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USER GUIDE

Vertex liquid particle counters

Lighthouse

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Vertex50/100

LIQUID PARTICLE COUNTERS





Operators Manual

LIGHTHOUSE
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Lighthouse Worldwide Solutions

Vertex50/100
Liquid Particle Counters





Operators Manual

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About this Manual

This manual describes the operation and use of the Lighthouse Worldwide Solutions Vertex50 and Vertex100 Liquid Particle Counters with MODBUS output.

A Note is posted to give additional related information.

A Warning is posted to warn of actions that could result in personal injury, damage to the instrument or loss of data.

The directional arrows generally point where to press or select the next step.

A dotted directional arrow indicates what comes next.

For additional help

For more information about the Vertex50 or Vertex 100 Liquid 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

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Chapter 1 General Safety

Product Safety

The Vertex family particle counters have been evaluated and tested in accordance with EN61010-1:2010, “Safety Requirement for Electrical Equipment for Measurement, Control, and Laboratory Use”

Laser Safety

Class 1 Laser Product. Complies with IEC/EN 60825-1 and 21 CFR 1040.10 except for deviations pursuant to Laser Notice No. 56, dated May 8th, 2019”.

Instrument Operating Pressure Warning

Vertex50 Max pressure 100PSIG. Internal flow meter may be damaged if exceeded. Vertex100 Max pressure 100PSIG. External flow meter may be damaged and personal injury may occur if exceeded.



Service and Calibration Safety Warning

The Vertex model family particle counters are not internally serviceable. Do not remove enclosure as this will void warranty. Contact Lighthouse Worldwide Solutions for service needs. The Vertex should be calibrated annually by a certified Lighthouse Worldwide Solutions Service Provider to ensure that your unit continues to perform within specifications. The LED service condition will illuminate during sampling and remain on when annual calibration is due.

Chemical Compatibility

The Vertex model family are designed for particle detection in ultra-pure DI water. Contact Lighthouse Worldwide Solutions Technical Support before attempting to sample other liquids. Failure to follow this condition may result in damage to the instrument’s flow control and void the warranty.
For further technical assistance, contact our technical support team at 1-800-945-5905 (USA Toll Free) or 1-541-770-5905 (Outside USA).

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Chapter 2 Introduction

Overview

This operating manual introduces the Lighthouse Worldwide Solutions Vertex50 and Vertex100 Liquid Particle Counters. Included in this manual are instructions for installation, operation, communications and maintenance.

Description

The Vertex family features channel size range of 50 to 500 nanometers and supplies continuous data collection using the Serial MODBUS, or Ethernet MODBUS/TCP and 4-channel 4-20mA protocols.

The Vertex family user-controlled flow rate of 100 mL/min., ±5%, is designed to accurately measure up to 4 channels of simultaneous particle counts in deionized water.



Vertex50 Front View

The Vertex family uses a laser diode light source and laser beam shaping optics to illuminate a cross section of the liquid flow path. As particles move through the flow cell, they enter the laser beam and scatter light. The light scattered is collected by the optical system and imaged onto a photodiode. The photodiode converts the light into current which is converted to voltage and amplified by the electronics.

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

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



Vertex100 Front View

The Vertex family of liquid particle counters were created for continuous, 24 hours per day, 7 days per week operation. The Vertex integrates seamlessly with many large facility monitoring or management systems and transfers up to 4 channels of simultaneous particle count data using the Ethernet MODBUS TCP, Serial MODBUS or the 4-20mA analog port.

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Specifications

Specifications	Vertex50	Vertex100
Size Range	50nm – 200nm	100nm – 500nm
Channels	4	2 or 4
Standard Channel Sizes	50nm, 100nm, 150nm, 200nm	100nm, 200nm, 300nm, 500nm
Flow Rate	100 mL/min	
Sample Volume	5.0 mL/min	
Zero Count Level	≤ 20 count/L	
Laser Source	Solid state laser	
Calibration	NIST Traceable	
Communication Modes	Ethernet, Serial RS-232, RS-485, 4-20mA	
Display	TFT color touch screen	
Concentration Limit	60,000 counts/mL @5% coincidence loss	
Enclosure	316L stainless steel	
Sample Inlet/Outlet	¼" Flare	
Operating Environment	50°F to 104° (10°C to 40°C) / 20% to 95% non-condensing	
Storage Environment	14°F to 122°F (-10°C to 50°C) up to 98% non-condensing	
Sample Temperature	50°F to 122°F (10°C to 50°C)	
Sample Pressure	7 PSI to 100 PSI (48 kPa to 689 kPa)	
Wetted Surface Materials	Quartz, PFA, Kalrez, PTFE, PCTFE	Quartz, PFA, Kalrez, PTFE, PCTFE, Borosilicate Glass, SS316
Communication Protocol	MODBUS TCP, MODBUS Serial, 4-20mA	
Ambient Operational Conditions	Refer to color shaded regions in Figures 2.0, 2.1, 2.2 *(RH% to °C)*	
Ambient Storage Conditions	-10 to 50°C, less than 90% RH *(Relative Humidity)* (No condensation and no freezing in internal piping)	
Power	External Supply: Rated Input 120-240V AC 50/60Hz, 0.7A – 1.4A. Rated Output: 24V DC, 5A	
Dimensions	9.0"(W) x 13.4"(D) x 8.4"(H), [22.9 x 34.0 x 21.3 cm]	9.0" (W) x 14.8" (D) x 8.4" (H) [22.9 x 37.6 x 21.3 cm]
Weight	13.5 lbs. (6.1 kg)	12.5 lbs (5.7 kg)

Specifications Vertex50 and Vertex100

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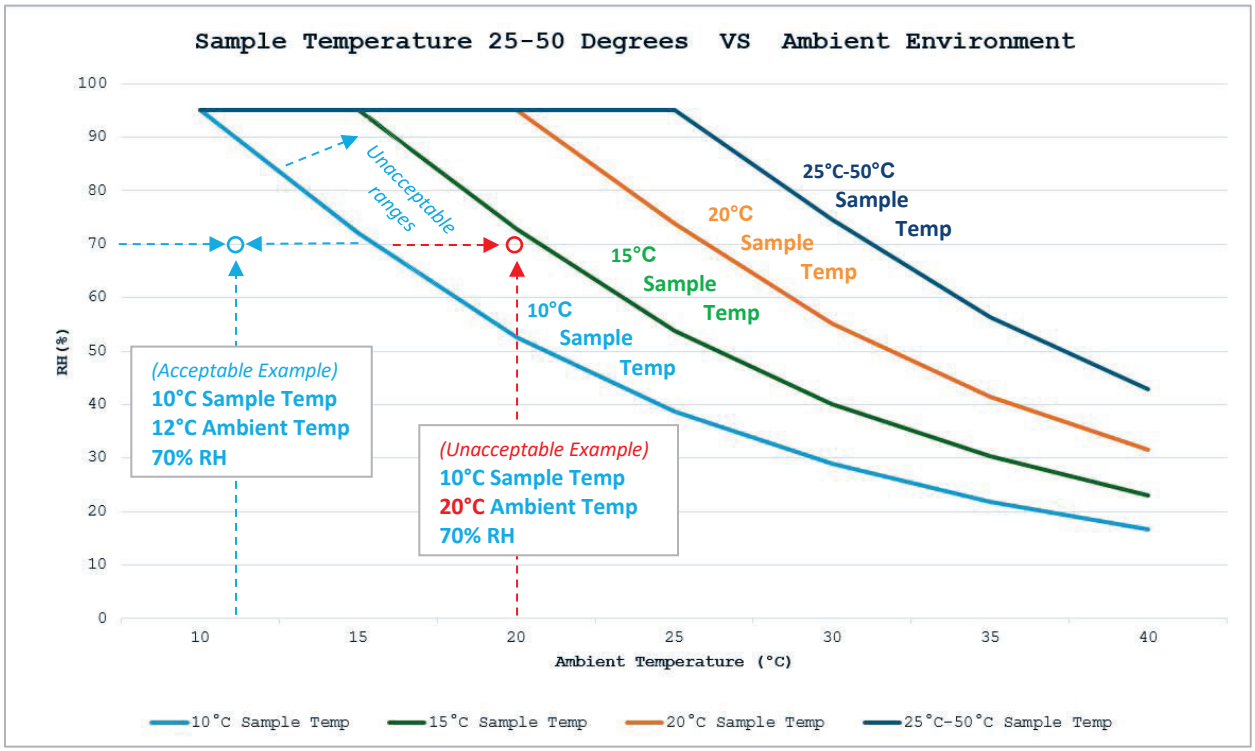


Figure 2.0 Acceptable ambient environment for sample temperatures at 10°, 15°, 20°, 25°-50°C

Figure 2.0 shows acceptable ambient temperatures lie in the region below the given Sample temperature graph line. Unacceptable ambient temperatures lay above the given Sample temperature graph line.

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Chapter 3 Getting Started

Initial Inspections

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 part, scratches, dents or other damage. If the carton is not damaged, keep it for reshipping the instrument for its annual factory calibration. RETAIN THE INLET AND OUTLET SHIPPING CAPS!

Annual Calibration

The manufacturer recommends that your Lighthouse Worldwide Solutions instrument be calibrated annually by a Certified Lighthouse Service Provider to ensure that your unit continues to perform within specification.

Shipping Instructions

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

1. Use the original container, nozzle caps and packing materials whenever possible. Refer to the RMA website for detailed instructions. Remove attachments and package to prevent physical and ESD damage.
2. If the original container and packaging 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 may result in additional repairs being billed to the customer. You may contact Lighthouse Worldwide Solutions to purchase a replacement shipping container and nozzle caps.
3. Seal container or carton securely. Mark “FRAGILE” and write the Return Merchandise Authorization (RMA) number on any unmarked corner.
4. Return the instrument to the address provided by your Lighthouse Worldwide Solutions representative or the RMA website.

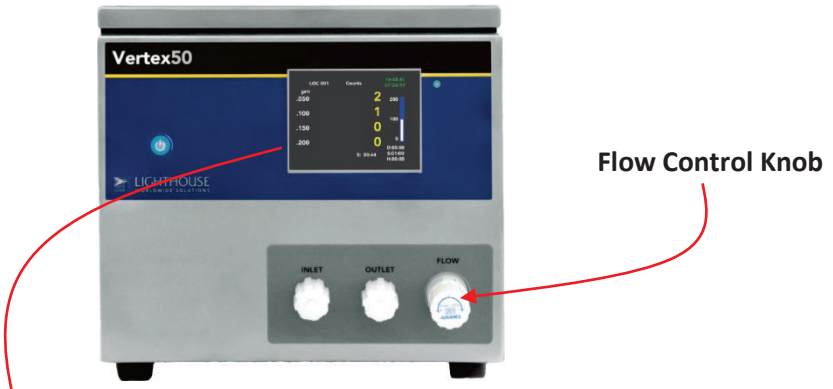
WARNING: If the sensor must be returned for service or when it is returned for calibration, the Flow Cell must be flushed with DI water or reagent grade isopropyl alcohol and filled completely with 10% Isopropanol (isopropyl alcohol) and the nozzles capped securely. Any chemicals present in the sensor at the time of shipping require specific hazardous materials warnings on the shipping container. A Material Safety Data Sheet (MSDS) must be included for every chemical inside the sensor at the time of its shipment. If the Flow Cell is not clean and filled with 10% isopropanol prior to shipping, it may be damaged (freeze-fracture, dried contaminants) and require replacement during servicing or calibration.

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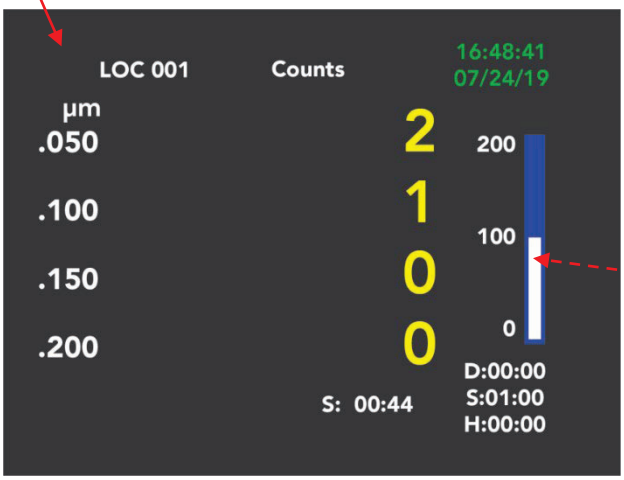
Vertex50 Flow Control and Meter

The Vertex50 Flow Control includes a digital flow indicator to adjust the liquid flow to 100 mL/min.

- Adjust the flow control knob and view the flow control meter display on the Main screen.
- Adjust the flow control knob until the meter reads 100 mL/min.



Vertex50 Front View



Digital Flow Meter
The white bar represents the current flow rate.

Adjust the flow to 100mL/min while viewing the screen.

Main Screen with Flow Meter set to 100 mL/min.

- With tubing connected to the instrument, turn the flow control valve fully counter-clockwise to purge air from the Vertex. This prevents erroneous particle counts.

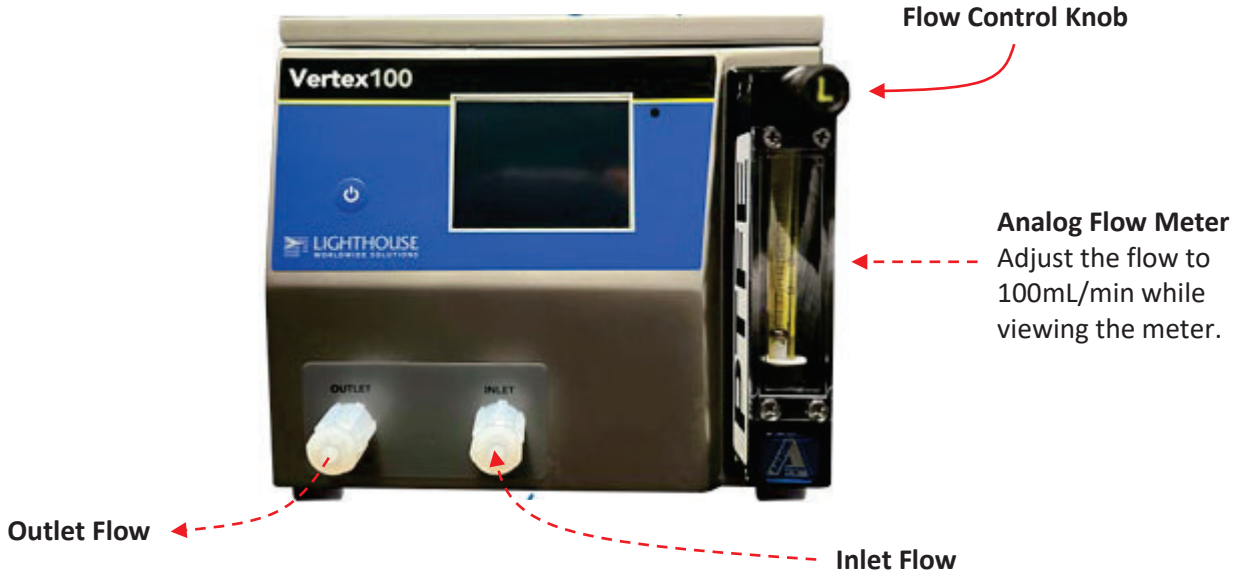
- Adjust the flow to 100 mL/min while viewing the screen.

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Vertex100 with Analog Flow Control Meter

The Flow Control is equipped with an analog flow meter, allowing for the adjustment of the liquid flow to 100 mL/min.

- To set the flow rate, turn the flow control knob while observing the needle on the analog flow meter.
- Adjust the knob until the meter's needle aligns with the 100 mL/min mark. Ensure the tubing is properly connected to the instrument.
- Then, open the flow control valve by turning it fully counterclockwise. This action purges any air from the system within the Vertex100, thereby preventing inaccurate particle counts.
- Continue to monitor the analog meter as you fine-tune the flow. Adjust the flow control knob until the needle is steadily pointing at the 100 mL/min mark, ensuring accurate and consistent flow measurement.



Vertex100 Front View

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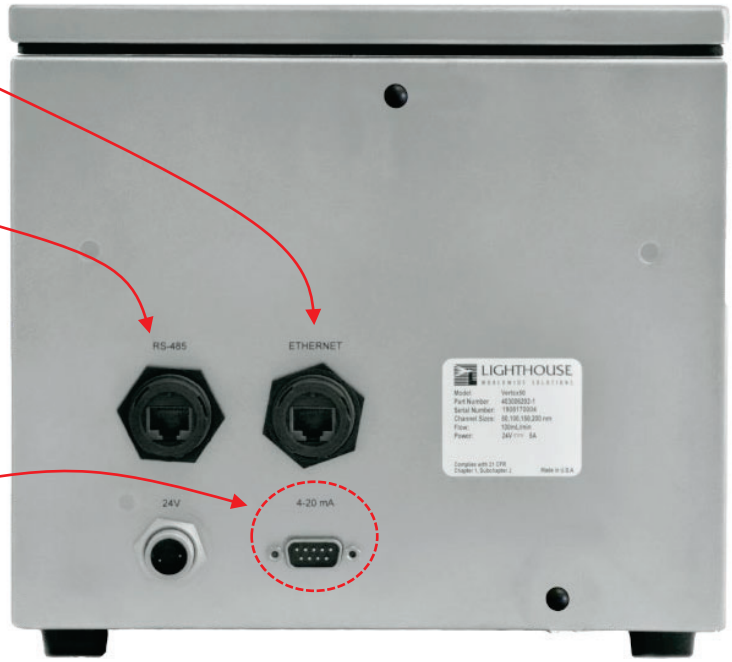
Connections

The Vertex can communicate data counts collected through the communication ports on the rear of the instrument.

Ethernet
The Ethernet port connects to Ethernet LANs and allows data collection to the LMS Express Software or other Facility Management Systems.

Serial (10101)
The Serial port connects Serial communications to the LMS Express Software or other Facility Management Systems.

Analog (4-20mA)
The 4-20mA DB-9 provides 4-channel 4-20mA communications and is sealed to help prevent liquid or gas infiltration into the NEMA style enclosure.

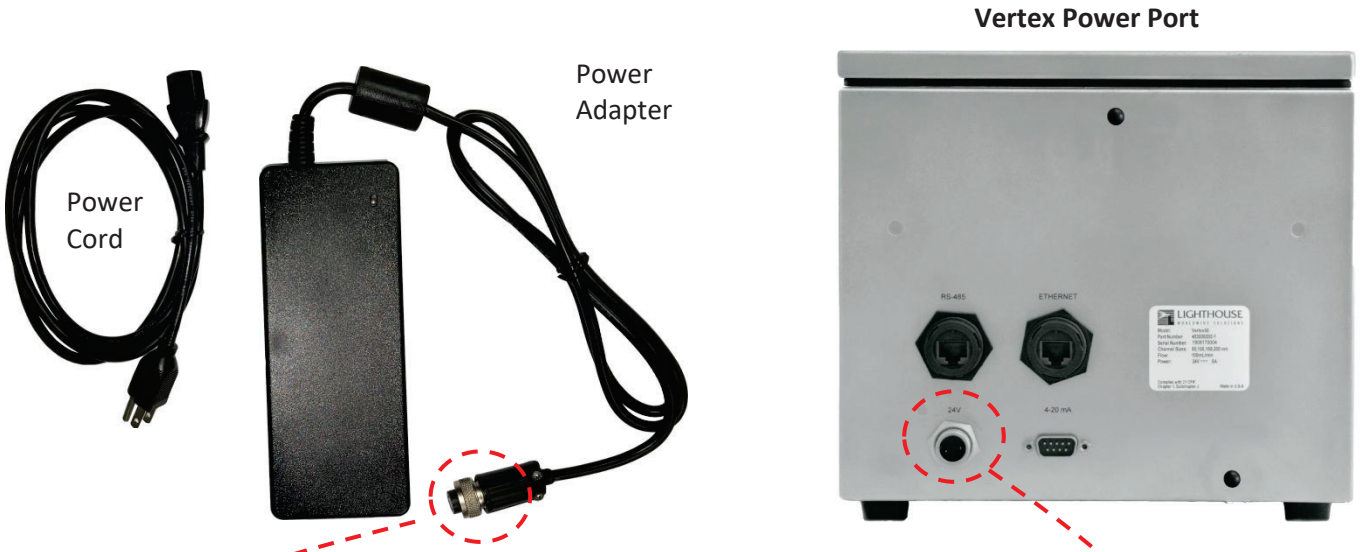


Vertex50/100 Back View

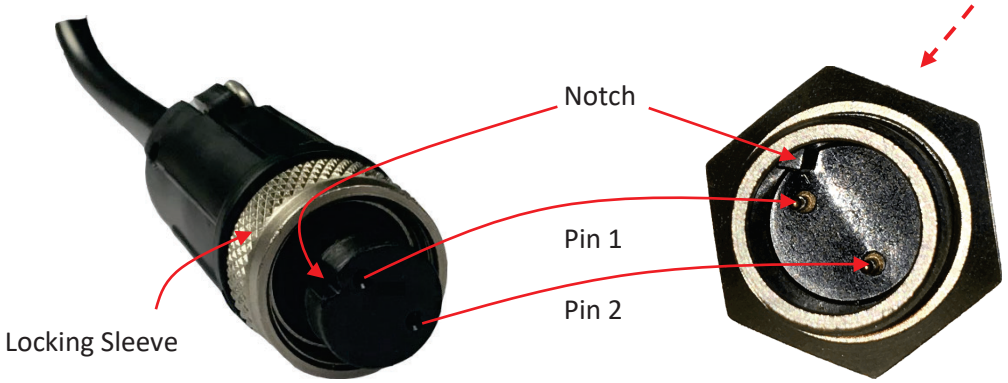
WARNING: The Vertex is not designed for daisy-chaining. Doing so may damage the sensor and void its warranty.

Power Connection

The Vertex instrument uses an external power supply with a rated input 120-240V AC 50/60Hz, 0.7A - 1.4A and rated Output: 24V DC, 5A.



Match the two-pin-notched Power-Adapter-Connector with the Vertex notched-two-pin Power Port . Then tighten the connector locking sleeve rotating in a clockwise direction. Rotate counter clockwise to loosen.



Power Adapter Connector **Power Port**

Note: The power connection point has a notched power input receptacle. The 24V power adapter connector is also notched at the female end and fits into the power

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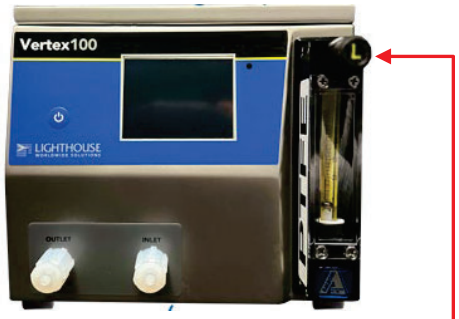
Inlet and Outlet Nozzles

The inlet and outlet nozzles on the front on the instrument use ¼" flare tubing. Each tube has a flare nut on the each end of the tube to secure the inlet and outlet tubes to the nozzles.

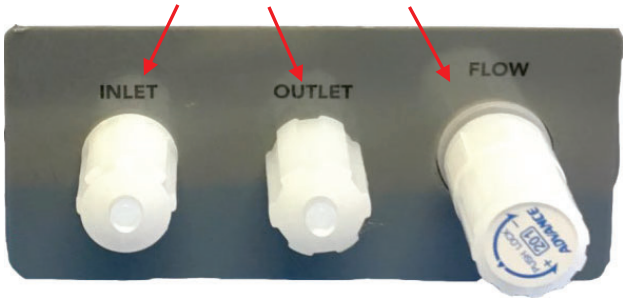




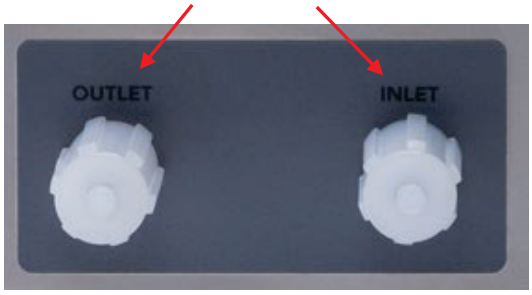
Flare Nut & Nozzle Cap



Vertex50: Inlet – Outlet – Flow Control



Vertex100: Outlet – Inlet – Flow Control



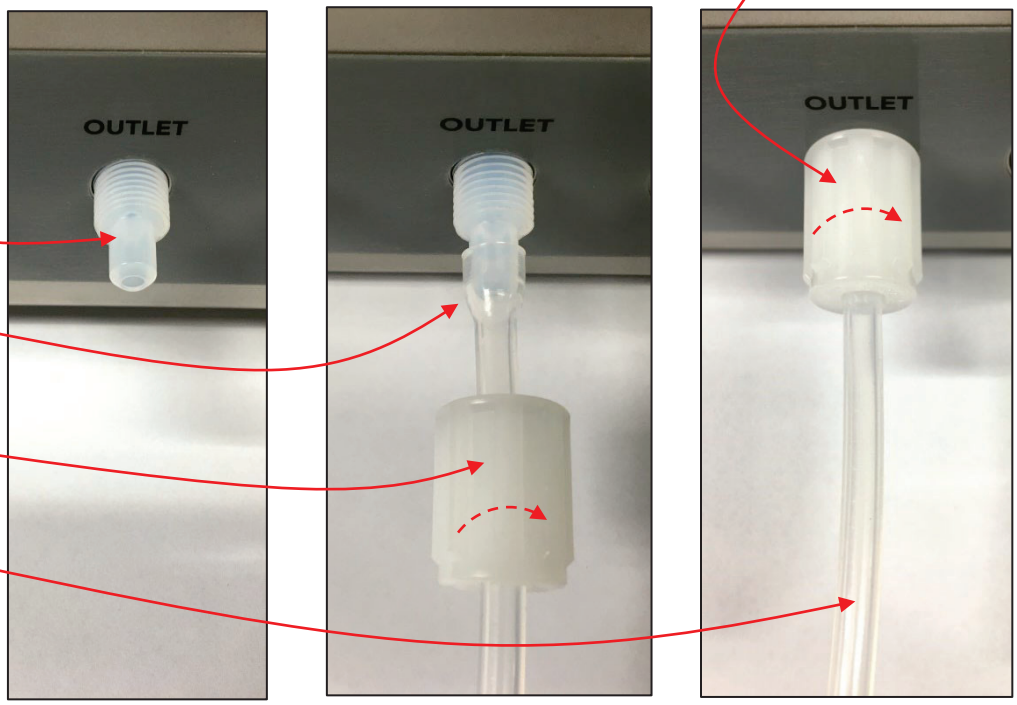
Tighten flare nut finger tight only.

Outlet Nozzle

Flare tip tube

Flare nut

Outlet tube
¼" tubing



Vertex Outlet nozzle, flare tip tubing and flare nut.

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Attaching the Sensor

1. There should be no liquid in the Vertex system and the power should be OFF.

2. Connect the ¼" flare outlet tubing provided to the Vertex Outlet nozzle. Insert the tubing firmly onto the nozzle and tighten the knurled nut finger-tight only. Connect the other end of the outlet tubing to a liquid drain.

3. Connect the Inlet ¼" flare tubing provided to the Vertex Inlet nozzle. Insert the flared tip of the tubing firmly onto the nozzle and tighten the knurled nut finger-tight only. Connect the other end of the Inlet tubing to your liquid sample source.

4. Ensure that the flow path is clear and connected securely from liquid sample source to Vertex and then out of Vertex to the liquid drain or waste.

5. Turn the liquid system on and allow liquid to flow through the Vertex making sure that there are no leaks at the sensor inlet or outlet or any other connection point.

6. If leaks occur, immediately stop the flow of liquid. Disconnect and clear the flare fittings and connectors of debris or burrs. Repair any other leak and return to step 1.

7. If no leaks occur, connect power to the Vertex.

8. Make sure the sample liquid is bubble-free. Bubbles will be counted as particles and large amounts may cause sensor errors.

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

10. If there are no leaks and the service LED is off, the instrument is ready to configure the communications. Refer to Chapter 4 – Communications".

Note: When connecting flare nuts to the Vertex do not use a wrench or other tool to tighten the flare nut. Doing so will damage the instrument, tubing or nut. The connections must be finger-tight only.

Note: Adding devices or additional connections between the sample source and the sensor will increase the chances for leaks and bubbles.

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Flow Cell Cleaning

The flow cell is an integral part of the Vertex instrument and must be cleaned periodically to maintain the detection accuracy of the sensor. The Vertex will detect when the flow cell needs cleaning and indicate this by turning on the service LED.

The Flow Cell Cleaning Kit includes:

2x 25ml syringes with Luer-Lock tips
2x PFA tubes with flare fittings (one end open, the other end flared for use with a threaded sleeve)
1x 3oz bottle of flow cell cleaner liquid (Micro-90)

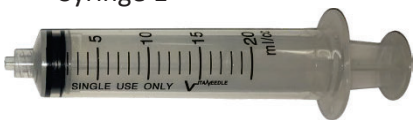


Flow Cell Cleaning Solution

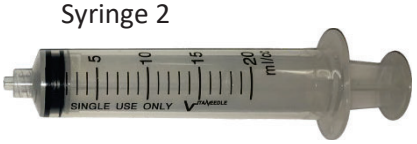

Connection Tube 1


Connection Tube 2

Syringe 1



Syringe 2



A. Prepare Vertex for cleaning

1. Turn off power to the Vertex and disconnect all cables.
2. Stop liquid flow to the Vertex.
3. Wrap a towel around the outlet nozzle to prevent liquid from spilling out of or onto the sensor.
4. Unscrew the flare nuts on the inlet and outlet nozzles. Remove the tubing and make sure the instrument drains the liquid safely.
5. Prepare a solution 5% Micro90 cleaner and 95% deionized (DI) water, enough to fill three syringes.
6. Turn the instrument flow valve knob fully counter-clockwise to allow full flow through the cell.

WARNING: If the sensor must be returned for service or when it is returned for calibration, the Flow Cell must be flushed with DI water or reagent grade isopropyl alcohol and filled completely with Isopropanol (isopropyl alcohol) and the nozzles capped securely. Any chemicals present in the sensor at the time of shipping require specific hazardous materials warnings on the shipping container. A Material Safety Data Sheet (MSDS) must be included for every chemical inside the sensor at the time of its shipment. If the Flow Cell is not clean and filled with isopropanol prior to shipping, it may be damaged (freeze-fracture, dried contaminants) and require replacement during servicing or calibration.

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B. Empty sample water from the flow path.

1. Retract the 1st syringe plunger to its fully extended position then connect the complete assembly to the Inlet port.
2. Fully compress the 2nd syringe plunger and connect the complete assembly to the outlet port. This prevents spillage of the sample liquid during the next step.
3. Fully compress the 1st syringe plunger. This will push any water out of the flow cel l through the outlet port into the 2nd syringe!
4. If any liquid has accumulated in the 2nd syringe, disconnect the syringe from the its tube, dispose of the liquid safely then reconnect the syringe to its tube, fully compressed.
5. Disconnect the 1st syringe from its tube and retract the plunger fully then reconnect it to its tube.
6. Repeat steps "B1 – B5" until all the water is out of the cell and only air is coming out of the outlet port.

C. Fill flow path with cleaning solution

1. Disconnect the complete 1st syringe assembly from the inlet port.
2. Fully compress the 1st syringe plunger, pull the threaded sleeve back out of the way and place the flared end of its tube into the 5% cleaning solution; fully retract the plunger to full the syringe with the solution. Try to eliminate air bubbles from the syringe while filling it.
3. Reconnect the 1st syringe flare fitting to the inlet port and tighten the threaded sleeve to prevent leakage.
4. Make sure the full-compressed 2nd syringe and its attached tubing are properly connected to the outlet port to prevent the solution from spilling while performing the next steps.
5. Fully compress the 1st syringe plunger, pushing the cleaning solution into the flow circuit. If no solution exits the instrument into the 2nd syringe, disconnect the 2nd syringe from it's tube, fully compress the plunger then reattach the syringe.
6. Repeat steps C1 through C5 until the 5% cleaning solution starts to come out of the outlet port.
7. Disconnect and compress the 2nd syringe all the way, expelling any solution that has collected into a safe container for proper disposal.
8. Reconnect the 2nd syringe to its tube on the outlet port.
9. Remove the 1st syringe from the inlet port.
10. Perform step C2 to fill the 1st syringe, reconnect the syringe then compress its plunger to push the 5% solution through the flow circuit into the 2nd syringe. The 2nd syringe should be filled with the solution at this point.
11. Allow the cleaning solution to remain in the instrument for 15-20 minutes.

WARNING: DO NOT allow any liquid that has been used to flush the sensor of contamination to re-enter the sampling system.

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D. Clean the cell by cycling the syringes.

1. Cycle the solution through the cell by depressing one syringe plunger all the way and then pressing the other syringe plunger all the way. As you compress each syringe plunger the other syringe plunger will slide out and fill with solution.
2. Repeat this process 20-30 times, sometimes compressing the plunger quickly and at other times compressing the plunger slowly.



E. Remove the cleaning solution

1. Compress the 1st syringe plunger al all the way in.
2. Remove the 2nd syringe from the outlet port and carefully discharge the 5% solution into an appropriate container for storage until it can be properly disposed.
3. Reconnect the 2nd syringe to the outlet port then disconnect the 1st syringe.
4. Fully retract the 1st syringe plunger, reconnect it to the inlet port then fully compress the plunger to push the air into the flow path and force the liquid out.
5. Repeat steps E1 through E4 until nothing but air is cycled through.
6. Remove the 1st syringe from the inlet port completely by unscrewing the sleeve and pulling the tube off. Similarly remove the 2nd syringe and its tubing.

F. Flush the system with deionized water

1. Connect the sample input to a supply of deionized water.
2. Connect the outlet tube to a proper disposal container.
3. Flush the cell with deionized water for 5-10 minutes. Allow the deionized water to stay in the flow path to perform the next tests.

G. Check Sensor Functionality

1. Turn the instrument on and check its background voltage with the deionized water still in the flow path. If the 1st check of background voltage shows it too high, reconnect both syringes to the Vertex and repeat steps C7 through C11 followed by section D up to 3 more times.
   * Repeat steps E1 through E6 and section F then perform check again.
   * If the 2nd check of background voltage shows it is still too high, this means cleaning with the Micro90 5% solution may be failing to clean the flow cell adequately.
2. Turn on sample liquid and let it flow through the Vertex.
3. Reconnect power to the Vertex and verify the service light is off; this determines that the flow cell was cleaned successfully.

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Using the Flow Cell Cleaning Brush

Use of the Flow Cell Cleaning Brush is only recommended if the previous steps have failed to clear the indicated Service condition.

A. Fill the brush tube with 5mL of Micro-90 soap

B. Insert brush past inlet into Flow Cell

C. Gently Brush up & down 6-8 times

D. Flush quickly with DI water at high flow if possible

E. Rinse the brush and the brush tube with DI water



Note: Ensure the cleaning brush is not bent and has no missing bristles. These conditions can damage the flow cell

Vertex Wipe Down Cleaning

To perform a thorough wipe down of the system, use cleanroom-approved wipes and isopropyl alcohol (IPA) to clean the surfaces of the Vertex units, including the flow meter and surrounding areas. This is essential to maintain the stringent cleanliness standards of cleanrooms.

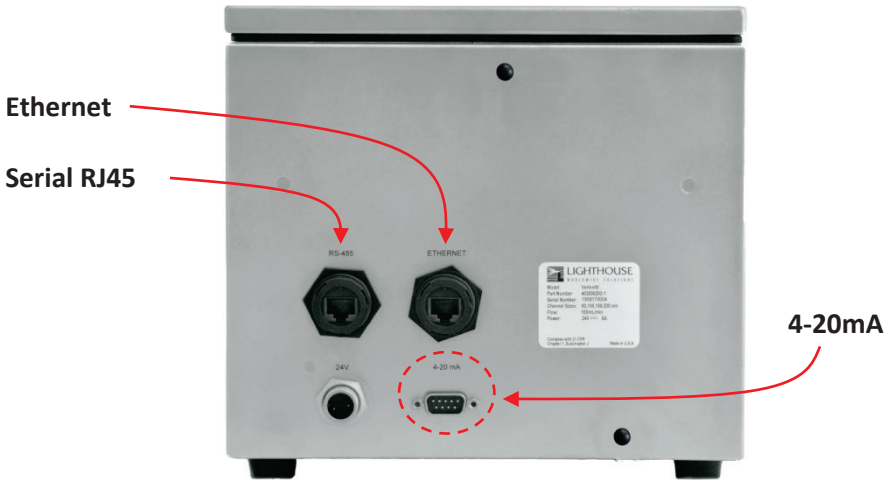
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Chapter 4 Communications

Communicating with the Instrument

The Vertex can communicate with a Network or PC through the following communication ports.



Ethernet Communications

The Vertex Ethernet interface uses MODBUS over TCP/IP as its communication protocol.

Standard Ethernet hubs, switches, routers and wiring can all be used with the Vertex.

Connect the industrial connector end of the included Ethernet cable to the Vertex Ethernet port on the back panel of the instrument. Insert the RJ-45 adapter into the Ethernet port and tighten the sealing collar to finger tight only.

Connect the other end of the included Ethernet cable to your local area network.

If one of the communication ports is not in use then it is recommended to connect the port cap.

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Serial Communications

The Vertex can communicate Serial by using the included USB to serial adapter cable. The industrial connector end of the cable connects to the Serial port (10101) on the Vertex and the other end of the cable connects to a USB port on a PC.

RJ-45 Pin	Wire Color	Signal Name
1	White/Orange	RS232-TX
2	Orange	RS232-RX
3	White/Green	Reserved
4	Blue	RS485 - B
5	White/Blue	RS485 - A
6	Green	Reserved
7	White/Brown	Reserved
8	Brown	GND

Serial RJ45 Pin Assignments

SPECIFICATIONS	RS485	RS232
Mode of Operation	Differential	Single Ended
Total number of drivers and receivers on one line (one driver active at a time for RS485 networks)	Multiple Drivers/Receivers	1 Driver 1 Receiver
Maximum Cable Length	4,000 ft. (1,219.2 m)	25 feet
Maximum Data Rate (40 ft. to 4000 ft. for RS422/RS485)	9,600 b/s to 115,200 b/s	9,600 b/s to 115,200 b/s
Driver Output Signal Level (Loaded Min.): LOADED	±1.5V	±5V
Receiver Input Voltage Range	-7V to +12V	±15V
Receiver Input Sensitivity	±200mV	0.6 – 2.4V

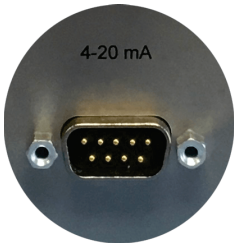
EIA Industry Standards for Serial Communications

Warning: The Vertex is not designed for daisy-chaining. Doing so may damage the sensor

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4-20mA Communications

The 4-20mA DB-9 provides 4-channel 4-20mA communications and is sealed to help prevent liquid or gas infiltration into the NEMA style enclosure.



DB-9 Pin#	Signal Assigned
1	CH1 +
2	GND
3	CH2 +
4	GND
5	CH3 +
6	GND
7	CH4 +
8	GND
9	GND

DB-9 Pinouts

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LED Status Color Key

The LED on the front panel of the Vertex50/100 illuminates according to the current state of the instrument. See the LED Status Color Key below.



LED	COLOR	STATUS
●	Black	Power Off
●	Yellow	Power On, Not Counting, Calibration Due
●	Blue	Sampling
●	Green (bright)	Count Mode (Hold time, Delay time, Idle)
●	Green (flashing)	Unit Flow out of tolerance (Vertex50 only)
●	Orange	Instrument needs service (laser power, flow cell)
●	Red	Flow Sensor Overheat condition (Vertex50 only)
●	Red (flashing)	Flow Sensor Error (Vertex50 only)

Vertex LED Status Color Key

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Installing the RJ-45 industrial connector

Requirements

RJ-45 industrial connector kit
Category 5e unshielded twisted-pair 24AWG wire (CAT5eUTP)
Wire strippers
RJ-45 crimp tool

Procedure

1. Strip 1 ½ to 2” of insulation from the end of the cable, taking care not to cut the individual wires.
2. Remove the contents of the RJ-45 industrial connector kit and identify each piece included.

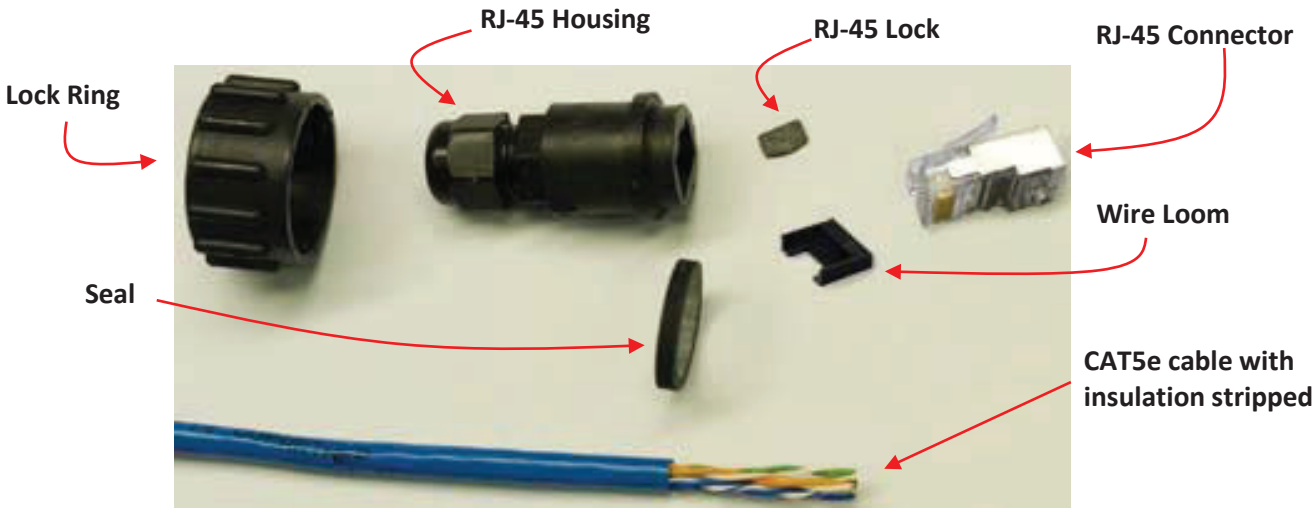


Figure 3-1 Industrial RJ-45 cable parts

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 Ethernet cable, push the stripped end of the cable through the large Lock Ring and RJ-45 housing as illustrated below. Make sure the ring is oriented as shown.

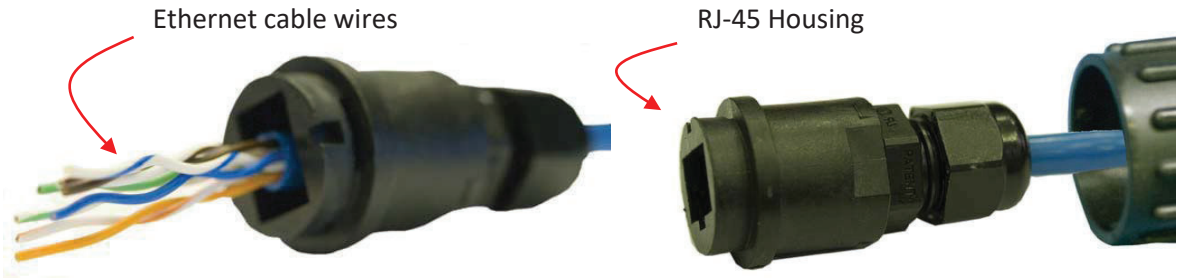


Figure 3-2 Housing can cable inserted

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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 color wire of the pair. Take care to distinguish between the orange and the brown colored pairs of wires as they look similar under low lighting.

7. Carefully untwist each pair of wires and straighten. Insert the wires into the loom shown in figure 3-3 and note the loom's flat tray shape. Insert the wires into the loom based on the EIA/TIA-568B standard as shown in figure 3-4.

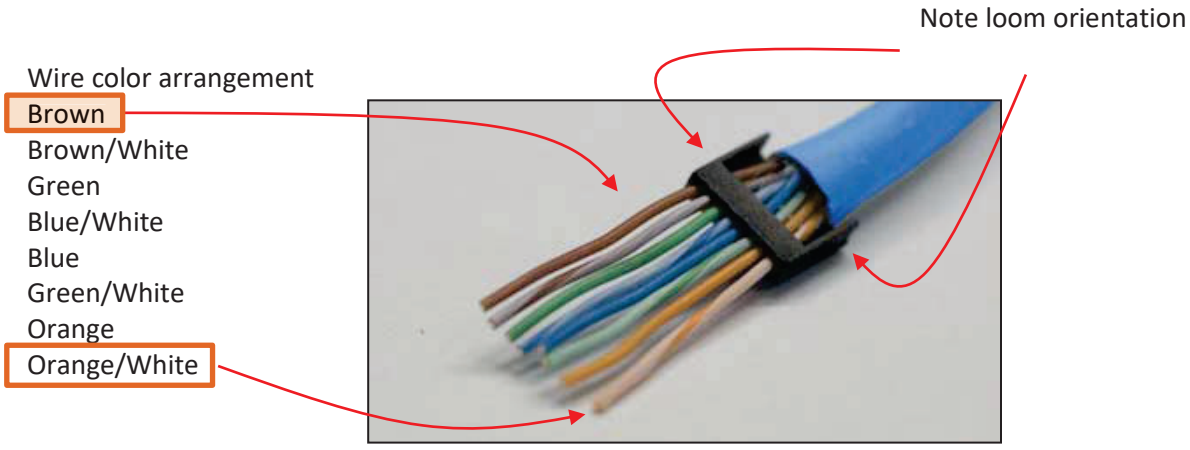


Figure 3-3 Close-up of wire loom

8. 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-quarter-inch of each wire extends beyond the edge of the loom. This allows for trimming the wires in a straight line parallel to the loom edge. One-eight-inch is required for crimping into the RJ-45 connector so, instep 9, do no trim shorter than 1/8". Review the photos in figure 3-4 to ensure accuracy.



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

9. Continue to push the cable into the loom and trim the ends of the wires in a straight line to 1/8" see figure 3-4.

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

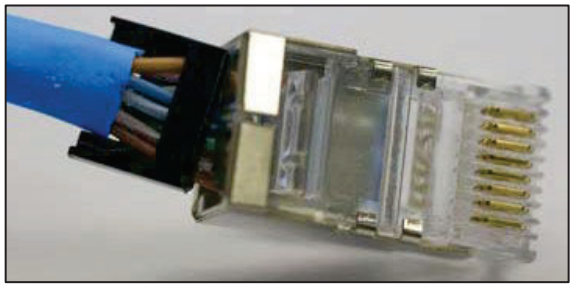


Figure 3-5 Loomed wires inserted into RJ-45

- Insert the RJ-45 connector into a crimp tool similar to figure 3-6. Maintain inward pressure while crimping the wires into their channels.



Figure 3-6 Typical RJ-45 crimp tool

11. Check the cable wire ends in the RJ-45 to make sure they have been crimped properly. Figure 3-7 illustrates the wire ends tightly against the end of each channel.

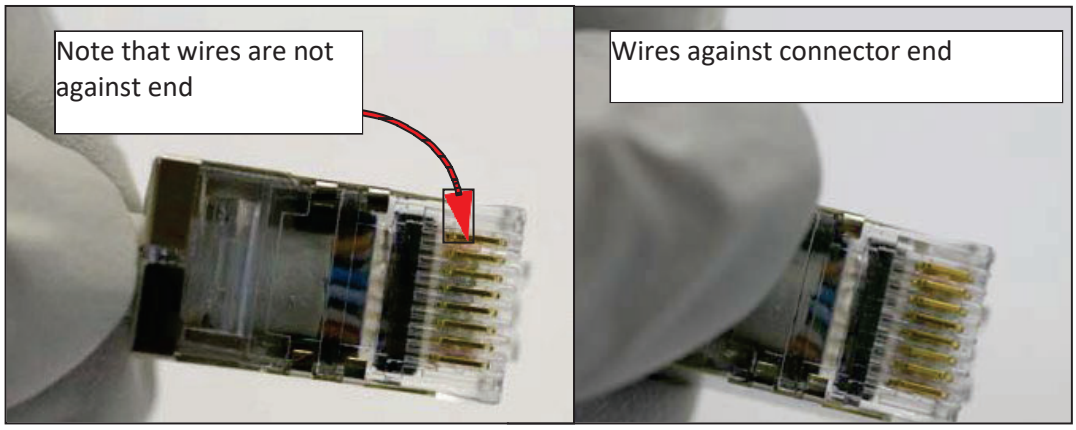


Figure 3-7 Close-up of RJ-45 Wire Detail

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12. 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.

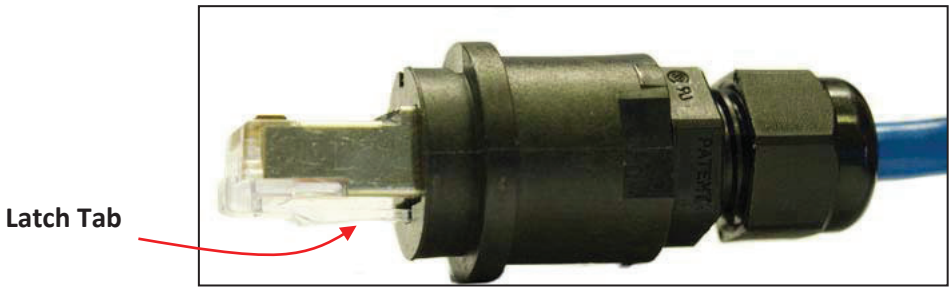


Figure 3-8 Close-up of RJ-45 Latch

13. Push the RJ-45 connector fully into the housing and insert the lock clip, round edge out, as illustrated in figure 3-9.

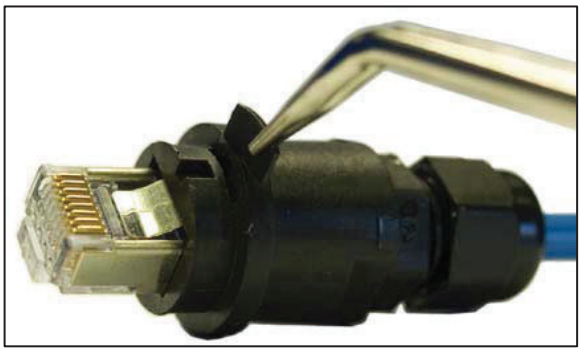


Figure 3-9 Lock clip installation

14. Hand tighten the housing cable clamping nut until snug. See figure 3-10.

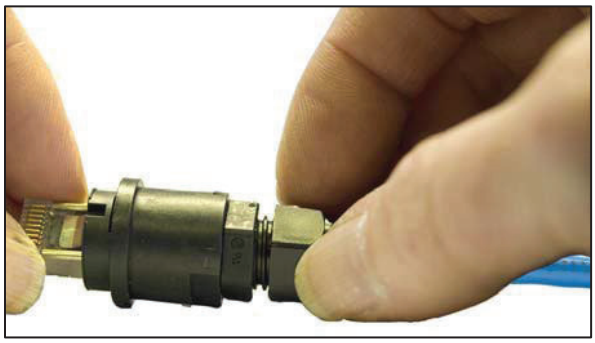


Figure 3-10 Tighten cable clamp nut

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15. 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.

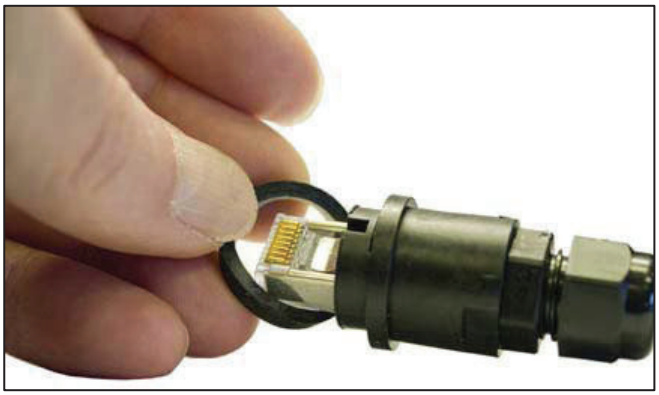


Figure 3-11 Install connector seal

16. Slide the large lock ring down the cable and over the cable housing body. It may need a twisting action to full position it against its retainer ring. Verify that the larger opening is facing outward, away from the cable. See figure 3-12.

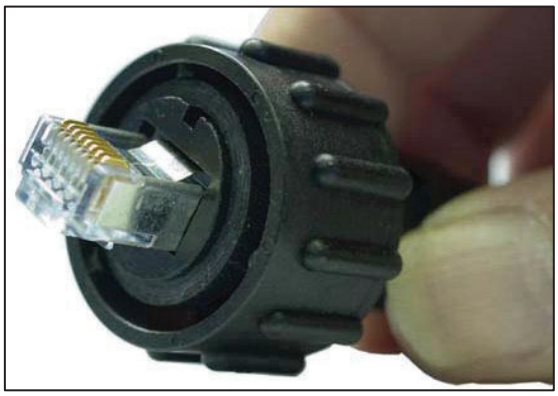


Figure 3-12 Cable connector completed

17. The hub end of the cable can now be terminated. The wire should be checked with an Ethernet 100baseT cable 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.

18. 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.

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Chapter 5 Operating the Vertex

Connecting the Inlet and Outlet Sample Tubes

1. Position the instrument within 10 feet of the liquid sample source to be measured.
2. Attach one end of the outlet sample tube to the Vertex Outlet nozzle and then attach the other end to a liquid drain.
3. Attach one end of the inlet sample tube to the Vertex Inlet nozzle and then attach the other end to the sample source.
4. Make sure the sample liquid is bubble-free. Bubbles will be counted as particles and large amounts may cause sensor errors.
5. Attach instrument to power and turn ON the power switch on the front panel.
6. While booting, the unit displays the Lighthouse Worldwide Solutions splash screen.
7. Next the MAIN screen will display as shown in Figure 5-1.
8. Use the Instrument Flow Adjustment knob to adjust the flow to 100mL/min.
9. All instrument functions are controlled through MODBUS. There is no start/stop button displayed on the touch screen. The chapter on "Programing with MODBUS Protocol" provides details on the use of MODBUS.
10. When the instrument starts counting, the letter 'S' appears on the display and indicates the elapsed sample time. Particle counts are grouped and displayed according to the size of each particle.
11. If the instrument is in HOLD time, the letter 'H' is displayed with the hold time elapsed.
12. If the instrument is in DELAY time, the letter 'D' is displayed with the delay time elapsed.

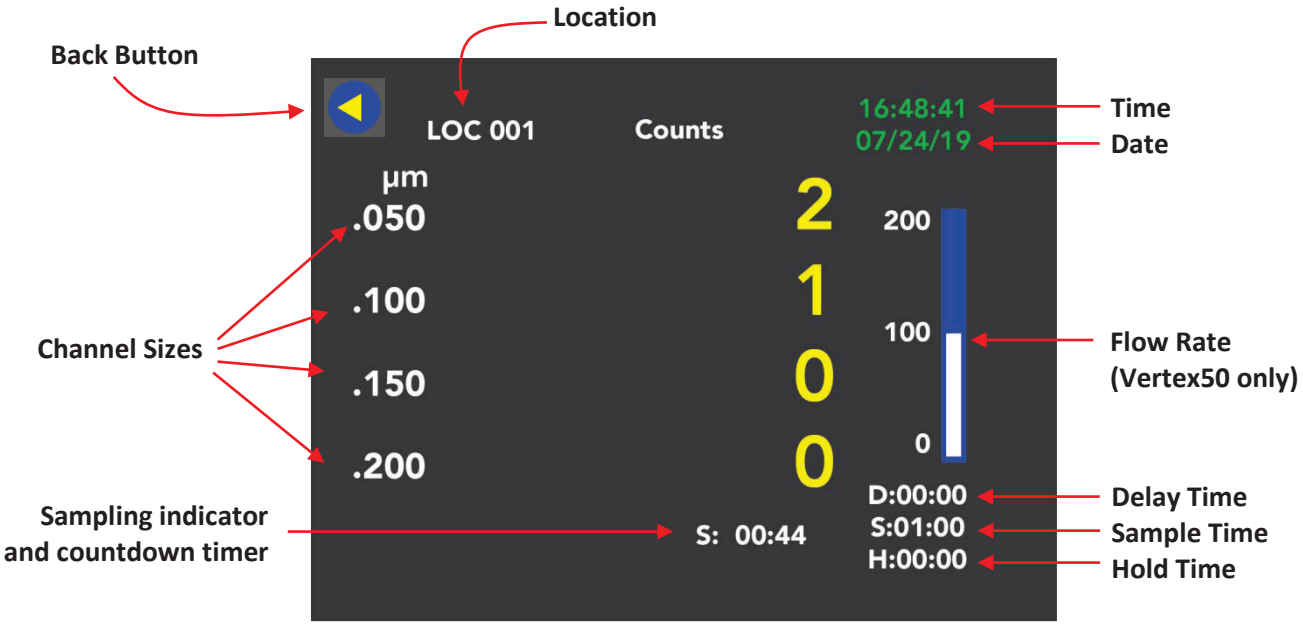


Figure 5-1 Vertex50 Main Screen

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Touch Screen Overview

The Vertex instrument incorporates a unique touch screen interface to control and configure the instrument. This interface allows the user to easily view and configure the instrument for their specific needs and applications.

Menu Screen

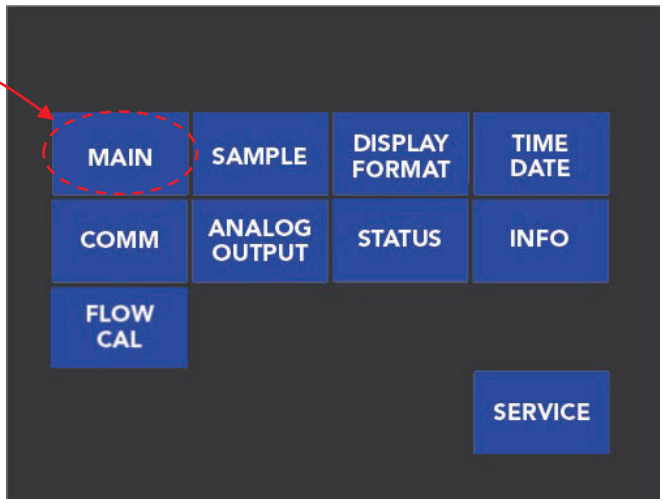
The Menu screen displays buttons to access:

Main Screen
Displays real time particle counts

Sample Screen
The sample screen displays delay, sample and hold times.

Display Format Screen
Select Normalize and Mode.

Time Date Screen
Set the time and date.



Menu Screen Vertex 50

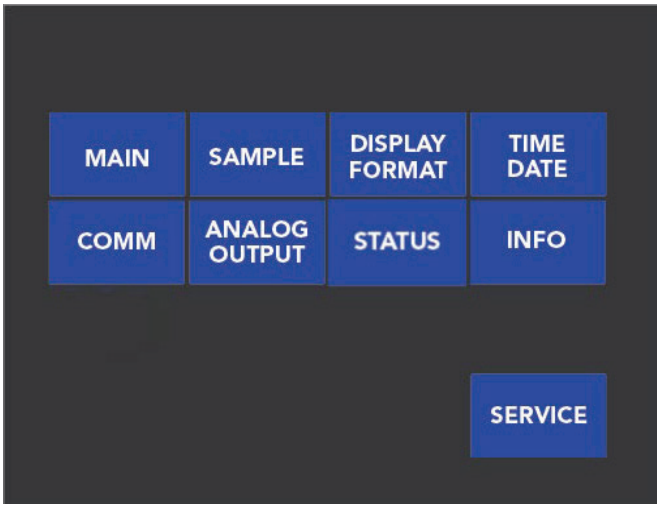
COMM Screen
Enable either Ethernet or Serial communications.

Analog Output Screen
Enable High and Low thresholds.

Status Screen
View Laser, Flow and Photo Amp status.

Info Screen
View Model, Serial #, Cal Date, and Firmware version numbers.

Flow Calibration Screen (Vertex50 only)
Calibrate the current flow rate.



Menu Screen Vertex100

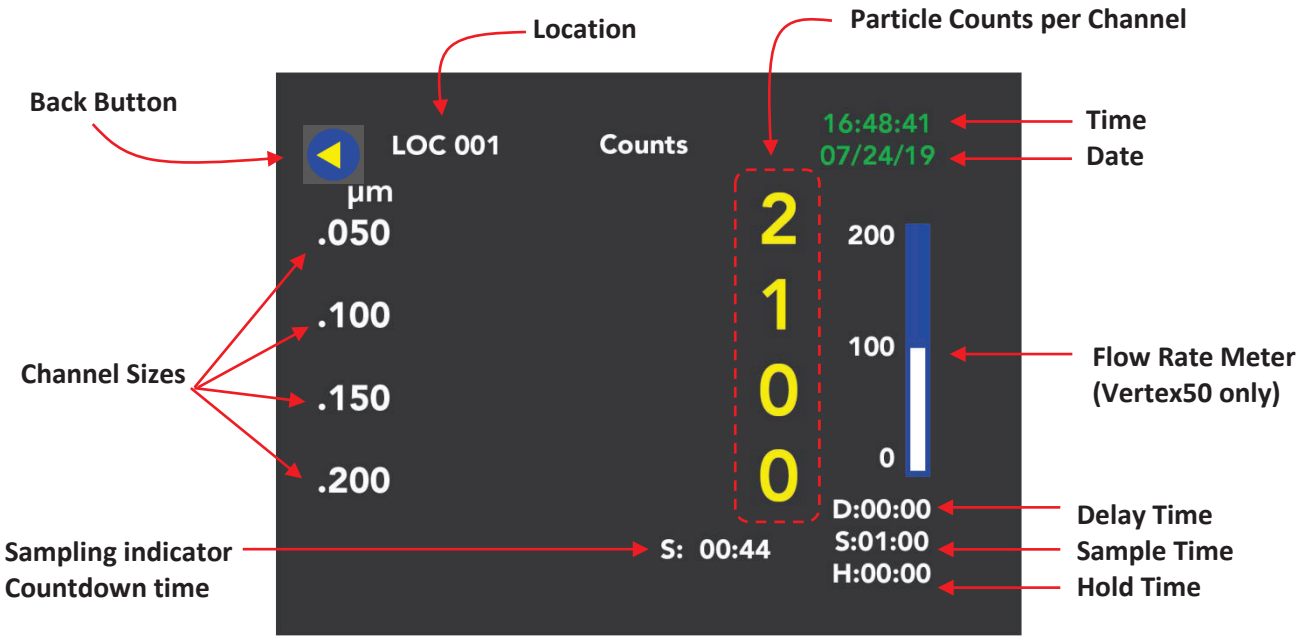
The Service Screen
Set up

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Main Screen

The main screen display:

- Particle channel sizes (µm)
- Particle counts per channel
- Flow rate meter
- Location
- Time
- Date
- Sampling status



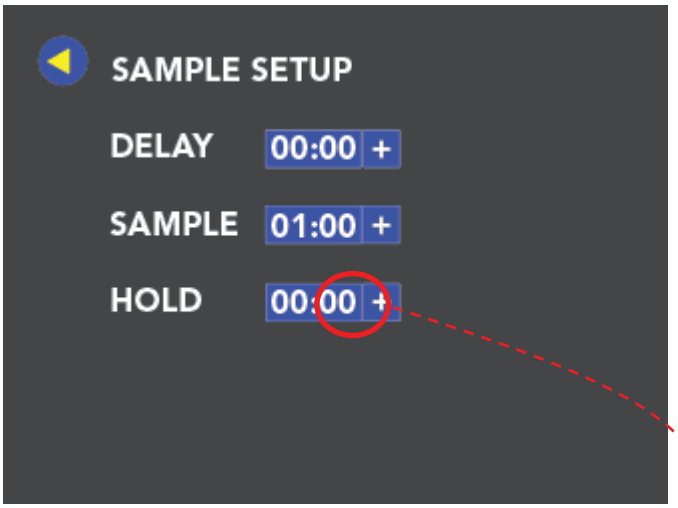
Vertex Main Screen

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Sample Setup Screen

The Sample Setup screen accepts input for the delay time, sample time and hold time.

The delay time is the time period before a sample starts. No particles will be counted during the delay time period. The sample time is the time that particles will be counted in the liquid. The hold time is the time period between sample periods and no particle will be counted.

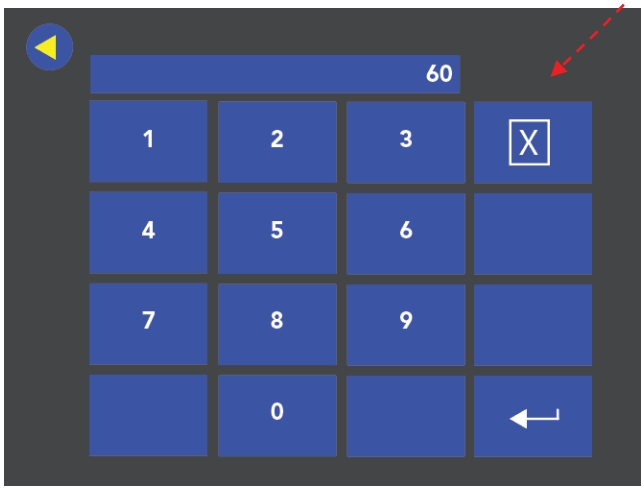


The Sample Setup Screen

Numeric Keypad



Press the + button next to the Delay, Sample or Hold times and the numeric key pad and enter the value for each sample setup parameter. Use the delete button to erase the last entry. Then press the return button to save your input. Or press the back button to return to the Sample Setup screen with no changes.



The Numeric Key Pad

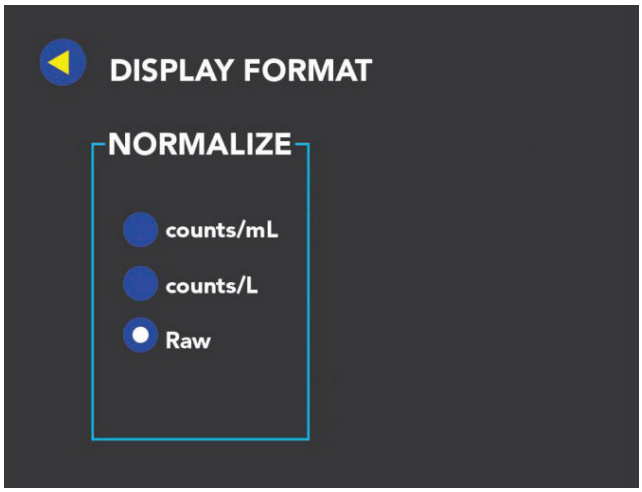
Delay, Sample and Hold Times

The Vertex liquid particle counter will count particles continuously while powered on. The delay time will begin when the sensor is powered on and started. The minimum delay time is 3 seconds. The sample time will begin after the delay time expires. The Hold time will begin after the sample time has expired. After the Hold time has expired then the next sample time will start. The sample and hold time periods will cycle until the instrument is powered off. Particles will not be counted during the Delay or Hold time periods. Liquid particle counting will only be recorded during the Sample time period.

Display Format Screen

Choose to normalize the particle counts to counts/mL or counts/L or Raw for total particle counts.

- Press the normalize button and a white dot will display indicating that normalize format has been selected.



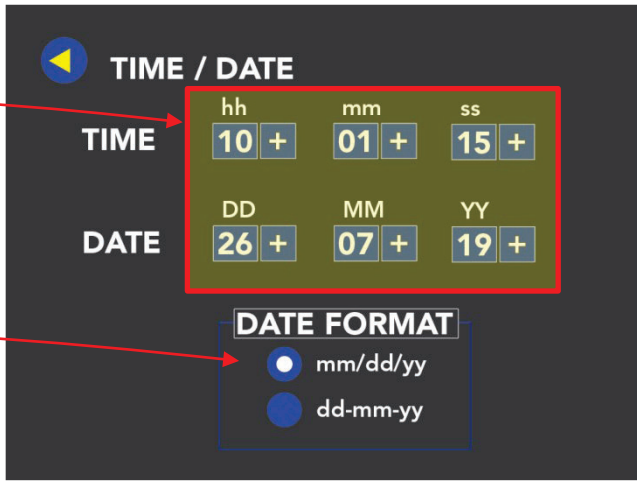
The Display Format Screen

Time and Date Format Screen

Set the current time and date.
Press the + button to display the numeric keypad and change the time and date.

Set the desired date format.
Press the date format button and a white dot will display indicating it has been selected.

mm/dd/yy
or
dd-mm-yy



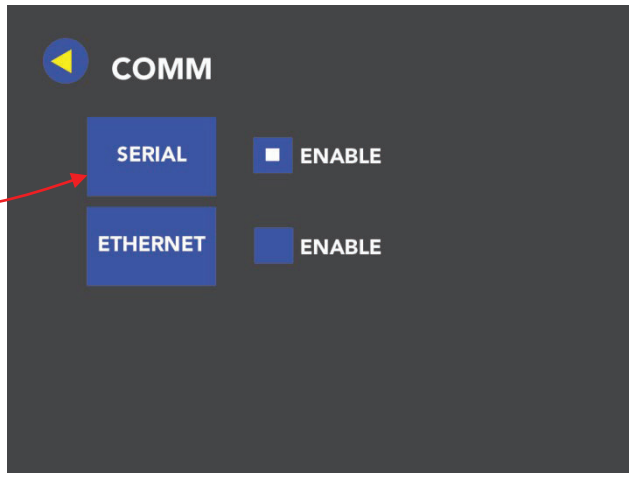
The Time and Date Format Screen

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Communication Screen

Select Serial Communications

- Press Serial button to display the Serial Address screen.

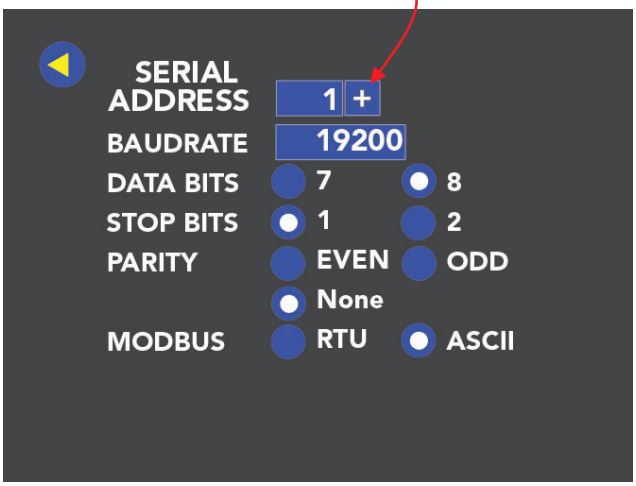


The Communications Screen

Select Serial Address



- Press the serial address + button and the numeric keypad will display. Enter the serial address and press the return button.
- Press the baudrate button and select from the drop down list.
- Select data bits 7 or 8 and that button will highlight with a white dot indicating that it has been selected.
- Select either 1 or 2 Stop Bits.



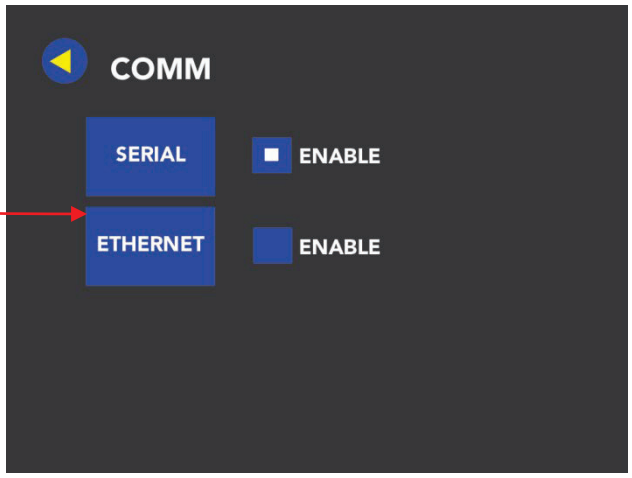
The Serial Address Screen

- Choose the parity as even, odd or none and that button will highlight with a white dot indicating it has been selected.
- Select the MODBUS RTU or ASCII.

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Select Ethernet Communications

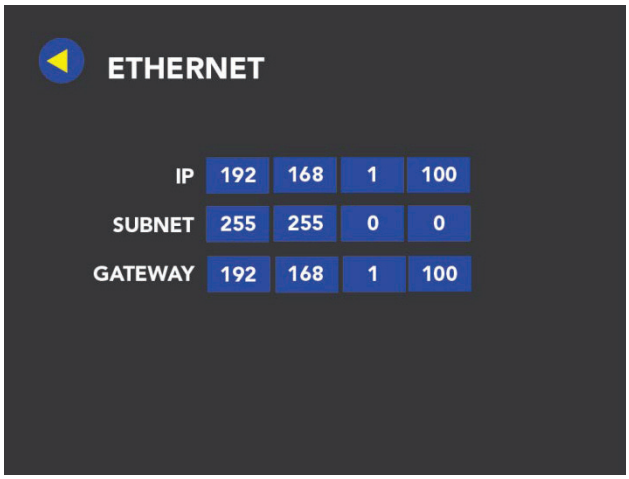
- Press the Ethernet button to set up the Ethernet address.



The Communications Screen

Select Ethernet Address

- Press the IP address buttons to edit the IP address.
- Press the Subnet address buttons to edit the Subnet address.
- Press the Gateway address buttons to edit the gateway address.
- Press the back button to return to the Main Menu screen.



The Ethernet Address Screen

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Analog Output

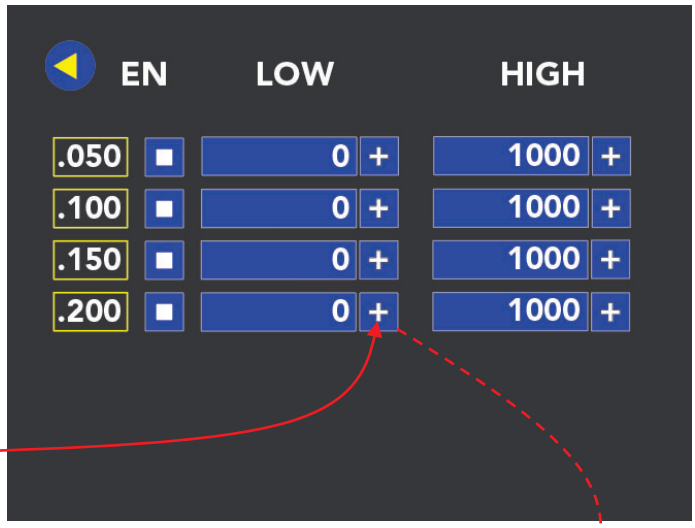
Set the analog (4-20mA) upper thresholds equivalent to 20mA for each channel size. Zero counts will be set to 4mA and anything between 0 and the value falls proportionately between 4 and 20mA.



- Press the channel enable button and a white square will display indicating that channel size has been enabled.



- Press the + button to display the numeric keypad screen and enter threshold values.



Analog Output Screen

Analog Thresholds

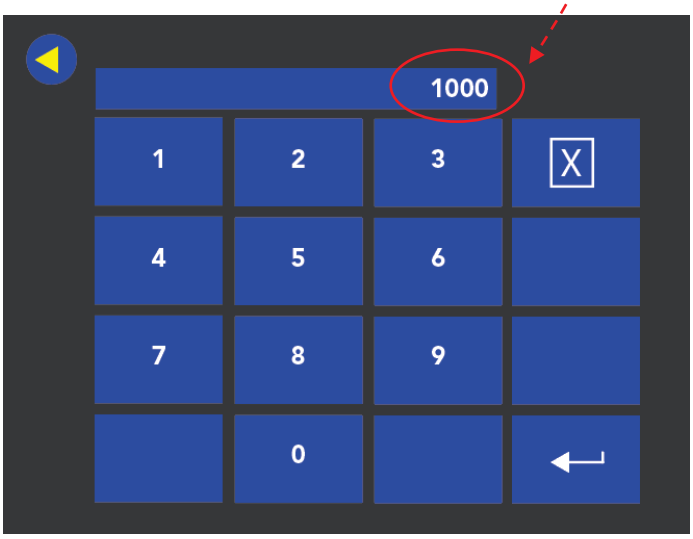
- Enter the threshold value.



- Press the return button to save that value.



- Press the back button to return to the Analog Output screen.



Numeric Keypad

DB-9 Pin#	Signal Assigned
1	CH1 +
2	GND
3	CH2 +
4	GND
5	CH3 +
6	GND
7	CH4 +
8	GND
9	GND

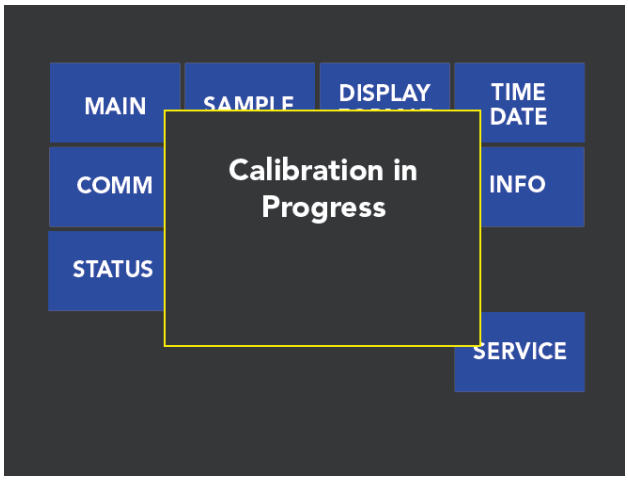
Table 5-1: DB-9 Pinouts

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Flow Calibration (Vertex50 only)

Vertex is designed and calibrated for particle detection in DI Water. The flow calibration calibrates the zero flow point of the flow meter. The instrument must have liquid in the unit, but no liquid should be flowing before performing this calibration.

After setup a zeroing is recommended. Assure that the sensor is completely filled DI Water and is free of bubbles. Stable liquid properties should be assured by flushing the circuit with the final liquid until temperature and viscosity becomes stable. After this zero flow shall be realized.

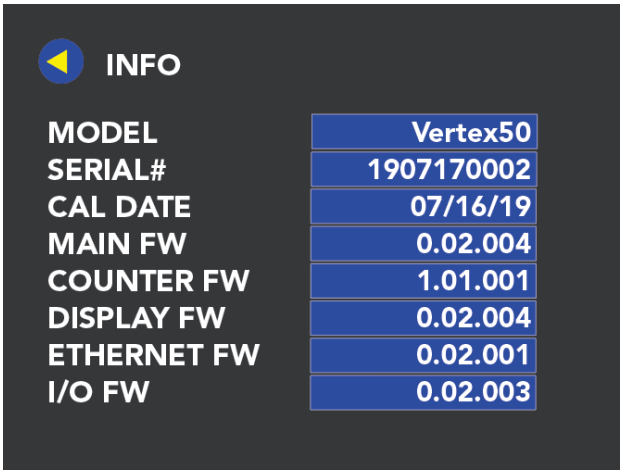


Flow Calibration Screen

Info Screen

The Info Screen displays:

- Model Name
- Serial #
- Calibration Date
- Main firmware version
- Counter firmware version
- Display firmware version
- Ethernet firmware version
- I/O firmware version

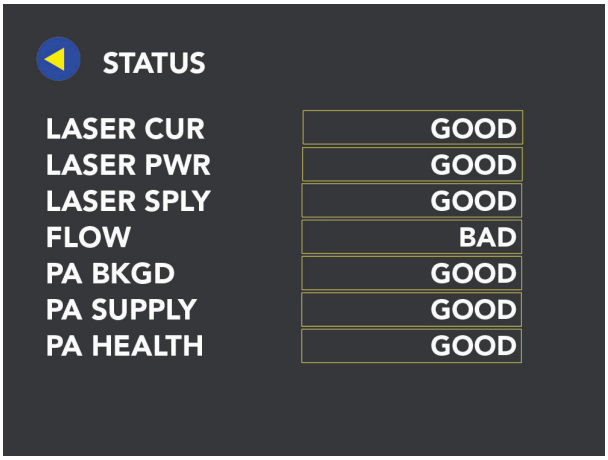


Info Screen

Status Screen

The Status screen displays:

- Laser Current (Vertex50 only)
- Laser Power (Vertex50 only)
- Laser Supply (Vertex50 only)
- Flow
- Photo Amp Background (Vertex50 only)
- Photo Amp Supply (Vertex50 only)
- Photo Amp Health (Vertex50 only)



Status Screen

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Chapter 6 Programming with MODBUS Protocol

The Vertex can be programmed using the MODBUS Protocol. The full protocol is detailed in "Vertex50 MODBUS Register Map v1.50" in Appendix A. This chapter contains the information needed to program the basic configuration for the instrument using the MODBUS protocol.

Protocol Settings

The MODBUS Protocol is defined through an RS485 interface with:

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

Power On/Auto Start

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

Location	= Loc001
Sample Time	= 60 seconds
Hold Time	= 0 seconds

Stopping the instrument sets the RUNNING and SAMPLING bit of the status register = 0.

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

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

NOTE: The automatic starting of the sampling accommodates systems that do not send a START command, but only poll the instrument for its data.

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Running the instrument using MODBUS

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

Table 6-1 Application Action Commands

Value	Action
1	Saves all writable 4xxxx register values to the EEPROM.
3	Clears the Data Buffer. Record count is set = 0
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 a data record to equal the time interval between the Manual Start and the 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. The Data Buffer will retain up to 3000 records, utilizing a FIFO (First In First Out) protocol to drop the oldest record to make room for the newest one once the buffer is full.

After setting all the instrument parameters as described in “Changing the Default Instrument Parameters” on page 44, write these commands to the Command register (40002):

11	Start Instrument:	To Start Recording
12	Stop Instrument:	To Stop Recording

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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 sample time.

Configuring with 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 are stored in a 4-byte unsigned integer or as a 32-bit unsigned integer.

Table 6-2 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, the Data Set registers. See Table 6-3.

Table 6-3 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.
40036	Unsigned integer	Data Set [low]

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).

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Changing the Default Instrument Parameters

The instrument parameters include Location, Sample Time, and Hold Time. See table 6-4.

The Location is set by writing an unsigned integer to register 40026. The range of values is from Loc001 to Loc999.

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, 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.
Device SAMPLING bit = 0 during Hold time.

Table 6-4 Instrument Parameters

Register	Data Type	Description
40026	Unsigned integer	Location Number Specifies location of the liquid particle counter. Loc001 – Loc999
40031	Unsigned integer	Hold Time [high] Works in conjunction with 40032. Number of seconds to wait between sample periods. Max Hold Time = 59 mins 59 seconds.
40032	Unsigned integer	Hold Time [low]
40033	Unsigned integer	Sample Time [high] Works in conjunction with 40034. Number of seconds to sample. Max Sample Time = 59 mins 59 seconds.
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 are to that position on the manifold. Value 0 move the arm to the Home position.

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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 n 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, specified in seconds. The maximum value is 86,399 seconds (high word: 1, low word: 20863) which is 23 hours, 59 minutes, 59 seconds. The instrument is programmed at the factory with a default value of 60 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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Definitions of Terms Used

- **ARP**- Address Resolution Protocol, a program that can change the ARP Cache of a host by adding or removing IP addresses. Each IP address is associated to a MAC address.
- **ARP Cache** – List of IP addresses and their associated MAC addresses for hosts whose addresses cannot be resolved normally.
- **Gateway** – a network device that controls traffic between two or more networks.
- **Hardware address** – a unique identifying code programmed by the factory into a network device, such as a network PCB, comprised of six two-digit groups of letter A-F and number 0-9.
- **Host** – a computer of device that allows access to itself via a LAN.
- **IP** (Internet Protocol) Address – a unique logical address used to identify a host on a TCP/IP network.
- **LAN** – Local Area Network, a group of computers or hosts connected together in a relatively small geographical area, such as a building or floor of a building.
- **MAC address** – the same as Hardware Address.
- **Netmask** – a logical hexadecimal number that prevents accessing hosts outside of its range. A bit value of zero allows access and a non-zero blocks access.
- **Subnet** – a logical grouping of hosts based on their IP addresses.
- **TCP/IP** – a communication protocol suite that is used for the Internet and a large number of LANs that allow hosts to share data.
- **Telnet** – a communication program used primarily to issue commands directly to a TCP/IP-based host.

NOTE: The network where the instruments will operate must have an available IP address for each instrument. The IP scheme, or subnet, must match that of the PC that will be used to retrieve the data from the instruments.

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Appendix A Vertex MODBUS Register Map v1.50

Supported Instruments

The following Lighthouse particle counters use the MODBUS register map specified in this document:

- Solair Series
- Handheld Series
- Remote 4 Series
- Remote P Series
- Remote PN Series
- Universal Manifold Controller
- Mini Manifold
- Mini Multiplexer
- Remote Liquid Series
- Liquid Sampler

Communication Settings

Lighthouse particle counters have the following communication settings:

Baud Rate:	19200
Data Bits:	8
Stop Bits:	1
Parity:	None
Hardware Protocol:	RS-485 Standard
Software Protocol:	MODBUS ASCII (Supports upper and lower case.)

NOTE: Solair, Handheld, Remote 4, Remote P, Remote PN, and Remote Liquid Series currently support only upper case

The MODBUS slave address can be set on the particle counter. Valid addresses are 1-247. Address 0 is the broadcast address.

Supported MODBUS Commands

Hex Command	Description
01	Read Coils
03	Read Holding Registers
04	Read Input Registers
05	Write Single Coil
06	Write Single Holding Register

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

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1. REGISTER BANKS

1. Relay Coils (0000x series)
2. Instrument Settings Registers (40xxx series)
3. Data Type Registers (41xxx series)
4. Unit Registers (42xxx series)
5. Enable Registers (43xxx series)
6. Threshold Low Registers (44xxx series)
7. Threshold High Registers (45xxx series)
8. Sequence Registers (46xxx series)
9. Data Minimum/Offset Registers (47xxx series)
10. Data Maximum/Scalar Registers (48xxx series)
11. Configuration Registers (49xxx series)
12. Data Registers (30xxx series)

2. INSTRUMENT SETTINGS REGISTERS

Instrument settings are stored in holding registers (the 40xxx series), which are read/write-able. (Not all holding registers are writable, in that hard coded information is storage and re-stored on power up).

Register	Data Type	Description
40001	unsigned int	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 int	Command register. Makes the counter execute a command. See the description of this register in the table below.
40003	unsigned int	Device Status. [bit 0=RUNNING, bit 1=SAMPLING, bit 2=NEW DATA, bit 3= DEVICE ERROR
40004	unsigned int	Firmware version. Major version digits are hundreds. Minor version digits are ones and tens digits. For example: 235d = v2.35.
40005	unsigned int	Serial number [high].
40006	unsigned int	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].

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Register	Data Type	Description
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].
40021	ASCII string	Model name char[12], char[13].
40022	ASCII string	Model name char[14], char[15].
40023	unsigned int	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	signed int	Record count. Total number of records stored in counter.
40025	signed int	Record index. Zero based index to data in the 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 the last record stored by the counter.
40026	signed int	Location number. Particle Counters not supporting location names: Must be 0 to 999. Particle Counters supporting location names: Must be 1 to 200. (Maps to location names associated with registers 40200-40999.) Manifold Controllers: Specifies manifold position. Values 1 to 32 moves to that position on manifold. Value 0 moves to home position. Apex Remote: With location bracket, location number matches low word Location ID in 40055. Without location bracket, location number behaves as legacy mode.
40027	signed int	Clock [high]. Displays instrument's real-time clock. Must be number of seconds since midnight of 1/1/1970. Can be generated by ANSI C/C++ time() function.
40028	unsigned int	Clock [low].
40029	unsigned int	Initial delay [high]. Seconds to wait before starting the first sample. Max Delay Time = 59mins 59 seconds.
40030	unsigned int	Initial delay [low].
40031	unsigned int	Hold time [high]. Seconds to wait between samples. Max Hold Time = 59mins 59 seconds.
40032	unsigned int	Hold time [low].
40033	unsigned int	Sample time [high]. Number of seconds to sample. Max Sample Time = 59 mins 59 seconds.
40034	unsigned int	Sample time [low].

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Register	Data Type	Description
40035	unsigned int	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 int	Data Set [low].
40037	unsigned int	Relay Mode and Alarm mode. Type of alarming performed or use of relay.
40038	unsigned int	Relay Parameter. Control parameter for given relay mode.
40039	unsigned int	Laser Reference Voltage (millivolts)
40040	unsigned int	View Volume. Divide by 100 to get the percentage. For example: 6550d = 65.50%
40041	ASCII string	Flow Unit. Defines unit the flow rate value is based on. Char[0], char[1]. (NULL terminated string.)
40042	ASCII string	Flow Unit. Char[2], char[3]
40043	unsigned int	Calibration Reference Voltage (millivolts)
40044	unsigned int	IAQ Handheld: Assumed Particle Density (g/ml). Divide by 1000 to get value. For example: 2500d = 2.5 LS-60: Position setting: Loader stage position (0 = HOME, 30000 = MAX)
40045	unsigned int	LS-60: Speed setting: Stirrer (0 = OFF, 100 = MAX)
40046	unsigned int	LS-60: Syringe size. 10 ml and 25 ml are supported
40047	signed int	Remote 4: 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 int	Remote 4: Calibration Due Date [low]
40049	signed int	Printer Options
40050	signed int	Device Options
40051	signed int	Current record. Displays last record number recorded by instrument.
40052	signed int	Record number. Set this value to desired record number to display data in 3xxxx registers. Value corresponds to record number in instrument data buffer. Set to -1 to retrieve the last record stored by the counter.
40053	unsigned int	Sample cycle. Set this value to desired number of cycles.
40054	unsigned int	Location ID[high]. Value is 0 when no location bracket is present.
40055	unsigned int	Location ID[low]. Value is 0 when no location bracket is present. Value matches 40026 location number when bracket is present.
40056	unsigned int	Device Status[high].
40057	unsigned int	Device Status[low].

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Register	Data Type	Description
40058	unsigned int	Serial number [high].
40059	unsigned int	Serial number [low].
40060	signed int	Last Sample Timestamp [high] (# of seconds since midnight, 1/1/1970.)
40061	signed int	Last Sample Timestamp [low]
40062	signed int	Last Setting Change Timestamp [high] (# of seconds since midnight, 1/1/1970.). Value indicates
40063	signed int	Last Setting Change Timestamp [low]
40064	signed int	Run-time particle channel alarm high flags (bit 0 = channel 1, …)
40065	signed int	Run-time particle channel alarm low flags (bit 0 = channel 1, …)
40066	signed int	Run-time analog channel alarm high flags (bit 0 = channel 1, …)
40067	signed int	Run-time analog channel alarm low flags (bit 0 = channel 1, …)
40068	unsigned int	Software controlled RGB LED red channel. Uses values from 0-100 for duty cycle percentage every even second from UNIX time
40069	unsigned int	Software controlled RGB LED green channel. Uses values from 0-100 for duty cycle percentage every even second from UNIX time
40070	unsigned int	Software controlled RGB LED blue channel. Uses values from 0-100 for duty cycle percentage every even second from UNIX time
40071	unsigned int	Software controlled RGB LED red channel. Uses values from 0-100 for duty cycle percentage every odd second from UNIX time
40072	unsigned int	Software controlled RGB LED green channel. Uses values from 0-100 for duty cycle percentage every odd second from UNIX time
40073	unsigned int	Software controlled RGB LED blue channel. Uses values from 0-100 for duty cycle percentage every odd second from UNIX time

The command register (40002) is used to make the device perform an action. This register performs an action when writing an integer value to it. The action is completed when the device sends a MODBUS response. When this command register is read, it always returns zero.
The following commands are supported…

Value	Action
1	Saves all writable 4xxxx register values to the device's EEPROM.
2	Reserved for future use. Apex Remote: Restores all writable 4xxxx register values to the device
3	Clears the data buffer. Record count is set to zero.
4	Saves the instrument parameters in the 40xxx registers to the EEPROM; this includes sample time, hold time, initial delay and location. Apex Remote: Same as cmd 1
5	Enable Remote Control. Locks out instrument's user interface. Can only change instrument parameters via MODBUS.
6	Enable Local Control. Unlocks instrument's user interface. Instrument changes can be made at the device itself and through MODBUS.

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Value	Action
7	Turns on pump. Flow regulated by internal setpoint.
8	Stop pump.
9	External Start Counter. Continually samples until receiving “External Stop” command. Does not turn on the pump. Ignores configured counting mode.
10	External Stop Counter. Records counts since “External Start”.
11	Instrument Start. Particle Counters: Uses defined initial delay, hold time, sample interval, and counting mode. Instrument cycles (sample/hold) until “Instrument Stop” command is issued. Manifold Controller: Uses defined manifold sequence. Stops counting and changing positions when “Instrument Stop” command is issued.
12	Instrument Stop. Aborts current sample. Stops data collection.
13	Set Real Time Clock. Writes “Data Set” values to the local Real Time Clock. New time value is saved.

Recommended Particle Counter Initialization Command Sequence
When initializing the instrument, there are a number of steps that need to be taken to prepare the instrument before data is collected. The following is the recommended command sequence to initialize an instrument.

NOTE: that in some cases, you may not need to read all the instrument registers, so you may not need to perform all these steps. For example, if the computer software uses fixed channel sizes rather than reading the channel sizes from the instrument, you can skip step 9. However, if you are unsure whether or not to perform any of these steps, don’t skip any steps, since failure to perform the necessary steps can cause data collection problems.

1. Read general instrument info
   - Read holding registers 40001-40042.

2. Set to REMOTE mode
   - Write 5 to holding register 40002.

3. Delay for about 1 second for the mode to switch.

4. Send the STOP command.
   - Write 12 to holding register 40002.

5. Delay for about 100 milliseconds for the STOP to complete.

6. Clear the instrument’s data buffer.
   - Write 3 to holding register 40002.

7. Delay for about 500 milliseconds for the above operation to complete.

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8. Fetch “Enabled Channels” flags.
    - If Modbus Map Version >= 138, then read holding registers 43001-43072.
    - Else read input registers 31001-31072.

9. Fetch channel names/type strings.
    - If Modbus Map Version >= 138, then read holding registers 41001-41072.
    - Else read input registers 32001-32072.

10. Update instrument’s clock use ANSI ctime (Unix time epoch) in “local time”.
    - Write datetime’s high word to holding register 40027.
    - Write datetime’s low word to holding register 40028.
    - Write 13 to holding register 40002 to update the clock.

11. Set the counter’s “initial delay” to zero.
    - Write zero to holding register 40029.
    - Write zero to holding register 40030.

12. Set the counter’s “holding time” in seconds. (This would usually be zero.)
    - Write high word to holding register 40031.
    - Write low word to holding register 40032.

13. Set the counter’s “sample time” in seconds.
    - Write high word to holding register 40033.
    - Write low word to holding register 40034.

14. Save the above settings to instrument EEPROM.
    - Write 1 to holding register 40002.

15. Delay for about 500 milliseconds for the above operation to complete.

16. Set the data buffer index to always point to the newest data record.
    - Write -1 to holding register 40025.

17. Start the particle counter.
    - Write 11 to holding register 40002.

Value	Action
71	Changes minimum programmable sample time (sample time value written in Reg 40036
81	Changes channel size label for particle channel 1 (channel labels written in Regs 40035 – 40036)
82	Changes channel size label for particle channel 2.
83	Changes channel size label for particle channel 3.
84	Changes channel size label for particle channel 4.
85	Changes channel size label for particle channel 5.
86	Changes channel size label for particle channel 6.
87	Changes channel size label for particle channel 7.
88	Changes channel size label for particle channel 8.

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The device status register (40003 and 40057) bits that are supported are…

Bit	Action
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 remain 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.
3	**DEVICE ERROR**: In the event that there is a failure on the device, this bit is set to indicate possible invalid data collected. Manifold Controller: Manifold positioning error.
4	LS-60: **PURGE**: Set to 1 when purging occurs, else set to zero.
5	LS-60: **STIRRER**: Set to 1 when stirrer is on, zero when stirrer is off.
6	LS-60: **SLIDE**: Set to 0 when slide is HOME, else set to 1
7	RAC: **LAST CYCLE**: Set to 1 when done with last cycle of sample, else set to 0
8	RAC: **PAUSING**: Set to 1 when instrument is in pause state, else set to 0
9	Apex Remote: **DATA VALIDATION**: Set to 1 when unit is in data validation mode, else set to 0
10	Apex Remote: **LOCATION VALIDATION**: Set to 1 when unit is in location validation mode, else set to 0
11	Apex Remote: **LASER STATUS**: Set to 1 when unit's laser is out of spec, else 0
12	Apex Remote & RAC: **FLOW STATUS**: Set to 1 when unit's flow is out of spec, else 0
13	Apex Remote: **SERVICE STATUS**: Set to 1 when unit needs to be serviced, else set to 0
14	Apex Remote: **THRESHOLD HIGH STATUS**: Set to 1 when unit's high alarm threshold is exceeded, else set to 0
15	Apex Remote: **THRESHOLD LOW STATUS**: Set to 1 when unit's low alarm threshold is not met, else set to 0

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The device status register (40056) bits that are supported are…

Bit	Action
0	Apex Remote: **LASER POWER STATUS**: Set to 1 when unit's laser current is out of spec, else set to 0
1	Apex Remote: **LASER CURRENT STATUS**: Set to 1 when unit's laser power is out of spec, else set to 0
2	Apex Remote: **LASER SUPPLY STATUS**: Set to 1 when unit's laser supply is out of spec, else set to 0
3	Apex Remote: **LASER LIFE STATUS**: Set to 1 when unit's laser supply is out of spec, else set to 0
4	Apex Remote: **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	Apex Remote: **PHOTOAMP SUPPLY STATUS**: Set to 1 when unit's photoamp supply is out of spec, else set to 0
6	Apex Remote: **BACKGROUND STATUS**: Set to 1 when unit's photoamp background is out of spec, else set to 0
7	Apex Remote: **PHOTODIODE STATUS**: Set to 1 when photodiode has failed, else set to 0
8	Apex Remote: **CALIBRATION DUE DATE STATUS**: Set to 1 when unit is past calibration due date, else set to 0
9	Apex Remote: **LOCATION BRACKET STATUS**: Set to 1 when unit is in location bracket mode and bracket is missing, else set to 0

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3. DATA UNITS REGISTERS

The 42xxx 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 30041's units register would be located at 42041.

Units are stored as 4 character ASCII strings across 2 registers. If the units string contains less than 4 characters or no characters at all, then the rest of the string is padded with NULLs. Note that a units string using all 4 characters will not end with a NULL.
(Not all data types have units!)

Below are units that may be sent by the instrument. However, be aware that an instrument might use units not in this table. Some of these units are not currently used, but are reserved for future use.

Units	Description
#	Count (For particles.)
%	Percent
PCT	Percent
s	Seconds
SEC	Seconds
min	Minutes
hour	Hours
F	Fahrenheit
C	Celsius
K	Kelvin
ft	Feet
m	Meters
ft^2	Square feet
m^2	Square meters
ft^3	Cubic feet
m^3	Cubic meters
L	Liters
CFM	Cubic Feet per Minute
CMM	Cubic Meters per Minute
L/m	Liters per Minute
LPM	Liters per Minute
MLPM	Milliliters per Minute
p/f^3	Particles per cubic feet
p/m^3	Particles per cubic meter
p/L	Particles per Liter
p/ml	Particles per milliliter

Units	Description
ft/m	Feet per minute
FPM	Feet per minute
m/s	Meters per second
MPS	Meters per second
"H2O	Inches of water
IH2O	Inches of water
"Hg	Inches of mercury
IHG	Inches of mercury
mmWa	Millimeters of water
mmHg	Millimeters of mercury
cmHg	Centimeters of mercury
Pa	Pascals
kPa	Kilopascals
Bar	Bar
mBar	Millibar
V	Volts
mV	Millivolts
A	Amps
mA	Milliamps
Ohm	Ohms
mOhm	Milli-ohms

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