:
43009 - 43010	1	0	1
43011 - 43012	2	1	1
43013 - 43014	3	0	1
43015 - 43016	4	0	1

Use the Threshold registers to set the alarm threshold values, as 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 A-9 shows the registers for a 4 channel particle counter. Counters with less channels do not use the extra registers. The smallest particle channel starts at the xxx09 position.*

The Data Status flag is set if any of the channels have a threshold exceeded state as true.

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-9 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]

Setting the Alarm Threshold Value

Note: *Thresholds are independent of each so the value set for one channel does not affect another.*

The Alarm Threshold Value is set in the low register of the channels. Each channel has independent threshold value registers. Setting a value for channel 1 as 100 will not affect channel 2 setting of, say, 500.

Table A-10 Alarm Threshold Registers set to 1000

Registers	Particle Channel	Threshold Value
45009 - 45010	1	1000
45011 - 45012	2	1000
45013 - 45014	3	1000
45015 - 45016	4	1000

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 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>

Not all particle channels are 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-11 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)

Table A-11 Data Registers

Register	Data Type	Description
30004	unsigned integer	Sample Time [low]
30005	unsigned integer	Location [high] (Place where data was recorded)
30006	unsigned integer	Location [low]
30007	unsigned integer	Device Status [high]
30008	unsigned integer	Device Status [low]
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]
30065	IEEE Float	Background Voltage [low] (percentage based on Calibration Reference value) - REMOTE 4
30066	IEEE Float	Background Voltage [high]
30067	IEEE Float	Flow Value [low] (0.0 if flow is below reference, 1.0 if flow is within reference, 1.1 if flow is above reference)
30068	IEEE Float	Flow Value [high]
30069	IEEE Float	Laser Voltage [low] (Percentage based on Laser Reference value)
30070	IEEE Float	Laser Voltage [high]

Note: *Particle data is 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.

Device Status Word

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

The registers used for the Device Status Word are 30007 and 30008.

The bit order of the Device Status Word is 7 to 0 (right to left), where bit 7 is the most significant bit and bit 0 is the least significant bit.

The bits within the Device Status Word are flagged to indicate particular 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-12 Device Status Word

Bit	Description
0	Laser Alert Status 0 = Laser is good 1 = Laser Alert
1	Flow Alert Status 0 = Flow Rate is good 1 = Flow Rate Alert
2	Particle Overflow Status 0 = No overflow 1 = Overflow occurred
3	Instrument Service Status 0 = Working correctly 1 = Instrument malfunction detected.
4	Particle Threshold Exceeded Status 0 = Threshold not exceeded 1 = Threshold exceeded

Data Enable Registers

Note: *All data records have the same enable states. The user does not have to read the enable registers for every record.*

The 31xxx register series is used to determine which data items in 30xxx are enabled. Enabled items contain recorded data. Data retrieved from disabled items return garbage. Data items are disabled for particle channels not supported by the device or when the device software is configured not to record data for those items.

The Enable Registers (31xxx series) run in parallel with the Data Registers (30xxx series). For example, Data Register 30010's Enable Register is 31010. Data Register 30016's Enable Register is 31016.

The 31xxx register states are:

00000000h = Disabled
FFFFFFFFh = Enabled

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 32xxx register series is used to identify the type of data 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 32041.

Data Types are assigned 4 ASCII characters across 2 registers. A Data Type string containing less than 4 characters is padded with NULL characters but a Data Type using all four characters will not end with a NULL.

Table A-13 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 special data types. They may contain numbers, spaces and use periods as decimal points. They are used to identify particle channel sizes and are always expressed in microns. They also

represent raw counts only.

Table A-14 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

Data Units Registers

The 33xxx register series identifies the units used by data items in the 30xxx series. The Units Registers run in parallel with the Data Registers. For example, Data Register 30010's Units Register is 33010.

Note: *Not all data types have units.*

Units are stored as 4 character ASCII strings across 2 registers. A Units string containing less than 4 characters or no characters is padded with NULLs but a Units string using all 4 characters does not end with a NULL.

Note: *Be aware that LWS Particle Counters may use units not on the table.*

Table A-15 shows Units that may be used by the device for recording data. Not all Units are used by the device and are reserved for other equipment or for future use.

Table A-15 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		

B Maintenance

Safety Considerations

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

Routine Maintenance

Routine maintenance activities should be established by the end-user and may include cleaning of the exterior of the instrument and checking of the status LEDs.

No other routine activities are suggested by the manufacturer at this time. The manufacturer recommends that a Lighthouse instrument be calibrated annually by a Certified Lighthouse Service Provider to ensure that the unit continues to perform within specification.

There are no user-serviceable components within the instrument and opening it is strongly discouraged.

THIS EQUIPMENT IS SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C & D OR NON-HAZARDOUS LOCATIONS ONLY.

Laser Safety Information

This product contains a Laser-based sensor that is a Class I when used under normal operation and maintenance conditions. Servicing 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 ISA-82.02.01 2nd Ed., July 2004, "Safety Requirements For Electrical Equipment for Measurement, Control, and Laboratory Use" and ANSI/ ISA-12.12.01-2000, "Nonincendive Electrical Equipment for Use in Class I and II, Division 2 and Class III, Divisions 1 and 2 Hazardous (Classified) Locations. See Figure B-1.

WARNING: ***The use of controls, adjustments, or performance of procedures other than those specified within this manual may result in exposure to invisible (infrared) radiation that can quickly cause blindness.***

Figure B-1 Explosion Hazard Label

WARNING: EXPLOSION HAZARD - DO NOT DISCONNECT WHILE CIRCUIT IS LIVE UNLESS THE AREA IS KNOWN TO BE NON-HAZARDOUS.

AVERTISSEMENT - RISQUE D'EXPLOSION - NE PAS DÈBRANCHER TANT QUE LE CIRCUIT EST SOUS TENSION, A MOINS QU'IL NE S'ÀGISSE D'UN EMPLACEMENT NON DANGEREUX.

WARNING: EXPLOSION HAZARD - SUBSTITUTION OF COMPONENTS MAY IMPAIR SUITABILITY FOR Class I, DIVISION 2.

AVERTISSEMENT - RISQUE D'EXPLOSION - LA SUBSTITUTION DECOMPOSANTS PEUT RENDRE CE MATERIEL INACCEPTABLE POUR LES EMPLACEMENTS DE CLASSE 1, DIVISION 2.

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

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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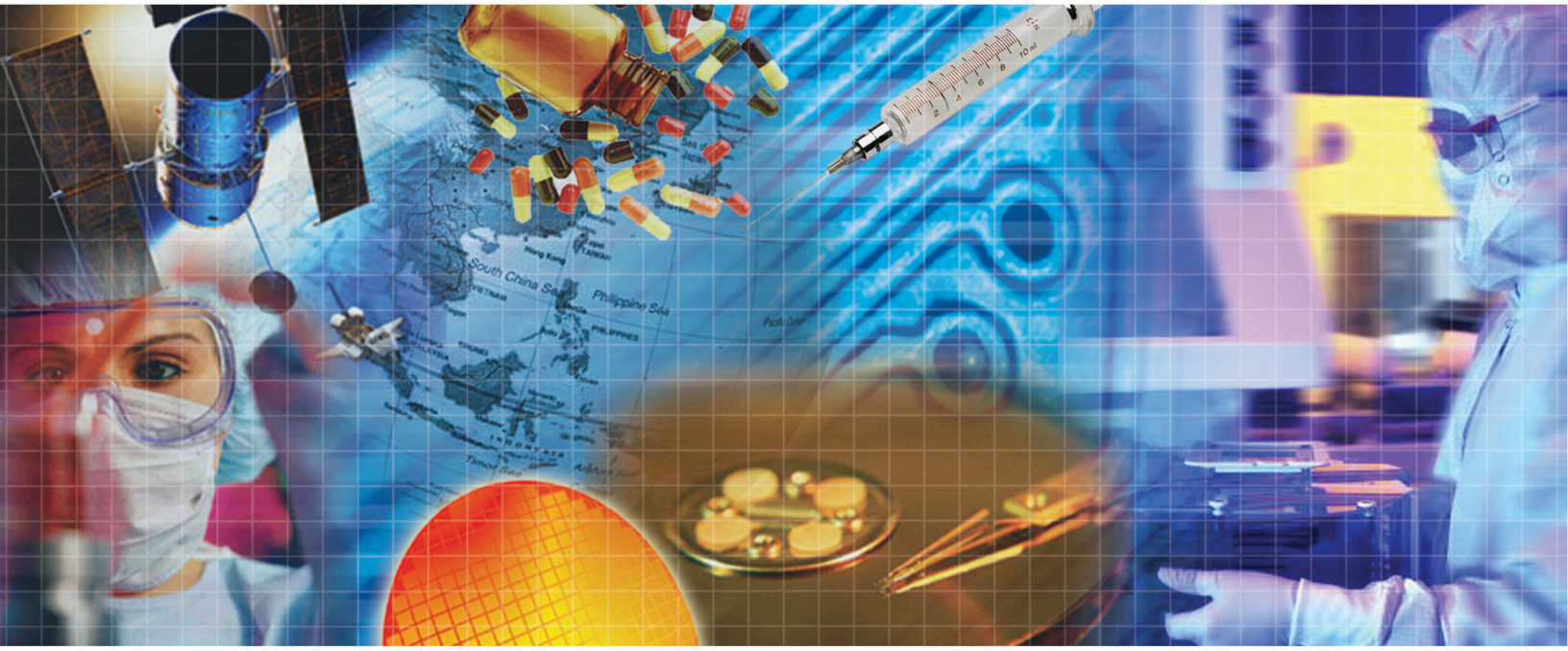

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