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USER GUIDE

ApexRp remote particle counters with pump

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Apex Remote With Pump

AIRBORNE PARTICLE COUNTER WITH PUMP













Operators Manual

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Lighthouse Worldwide Solutions

Apex Remote with Pump

Airborne Particle Counter

Models: ApexR3p, ApexR5p, ApexRBp, ApexR02p, ApexR03p, ApexR05p

Operators Manual

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LWS Part Number 248083480-1 R5

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About this Manual

This manual describes the detailed operation and use of the Lighthouse Worldwide Solutions Apex Remote With Pump, **ApexRp** Airborne Particle Counters.

Text Conventions

Boldface Introduces or emphasizes a term.

ApexRemoteWithPump, ApexRp, ApexRXp, ApexR0Xp, and Instrument can all refer to any or all models ApexR3p, ApexR5p, ApexRBp, ApexR02p, ApexR03p, or ApexR05p.

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 indicates a condition, which if not met, could cause serious personal injury or death, or damage to the instrument.

Additional Help

For more information about Lighthouse Airborne Particle Counters, contact

Lighthouse Worldwide Solutions
Service and Support
Tel: 1-800-945-5905 (USA Toll Free)
Tel: 1-541-770-5905 (Outside of USA)
techsupport@golighthouse.com
www.golighthouse.com

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1 General Safety

Safety Considerations

Warnings and cautions are used throughout this manual and the reader should become familiar with the meaning of a warning before operating the particle counter. Most warnings will appear in the left margin of the page next to the subject or step to which it applies. Take care when performing any procedures preceded by or containing a warning. The classifications of warnings are defined as follows:

- **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 a Class 1 LASER product (as defined by FDA 21 CFR, §1040.10) when used under normal operation and maintenance. Performing service on the internal sensor can, however, result in exposure to invisible radiation. 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”.

Electrostatic Safety Information

Electrostatic discharge (ESD) can damage or destroy electronic components. Therefore, any service or maintenance work should be done at a static-safe workstation. A static-safe workstation requires an ESD consultant to evaluate the work environment and propose the equipment and apparel needed for just such a workstation to be successful.

WARNING: There are no user-serviceable components inside the instrument.

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.

WARNING: Attempts by untrained personnel to disassemble, alter, modify, or adjust the electronics or optics may result in personal injury and damage to the instrument and will void its warranty. There are no user-serviceable components inside the particle counter. Only factory authorized service personnel should repair or service this instrument and its optical system. Review Lighthouse specifications before installing a DC power supply, and in the case of the ApexR0Xp instruments only, the PoE switch. Attempting to use under-rated power source equipment can expose the instrument, adjacent equipment and the user to dangerous shock and fire hazards. Failure to meet the specifications as provided by Lighthouse Worldwide Solutions will void the instrument Warranty and CE certification and may cause serious personal injury.

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

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2 Introduction

Overview

This operating manual introduces the Lighthouse **ApexRp** Remote Airborne Particle Counter With Pump and includes instructions for inspecting, installing, using and maintaining the instrument.

Description

The **ApexRp** instrument comes standard with two channel sizes and a flow rate of either 1.0 or 0.1 CFM. Optionally, the ApexRp can be shipped with up to four particle-size channels. Figure 2-1 below shows the ApexR3p and ApexR03p.



Figure 2-1: ApexR3p and ApexR03p Remote Airborne Particle Counters

The instrument uses a LASER diode light source and LASER beam shaping optics to illuminate a cross section of the air flow path. As particles move along this path, they cross the LASER beam and scatter light. The light scattered is collected by an optical imaging system onto a photodiode. The photodiode converts the image 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 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 analyze the height of each pulse and therefore the size of each corresponding particle. The result is that the number of particles of various sizes is determined.

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These instruments are effective in both ultra-clean areas (such as ISO Class 1 or Grade A) and in more traditional clean zones rated as ISO Class 3 or higher. Refer to Specifications tables in this manual for additional instrument information. The ApexRp line of Airborne Particle counters with pumps were created for continuous operation 24 hours per day, 7 days per week.

The instrument provides versatile mounting options and can be installed where space is at a premium.

The ApexRp integrates seamlessly with large facility monitoring/management systems and transfers particle count data using RS-485 (using MODBUS RTU or ASCII protocols) or Ethernet via MODBUS TCP for ApexRXp instruments or PoE (Power over Ethernet – IEEE 802.3af compliant) for ApexR0Xp instruments.

Accessories

Several optional accessories can be ordered to tailor the instrument to specific needs. These accessories are listed here:

- Isokinetic Sampling Probe (specify flow rate 1.0 CFM or 0.1 CFM)
- Sample Tubing (per foot)
- Cable (per foot)
- Wall Bracket (specify 1.0 CFM or 0.1 CFM Wall bracket size)
- Smart Bracket
- 0.1µm Purge Filter Assembly (Specify Flow Rate) with Tubing
- 24VDC Power Supply (1.0 CFM, 5A 120W, 0.1 CFM, 1A 25W)
- Configuration Kit (one included per order)**:**
- SmartPort Cable
- USB Flash Drive with Operation Manual
- Read Me First
- Parts List
- LMS XChange software (downloadable from website)

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3 Get Started

Unpacking and Initial Inspection

The instrument is thoroughly inspected and tested at the factory and is ready for use upon receipt. It is presumed that when the instrument was received, its shipping carton was inspected for damage. If the carton was damaged, the carrier was notified, and the carton was saved for carrier inspection. The instrument and other components were then removed from their packing materials and inspected for broken parts, scratches, dents, or other damage. Any damage was immediately reported to Lighthouse. Damaged cartons may be replaced by calling Lighthouse Sales. Keep an undamaged carton for reshipment of the instrument for its annual factory calibration.

Identify the ApexRp Model

The **ApexRp** is available in six (6) models:

ApexR3p	1.0 cfm flow rate, 0.3µm minimum channel size
ApexR5p	1.0 cfm flow rate, 0.5µm minimum channel size
ApexRBp	1.0 cfm flow rate, 5.0 µm minimum channel size
ApexR02p	0.1 cfm flow rate, 0.2µm minimum channel size
ApexR03p	0.1 cfm flow rate, 0.3µm minimum channel size
ApexR05p	0.1 cfm flow rate, 0.5µm minimum channel size

Compare Contents

Compare the contents with the pack slip / invoice / parts list. Report immediately any missing or wrong parts to Lighthouse Support at 1-800-945-5905 in the USA or 1-541-770-5905 outside of USA.

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Configuration Kit

Each order is shipped with a Configuration Kit, which includes the SmartPort Cable and software download instructions on the USB key. This cable and the software are required to set up all ApexRp instruments for use. Download and run the LMS XChange software from the www.golighthouse.com website at Software / Firmware Downloads » LWS - Lighthouse Worldwide Solutions (golighthouse.com)

Running the LMS XChange software will install the FTDI USB drivers and the LMS XChange software required to communicate with the instrument through the communication cable. This cable and the software are required to set up all ApexRemote instruments for use.

Software and SmartPort Cable Setup

- Turn DIP switch 7 ON to communicate with LMS XChange.
- Refer to Figure 3-1 and insert the SmartPort Cable's USB connector into a USB port on the computer. The computer should acknowledge the cable and report that it has found a new device – a Serial USB cable - and is installing its drivers. A COM port will be assigned to the cable.



Figure 3-1 SmartPort Cable Connections

NOTE: All ApexRp instruments require the SmartPort cable to set or change the IP address and set Alarms and Alarm Thresholds. Changes to MODBUS registers are the only other way to make these changes. Once changes are made you must update the ApexRp to save settings. Disconnect the cable BEFORE connecting the ApexRp to the instrument network!

- View the COM port assigned by using *Computer|Properties|Device Manager*. It will show as a USB Serial COM Port with a COM port number (see Figure 3-2). Right-click the Windows Start Icon, choose Device Manager and view COM ports assigned.

Note: While the USB connector is inserted in the computer port receptacle, its assignment will be displayed. If it is disconnected, the assignment will disappear until it is reconnected. Using this technique can quickly identify the correct port. This is handy if several ports are shown during this step.

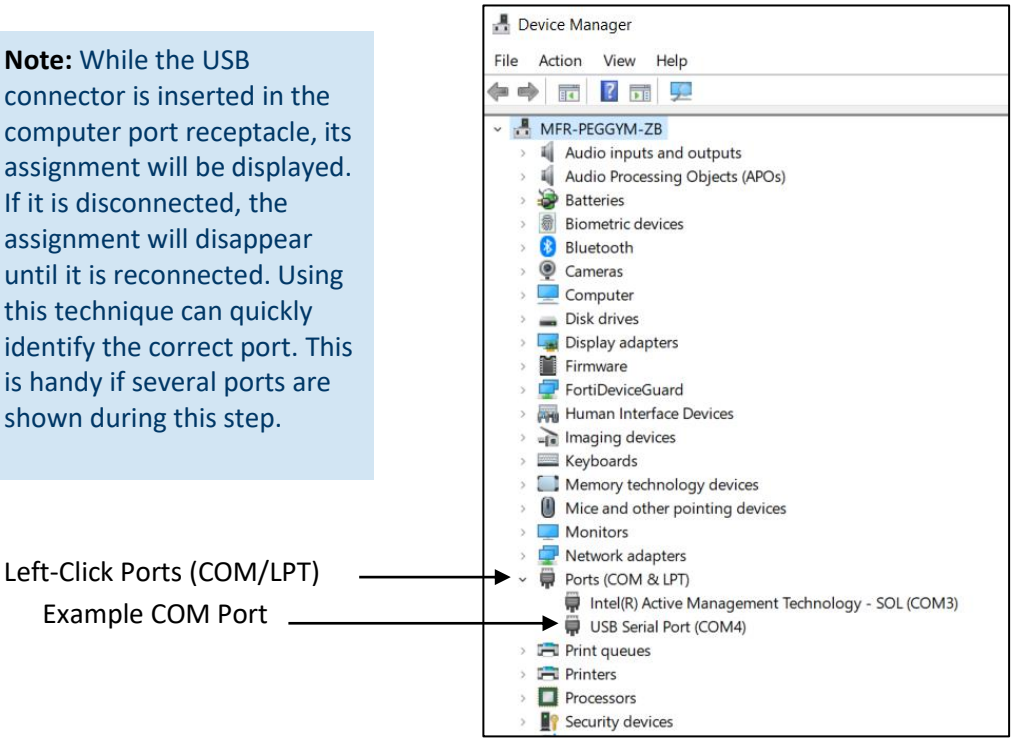


Figure 3-2 Viewing COM Port Assigned

- Exit menu.
- The **SmartPort Cable** can be used with all **ApexRp** sensors and must be used to set IP Address, date and time, and all Alarm and Alarm Threshold settings.
- Locate **SmartPort** on bottom of **ApexRp** as shown in Figure 3-3**.**

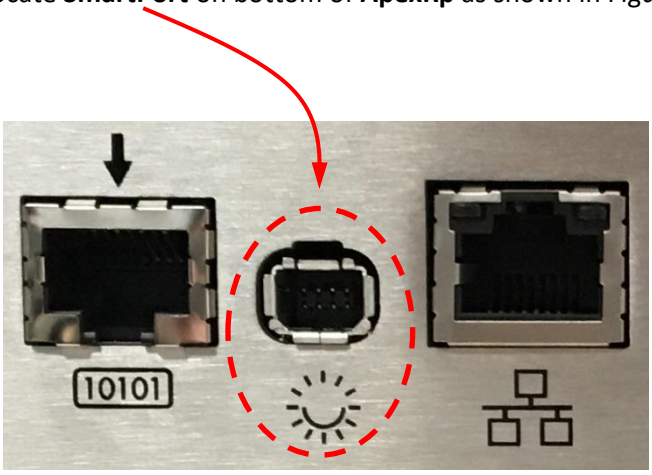


Figure 3-3 SmartPort Location

- Connect the **SmartPort Cable** to the **SmartPort** on **ApexRp**.
- Connect the Zero Count filter to the inlet barb.
- Attach the Power Supply to **ApexRp** and Attach the Power Supply to AC power.
- Verify the **ApexRp** Power LED comes on solid after a few seconds before attempting to run the LWS XChange Software.
- Open the LMS XChange program.
- Run the LMS XChange program (Reference LMS XChange Operators Manual available on the www.golighthouse.com website).
- Connect with the ApexRp
- After LMS XChange loads click on the Configuration tab and then



- Click on the Find an Instrument icon and the Instrument Details window will popup.

- Select the Instrument Model: Other, Connection Type: Serial, and COM Port: #.
- Press Connect and the Instrument Model and Serial # will appear.
- Press Continue. See Figure 3-4

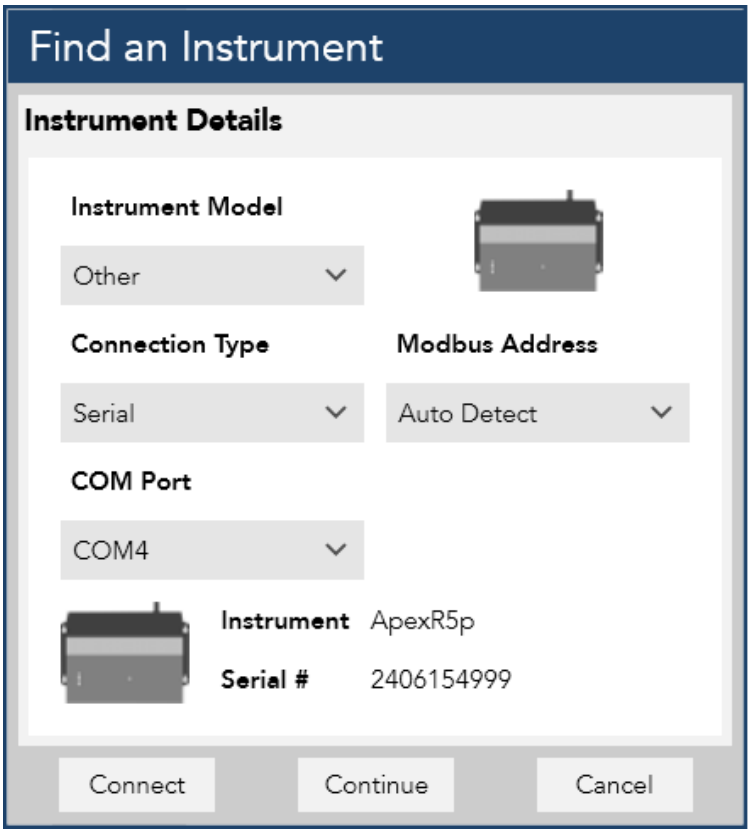


Figure 3-4 Find an Instrument – Instrument Details

- Click the Menu tab on the left screen. You should see Manage Configuration per Figure 3-5.

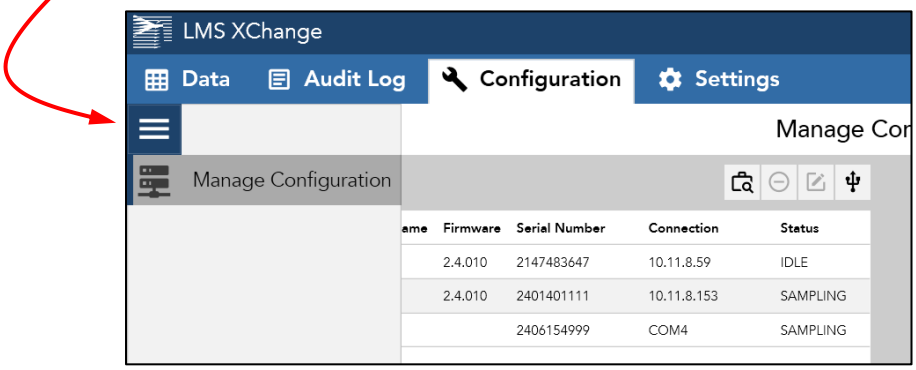


Figure 3-5 Configuration – Manage Configuration

- Double click the Instrument from the list of connected instruments. This will bring up the configuration menu tabs. See Figure 3-6

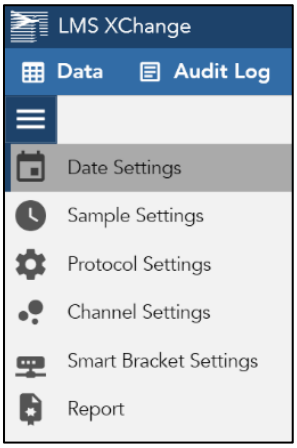


Figure 3-6 Configuration – Configuration Menus



- Click **Date Settings** tab and set the Instrument Date and Time. See Figure 3-7

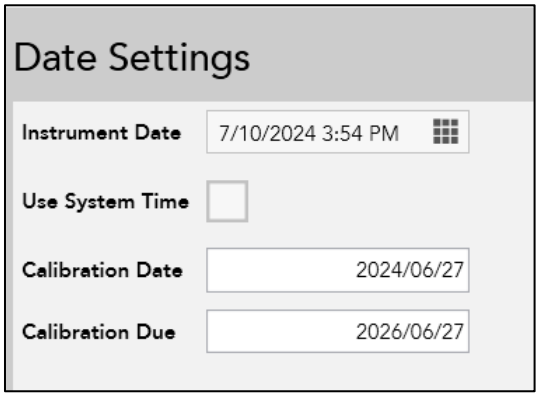


Figure 3-7 Configuration Menu – Date Settings

- Click on **Sample Settings** tab. Figure 3-8 shows the default Sample/Hold/Delay Time.

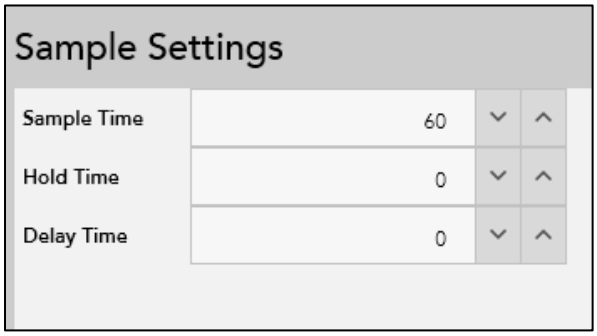


Figure 3-8 Configuration Menu – Sample Settings

- Click on **Protocol Settings** to view Ethernet (left) or Serial (right) settings. The **ApexRp** standard network settings are set to the same values for all **ApexRp**'s shipped. These values are 10.11.xx.xxx for IP, 255.255.0.0 for netmask and 0.0.0.0 as Default Gateway setting. To view the **ApexRp** web page, type its IP address into a web browser on a computer in the same network subnet. The IT group should provide IP, Mask and Default Gateway values that meet the local network needs. The **ApexRp** must be changed to meet these requirements. Each device will require the IP to be changed to a new IP, as shown in Figure 3-9, to prevent address conflicts.

- The **ApexRp** Serial address is set via the switches on the bottom of the instrument, based on Switch 7's state (see Table 4-1). The Address can be shown in the Protocol Settings screen.

- The **ApexRp** Serial must have its address set to a correct value, or it won't be recognized by various management programs, including LMS Express and LMS Express RT. The full switch address list can be found in Table 4-3.

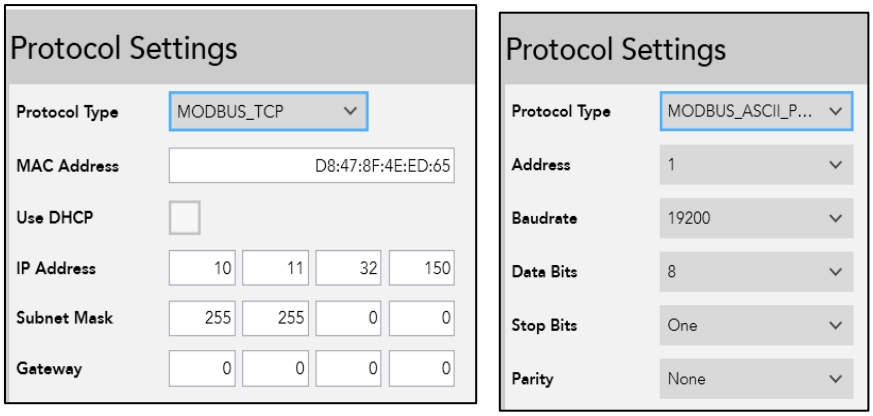


Figure 3-9 Configuration Menu – Protocol Settings



- Click on **Channel Settings** tab and review default limits and settings. When Temp or RH sensors are connected click on the box to enable those channels. Default Alarm Threshold settings are the same as all **ApexRp** models: Ch1 threshold = 1000, Ch2 threshold = 1000 and channel alarms are disabled. If the Alarm is enabled, the Alarm LED will turn on solid green until that Alarm's threshold value is exceeded, in which case the LED will turn red.

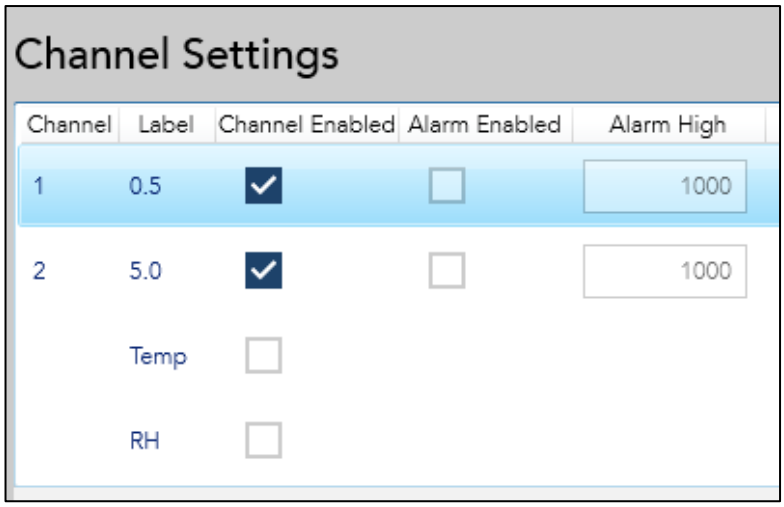


Figure 3-10 Configuration Menu – Channel Settings



- Click on **Smart Bracket Settings** tab to enable/disable Smart Bracket

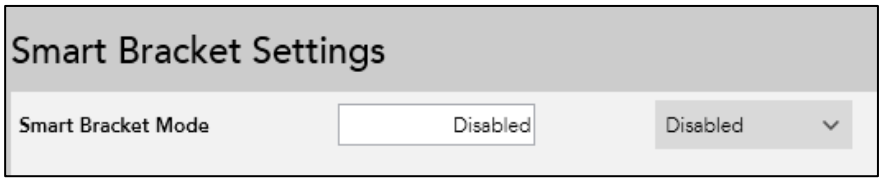


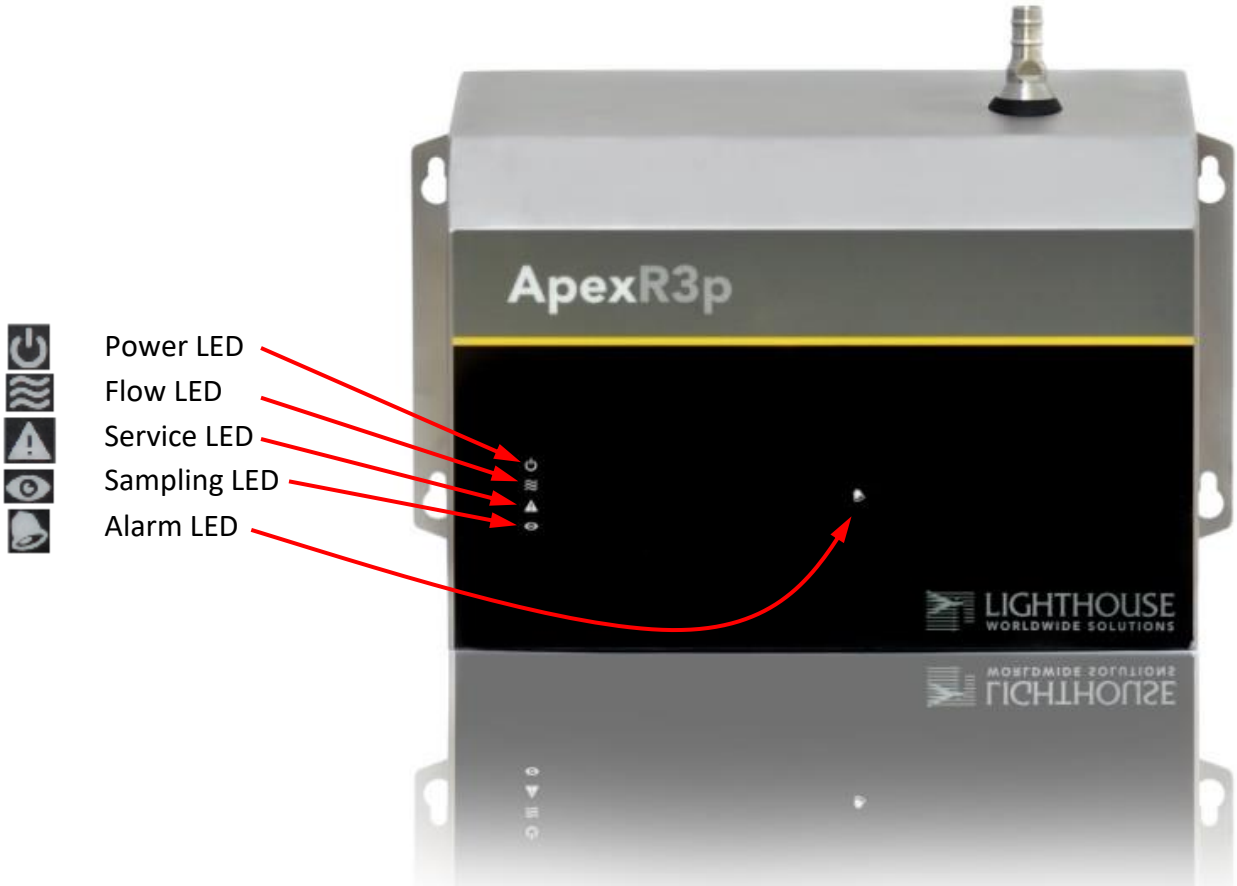
Figure 3-11 Configuration Menu – Smart Bracket Settings

- Click on **Report** tab to review the LWS Apex Remote Customer Report.

Operation

Understanding the LEDs

- The **ApexRp** LEDs have specific meanings when illuminated. Figure 3-10 below shows the location of the LEDs and gives a brief description of their meaning.



Power LED	**OFF** **GREEN**	= Power OFF. = Power ON.
Flow LED	**GREEN** **GREEN-BLINKING**	= Flow is within specification. = Flow is out of specification.
Service LED	**OFF** **AMBER** **AMBER-BLINKING**	= Normal Operation. = Laser power or current, Laser supply, photo amp is out of range. = Sensor background voltage is out of range.
Sampling LED	**OFF** **BLUE**	= Idle = Sampling
Alarm LED	**OFF** **GREEN** **RED** **BLUE-FLASHING 5Hz** **WHITE-FLASHING 5Hz**	= No alarms enabled. = Alarms enabled, within limits. = Alarm enabled, exceeding limits. = Validation mode. = Smart Bracket mode, bracket not detected.

Figure 3-10 Front Panel LEDs

4 Communications

This chapter contains information regarding how to set up communication with the **ApexRp** instrument.

ApexRp Serial DIP Switches

The **ApexRp** DIP switches are used to set up Serial communication. Refer to Table 4-1 for detailed DIP switch settings, their meaning, and effects.

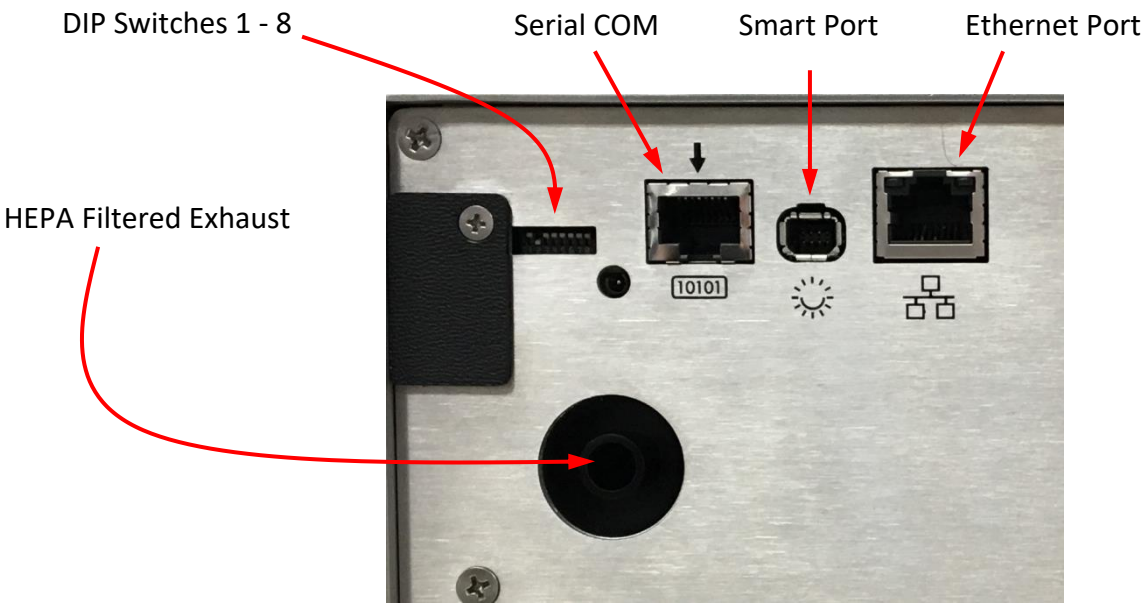


Figure 4-1 ApexRp Serial Connectors and DIP Switch

DIP Switch Definitions

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

Note: To change the DIP Switch settings use a tool with a very small, pointed tip.

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	COM Mode	See Table 4-2
7	Serial Protocol	UP=For Serial Communications, uses DIP Switch Addressing. DOWN= For Ethernet communication (i.e. to communicate with the XChange via Smart Port).
8	Reserved	

Table 4-1 DIP switch general settings

Communication Modes

The **ApexRp** Serial has options for MODBUS ASCII and MODBUS RTU. Table 4-2 displays those modes.

COMMUNICATIONS MODE	DIP SW 6
MODBUS ASCII (UP)	OFF
MODBUS RTU (DN)	ON

Table 4-2 DIP Switch Settings for ApexRp Serial COM Mode

DIP Switch Addressing

Table 4-3 details the addresses set by the binary DIP switches 1-5.

Note: Because Address 0 is reserved for broadcasting in MODBUS RS-485 communications, Address 1 is the lowest DIP switch setting that can be used. All switches OFF can cause communication failures on the network and must not be used.

DIP SWITCHES	ADDRESS	DIP SWITCHES	ADDRESS
0 0 0 0 0	Do Not Use	0 0 0 0 1	16
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

Table 4-3 DIP Switch Addressing

Communicating Serial with ApexRp Instrument

Serial Data / Power Port

The **ApexRp** is equipped with the Serial COM Port shown in Figure 4-2 to communicate to an RS-485 network incorporating LMS equipment, such as the LMS 485 Gateway and Lighthouse System Control Cabinet.

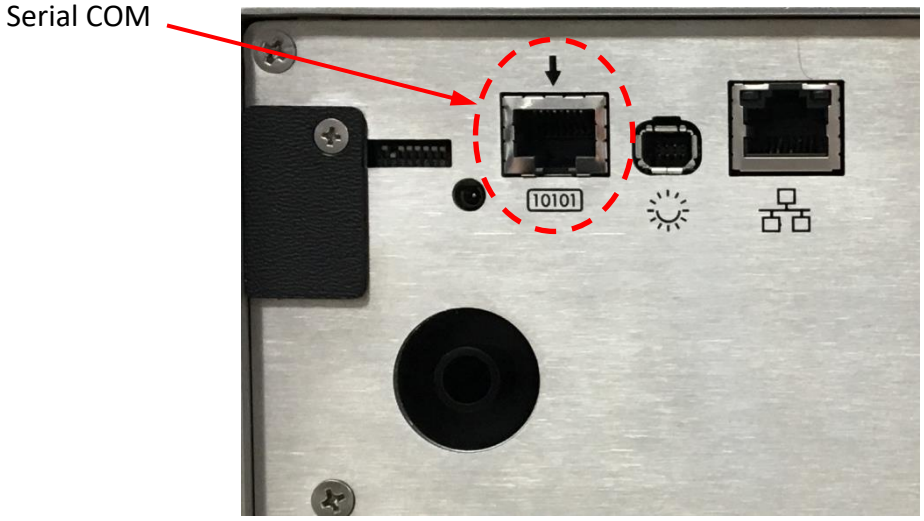


Figure 4-2 Serial COM Port

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The connector pinouts are shown in Table 4-4.

RJ45 Pin	Signal Name
1	RS-232 TX (Output)
2	RS-232 RX (Input)
3	RESERVED for future use
4	RS-485B
5	RS-485A
6	RESERVED for future use
7	Not Connected
8	GROUND

Table 4-4 RJ45 Pinouts

To connect the instrument to an RS-485 network:

1. Make sure the **SmartPort Cable** is disconnected from the instrument.

2. Install the **ApexRp** in a perpendicular position with its Inlet barb upward. Connect one end of a CAT5e cable to the Serial COM port on the instrument (shown in Figure 4-2).

3. Connect the other end of the cable to an available RS485 port on an LWS 485 Gateway, an LWS System Control Cabinet RS485 port or other similar equipment port.

RS-485 Communications

RS-485 must be used if the instrument is more than 50 feet from a computer or is installed in an industrial network. Refer to Table 4-5 for specifics about RS-485. Contact Lighthouse Technical Support for more information.

Table 4-5 shows the Electronics Industry Association (EIA) industry Standards RS485 specifications.

SPECIFICATIONS	RS-485
Mode of Operation	Differential
Total Number of Drivers and Receivers on One line (one driver active at a time for RS-485 networks)	32 Drivers 32 Receivers
Maximum Cable Length	4,000 ft (1,219.2 m)
Maximum Data Rate (40 ft – 4000 ft for RS422/RS-485)	100 Kbs – 10 Mbs
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 Lad for RS-485)	>12k

Table 4-5 EIA Industry Standards for RS-485 Communications

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Ethernet Settings:

The ApexRXp and ApexR0Xp comes with the Ethernet Enabled (default) and the DHCP disabled.

The ApexR0Xp can use a PoE (Power over Ethernet – IEEE 802.3af compliant) switch to get its data and power which eliminates the need for an external power supply. This allows convenient installation because only one CAT6 cable is required. It can also use a non-powered Ethernet connection with an external 24VDC power supply.

Enter the correct settings in **IP Address**, **Subnet and Gateway**.

The IT group should provide these numbers to prevent conflicts with devices already on the network. All TCP/IP values should be static.

Checking the DHCP checkbox (Figure 4-3) can cause the instrument and its data to become 'lost' when its IP Address is changed during updates from the DHCP server. Ensure DHCP is OFF.

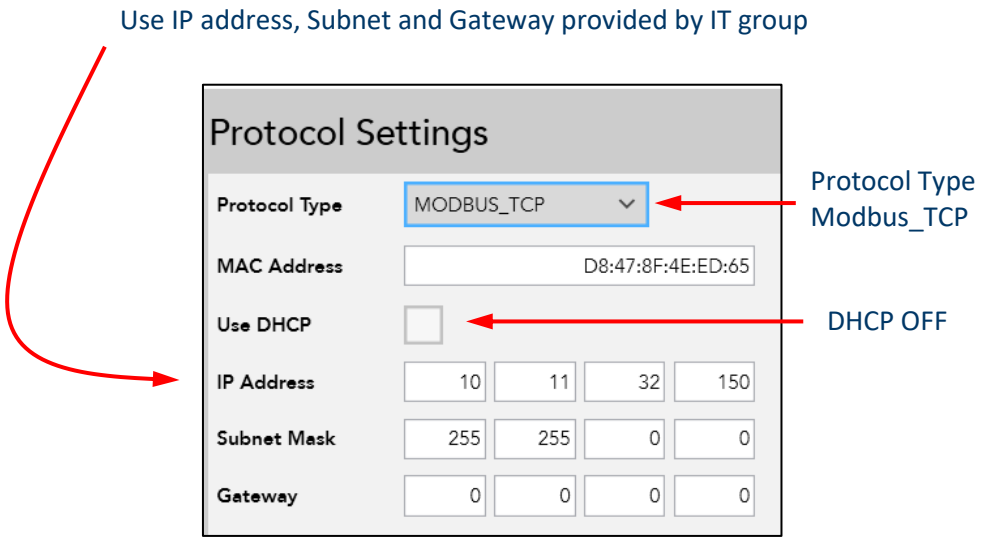


Figure 4-3 Configuration Menu: XChange Protocol Settings Screen

ApexRp Web Page Interface

Another feature of the **ApexRp** is the Web Interface that allows real time monitoring of the instrument's data. All monitor points will show current record data, last 5 data records, location info, serial number, model, sampling parameters, location status, flow status, service status and alarm status. All diagnostic results will also be displayed.

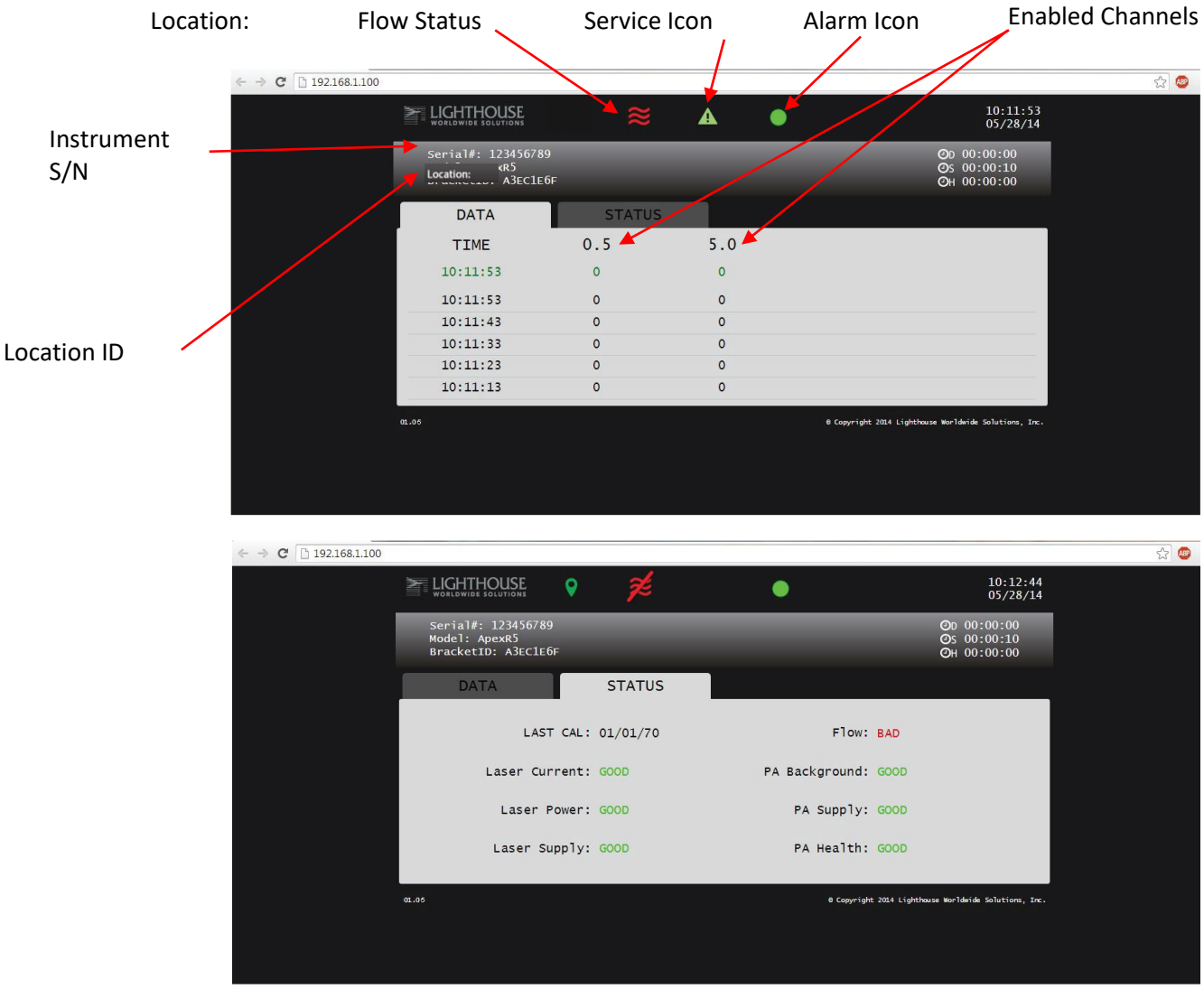


Figure 4-5 ApexRp Data and Status Web View

NOTE: It has been learned that certain antivirus programs may block, interrupt or seriously affect ApexRp's web server functions.

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5 Maintenance Procedures

Introduction

This chapter provides routine maintenance instructions that the **ApexRp** instrument requires. The maintenance procedures described in this chapter are not required on regular or prescribed intervals and should be performed only if the user has reason to question the data they are receiving.

Safety

Before performing any of the maintenance tasks described in this chapter, read Chapter 1 of this manual and become familiar with the warnings and caution labels.

Maintenance Calibration

To maintain optimum performance of this instrument, it should be recalibrated annually by a Lighthouse Authorized Service Provider.

False Count Test

This section will provide the user a procedure to determine if the **ApexRp** can successfully complete several zero counts. A purge filter must be attached to the instrument and six (6) five (5) minute samples must be taken. There should be no more than 1 count on average per five-minute sample.

1. Connect the Purge filter to the sample inlet.
2. Apply power to the instrument.
3. Configure the unit to sample for 30 minutes.
4. Allow the instrument to sample through a 30-minute period. This time allows the unit to warm up and purge any residual particles that might be inside it.
5. Configure the unit to sample for 5 minutes with a 10-second hold.
6. Allow the instrument to take 6 samples.
7. If an average of more than one count per five-minute period is reported, allow the instrument to sample for 30 minutes to purge it, then repeat the test (Steps 5 & 6).
8. After the instrument has met the requirement of the Purge Count test, return the instrument to its normal location and operating status.

Fault Isolation

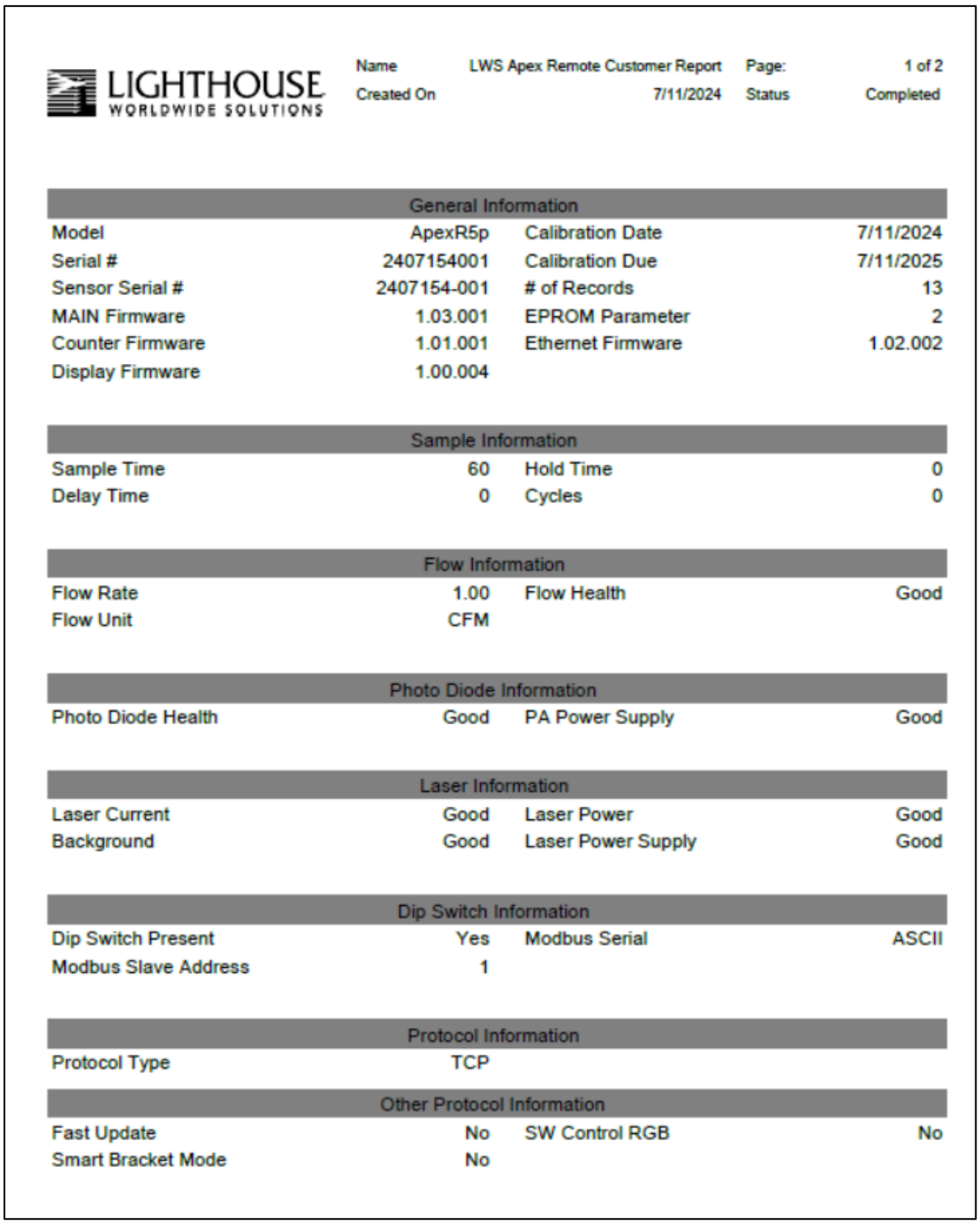
If the instrument does not pass the Purge Count test, perform the following procedure:

1. Verify that the Inlet and Outlet barbs are finger-tight - do NOT over tighten.
2. Check the data over the last 6 five-minute sample times.
3. If sporadic counts are occurring over all channels, the unit may still have particles inside it. Allow the unit to sample overnight with the purge filter attached before retesting it. If the counts are still high after the overnight purge, call Lighthouse Technical Support for assistance.
4. If the data shows consistent counts in the smallest channel only, the instrument may have electrical problems and may need to be returned to Lighthouse. Call a Lighthouse Service Representative for assistance.

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Instrument Customer Report

The Instrument Customer Report screen shows **ApexRp** diagnostic information. The displayed information can be saved to a pdf file. Figure 5.1a and 5.1b shows both the first and second pages of the report.



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Name	LWS Apex Remote Customer Report	Page:	1 of 2
Created On	7/11/2024	Status	Completed

General Information			
Model	ApexR5p	Calibration Date	7/11/2024
Serial #	2407154001	Calibration Due	7/11/2025
Sensor Serial #	2407154-001	# of Records	13
MAIN Firmware	1.03.001	EPROM Parameter	2
Counter Firmware	1.01.001	Ethernet Firmware	1.02.002
Display Firmware	1.00.004		

Sample Information			
Sample Time	60	Hold Time	0
Delay Time	0	Cycles	0

Flow Information			
Flow Rate	1.00	Flow Health	Good
Flow Unit	CFM		

Photo Diode Information			
Photo Diode Health	Good	PA Power Supply	Good

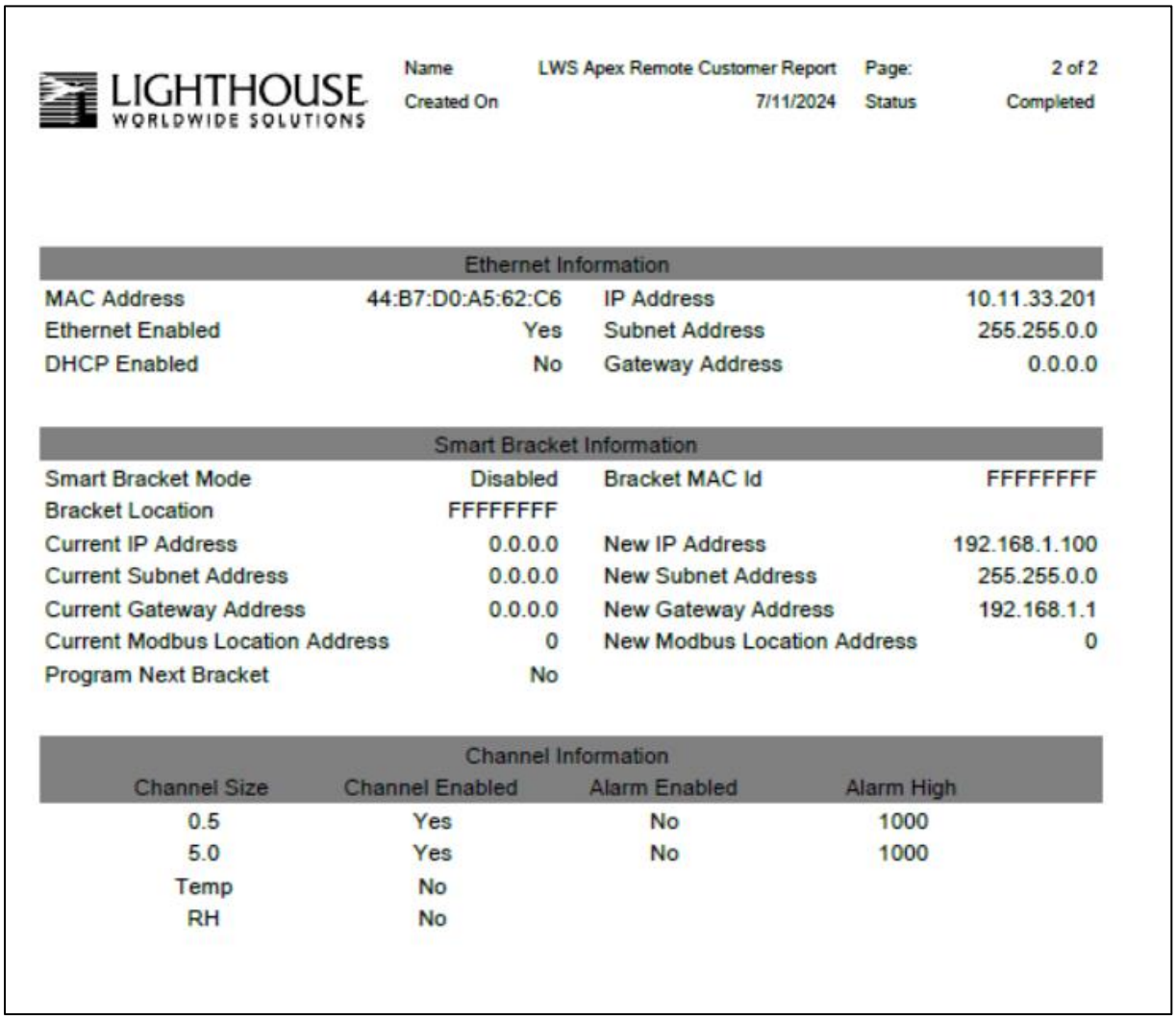
Laser Information			
Laser Current	Good	Laser Power	Good
Background	Good	Laser Power Supply	Good

Dip Switch Information			
Dip Switch Present	Yes	Modbus Serial	ASCII
Modbus Slave Address	1		

Protocol Information	
Protocol Type	TCP

Other Protocol Information			
Fast Update	No	SW Control RGB	No
Smart Bracket Mode	No		

Figure 5-1a LWS Apex Remote Customer Report – First Page



LIGHTHOUSE WORLDWIDE SOLUTIONS

Name	LWS Apex Remote Customer Report	Page:	2 of 2
Created On	7/11/2024	Status	Completed

Ethernet Information

MAC Address	44:B7:D0:A5:62:C6	IP Address	10.11.33.201
Ethernet Enabled	Yes	Subnet Address	255.255.0.0
DHCP Enabled	No	Gateway Address	0.0.0.0

Smart Bracket Information

Smart Bracket Mode	Disabled	Bracket MAC Id	FFFFFFFF
Bracket Location	FFFFFFFF		
Current IP Address	0.0.0.0	New IP Address	192.168.1.100
Current Subnet Address	0.0.0.0	New Subnet Address	255.255.0.0
Current Gateway Address	0.0.0.0	New Gateway Address	192.168.1.1
Current Modbus Location Address	0	New Modbus Location Address	0
Program Next Bracket	No		

Channel Information

Channel Size	Channel Enabled	Alarm Enabled	Alarm High
0.5	Yes	No	1000
5.0	Yes	No	1000
Temp	No		
RH	No		

Figure 5-1b LWS Apex Remote Customer Report – Second Page

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6 Program with MODBUS Protocol

ApexRp instruments can be programmed using MODBUS Protocol. The full protocol, as used, is detailed in Appendix A: "**ApexRp** MODBUS Register Map v1.50" 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, ApexRp reads the DIP switches.

Note: When changing the DIP switch settings, the instrument must be power-cycled.

Protocol Settings

The MODBUS Protocol is defined through an RS-232 or RS-485 interface with:

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

Power On/Auto Start

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

- Sample Time = 60 seconds
- Hold Time = 0 seconds
- Alarm Channel = Disabled

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

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

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

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Running the Instrument Using MODBUS

The applicable action commands are displayed in Table 6-1.

Value	Action
1	Saves all writable 4xxxx register values to the EEPROM.
3	Clears the Data Buffer. Record count is sent to zero.
4	Saves the instrument parameters in the 40xxxx registers to the EEPROM. Parameters include Sample Time, Hold Time and Location.
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.

Table 6-1 Action Commands

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, any partial data will not record to the buffer.

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

11 Start Instrument; to start recording

12 Stop Instrument; to stop recording

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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 6-2.

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.

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

Table 6-2 Real Time Clock Registers

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 6-3.

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]

Table 6-3 Data Set Registers

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).

The Real Time Clock can also be set in the Configuration Software Tool.

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Changing the Default Instrument Parameters

The main instrument parameters involved with the operation of the ApexRp are Location, Sample Time, and Hold Time. See Table 6-4.

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 (32,767 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.

Register	Data Type	Description
40026	Unsigned Integer	Location Number [low] Provides location ID for where data was recorded. State is read/write.
40031	Unsigned Integer	Hold Time [high] Works in conjunction with 40032. Number of seconds to wait between sample period. 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]

Table 6-4 Instrument Parameters

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 the location where a sample was recorded.

Hold Time (Registers 40031, 40032)

The Hold Time is used for pausing in between samples for multiple cycles. 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).

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Alarm and Threshold Registers

Alarm Enable Registers

The Alarm Enable input registers (43xxx series) shown in Table 6-5 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.

Note: Alarm Enable currently only works for Particle Channels.

Bit	Description
0	Channel Enable (0=disable, 1=enable), works in conjunction with Alarm Enable.
1	Alarm Enable (0=disable, 1=enable), requires channel enable, as well.
2	RESERVED

Table 6-5 Alarm Enable/Disable Bits

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.

Enabling the Alarm for a particle channel requires the channel be enabled, as well, setting the bit in the low word of that channel. The user can enable any or all active particle channels at a time and can set a different alarm threshold for each.

Particle data registers for the Alarm Enable setting start at 43009 for the high word and 43010 the low word for channel 1. See Table 6-6.

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

Table 6-6 Alarm Enable Registers

Enable Alarming for a Channel

Alarm 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 as shown in Table 6-7, the user would 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 and 43012.

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

Registers	Particle Channel	Bit 1 Enabled
43009 - 43010	1	0
43011 - 43012	2	1

Table 6-7 Example of Alarming on Channel 2

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.

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.

The threshold registers (45xxx series) shown in Table 6-8, 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.

Note: The **ApexRp** comes standard with 2 particle channels.

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Register	Data Type	Description
45009	unsigned integer	Threshold for Particle Channel 1 [high] (smallest particle size starts here)
45010	unsigned integer	Threshold for Particle Channel 1 [low]
45011	unsigned integer	Threshold for Particle Channel 2 [high]
45012	unsigned integer	Threshold for Particle Channel 2 [low]
45013	unsigned integer	Threshold for Particle Channel 3 [high]
45014	unsigned integer	Threshold for Particle Channel 3 [low]
45015	unsigned integer	Threshold for Particle Channel 4 [high]
45016	unsigned integer	Threshold for Particle Channel 4 [low]

Table 6-8 Alarm Threshold Registers

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 6-9.

Registers	Particle Channel	Threshold Value
45009 – 45010	1	1000
45011 – 45012	2	1000

Table 6-9 Alarm Threshold Registers set to 1000

7 Install

Install the ApexRp

Installation Basics:

This section is provided as an example of a typical **ApexRp** installation. The tools and hardware shown are examples and may not apply to all installations. It is suggested that safety glasses and other equipment be used to prevent injury. Do **NOT** attempt to drill into a wall that may have live AC power behind the wallboard being drilled. Contact Facilities Management personnel to have the area made safe before beginning installation.

The **ApexRp** must be mounted on a vertical flat surface and must have the Inlet to Outlet path as close to vertical as possible.

WARNING: Power Supply specifications are 100-120VAC, 47-63Hz, 24VDC, 1A output 25W max (for 0.1 units) OR 5A output 120W max (for 1.0 units). Replacing with a power supply that does not meet these specifications may void the **ApexRp** warranty and risk exposing equipment and users to fire and shock hazard. If replacement of the power supply or its AC power cord is required, replace only with a power supply or cord having as good as or better ratings than the items provided by Lighthouse Worldwide Solutions. Attempting to use an under-rated power supply or cord can expose the instrument power supply, adjacent equipment or the user to dangerous shock and fire hazards. Failure to heed this warning can result in personal injury or death.

WARNING: Make sure the installation point for the ApexRp **does not** prevent easy disconnect of the instrument power.

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Installing the Wall Bracket/ApexRp

Tools/Hardware Required:

Every installation of measuring instrument is dependent upon facility surroundings, construction materials and points of placement. Due to these differences, specific instructions cannot be supplied in this document. However, the listed tools and hardware shown in Figure 7-1 are typical for most installations.



Figure 7-1 Required Tools and Hardware

WARNING: Make sure target location is electrically safe for drilling. Wear safety goggles while drilling.

1. Find a point close to necessary connections, such as network and AC power, and where the instrument can be easily accessed by operators or technical support personnel. The power input connection must allow safe and easy manual disconnect of power if needed.

2. If the optional Wall Bracket was not ordered, the body of the ApexRp can be used as a template to mark the two mounting holes. Make sure the instrument is level then use a pencil to mark the center of the mounting holes. The distance between the holes should be 5.75". Proceed to step 4.

3. If the Wall Bracket was ordered, use the Wall Bracket as a template. Make sure it is level then use a pen or pencil to mark the center of the mounting holes. The Wall Bracket has 3/16" holes and has been designed to accept 3/16-24, #8 or #10 flat head screws. See Figure 7-2.

4. Use the appropriate size drill bit and drill the holes as marked.

5. Install the Anchors into the drilled holes.



Figure 7-2 Mark Location of Mounting Holes

6. For ApexRp installation without Wall Bracket, install the ApexRp using the installed anchors and appropriate screws. Proceed to step 9.

7. For Wall Bracket installation, attach the Wall Bracket using the installed anchors. Make sure to use flat head screws to maintain clearance from the rear of the ApexRp.

8. Attach the ApexRp to the Wall Bracket by slipping it over the mounting screws provided and sliding it downward on the Bracket. Tighten the two screws.

9. The ApexRp is now ready for connection to the network.

Installing ApexRp without Wall Bracket

1. Using a bubble level to ensure ApexRp is level, place the ApexRp against the vertical surface upon which it will be mounted.

2. Mark the center of each mounting tab's larger hole then remove the ApexRp from the surface and drill pilot holes for the mounting hardware.

3. Install the mounting hardware then the ApexRp, snugging the instrument to prevent wobble or movement while it is in use.

4. Connect the communication cable and the power cable.

5. The instrument is ready for connecting and integrating into the instrumentation network.

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Connections

The top of the instrument has one connection: the inlet nozzle for sample input shown in Figure 7-6.



Figure 7-6 Connections on Top

The 1.0 CFM instruments (ApexR3p, ApexR5p) sensors can be used with a 3/8” barbed inlet ISO probe attached via 3/8" ID tubing.

The 0.1 CFM instruments (ApexR02p, ApexR03p, ApexR05p) sensors can be used with a 1/8” barbed inlet ISO probe attached via 1/8" ID tubing.

The ApexRBp should be used with the ISO probe only. Use of tubing with the ApexRBp is not recommended, as the larger particle sizes may drop out, affecting accuracy of counting.

The sum of exhaust tubing length plus inlet tubing length to ISO kinetic probe may not exceed 10 feet, (3.0 meters).

Figure 7-7 shows both the Serial and Ethernet/PoE connections at the bottom of the ApexR0Xp.

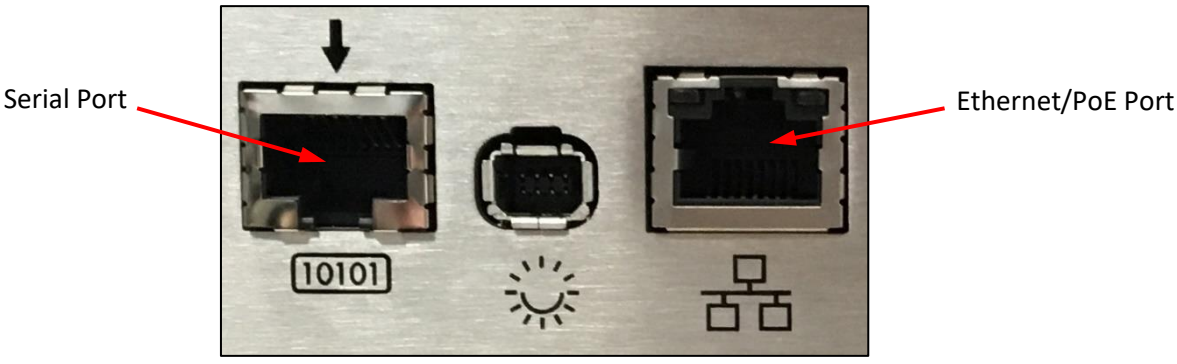


Figure 7-7 ApexR0Xp Serial and Ethernet Instrument Connections

Power Consumption:

The ApexRp has a connection for an external 24VDC supply. See figure 7-8.

Exhaust Port

ApexRp uses an internal blower to provide a vacuum source. The blower exhaust is HEPA filtered so as not to contaminate the surrounding monitoring environment. See figure 7-8.

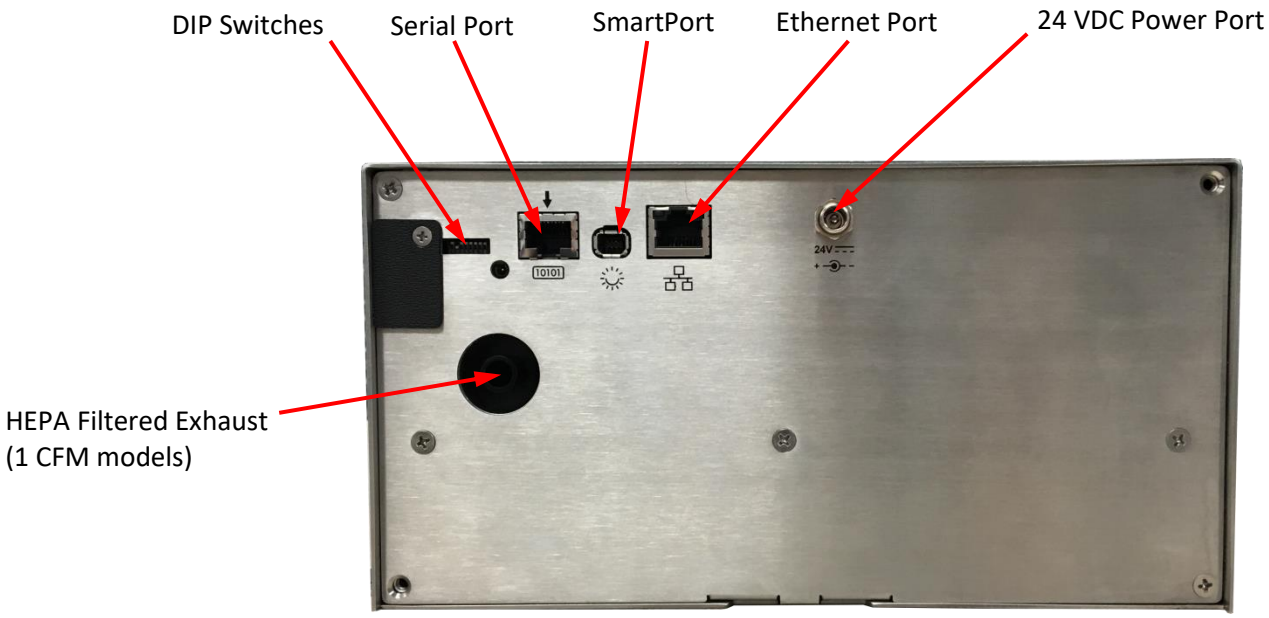


Figure 7-8 ApexRp Connections

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Real-time LMS Pro/Pharma Data Download

Lighthouse offers several software products to download, monitor and manage data gathered by the **ApexRp** instruments, as well as other RS-485/MODBUS particle counters. When these instruments are connected to an RS-485 or Ethernet network that is monitored and managed by a PC running the Lighthouse Monitoring System (LMS) Express or Express RT (Real Time), they can be identified and controlled by the software. Data can be downloaded from the instruments and put into graphs and charts and archived for future use. Make sure the COM port is set to 19200 BAUD to connect to the USB to-RS-485 converter.

For 3rd-party software use, contact Lighthouse Sales and Support.

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 Material Authorization (RMA) number. Reference this number on all shipping documentation and purchase orders. After receipt of the RMA number follow the shipping instructions below:

1. Use the original container, nozzle caps and packing materials whenever possible. Remove attachments, such as TRH or Isokinetic probes, and package to prevent physical and ESD damage.

2. If the original container and packing materials are not available, contact Lighthouse to purchase a replacement shipping container and nozzle caps. If it necessary, 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.

3. If the instrument is damaged during shipment due to inadequate user packing, the warranty may be voided and result in additional repairs being billed to the customer.

4. Seal container or carton securely. Mark “FRAGILE” and write the Return Material Authorization (RMA) number on any unmarked corner.

5. Return the instrument to the address provided by a Lighthouse representative or the RMA website.

WARNING: If the instrument is damaged during a return shipment due to inadequate user packing, the warranty may be voided and result in additional repairs being billed to the customer.

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A ApexRp MODBUS Register Map v1.50

COMM Settings

Lighthouse particle counters with MODBUS use the following communications settings:

Note: **ApexRp** currently supports only upper case.

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

Table A-1 MODBUS Communications Settings

The MODBUS slave address is set on the particle counter.

Supported MODBUS Commands

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

Table A-2 MODBUS Registers

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

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Sensor Settings Registers

Instrument settings are stored in holding registers (the 40xxx series), which are mostly read/writable. Not all holding registers are writable. Table A-3 describes the content of these 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, 135d = v1.35.
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, 235d=v2.35
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]
40020	ASCII string	Model Name char[10], char [11]

Table A-3 Sensor Settings Registers

Register	Data Type	Description
40021	ASCII string	Model Name char[12], char [13]
40022	unsigned integer	Model Name char[14], char [15]
40023	unsigned integer	Flow Rate. See registers 40041-40042 for flow rate units. Liquid Particle Counters and Samplers: Value equals flow rate. For example: 100d=100. All Other Instruments: Divide by 100 to get flow rate. For example: 100d=1.00
40024	unsigned integer	Record Count. Total number of records stored in the counter.
40025	unsigned 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 where data was recorded. Must be 1 to 200 (maps to location names associated with registers 40200 - 40999).
40027	signed integer	Real Time Clock (RTC) [high]. Displays 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.
40034	unsigned integer	Sample Time [low]

Table A-3 Sensor Settings Registers

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Register	Data Type	Description
40035	unsigned integer	Data Set [high]. Works in conjunction with 40036. Updates the instrument's real time clock. Setting is the number of seconds since midnight, 1/1/1970. This number can be generated by the ANSI C/C++ time() function.
40036	unsigned integer	Data Set [low]
…		
40041	ASCII string	Flow Unit - Defines the Unit that Flow Rate 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	**ApexRp**: 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].
…		
40050	signed integer	Device Options
…		
40054	unsigned integer	Location ID[high]. Value is 0 when no location bracket is present.
40055	unsigned integer	Location ID[low]. Value is 0 when no location bracket is present. Value matches 40026 location number when bracket is present.
40056	unsigned integer	Device Status[high]
40057	unsigned integer	Device Status[low].
40058	unsigned integer	Serial number [high].
40059	unsigned integer	Serial number [low].

Table A-3 Sensor Settings Registers

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Register	Data Type	Description
40060	signed integer	Last Sample Timestamp [high] (# of seconds since midnight, 1/1/1970.).
40061	signed integer	Last Sample Timestamp [low].
40062	signed integer	Last Setting Change Timestamp [high] (# of seconds since midnight, 1/1/1970.). Value indicates.
40063	signed integer	Last Setting Change Timestamp [low].
40064	signed integer	Run-time particle channel alarm high flags (bit 0 = channel 1, …).
40065	signed integer	Run-time particle channel alarm low flags (bit 0 = channel 1,…).
40066	signed integer	Run-time analog channel alarm high flags (bit 0 = channel 1,…).
40067	signed integer	Run-time analog channel alarm low flags (bit 0 = channel 1,…).
40068	unsigned integer	Software controlled RGB LED red channel. Uses values from 0-100 for duty cycle percentage every even second from UNIX time.
40069	unsigned integer	Software controlled RGB LED green channel. Uses values from 0-100 for duty cycle percentage every even second from UNIX time.
40070	unsigned integer	Software controlled RGB LED blue channel. Uses values from 0-100 for duty cycle percentage every even second from UNIX time.
40071	unsigned integer	Software controlled RGB LED red channel. Uses values from 0-100 for duty cycle percentage every odd second from UNIX time.
40072	unsigned integer	Software controlled RGB LED green channel. Uses values from 0-100 for duty cycle percentage every odd second from UNIX time.
40073	unsigned integer	Software controlled RGB LED blue channel. Uses values from 0-100 for duty cycle percentage every odd second from UNIX time.
40074	signed integer	**ApexRp**: Last Calibration Date [high]. Indicates when instrument was last calibrated. This number can be generated by ANSI C/C++ time() function.
40075	signed integer	**ApexRp**: Last Calibration Date [low]

Table A-3 Sensor Settings Registers

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Device Options

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

Bits	Description
5	ApexRp: Software controlled RGB LED (1=Enabled, 0=Disabled)
6	ApexRp: Location Bracket (1=Enabled, 0=Disabled)

Table A-4: Device Options

Device Status

The Device Status registers (40003 and 40057) display the status of the device (Table A-5). Additional status bits are shown in 40056 (Table A-6).

Bits	Description
0	**RUNNING:** Set when a start command is executed via Command 11 (instrument start) or through the user interface. The flag will remain set until a stop command is executed.
1	**SAMPLING:** This is set only when the instrument is 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.
3	**DEVICE ERROR:** if there is a failure on the device, this bit is set to indicate possible invalid data has been collected.
9	ApexRp: **DATA VALIDATION:** Set to 1 when unit is in data validation mode, else set to 0.
10	**ApexRp**: **LOCATION VALIDATION:** Set to 1 when unit is in Location Validation mode, else set to 0.
11	**ApexRp**: **LASER STATUS:** Set to 1 when unit's LASER is out of spec, else set to 0.
12	**ApexRp**: **FLOW STATUS:** Set to 1 when unit's flow is out of spec, else set to 0.
13	**ApexRp**: **SERVICE STATUS:** Set to 1 when unit needs to be serviced, else set to 0.
14	**ApexRp**: **THRESHOLD HIGH STATUS:** Set to 1 when unit's high alarm threshold is exceeded, else set to 0.
15	**ApexRp**: **THRESHOLD LOW STATUS:** Set to 1 when unit's low alarm threshold is not met, else set to 0.

Table A-5 Device Status (40003/40057)

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Additional status bits are shown in 40056 displayed in Table A-6.

Bit	Description
0	**ApexRp**: **LASER POWER STATUS**: Set to 1 when unit's LASER power is out of spec, else set to 0
1	**ApexRp**: **LASER CURRENT STATUS:** Set to 1 when unit's LASER current is out of spec, else set to 0
2	**ApexRp**: **LASER SUPPLY STATUS:** Set to 1 when unit's LASER supply is out of spec, else set to 0
3	**ApexRp**: **LASER LIFE STATUS:** Set to 1 when unit's LASER Life is out of spec, else set to 0
4	**ApexRp**: **NO FLOW STATUS:** Set to 1 when unit's flow is below no flow threshold causing LASER to turn off, else set to 0.
5	**ApexRp**: **PHOTOAMP SUPPLY STATUS:** Set to 1 when unit's photo amp supply is out of spec, else set to
6	**ApexRp**: **BACKGROUND STATUS:** Set to 1 when unit's photo amp background is out of spec, else set to 0
7	**ApexRp**: **PHOTODIODE STATUS:** Set to 1 when photodiode has failed, else set to 0
8	**ApexRp**: **CALIBRATION DUE DATE STATUS**: Set to 1 when unit is past calibration due date, else set to 0
9	**ApexRp**: **LOCATION BRACKET STATUS:** Set to 1 when unit is in location bracket mode and bracket is missing, else set to 0.

Table A-6 Device Status (40056)

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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 Bit Description response. When this register is read, it always returns a zero.

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.
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.
17	Instrument Location Validation Start: **ApexRp**: Start blinking Alarm LED blue
18	Instrument Location Validation Stop **ApexRp**: Stop blinking Alarm LED blue
19	Instrument Data Validation Start **ApexRp**: Start sampling with dummy data using current sampling parameters. Data is also tagged as validation.
20	Instrument Data Validation Stop **ApexRp**: Stop sampling with dummy data using current sampling parameters. Data is also tagged as validation.

Table A-7 Command Register

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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.

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

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.

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

Table A-8 Alarm Enable/Disable Bits

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.

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.

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.

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

Table A-9 Alarm Enable Registers

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.

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

Table A-10 Example of Alarming on Channel 2

Use the Threshold registers to set the alarm threshold value.

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.

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

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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.

Note: The Table A-11 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.

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

Register	Data Type	Description
45009	unsigned integer	Threshold for Particle Channel 1 [high] (smallest particle size starts here)
45010	unsigned integer	Threshold for Particle Channel 1 [low]
45011	unsigned integer	Threshold for Particle Channel 2 [high]
45012	unsigned integer	Threshold for Particle Channel 2 [low]
45013	unsigned integer	Threshold for Particle Channel 3 [high]
45014	unsigned integer	Threshold for Particle Channel 3 [low]
45015	unsigned integer	Threshold for Particle Channel 4 [high]
45016	unsigned integer	Threshold for Particle Channel 4 [low]

Table A-11 Alarm Threshold Registers

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. For example, setting a value for channel 1 of 100 will not affect channel 2 setting of 500.

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

Table A-12 Alarm Threshold Registers set to 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 and analog 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.

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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	Sample Status [high]
30008	unsigned integer	Sample 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]
...		
30041	IEEE Float	Analog Channel 1 [high]
30042	IEEE Float	Analog Channel 1 [low]
30043	IEEE Float	Analog Channel 2 [high]
30044	IEEE Float	Analog Channel 2 [low]
30045	IEEE Float	Analog Channel 3 [high]
30046	IEEE Float	Analog Channel 3 [low]
30047	IEEE Float	Analog Channel 4 [high]
30048	IEEE Float	Analog Channel 4 [low]
...		
30063	IEEE float	LASER Supply [low]
30064	IEEE float	LASER Supply [high] (percentage based on LASER Supply Reference Value.
30065	IEEE Float	Background Voltage [low] (percentage based on Calibration reference value) - **ApexRp**
30066	IEEE Float	Background Voltage [high]
…		
30069	IEEE Float	LASER Voltage [low] (Percentage based on LASER Reference value)
30070	IEEE Float	LASER Voltage [high]

Table A-13 Data Registers

Bit	Action
0	**Service LASER Status** 0 = LASER is good. 1 - LASER needs to be serviced.
1	**Bad Flow** Status 0 = Flow rate is good. 1 = Flow rate is bad.
2	**Particle Overflow** Status 0 = No overflow 1 = Overflow occurred.
3	**Instrument Service** Status 0 = Instrument is working correctly. 1 = Service light is on. Instrument 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.
7	**ApexRp:** 0 = LASER power in spec. 1 = LASER power out of spec.
8	**ApexRp**: LASER current status 0 = LASER current in spec. 1 = LASER power out of spec.
9	**ApexRp**: **LASER supply** status 0 = LASER supply in spec. 1 = LASER supply out of spec.
10	**ApexRp**: **LASER life** status 0 = LASER life in spec. 1 = LASER life out of spec.
11	**ApexRp: No flow status** 0 = There is flow in the unit. 1 = no flow in unit.
12	**ApexRp**: **Photoamp supply** status 0 = Photoamp supply in spec. 1 = Photoamp supply out of spec.
13	**ApexRp: Background** status 0 = Photoamp background good. 1 = Photoamp background out of spec.
14	**ApexRp**: **Photodiode health** status 0 = Photodiode good. 1 = Photodiode failure
15	**ApexRp**: **Validation mode** status 0 = Normal operation data. 1 = Validation dummy data.
16	**ApexRp**: Calibration due date status 0 = Unit has not passed calibration date. 1 = Unit has passed calibration.

Table A-14: Instrument Current Status

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

The registers used for the Sample Status Word are 30007-30008 to sample status. 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 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 4 are set TRUE).

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
3	Instrument Service Status 0 = Working correctly 1 = Instrument malfunction detected.
4	Particle Threshold Exceeded Status 0 = Threshold not exceeded 1 = Threshold exceeded

Table A-15 Device Status Word

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 and analog 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

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