



SEA-BIRD
SCIENTIFIC

User manual

SBE 16plus-IM V2 SeaCAT Recorder

Conductivity and temperature sensor



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Software:

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B
Seasoft V2

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Section 1 Safety information

Please read this entire manual before this equipment is unpacked, set up, or operated. Pay attention to all danger, warning, and caution statements. Failure to do so could result in serious injury to the operator or damage to the equipment.

⚠ DANGER

Indicates a potentially or imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

Indicates a potentially or imminently hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

Indicates a potentially hazardous situation that may result in minor or moderate injury.

NOTICE

Indicates a situation which, if not avoided, may cause damage to equipment. Information that requires special emphasis.

1.1 Hazard information

⚠ WARNING



If the user thinks that the alkaline batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.

For optional lithium batteries:

⚠ WARNING



If the user thinks that the lithium batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.

⚠ CAUTION



The pressure housing contains Electrostatic Discharge (ESD) sensitive parts and assemblies that are susceptible to damage from ESD. Follow ESD protocols:

- Put on protective eye wear before you open the pressure housing.
- Any electrostatic charge on the body of the human operator must be released before the pressure housing is opened: put a hand on a grounded surface, or better, wear a grounded antistatic wrist strap.
- At a minimum, wear short-sleeved antistatic clothing, such as cotton, or better, wear an antistatic smock for this service activity. *Do not wear a sweater, fleece or polyester-based clothing.*
- At a minimum, use a workstation with a wood or metal tabletop, or better, a tabletop that dissipates static. *Do not use a workstation with a synthetic or polymeric-based tabletop.*

⚠ CAUTION

AF24173 anti-fouling devices contain bis(tributyltin) oxide. Wear rubber or latex gloves and eye protection to replace these devices on the sensor if it is so equipped. Wash hands with soap and water when finished.

Read the precautions on the product label.

It is a violation of US federal law to use this product in a manner that is inconsistent with its label.

NOTICE

The manufacturer is not responsible for any damages due to misapplication or misuse of this product including, without limitation, direct, incidental and consequential damages, and disclaims such damages to the full extent permitted under applicable law. The user is solely responsible to identify critical application risks and install appropriate mechanisms to protect process during a possible equipment malfunction.

1.2 Equipment labels

Read all labels and tags attached to the equipment. Personal injury or damage to the equipment could occur if not observed. A symbol on the equipment is referenced in the manual with a precautionary statement.



Electrical equipment marked with this symbol may not be disposed of in European domestic or public disposal systems. Return old or end-of-life equipment to the manufacturer at no charge to the user.



EFUP e: No hazardous material exists over the threshold of GB/T 26572-2011 standard, China's Requirements for Concentration Limits for Certain Hazardous Substances in Electrical and Electronic Products. This product should be recycled after its environmentally friendly use period.








ATTENTION!

Remove sticker before deployment!

This sticker protects your instrument during shipping. **REMOVE BEFORE DEPLOYMENT**; if it is not removed, your instrument will not operate properly and you may cause severe damage to the conductivity cell. The conductivity cell is made of glass and will break if mishandled or frozen while filled with water. Apply new sticker to protect instrument when not in use (see spares kit).

NOTICE: Sticker may have come in contact with the AF24173 Anti-foulant device, which contains TBTO. Dispose of the removed sticker. See SDS for handling precautions.

Section 2 SBE 16plus V2 quick start guide

⚠ WARNING	
	If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.
⚠ WARNING	
	If the user thinks that the alkaline batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.
⚠ WARNING	
	If the user thinks that the NiMH batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.
⚠ CAUTION	
 	<p>The pressure housing contains Electrostatic Discharge (ESD) sensitive parts and assemblies that are susceptible to damage from ESD. Follow ESD protocols:</p> <ul style="list-style-type: none">• Put on protective eye wear before you open the pressure housing.• Any electrostatic charge on the body of the human operator must be released before the pressure housing is opened: put a hand on a grounded surface, or better, wear a grounded antistatic wrist strap.• At a minimum, wear short-sleeved antistatic clothing, such as cotton, or better, wear an antistatic smock for this service activity. <i>Do not wear a sweater, fleece or polyester-based clothing.</i>• At a minimum, use a workstation with a wood or metal tabletop, or better, a tabletop that dissipates static. <i>Do not use a workstation with a synthetic or polymeric-based tabletop.</i>

This quick start guide gives the steps necessary to make sure that the SBE 16plus-IM V2 SeaCAT sensor operates correctly and collects data before it is deployed.

What's in the box:

- 16plus-IM V2 SeaCAT sensor
 - CD or USB drive with software, calibration files, documentation
 - Dummy plugs and lock collars for each bulkhead connector
 - Data I/O cable to connect the sensor to a PC
 - Non-ionic surfactant to clean sensor flow path
 - Conductivity cell tubing and storage kit
 - Spare hardware and O-ring kit.
1. If necessary, install new batteries. Refer to [Replace alkaline batteries](#) on page 41 for details.
 2. Install the manufacturer-supplied software on a PC. Refer to [Install software and test sensor](#) on page 17 for details.

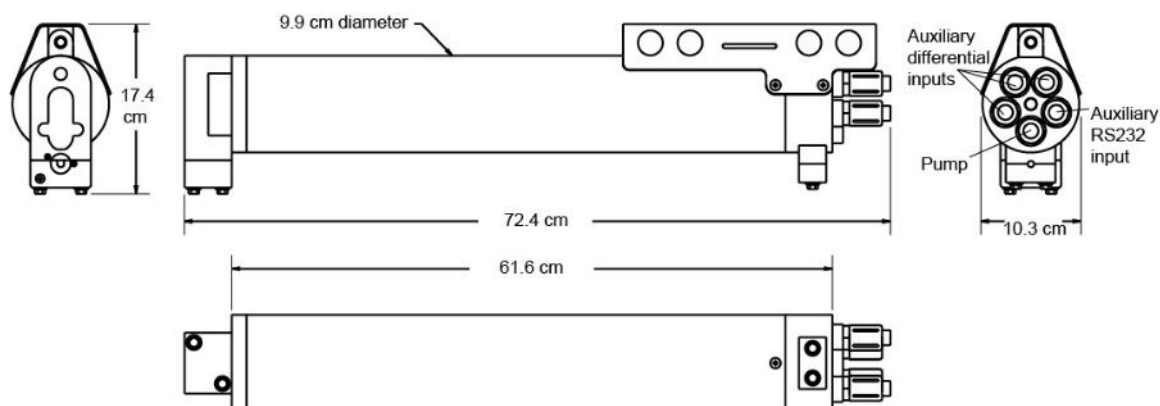
3. Connect the data I/O cable to the sensor and the PC and double-click on **SeaTermV2.exe** to start the software.
4. Make sure that all data stored in the sensor is transmitted to a PC.
5. Set the date and time and configure the data collection settings.
6. Set up the SIM or IMM. Refer to [Inductive modems](#) on page 18 for setup details.
7. Install dummy plugs and lock collars on bulkhead connectors that are not used.
8. Remove the protective plugs from the antifouling device cups and verify that antifouling devices are installed.
Keep the protective plugs to install again after a deployment
9. If necessary, remove the end-to-end loop of Tygon® tubing from around the conductivity cell. It is used when the SeaCAT is in storage.
10. If necessary, connect the tubing from the pump to the conductivity cell.
11. Send the #iiDS and #iiDCal commands to verify status and calibration coefficients.
12. Send #iiStartNow to start data collection. Send #iiStartDateTime= and #iiStartLater to start data collection at a specified date and time, every #iiSampleInterval=seconds. Refer to [Set up for deployment](#) on page 25 for details.
13. Deploy the sensor. For most applications, make sure the connector is at the bottom (lowest point).
14. Immediately after the sensor is recovered from a deployment:
 - a. Transmit data from the sensor to a PC. Refer to [Transmit and convert data](#) on page 37 for details.
 - b. Turn off the sensor.
 - c. Flush the sensor with fresh water.
 - d. Keep the SeaCAT out of direct sunlight between deployments.
15. Refer to [CTD storage](#) on page 46 for details to prepare the sensor for short- or long-term storage.

Section 3 Specifications

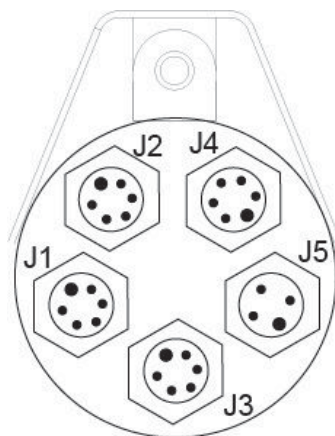
3.1 Mechanical

Weight , 600 m, plastic, no pump, in air, water	9, 4 kg
Weight , 10500 m, titanium, no pump, in air, water	17, 12 kg
Weight , 5M, plastic	0.3, 0.1 kg
Weight , 5M, titanium	0.4, 0.3 kg
Weight , 5T, P, plastic	0.5, 0.1 kg
Weight , 5T, P, titanium	0.7, 0.3 kg
Depth rating , acetal plastic	600 m
Depth rating , 3AL–2.5V titanium	7000 m
Depth rating , 6AL–4V titanium (limited to 8000 m with SIM or IMM)	10500 m

3.1.1 Dimensions

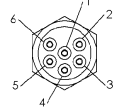


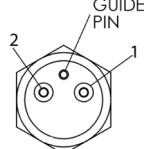
3.1.2 Connectors and cables

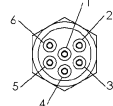


J1 auxiliary differential input 0,1				
Contact	Function	Contact	Function	MCBH6MP
1	Common	4	Voltage 1 signal	
2	Voltage 0 signal	5	Voltage 1 common	
3	Voltage 0 common	6	Auxiliary power out	

Specifications

J2 auxiliary differential input 2, 3				
Contact	Function	Contact	Function	MCBH6MP
1	Common	4	Voltage 3 signal	
2	Voltage 2 signal	5	Voltage 3 common	
3	Voltage 2 common	6	Auxiliary power out	

J3 pump		
Contact	Function	MCBH2MP
1	Pump power common	
2	Pump power +	

J4 auxiliary differential input 4, 5				
Contact	Function	Contact	Function	MCBH6MP
1	Common	4	Voltage 5 signal	
2	Voltage 4 signal	5	Voltage 5 common	
3	Voltage 4 common	6	Auxiliary power out	

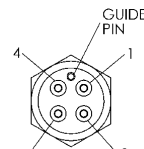
J5 auxiliary serial input		
Contact	Function	MCBH4MP
1	Common	
2	RS232 data transmit to RS232 sensor	
3	RS232 data receive from RS232 sensor	
4	Power to RS232 sensor	

Figure 1 SBE 5 pump cable

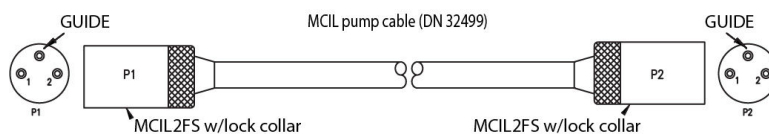
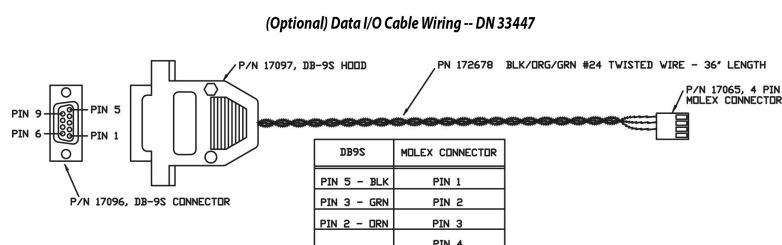


Figure 2 Data I/O cable



3.2 Electrical

Current draw, data collection	70 mA
Current draw, 5M pump	100 mA
Current draw, 5T, 5P	150 mA
Current draw, communications	4 mA
Current draw, low power	140 μ A
Internal battery capacity, 9 alkaline D-cells	14 Ah
Auxiliary power out at 10.5–11 VDC	to 500 mA
Voltage A/D resolution	14 bits
Voltage sensor input range	0–5 VDC

3.3 Analytical

Parameter	Range	Accuracy	Stability	Resolution
Conductivity	0–9	± 0.005 V	0.0003 S/m/month	0.00007 S/m
Temperature	-5–35 °C	± 0.005 V	0.0002 °C/mo	0.0001 °C
Pressure, strain gauge	various to 10,500 m	$\pm 0.1\%$ full scale range	$\pm 0.1\%$ full scale range	0.002% full scale range
Pressure, quartz	various to 10,500 m	$\pm 0.02\%$	$\pm 0.02\%$	0.0025% of full scale range

Section 4 Overview

4.1 System description

SeaCATs are available with an optional pump, which is required if the sensor has a dissolved oxygen sensor. The pump flushes water from the conductivity cell and gives better anti-fouling protection.

Available pump models:

- SBE 5M miniature pump, in plastic or titanium.
- SBE 5P or 5T, plastic or titanium pump with more power than the 5M. Use when the 16plus has a SBE 43 or SBE 63 dissolved oxygen sensor.

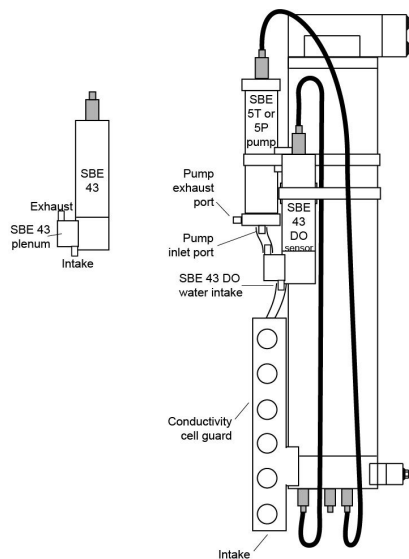
Other options:

- Strain-gauge or quartz internal pressure sensor.
- Lithium battery pack holder (batteries not supplied) for longer deployments (cannot be used with a 5P or 5T pump).
- Inductive Modem (IM) interface as an alternative to RS232. The IM uses a mooring cable for communications. The user can place the SeaCAT at any depth without the use of cable connectors. Up to 100 sensors can be attached to a single mooring line.

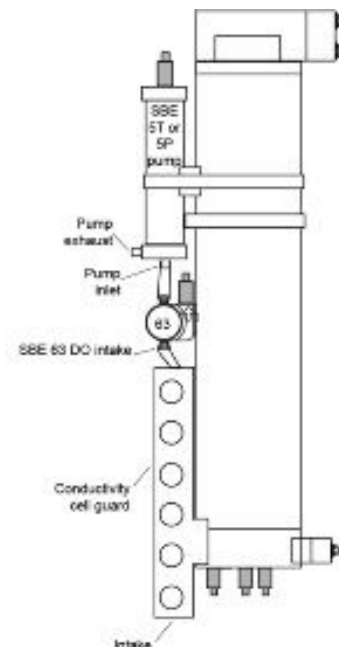
The SeaCAT can be used with RS232 and voltage signal auxiliary sensors:

- SBE 43 dissolved oxygen sensor
- SBE 63 optical dissolved oxygen sensor
- SBE 38 secondary temperature sensor
- SBE 50 secondary strain-gauge pressure sensor
- WET Labs ECO sensors (1, 2, or 3 channels)
- WET Labs WETStar pumped fluorometer
- WET Labs C-Star transmissometer
- WET Labs SeaOWL UV-A oil-in-water sensor
- Pro-Oceanus Gas Tension Device (up to two)
- Aanderaa Optode 4330 or 4835

Shown below is the 16plus-IM V2 with a 5T or 5P pump and a SBE 63 and 43.

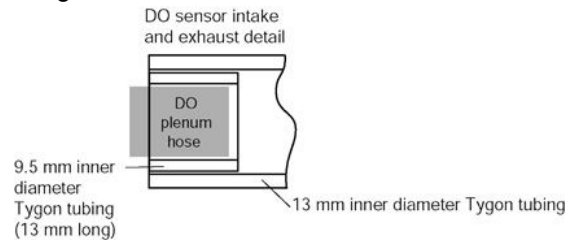


16plus-IM V2 with SBE 43



16plus-IM V2 with SBE 63

Tygon tubing detail is shown below.



4.2 Inductive Modem Module and Surface Inductive Modem

An Inductive Modem Module (IMM) or Surface Inductive Modem (SIM) is required for communication with the SBE 16plus-IM V2. These devices *modulate* the mooring cable with a Differential Phase Shift Keying (DPSK) signal that is encoded with commands received from a PC or controller. The encoded signals are *demodulated* by inductive modem devices coupled to the cable. Responses from the inductive modem devices are also coupled to the cable and *demodulated* by these devices.

- Supply the IMM with 7–24 VDC. The maximum current draw during operation is approximately 15 milliamps.
- Supply the SIM with 7–25 VDC. The maximum current draw during operation is approximately 30 milliamps.

The user's PC or controller is connected to the IMM or SIM with an RS232 cable. The standard communication protocol is 1200, 2400, 4800, 9600, 19200, or 38400 baud, which is user-selected, 8 data bits, no parity, RS232C.

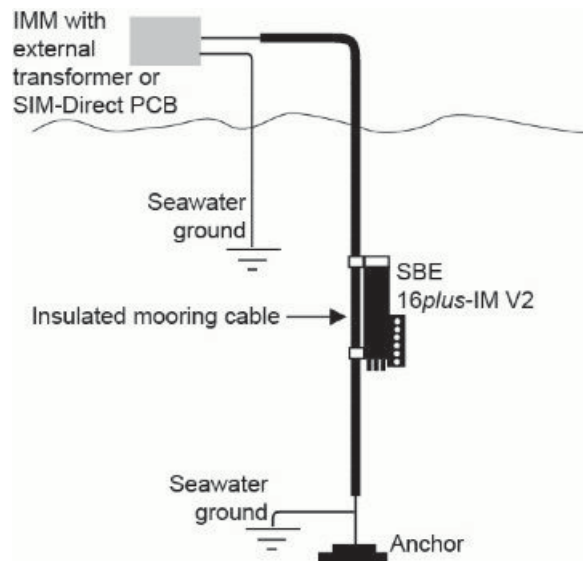
The DPSK communication between the IMM or SIM and IM sensor(s) is half-duplex. The DPSK modem communication between the IMM or SIM and IM sensors always operates at 1200 baud.

4.3 Mooring cable and wiring

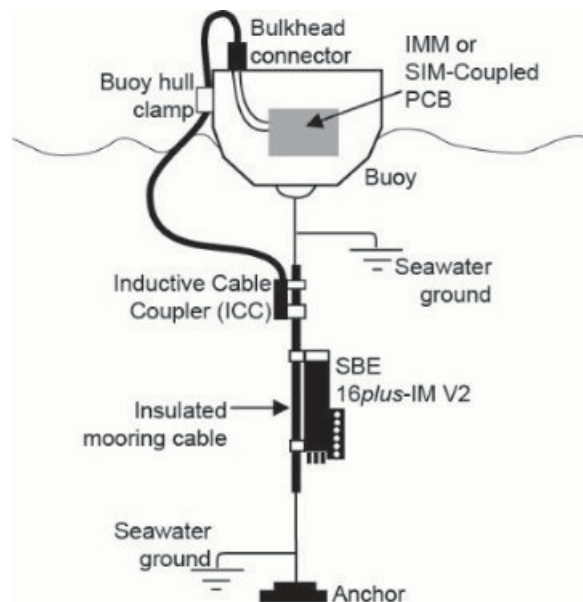
Sensors equipped with Inductive Modems can use mooring cables up to 16 mm in diameter. Clamps for specific cable diameters and other sizes can be supplied on a custom basis. Use mooring cables that are steel wire rope with a polypropylene or polyethylene jacket. The SIM can operate without data errors on a cable up to 8,000 m of 3 mm or larger cable.

Make sure that the mooring cable has a seawater ground below the deepest IM sensor. A metallic eye or clevis can make a good termination.

For a typical cable-to-shore application with a direct connection, the bottom end of the wire is grounded to seawater and the top end is insulated to the connection to the IMM or SIM. A second wire from the IMM or SIM connects to the seawater ground to complete the circuit (16plus-IM shown).



For a typical surface buoy, connect the jacketed mooring wire to the buoy with a length of chain, which grounds the jacketed wire to seawater at each end. An Inductive Cable Coupler (ICC) connects the IMM or SIM to the jacketed wire above the top IM sensor, below the point where the wire is grounded.



4.4 Data collection intervals

The number and types of auxiliary sensors have an effect on the time interval required for data collection. For autonomous operation, the 16plus-IM V2 requires a minimum of 5 seconds from the end of one sample to the start of the next. If the interval is less than 5 seconds, the 16plus-IM V2 shows an error message: `Error - - > alarm time not far enough in the future, resetting alarm to 5 sec from now.` The 16plus-IM V2 takes the next sample in 5 seconds. The minimum sample interval is 10 seconds.

Make sure that the interval is long enough for samples to be taken at even intervals. Examples are shown below.

Example 1

Overview

Pump operates for 0.5 seconds before each sample, `#iiPumpMode=1`. No pressure sensor. One measurement per sample, `#iiNCycles=1`.
Sample time = 0.5 seconds + 2.2 seconds basic time to sample = 7.7 seconds, < 10 second minimum.
Set the minimum `#iiSampleInterval=10`

Example 2

Pump operates during the sample, `#iiPumpMode=2`. There is a 15 second delay before the next sample, `#iiDelayBeforeSampling=15`. Quartz pressure sensor requires 3 seconds per sample, `#iiParosIntegration=3`. Four measurements per sample, `#iiNCycles=4`.
Sample time = $15 + 2.2 + 3 + (4-1) \times 0.25 = 20.95$ seconds = 20.95 + 5 (seconds between samples) = 25.95.
Set the minimum `#iiSampleInterval=28` to make sure there is sufficient time for each sample.

4.5 Battery pack

⚠ WARNING



If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.

⚠ WARNING



Explosion hazard. If the batteries are not installed correctly, explosive gases can be released. Make sure that the batteries are of the same approved chemical type and are inserted in the correct orientation.

⚠ WARNING



If the user thinks that the lithium batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.

⚠ WARNING



If the user thinks that the alkaline batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.

⚠ CAUTION



The pressure housing contains Electrostatic Discharge (ESD) sensitive parts and assemblies that are susceptible to damage from ESD. Follow ESD protocols:

- Put on protective eye wear before you open the pressure housing.
- Any electrostatic charge on the body of the human operator must be released before the pressure housing is opened: put a hand on a grounded surface, or better, wear a grounded antistatic wrist strap.
- At a minimum, wear short-sleeved antistatic clothing, such as cotton, or better, wear an antistatic smock for this service activity. *Do not wear a sweater, fleece or polyester-based clothing.*
- At a minimum, use a workstation with a wood or metal tabletop, or better, a tabletop that dissipates static. *Do not use a workstation with a synthetic or polymeric-based tabletop.*

The 16plus V2 uses nine D-cell alkaline batteries. These have a nominal capacity of 14 amp-hours. The manufacturer recommends that the user plan with a conservative value—

- 12.2 Ah for a 16plus V2 with no pump or auxiliary sensors
- 10.5 Ah for a 16plus V2 with a pump and auxiliary sensors.

An optional lithium battery pack is available, but cannot be used with a 5P or 5T pump.

The number and types of auxiliary sensors and user-specified settings have an effect on the current draw and data collection interval. The manufacturer recommends that the user use the **Deployment Endurance Calculator** to calculate the maximum deployment time. Note that if the 16plus V2 is in operation and the battery voltage goes below 7.5, the sensor will stop data collection and shows a "low battery" message in the data. The manufacturer recommends that batteries be replaced at least every two years.

The 16plus V2 has on-board lithium batteries to back-up the buffer and real-time clock. Replacement of the main alkaline batteries has no effect on the clock or the memory buffer.

Example:

A 16plus V2 is set up to collect data autonomously every 10 minutes, or 6 samples per hour. How long can it be deployed?

- 5T pump that operates during each sample, PumpMode=2
- 15-second delay before sample
- Pressure sensor that operates for 3 seconds per sample, ParosIntegration=3
- Current draw of auxiliary sensors = 100 mA
- 4 measurements per sample, NCycles=4

Time per sample = $2.2 + 3 + 15 + (4 - 1) \times 0.25 = 20.95$ seconds.

Current draw—

Data collection = $70 \text{ mA} \times 20.95 \text{ seconds} = 1.47 \text{ A-s/sample}$. In 1 hour, $6 \times 1.47 = \mathbf{8.8 \text{ A-s/hour}}$.

5T pump = $150 \text{ mA} \times 20.95 \text{ seconds} = 3.14 \text{ A-s/sample}$. In 1 hour, $6 \times 3.14 = \mathbf{18.9 \text{ A-s/hour}}$.

Auxiliary sensors = $100 \text{ mA} \times 20.95 \text{ seconds} = 2.10 \text{ A-s/sample}$. In 1 hour, $6 \times 2.10 = \mathbf{12.6 \text{ A-s/hour}}$.

Low power = $0.02 \text{ mA} \times [3600 \text{ seconds/hour} - 720 \times (0.28 \text{ seconds} + 0.05 \text{ seconds})] = 0.084 \text{ A-s/hour}$. In 1 hour, $6 \times 0.02 \times 3600 \text{ seconds per hour} = \mathbf{0.072 \text{ A-s/hour}}$.

Current draw per hour = $8.8 + 18.9 + 12.6 + 0.072 = 40.4 \text{ A-s/hour}$.

Capacity = $(10.5 \text{ A-hours} \times 3600 \text{ sec/hour}) \div 40.4 \text{ A-s/hour} = 935 \text{ hours} = 38 \text{ days} = 0.1 \text{ year}$.

4.6 Description of microcontrollers

The 16plus-IM V2 has two microcontrollers: an acquisition microcontroller and a communications microcontroller, which operate independently. The acquisition

microcontroller controls data acquisition and setup. The communications controller controls communications between the 16plus-IM V2 and the IMM or SIM.

Acquisition uses more power than communications, but for less time. Communications protocols take more time but use less power.

- Commands to the IMM or SIM use a ! prefix.
- Commands to the acquisition microcontroller use a # prefix.
- Commands to a group of sensors use #Gn or !Gn. **All 16plus-IM V2 sensors have been assigned to Group 0 and Group 9 by the manufacturer.**
- Global commands do not use a prefix and are used to communicate with all 16plus-IM V2s on the same inductive cable.

4.7 SIM timeout description

A SIM timeout puts control with the connected PC if there is no response from the 16plus-IM V2 within a user-specified time. This lets the user send new commands. There are two timeouts:

- DataNNMax, a timeout for !iiData and Dataii only.
- RelayMax, a timeout for all other commands. The default is 20 seconds. For RS232, push the **Esc** then **Enter** to start control again. When the S> prompt shows, new commands can be sent.

The 16plus-IM V2 timeout stops power to the communications circuits if a command is not sent for 2 minutes. To start control again:

- Select *Connect* from the **Communications** menu in the SeatermIM software, OR
- For SIM, Send PwrOn, OR
- For IMM, wait at least 1 second, then send ForceCaptureLine, then send SendWakeupTone.

The 16plus-IM V2 also has a user-specified timeout, !iiWait, to set the maximum amount of time for the communications microcontroller to wait for a response from the acquisition microcontroller.

Section 5 Set up sensor and verify operation

Install the software for the sensor and configure the hardware to make sure that the system functions correctly before deployment.

5.1 Install software and test sensor

Make sure that the sensor is connected to a power supply and PC through the serial connector on the supplied cable. Most PCs no longer have serial ports, and a serial-to-USB adapter is necessary. Make sure that the USB driver software is installed on the PC so that there is communication between the sensor and the PC.

1. Install the Seasoftware V2 software from the manufacturer-supplied CD or USB drive. The software is also available on the manufacturer's website.
2. Remove the dummy plug from the sensor.
3. Connect the I/O cable to the sensor and to the PC and a power supply (9–24 VDC).
4. Supply power to the sensor.
5. Double-click on **SeatermV2.exe** to start the launcher. If this is the first time the software is opened, a Serial Port Configuration window opens. The software automatically connects at the default baud rate but will try others if necessary. The software automatically looks for the serial port number of the connected sensor.
6. At the **Instruments** menu item, select the software version associated with the communication protocol of the sensor.
7. Push **OK** to close this window.
The main window opens. The area on the left shows available commands. The large area on the right shows commands and the responses from the sensor to those commands.

5.1.1 Software menu items

Note that the sensor will "time out" if it does not receive a command for two minutes. To start the sensor again, select *Connect* in the software **Communications** menu or push **Enter**.

Menu item	Description
File	<i>Load command file</i> opens the selected .xml command file in the "Send Commands" area. <i>Unload command file</i> closes the file and removes the commands from the "Send Commands" area. <i>Exit</i> closes the program.
Communications	<i>Connect</i> connects to the COM port. <i>Disconnect</i> disconnects from the COM port. <i>Configure</i> establishes COM port and baud rates. <i>Disconnect and reconnect</i> turns communications off then on. Useful if a sensor is non-responsive.
Command	<i>Abort</i> stops the sensor. (The Esc key is equivalent.) <i>Send 5-second break</i> is used with Serial Line Sync Mode. <i>Send stop command</i> stops sensor operation. <i>Set local time/Set UTC time</i> sets the clock in the sensor. (This is disabled if the baud rate is set at 115200 because the software cannot set the time at that rate.)
Capture	<i>Capture</i> sensor responses to save real-time data or for diagnostics. Select <i>Capture</i> again to turn it off. Capture status shows in the "Status" bar.
Upload	<i>Upload</i> data from the sensor to a PC. Data is in an .xml format and is automatically converted to .hex and .xmlcon files for the Data Conversion software module.
Tools	<i>Diagnostics log</i> saves diagnostic data. Use <i>Convert .xml data file</i> to manually convert data if the automatic Upload does not convert the data. <i>Send script</i> sends the same setup information to a number of MicroCAT sensors.
Options	Select (default) or deselect the option to <i>Prompt to launch data conversion after data upload</i> .

Set up sensor and verify operation

5.1.2 Verify anti-fouling devices

New sensors have two anti-fouling devices and a yellow protective label installed by the manufacturer.

NOTICE

Make sure to remove the label before the sensor is deployed or pressurized or the conductivity cell can be damaged.

1. Remove the yellow label.
 - The user can make sure the anti-fouling devices are installed. Refer to "Remove or replace AF24173 devices" below for details.
2. Keep the label to attach again to protect the intake and exhaust ports when the sensor is not deployed.

5.1.3 Communication troubleshooting

Do the steps below if the sensor does not respond to **ID**, **GetHD**, **GetHD** to troubleshoot the problem.

1. In the **Communications** menu, select *Configure*. In the Configure Communications window, select the COM port and baud rate for communication. The manufacturer-set baud rate is on the Configuration page that ships with the sensor.
If the ID is fixed, make sure that the ID is the correct one for that sensor.
2. Push **OK**.
3. In the **Communications** menu, select *Connect*.
 - If *Connect* is not available, select *Disconnect and reconnect*. The software will try to connect at the specified baud rate, but will try all other available baud rates to try to connect.
4. If there is still no communication, check the cable and connections with the sensor and the PC.
5. If there is still no communication, do step 1 with a different COM port or different fixed ID and try to connect again.

5.2 Inductive modems

A Surface Inductive Modem (SIM) or Inductive Modem Module (IMM) is required to communicate with the MicroCAT. A PC or buoy controller is the interface to the modem via RS232. The communication between the modem and MicroCAT is half-duplex, and the modems operate at 1200 baud.

- SIM: available data rates are 1200, 2400, 4800, or 9600 baud.
- IMM: available data rates are 1200, 2400, 4800, 9600, or 19200 baud.

5.2.1 Set up SIM

Verify that the sensor and modem operate correctly before deployment. Setup notes:

- Supply the SIM with 7–25 V.
- The maximum current for operation is approximately 30 mA.
- The manufacturer recommends a minimum of 20 ohms impedance to reduce noise during operational tests.

Configure the SIM to operate in one of two modes:

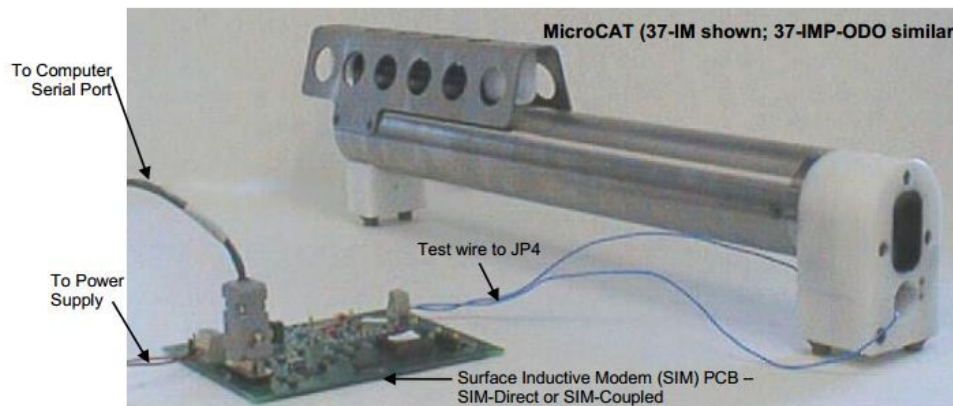
Normal power (default)—the SIM operates when power is supplied. SIM setup:

- Connect "Power Common" to JP1 pin 1.
- Connect 7–25 VDC to JP1 pin 2.
- Verify there is no connection to JP1 pin 3.
- Verify the jumper is across J3.

Logic-level controlled power—this switches power to the SIM. SIM setup:

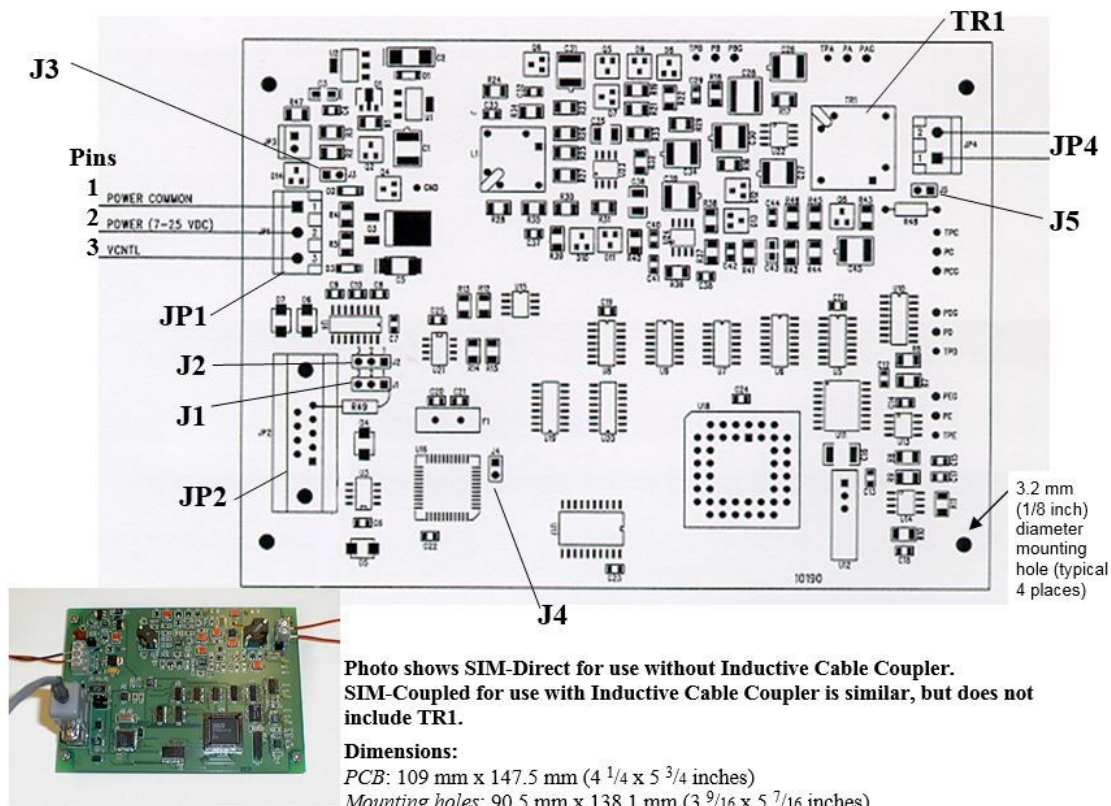
- Connect "Power Common" to JP1 pin 1.
- Connect 7–25 VDC to JP1 pin 2. If "VCNTL" is < 1 V, SIM is off. If "VCNTL" is > 2 V, SIM is on.
- Remove the jumper across J3.

1. Make a loop of insulated test wire through the modem coupling and connect the test wire ends to the SIM cable terminals at JP4.



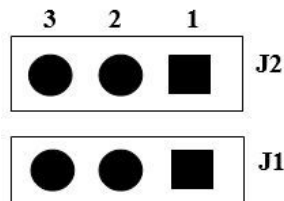
2. Remove the J5 jumper from the SIM.
This puts a 1K resistor in series with the inductive loop and reduces signal amplitude, so that any other MicroCATs that are close to the connected sensor do not respond to commands.
3. Connect the SIM to the serial port of the PC.

Set up sensor and verify operation



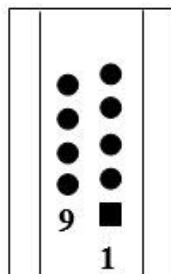
4. Interface connection: verify that the SIM is configured for RS232:

- The jumper is on J1 pins 2 and 3.
- The jumper is on J2 pins 2 and 3.
- Remove the jumper on J4.



5. Connect wires to JP2:

- Pin 2 is RS232 transmit from SIM to PC.
- Pin 3 is RS232 transmit from PC to SIM.
- Pin 5 is power common.



6. Inductive mooring cable:

- If the Inductive Cable Coupler (ICC) is installed, connect wires from the ICC to JP4.
- If the ICC is not installed, connect wires from the mooring cable and seawater ground to JP4 on SIM-direct.

Note that ICC v4 may have three wires. If the ICC has a pigtail termination, solder the white and white-black wires together and attach to one terminal of JP4. Attach the white-red wire to the other terminal.

- 7.** For normal deployment, make sure that the jumper is installed on J5.

5.2.2 Configure and test sensor with SIM

1. Start the Seaterm V2 software.
2. From the **Instrument** menu, select *[sensor] IM*.
SeatermIM starts.
3. After the first use of the software, it will automatically try to connect to a SIM or IMM, and if there is a connected modem, the software sends a command to "wake" all IM sensors.
 - If the software is set to "Automatically get instrument ID" it sends **id?** and waits for the sensor to communicate. The software then sends **!iiGetHD** and **#iiGetHD** to the ID sent by the sensor.
 - If the software is set to "Use fixed ID" it sends **!iiGetHD** and **#iiGetHD** to the ID that was set the last time the user used the software.

4. In the software, enter **#iDS**, then push **Enter**.
The output for the "Display Settings" command:

```

$PS1=PS1="$PS1"
$PS2=PS2="$PS2"
$PS3=PS3="$PS3"
$PS4=PS4="$PS4"
$PS5=PS5="$PS5"
$PS6=PS6="$PS6"
$PS7=PS7="$PS7"
$PS8=PS8="$PS8"
$PS9=PS9="$PS9"
$PS10=PS10="$PS10"
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$PS260=PS260="$PS26
```

5. Each sensor on a mooring must have a unique ID so that it can communicate with the IM and PC. Make sure that only one sensor is on-line at a time to set the ID.
 - a. Enter *ID=ii to set the sensor ID. (ii=user-assigned ID), then push **Enter**.
 - b. Enter the *ID=ii again, then push **Enter** to verify the information.
 - c. Record the ID.
 - d. Go to **Communications** menu, then *Configure*. Select *Use fixed ID*, then enter the new ID and push **OK**.

The software now has the correct ID information to send commands.
6. Enter **PwrOff**, then push **Enter** to put the sensor in a low power mode.

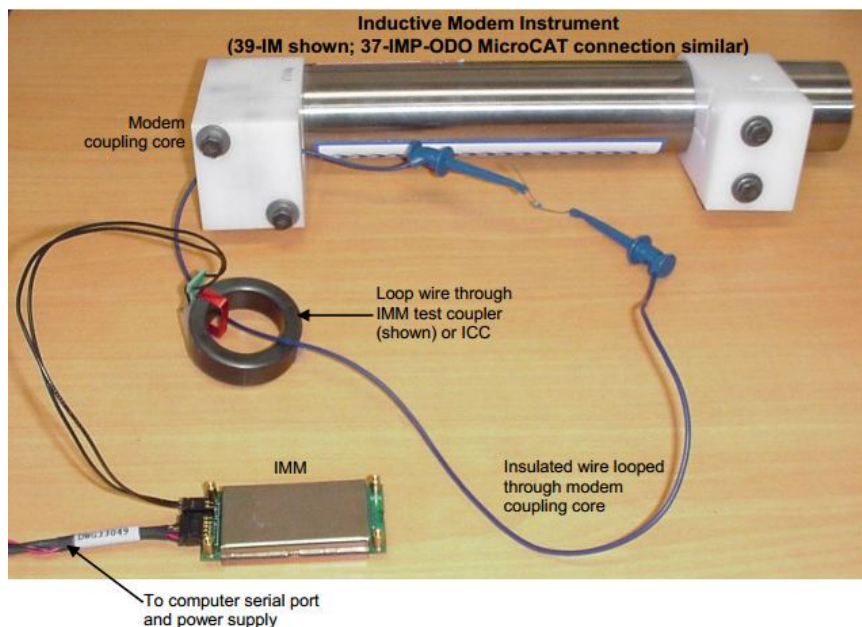
The sensor is ready for application-specific setup and deployment.

5.2.3 Set up IMM

Verify that the sensor and modem operate correctly before deployment. Operation notes:

- Supply the IMM with 7–24 V.
 - The maximum current for operation is approximately 15 mA.
 - The manufacturer recommends a minimum of 20 ohms impedance to reduce noise during operational tests.
1. Make a loop of insulated test wire through the modem coupling and put the other end of the loop through the IMM test coupler or ICC.

Set up sensor and verify operation



2. Connect the wire ends from the test coupler or ICC to J1 on the IMM.
3. Connect the IMM to the serial port of the PC.
4. Set up the IMM for either option A or B. **Make sure to add a script that has one of these setups to the buoy controller so the IMM can be re-set if it gets corrupted.**
 - a. Option: Full use of IMM
 - *Init
 - *Init (send twice to set IMM to default state)
 - SetConfigType=2
 - SetEnableAutoIMFlag=0
 - SetEnableBackSpace=1
 - SetEnableBinaryData=0
 - SetEnableEcho=1
 - SetEnableHostFlagConfirm=0
 - SetEnableHostFlagTerm=0
 - SetEnableHostFlagWakeup=0
 - SetEnableHostPromptConfirm=0
 - SetEnableHostServeOnPwrUp=1
 - SetEnablePrompt=1
 - SetEnableHostWakeupCR=0
 - SetEnableSignalDetector=0
 - SetTermFromHost=36
 - SetTermToHost=13
 - b. Option: IMM emulates the SIM
 - *Init
 - *Init (send twice to set IMM to default state)
 - SetConfigType=1
 - SetEnableBinaryData=0
5. Send the GetCD command to verify that the IMM is set up correctly

5.2.4 Configure and test sensor with IMM

1. Start the Seaterm V2 software.
2. From the **Instrument** menu, select *[sensor] IM*.
SeatermIM starts.
3. After the first use of the software, it will automatically try to connect to a SIM or IMM, and if there is a connected modem, the software sends a command to "wake" all IM sensors.
 - If the software is set to "Automatically get instrument ID" it sends **id?** and waits for the sensor to communicate. The software then sends **!iiGetHD** and **#iiGetHD** to the ID sent by the sensor.
 - If the software is set to "Use fixed ID" it sends **!iiGetHD** and **#iiGetHD** to the ID that was set the last time the user used the software.
4. In the software, enter **#iiDS**, then push **Enter**.
The output for the "Display Settings" command:


```

IMM 16plus-IM V 2.5.2 078747 001 01 Dec 2013 14:10:13
Vmax = 10.0, Vmin = 0.0, Taper = 0.0 ms, Taper = 20.0 ms,
Lutid = 16.0
Sensors = no logging
Sample 0, data = 200000
Sample interval = 15 seconds, number of measurements per sample = 1
Run pump for 0.5 sec, delay before sampling = 0.0 seconds, delay after
sampling = 0.0 seconds
Pressure sensor = atman gauge, range = 1000.0
SSE 10=nb, SSE 11 = no, RETARD = no, OPTIME = no, SSE 40 = no, Sse
Tension device = no
Ext Volt 0 = yes, Ext Volt 1 = no,
Ext Volt 2 = no, Ext Volt 3 = no,
Ext Volt 4 = no, Ext Volt 5 = no
Output format = converted decimal
Output salinity = no, output sound velocity = no, output sample number
= yes
      
```
5. To collect a sample, enter **#iiTS**, then push **Enter**.
The output for the "Take Sample" command, that shows output from an installed pressure sensor, no salinity or sound velocity, one auxiliary voltage on channel 0, and converted decimal format:
4000, 23.7658, 0.00019, 0.062, 0.5632, 01 Dec 2013, 14:10:10, 5
where
 - 4000 = 16plus-IM V2 SN
 - 23.7658 = temperature, °C
 - 0.00019 = conductivity, S/m
 - 0.062 = pressure, db
 - 0.5632 = voltage for auxiliary sensor channel 0
 - 01 Dec 2013, 14:10:10 = date, time
 - 5 = sample number in memory
6. Each sensor on a mooring must have a unique ID so that it can communicate with the IM and PC. Make sure that only one sensor is on-line at a time to set the ID.
 - a. Enter ***ID-ii** to set the sensor ID. (ii=user-assigned ID), then push **Enter**.
 - b. Enter the ***ID=ii** again, then push **Enter** to verify the information.
 - c. Record the ID.
 - d. Go to **Communications** menu, then *Configure*. Select *Use fixed ID*, then enter the new ID and push **OK**.
The software now has the correct ID information to send commands.
7. Enter **PwrOff**, then push **Enter** to put the sensor in a low power mode.
The sensor is ready for application-specific setup and deployment.

Section 6 Deployment and recovery

6.1 Set up for deployment

NOTICE

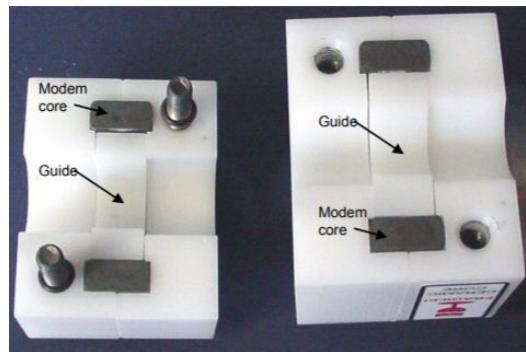
Do not use WD-40® or petroleum-based lubricant on bulkhead connectors. It will cause damage to the rubber.

Damaged connectors can cause a loss of data and additional costs for service.

Damaged connectors can cause damage to the sensor and make it unserviceable.

Use silicone-based lubricants only.

1. If necessary, install new batteries or make sure that the installed batteries have enough capacity for the intended deployment. Refer to [Replace alkaline batteries](#) on page 41 for details.
2. Use the SeatermIM software to configure the 16plus-IM V2.
 - a. Set the date and time.
 - b. If necessary, transmit all stored data to a PC.
 - c. Send #iInltLogging to make all of the memory available for data. If #iInltLogging is not sent, new data will be stored after the last stored sample.
 - d. Configure the data collection settings.
 - e. If the system has more than one 16plus-IM V2's on the mooring cable, verify that SeatermIM is set to *Use fixed ID* so that the **Send Commands** window can be used.
 1. Select *Configure* in the **Communications** menu.
 2. Select *Use fixed ID* and enter the 16plus-IM V2's ID.
 3. Push **OK**.
 - f. Send #iGetCD or #iIDS to verify the settings.
 - g. Optional: use StartDateTime= and StartLater to set a future start date and time for Profiling Mode (if IgnoreSwitch=Y) or Moored mode.
3. Use #iStartNow to start data collection, or use #iStartDateTime= and #iStartLater to start data collection at a user-specified date and time.
4. To use Seasave to collect and look at real-time data, select the **Capture** menu to save data to a file. Enter a file name, the push **Save**. Note that this data cannot be processed by the SBE Data Processing software because it does not have the required headers and format.
5. Attach a cable or a dummy plug and lock collar to each connector on the 16plus-IM V2.
6. Connect the cables to the applicable sensors.
7. If necessary, remove the plugs from the antifouling device caps.
8. If necessary, remove the Tygon tubing looped end-to-end around the conductivity cell for storage.
9. Connect the system plumbing again.
10. Attach the mounting brackets to the insulated mooring cable:
 - a. Remove the two large titanium hex bolts to open each bracket.
 - b. Put the insulated mooring cable inside the grooves of the brackets.
 - c. Attach the brackets again with the hex bolts.
 - d. Verify that the two halves of the modem coupler are in complete contact.

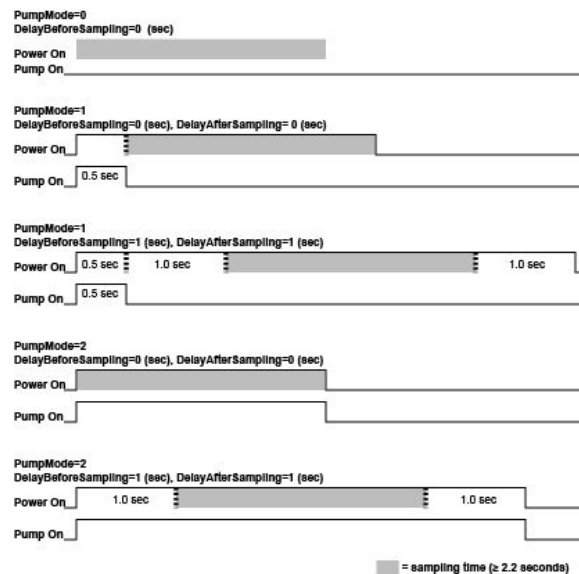


11. Verify that the hardware and external fittings are secure.
The 16plus-IM V2 is ready for deployment.

6.2 Pump operation

There are several user-selectable parameters to operate the pump:

- **#iiPumpMode=0, 1, 2**
Set up so that the pump does not operate.
Set up so that the pump operates for 0.5 seconds before each sample.
Set up so that the pump operates during each sample.
- **#iiDelayBeforeSampling=**
Set up so that data collection starts after power is supplied to external voltage and RS232 sensors: some require time to become stable after power is supplied, and WET Labs sensors with Bio-wipers require time for the wiper to open.
- **#iiDelayAfterSampling=**
Set up so that power is removed from the pump and external voltage and WET Labs sensors after data collection is complete so that the Bio-wiper closes.



Pump setting recommendations

SBE 5M, 5P, or 5T through conductivity cell only:

For most deployments, use #iiPumpMode=1 and #iiDelayBeforeSampling=0. The pump operates for 0.5 seconds before a conductivity measurement is made, so there is enough time for good airflow through the cell and to bring in a new sample of water.

If the SeaCAT is moored in an area with large thermal gradients, it may be necessary to operate the pump longer to remove any cell thermal mass effects on the measurement. In

this case, set #iiPumpMode=2 and #iiDelayBeforeSampling= to a non-zero value for additional airflow time before the measurement is made.

SBE 5P or 5T through conductivity cell and SBE 43:

Set #iiPumpMode=2. As the pump brings new water into the SBE 43 plenum, time is required for the sensor to adjust to the new oxygen level. The time required is a function of membrane thickness and water temperature. For 1.0 mil SBE 43 membranes post-2007, #iiDelayBeforeSampling= varies in a non-linear way from 25 seconds at 15 °C to 40 seconds at 0 °C.

SBE 5P or 5T through conductivity cell and SBE 63:

Set #iiPumpMode=2. As the pump brings new water into the SBE 63 plenum, time is required for the sensor to adjust to the new oxygen level. The time required is a function of water temperature. #iiDelayBeforeSampling= varies in a non-linear way from 25 seconds at 15 °C to 40 seconds at 0 °C.

SBE 5P or 5T through conductivity cell and Beckman or YSI-type dissolved oxygen sensor:

Set #iiPumpMode=2. Set #iiDelayBeforeSampling= to 120–180 seconds to give the oxygen sensor time to polarize before the measurement is taken.

6.3 Data collection modes

The 16plus-IM V2 can collect data in one of three modes:

- Polled
- Autonomous
- Combo

Commands can be used in various combinations. Note that the communications microcontroller automatically goes into a low power mode if no commands are received within 2 minutes.

6.3.1 Polled (controlled) mode

On command, the sensor collects one sample and transmits the data to the SIM or IMM. It is not possible to synchronize the data from each 16plus-IM V2.

Example, user input in bold:

Send "wakeup" tone to all IM sensors. Globally set date and time to September 1, 2020, 9:05 am. Set up each 16plus-IM V2 with one voltage sensor, no pump, collect and average 4 measurements for each sample, and transmit the data in converted decimal format. Verify setup after all parameters are entered. Send power-off command to all sensors.

Select *Connect* from the SeatermIM **Communications** menu to connect to and start sensors.

Enter **DATE TIME=09012020090500**

Enter **#01VOLT0=Y**

Enter **#01PUMP MODE=0**

Enter **#01NCYCLES=4**

Enter **#01OUTPUTFORMAT=3**

Enter **#01GETCD** to verify setup. Repeat #iiVOLT0= through #iiGetCD for 16plus-IM V2s 02 and 03.

Enter **PWROFF**

Send "wakeup" tone to all SeaCATs. Command each sensor to collect a sample and send data to the SIM or IMM. Send PWROFF command to all SeaCATs.

Select *Connect* in the SeatermIM **Communication** menu to put all sensors in standby mode.

Enter **#01TS** Take sample, transmit.

Enter **#02TS** Take sample, transmit.

Enter **#03TS** Take sample, transmit.

Enter **PWROFF** to put sensors into low power mode.

6.3.2 Autonomous mode

At user-selected intervals, the sensor collects one sample, stores that data in the flash memory, and goes into a low power mode for a minimum of 5 seconds between each sample. Start autonomous data collection with #iiStartNow or #iiStartLater and stop with #iiStop.

To synchronize the data for each 16plus-IM V2:

- Send a global command to set the date and time for all 16plus-IM V2s.
- Set the sample interval for each 16plus-IM V2 to the same value.
- Set the start date and time for each 16plus-IM V2 to the same value, then send #iiStartLater.

If the 16plus-IM V2 is in operation or ready to collect data (#iiStartLater has been sent, but the 16plus-IM V2 has not started, only the commands below can be sent:

- All SIM or IMM commands
- Communication microcontroller commands GData, SendGData (for IMM), Dataii, !iiData, ID? !iiDS
- Acquisition microcontroller commands #iiGetCD, #iiGetSD, #iiGetCC, #iiResetEC, #iiGetHD, #iiDS, #iiDCal, #iiTS, #iiSL, #iiSLT, #iiStop.

Example, user input in bold:

Send "wake" tone to all 16plus-IM V2s. Globally set date and time to 1 September 2020, 9:05 am. For each 16plus-IM V2, send #iiInitLogging to clear previous data in memory. Set up with one voltage sensor, take a sample every 120 seconds, take and average 4 measurements for each sample and transmit data in raw hex format. Set up pump to operate for 0.5 seconds before each sample. Send command to start operation on 15 September 2020 at 12:00:00. Verify setup when all commands have been sent. Send power-off command to all 16plus-IM V2s.

Select *Connect* in the **Communications** menu of SeatermIM to connect to and start sensor.

Enter **DATE TIME=09012020090500**

Enter **#01INITLOGGING**

Enter **#01VOLT0=Y**

Enter **#01SAMPLEINTERVAL=20**

Enter **#01NCYCLES=4**

Enter **#01OUTPUTFORMAT=0**

Enter **#01PUMPMODE=1**

Enter **#01STARTDATE TIME=09152020120000**

Enter **#01STARTLATER**

Enter **#01GETCD** to verify setup

Send #iiInitLogging through #iiGetCD for 16plus-IM V2s 02 and 03.

Enter **PWROFF**

Deploy the 16plus-IM V2s. Data collection starts automatically at the user-set date and time. To stop data collection and put sensor in low power mode, push any key, then enter #01Stop. Select the **Upload** menu and transmit the data to a PC. Enter #iiStop and select the **Upload** menu for 16plus-IM V2 02 and 03.

Enter **PWROFF**

6.3.3 Combo mode

Combo mode combines autonomous operation with the ability to get the last data sample from each 16plus-IM V2 and look at it while operation continues. There are two ways to get the last stored sample:

- From one 16plus-IM V2, send #iiSL.
- From all 16plus-IM V2s, send GData, or SendGData with IMM. These are global commands to each sensor to hold the last data sample in their buffers. Send !iiData to each 16plus-IM V2 to transmit the last data sample from its buffer.

Example, user input in bold:

Set up all 16plus-IM V2s as shown for Autonomous operation. After operation starts, look at the data from the last sample. Select *Connect* in the SeatermIM **Communications** menus to connect and "wake up" all 16plus-IM V2s.

```
#01SL
#02SL
#03SL
PWROFF
For SIM:
GDATA
!01DATA
!02DATA
!03DATA
PWROFF
For IMM: send FCL to send a carrier signal to reserve the IM line. Send SWT to send a "wake up" command to all 16plus-IM V2s online
SENDGDATA
!01DATA
!02DATA
!03DATA
PWROFF
Transmit all data as shown above for Autonomous mode.
```

6.4 Output formats

Data stored in the 16plus V2 is converted and transmitted to a PC in the user-selected format, so it can be transmitted in more than one format until the user sends a command to overwrite it.

The format of the data for the 16plus-IM V2 is #iiOutputFormat=0, 1, 2, 3, or 5, and OutputFormat=0, 1, 2, 3, or 5 for the 16plus V2. The command used to transmit data has an effect on the format as well. The output format is set by the user and by the command used to transmit the data. RS232 data is always in the same format:

- SBE 63 data is always phase delay and temperature voltage.
- SBE 38, GTD, and Optode data is always in engineering units.
- WET Labs sensor data is always in raw counts.

The "time" is the time at the start of the sample, typically 1 to 2 seconds after a command to start data collection. If, for example, #iiDelayBeforeSampling=20 or DelayBeforeSampling=20 (16plus V2), the output time for the first sample is 20 + 1 or 2 seconds.

6.4.1 Output format 0

Raw frequencies and voltages in hex

Data shows in the order listed, with no spaces or commas between parameters. Use the decimal equivalent of the hex data in the equations to calculate the parameter from the data.

- Set #iiOutputFormat=0 if Seasave is used to collect real-time data.
- SeatermIM always uploads data from memory in raw hex so that data is in a format the SBE Data Processing software can use.
- The raw output from the (absolute) pressure sensor includes the effect of atmospheric pressure (14.7 psi), as shown on the Calibration Sheet for the 16plus-IM

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V2. If the output from the 16plus-IM V2 is in engineering units, the pressure output shown is in decibars relative to the surface of the ocean.

The 16plus-IM V2 converts psia to decibars: $(\text{pressure, psia} - 14.7) \times 0.689476 = \text{decibars}$.

- Use #iiOutputFormat=1 for the SBE 50 so that the SBE Data Processing software can be used to process data.

Temperature A/D counts	ttttt
Conductivity frequency, Hz	ccccc ÷ 256
if #iiPType=1, strain-gauge pressure sensor pressure A/D counts	pppppp
if #iiPType=1, strain-gauge pressure sensor pressure compensation voltage	vvvv ÷ 13,107
if #iiPType=3, quartz pressure sensor pressure frequency	pppppp ÷ 256
if #iiPType=3, quartz pressure sensor temperature compensation voltage	vvvv ÷ 13,107
if #iiVolt0=Y, external voltage 0	vvvv ÷ 13,107
if #iiVolt1=Y, external voltage 1	vvvv ÷ 13,107
if #iiVolt2=Y, external voltage 2	vvvv ÷ 13,107
if #iiVolt3=Y, external voltage 3	vvvv ÷ 13,107
if #iiVolt4=Y, external voltage 4	vvvv ÷ 13,107
if #iiVolt5=Y, external voltage 5	vvvv ÷ 13,107
if #iiSBE38=Y, SBE 38 temperature, °C	(ttttt ÷ 100,000) - 10
if #iiSBE50=Y, SBE 50 pressure, decibars, psia, meters, feet	(pppppp ÷ 10,000) - 100
if #iiWetLabs=Y, WET Labs RS232 sensor	wwwxxxxxyyy
where www, xxxx, and yyyy are raw signal counts for each sensor. yyyy all 0's for dual sensor. xxxx and yyyy all 0's for single sensor.	
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 pressure, millibars	pppppppp ÷ 100,000
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 temperature, °C	(ttttt ÷ 100,000) - 10
if #iiDualGTD=Y, GTD #2 pressure, millibars	pppppppp ÷ 100,000
if #iiDualGTD=Y, GTD #2 temperature, °C	(ttttt ÷ 100,000) - 10
if #iiOptode=Y, Optode oxygen, µmoles/L	(ooooo ÷ 10,000) - 10
if #iiSBE 63=Y, SBE 63 oxygen phase, µsec	(ooooo ÷ 100,000) - 10
if #iiSBE 63=Y, SBE 63 oxygen temperature voltage	(ttttt ÷ 1,000,000) - 1
Time, Moored mode only, seconds since Jan. 1, 2000	ssssssss

Example: profiling mode, strain-gauge pressure sensor, 2 external voltages

= tttttcccccpppppvvvvvvvvvvssssssss

= 0A53711BC7220C14C17D8203050594

temperature	ttttt	0A5371	676721 decimal A/D counts
conductivity	ccccc	1BC72	1820450 decimal; $1820450 \div 256 = 7111.113$ Hz
pressure	pppppp	0C14C1	791745 decimal A/D counts
pressure sensor temperature compensation	vvvv	7D82	32,130 decimal; $32,130 \div 13,107 = 2.4514$ volts
first external voltage	vvvv	0305	773 decimal; $773 \div 13,107 = 0.0590$ volts

second external voltage	vvvv	0594	1428 decimal; $1428 \div 13,107 = 0.1089$ volts
time	sssssss	OEC4270B	247,736,075 decimal; seconds since Jan. 1, 2000 = 247,736,075

6.4.2 Output format 1

Engineering units in hex

Data shows in the order listed with no spaces or commas between parameters. Use the decimal equivalent of the hex data in the equations to calculate the parameter from the data.

Temperature, °C	(ttttt ÷ 100,000) - 10
Conductivity, S/m	(ccccc ÷ 1,000,000) - 1
if #iiPType=1, strain-gauge pressure sensor or #iiPType=3 quartz pressure sensor	(pppppp ÷ 1,000) - 100
if #iiVolt0=Y, external voltage 0	vvvv ÷ 13,107
if #iiVolt1=Y, external voltage 1	vvvv ÷ 13,107
if #iiVolt2=Y, external voltage 2	vvvv ÷ 13,107
if #iiVolt3=Y, external voltage 3	vvvv ÷ 13,107
if #iiVolt4=Y, external voltage 4	vvvv ÷ 13,107
if #iiVolt5=Y, external voltage 5	vvvv ÷ 13,107
if #iiSBE38=Y, SBE 38 temperature, °C	(ttttt ÷ 100,000) - 10
if #iiSBE50=Y, SBE 50 pressure, decibars, psia, meters, feet	(pppppp ÷ 10,000) - 100
if #iiWetLabs=Y, WET Labs RS232 sensor	wwwxxxxxyyy
where www, xxxx, and yyyy are raw signal counts for each sensor. yyyy all 0's for dual sensor. xxxx and yyyy all 0's for single sensor.	
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 pressure, millibars	pppppppp ÷ 100,000
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 temperature, °C	(ttttt ÷ 100,000) - 10
if #iiDualGTD=Y, GTD #2 pressure, millibars	pppppppp ÷ 100,000
if #iiDualGTD=Y, GTD #2 temperature, °C	(ttttt ÷ 100,000) - 10
if #iiOptode=Y, Optode oxygen, µmoles/L	(oooooo ÷ 10,000) - 10
if #iiSBE 63=Y, SBE 63 oxygen phase, µsec	(oooooo ÷ 100,000) - 10
if #iiSBE 63=Y, SBE 63 oxygen temperature voltage	(ttttt ÷ 1,000,000) - 1
Time, seconds since Jan. 1, 2000	sssssss

Example: profiling mode, 2 external voltages
 = tttttccccpppppvvvvvvssssss
 = 3385C40F42FE0186DE030505940EC4270B

temperature	ttttt	3385C4	3376580 decimal; $3376580 \div 100,000 = 23.7658$ °C
conductivity	ccccc	0F42FE	10000190 decimal; $(10000190 \div 1,000,000) - 1 = 0.00019$ S/m
pressure	pppppp	0186DE	100062 decimal; $(100062 \div 1,000) - 100 = 0.062$ dbar
first external voltage	vvvv	0305	773 decimal; $773 \div 13,107 = 0.0590$ volts
second external voltage	vvvv	0594	1428 decimal; $1428 \div 13,107 = 0.1089$ volts
time	sssssss	OEC4270B	247,736,075 decimal; 247,736,075 seconds since Jan. 1, 2000

6.4.3 Output format 2

Raw frequencies and voltages in decimal

Data shows in the order listed, with a comma and a space between parameters.

Temperature A/D counts	ttttt
Conductivity frequency, Hz	cccc.ccc
if #iiPType=1, strain-gauge pressure sensor pressure A/D counts	pppppp
if #iiPType=1, strain-gauge pressure sensor pressure compensation voltage	v.vvvv
if #iiPType=3, quartz pressure sensor pressure frequency	ppppp.ppp
if #iiPType=3, quartz pressure sensor temperature compensation voltage	v.vvvv
if #iiVolt0=Y, external voltage 0	v.vvvv
if #iiVolt1=Y, external voltage 1	v.vvvv
if #iiVolt2=Y, external voltage 2	v.vvvv
if #iiVolt3=Y, external voltage 3	v.vvvv
if #iiVolt4=Y, external voltage 4	v.vvvv
if #iiVolt5=Y, external voltage 5	v.vvvv
if #iiSBE38=Y, SBE 38 temperature, °C	ttt.ttt
id #iiSBE50=Y, SBE 50 pressure, decibars, psia, meters, feet	pppp.ppp
if #iiWetLabs=Y, WET Labs RS232 sensor	wwwxxxxxyyy
<i>where</i> www, xxxx, and yyyy are raw signal counts for each sensor. yyyy all 0's for dual sensor. xxxx and yyyy all 0's for single sensor.	
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 pressure, millibars	pppppppp ÷ 100,000
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 temperature, °C	tt.ttt
if #iiDualGTD=Y, GTD #2 pressure, millibars	pppppppp ÷ 100,000
if #iiDualGTD=Y, GTD #2 temperature, °C	tt.ttt
if #iiOptode=Y, Optode oxygen, µmoles/L	oooo.ooo
if SBE 63=Y, SBE 63 oxygen phase, µsec	oo.ooo
if #iiSBE 63=Y, SBE 63 oxygen temperature voltage	t.ttttt
Time, date, time	dd Mmm yyyy, hh:mm:ss

Example: profiling mode, strain-gauge pressure sensor, 2 external voltages

= ttttt, cccc.ccc, pppppp, v.vvvv, v.vvvv, v.vvvv, dd mmm yyyy, hh:mm:ss

= 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089, 7 Dec 2019, 07:34:35

temperature	ttttt	676721 A/D counts
conductivity	cccc.ccc	7111.113 Hz
pressure	pppppp	791745 A/D counts
pressure sensor temperature compensation	v.vvvv	2.4514 volts
first external voltage	v.vvvv	0.0590 volts
second external voltage	v.vvvv	0.1089 volts
date, time	dd mmm yyyy, hh:mm:ss	07 Dec 2019, 07:34:35

6.4.4 Output format 3

Engineering units in decimal

Data shows in the order listed, with a comma and a space between parameters.

Temperature °C	ttt.tttt
Conductivity frequency, S/m	cccc.ccc
if #iiPType=1, strain-gauge pressure sensor dbars	pppp.ppp
if #iiPType=3, quartz pressure sensor pressure frequency	pppp.ppp
if #iiVolt0=Y, external voltage 0	v.vvvv
if #iiVolt1=Y, external voltage 1	v.vvvv
if #iiVolt2=Y, external voltage 2	v.vvvv
if #iiVolt3=Y, external voltage 3	v.vvvv
if #iiVolt4=Y, external voltage 4	v.vvvv
if #iiVolt5=Y, external voltage 5	v.vvvv
if #iiSBE38=Y, SBE 38 temperature, °C	ttt.tttt
if #iiSBE50=Y, SBE 50 pressure, decibars, psia, meters, feet	pppp.ppp
if #iiWetLabs=Y, WET Labs RS232 sensor	wwwxxxxxyyy
<i>where</i> www, xxxx, and yyyy are raw signal counts for each sensor. yyyy all 0's for dual sensor. xxxx and yyyy all 0's for single sensor.	
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 pressure, millibars	pppppppp ÷ 100,000
if #iiGTD=Y or #iiDualGTD=Y, GTD #1 temperature, °C	tt.ttt
if #iiDualGTD=Y, GTD #2 pressure, millibars	pppppppp ÷ 100,000
if #iiDualGTD=Y, GTD #2 temperature, °C	tt.ttt
if #iiOptode=Y, Optode oxygen, µmoles/L	oooo.ooo
if #iiSBE 63=Y, SBE 63 oxygen phase, µsec	oo.ooo
if #iiSBE 63=Y, SBE 63 oxygen temperature voltage	t.ttttt
if #iiOutputSal=Y, salinity, psu	sss.ssss
if #iiOutputSV=Y, sound velocity, m/sec	vvvv.vvv
date, time	dd mmm yyyy, hh:mm:ss

Example: profiling mode, strain-gauge pressure sensor, 2 external voltages
 = ttt.tttt, cc.ccccc, pppp.ppp, v.vvvv, v.vvvv, dd mmm yyyy, hh:mm:ss
 = 23.7658, 0.00019, 0.062, 0.0590, 0.1089, 7 Dec 2019, 07:34:35

temperature	ttt.tttt	23.7658 °C
conductivity	cc.ccccc	0.00019 S/m
pressure	pppp.ppp	0.062 dbars
first external voltage	v.vvvv	0.0590 volts
second external voltage	v.vvvv	0.1089 volts
date, time	dd mmm yyyy, hh:mm:ss	7 Dec 2019, 07:34:35

6.4.5 Output format 5

Data shows in the order listed, with no carriage return or line feed (CRLF) between parameters. The CRLF occurs the after </datapacket> tag.

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	<?xml?>
	<datapacket>
	<hdr>
	<mfg>Sea-Bird</mfg>
	<model>19plus</model>
	<sn>nnnnnnnn</sn>
	</hdr>
	<data>
Temperature °C	<t1>ttt.ttt</t1>
Conductivity frequency	<c1>cc.ccccc</c1>
if #iiPType=1 or 3	<p1>pppp.ppp</p1>
if #iiVolt0=Y	<v0>v.vvvv</v0>
if #iiVolt1=Y	<v1>v.vvvv</v1>
if #iiVolt2=Y	<v2>v.vvvv</v2>
if #iiVolt3=Y	<v3>v.vvvv</v3>
if #iiVolt4=Y	<v4>v.vvvv</v4>
if #iiVolt5=Y	<v5>v.vvvv</v5>
	<ser1>
(RS232 sensor) <type>sbe38, sbe50, wetlabs, gtd, Optode, sbe63, SeaFET</type>	
if #iiSBE38=Y	<t38>ttt.ttt</t38>
if #iiSBE50=Y	<p2>pppp.ppp</p2>
if #iiWetLabs=Y	<wl0>www</wl0>
if #iiWetLabs=Y	<wl1>xxxx</wl1>
if #iiWetLabs=Y	<wl2>yyyy</wl2>
if #iiGTD=Y or #iiDualGTD=Y	<p1>pppppppp</p1>
if #iiGTD=Y or #iiDualGTD=Y	<t1>tt.ttt</t1>
if #iiDualGTD=Y	<p2>pppppppp</p2>
if #iiDualGTD=Y	<t2>tt.ttt</t2>
if #iiOptode=Y	<oox>oooo.ooo</oox>
if #iiSBE 63=Y	<oxph>oo.ooo</oxph>
if #iiSBE 63=Y	<oxtv>t.ttttt</oxtv>
	</ser1>
if #iiOutputSal=Y	<sal>sss.ssss</sal>
if #iiOutputSV=Y, sound velocity, m/sec	<sv>vvvv.vvv</sv>
	<dt>yyyy-mm-ddThh:mm:ss</dt>
	</data>
	</datapacket>

Example: profiling mode, 2 external voltages

```
= <?xml?><datapacket><hdr><mfg>Sea-Bird</mfg><model>16plus</model><sn>1234</sn></hdr>
<data><t1>23.7658</t1><c1>0.00019</c1><p1>0.062</p1><v0>0.0590</v0><v1>0.1089</v1></data></datapacket>CRLF
```

serial number	nnnn	1234
temperature	ttt.tttt	23.7658 °C
conductivity	cc.ccccc	0.00019 S/m
pressure	pppp.ppp	0.062 dbars
first external voltage	v.vvvv	0.0590 volts
second external voltage	v.vvvv	0.1089 volts

Polled data

Commands #iiSL, #iiSLT, #iiTS, #iiTSS: if OutputUCSD=Y and the 16plus-IM V2 collects data autonomously, the data is followed by—

```
<dens>ddd.dddd</dens><vb>vv.v</vb><i>ccc.c</i>
```

where

density sigma-t, kg/m³ = ddd.dddd

battery voltage = vv.v

operational current draw, mA = ccc.c

The rest of the data stream is as above for transmitted data.

6.5 Install Inductive Cable Coupler

The optional ICC attaches to the jacketed mooring wire and makes an electrical connection with the modem. Refer to Application Note 85 for more details.

1. Loosen the titanium hex head bolts that connect the halves of the ICC brackets and pull them apart.
2. Put the insulated mooring cable inside the grooves of the bracket.
3. Insert and tighten the hex bolts into brackets again.
4. Verify that the halves of the modem coupling toroid are connected evenly and the mounting clamp is secure.



1: Mounting guide that contains the modem coupling toroid	2: Mounting clamp, sized to the specified cable diameter
3: Buoy hull clamp	4: Optional molded-on cable connector
5: Optional bulkhead connector	6: Wires to SIM PCB

6.6 Recovery

⚠ WARNING



If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.

⚠ WARNING



If the user thinks that the alkaline batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.

⚠ WARNING



If the user thinks that the NiMH batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.

⚠ CAUTION



The pressure housing contains Electrostatic Discharge (ESD) sensitive parts and assemblies that are susceptible to damage from ESD. Follow ESD protocols:

- Put on protective eye wear before you open the pressure housing.
- Any electrostatic charge on the body of the human operator must be released before the pressure housing is opened: put a hand on a grounded surface, or better, wear a grounded antistatic wrist strap.
- At a minimum, wear short-sleeved antistatic clothing, such as cotton, or better, wear an antistatic smock for this service activity. *Do not wear a sweater, fleece or polyester-based clothing.*
- At a minimum, use a workstation with a wood or metal tabletop, or better, a tabletop that dissipates static. *Do not use a workstation with a synthetic or polymeric-based tabletop.*

⚠ CAUTION

AF24173 anti-fouling devices contain bis(tributyltin) oxide. Wear rubber or latex gloves and eye protection to replace these devices on the sensor if it is so equipped. Wash hands with soap and water when finished.

Read the precautions on the product label.

It is a violation of US federal law to use this product in a manner that is inconsistent with its label.

1. Flush the sensor and conductivity cell with fresh water.
2. Make sure there is enough battery life to transmit data from the SeaCAT to a PC. Refer to [Replace alkaline batteries](#) on page 41 for details.
3. If so-equipped, remove and store the anti-fouling devices.
4. If so-equipped, install the protective plugs in the anti-fouling device cups.
5. If the SeaCAT will not be deployed immediately, put the sensor in a low power mode, which draws only 20 μ A. If the sensor will be stored, remove the batteries.

Section 7 Transmit and convert data

Data can be transmitted to a PC with the inductive modem or the RS232 connection.

- Inductive modem: transmit data while the SBE 16plus V2 is deployed or is wired in the laboratory. Speed is limited to 1200 baud.
- RS232: transmit data at 115,200 baud. The user must open the SBE 16plus V2 to access the internal RS232 connector. In the **Instrument** menu of the SeatermV2 software, select *SBE 16plus V2 RS232* to start Seaterm232. Make sure to select "Text," not "Binary."

7.1 Transmit data to PC

Transmit data with an RS232 connection after the sensor is recovered from a deployment. The pressure housing needs to be opened to use this method to transmit data.

NOTICE

Do not disconnect the 2-contact power cable from the battery pack when the electronics are removed from the pressure housing. The sensor will draw power from the back-up lithium batteries which could cause a loss of data.

1. Remove the end flange of the sensor.



2. Disconnect the IM boardset from JP6 on the PCB. Connect the manufacturer-supplied RS232 cable to JP6 and to a PC with the data I/O cable.
3. If necessary, start the Seaterm V2 software.
4. In the **Instruments** menu, select *16plus-IM V2 RS232*. Seaterm232 opens.
5. Seaterm232 automatically tries to connect to the sensor with the last-used configuration.
6. Go to the **Communications** menu and select *Configure*. In the "Serial Port Configuration" area, select the comm port and select 1200 as the baud rate. Push **OK**.
7. Go to the **Communications** menu and select *Connect*. If it is not available, select *Disconnect and reconnect*. The software sends GetHD and shows the response.
8. Send a command to stop: press any key, then type **Stop** and push **Enter**. It may be necessary to send the "Stop" command several times.
9. Type Baud=38400 or Baud=115200, then push **Enter**.
Sensor response: switching to [38400 or 115200] for 5 minutes.
10. Go to the **Communications** menu and select *Configure*. Select the comm port and the baud rate from the previous step. Push **OK**.
11. Type **DS** then **Enter** and look for the output to show `status = not logging` at approximately the fourth line.
12. Select the **Upload** menu.
 - a. The software sends **GetSD** and the response shows the number of samples stored in the sensor.
 - b. The software sends **DH** and the response shows information on the headers in memory.

- c. In the **Save as** box enter a file name for the data to be transmitted from the sensor. The file has an .xml extension. The **Upload Data** window shows.
13. In the *Upload Data* tab, select the options to transfer data:
 - a. Upload format: select "Text." The software converts data to ASCII text.
 - b. Block size: enter the number of bytes to transmit in each block. The software calculates a checksum at the end of each block of data. If a block fails the checksum verification, the software cuts the block size in half and tries to transmit it again.
 - c. Upload data options: either select "All data as a single file" or "By scan number range" to break data into separate files. Enter the start and end values in the "Scan range" area. The "Memory summary" at the top of the tab shows the number of samples collected.
 - d. To change the name or location of the data file(s), push **Browse**.
14. Optional: select the *Header Form* tab.
15. If necessary, select "Prompt for Header Information" at "Header Choice."
16. Enter up to 12 lines of header information that will identify the transmitted data. Examples include mooring description, latitude/longitude, deployment start date, deployment end date.
17. Select the *Upload Data* tab again. Push **Upload**. The Status bar at the bottom of the window shows transmit status:
 - a. The software sends several status commands that give information about the number of samples in memory, calibration coefficients, and more, and writes this information to the .xml file.
 - b. The software sends the "data upload" command based on the entry in the Upload range area.

Data is transmitted from the sensor to the PC. The software makes a .hex data file in addition to the .xml file. The hexadecimal file can be used in the Data Conversion module of the Data Processing software.

7.2 Transmit data with IMM

The baud rate in the software must be the same as the IMM or the SIM. This rate is set by the manufacturer to 9600, but can be changed by the user. If there is only one 16plus-IM V2 on-line, use *Automatically get instrument ID*. Use *Use fixed ID* if there is more than one 16plus-IM V2 on-line.

1. Start the SeatermV2 software.
2. In the **Instruments** menu, select *SBE 16plus V2 IM*.
The SeatermIM software looks for an IMM or a SIM, and sends the applicable command to connect to all sensors on-line, and adds the available list of commands for the 16plus-IM V2.
3. If necessary, send #iiStop to stop data collection. It may be necessary to send this command several times.
4. Enter #iiDS to see the status of the 16plus-IM V2.
5. Verify that the status shows `status = not logging`.
6. Select the **Upload** menu to transmit the stored data in a format the SBE Data Processing software can use. The software sends:
 1. "wake-up" tone
 2. #iiOutputExecutedTag=Y
 3. #iiGetSD, and shows the 16plus-IM V2 status and the number of samples in memory.

7. **Save As** box, enter the filename chosen and push **OK**.
The file is an .xml filetype. An **Upload Data** box shows.
8. In the *Upload data* tab of the **Upload Data** window:
 - a. Block size [bytes]: Select the number of bytes to transmit in each block. The software calculates a checksum at the end of each block. If a block fails the checksum verification, the software cuts the block size in half and tries to transmit again.
 - b. Upload data options: If "By scan number range" is selected, enter the "Beginning with scan #" and the "Number of scans to upload."
 - c. Upload file: Push **Browse** to change the name of the file to transmit.
9. Select the *Header Form* tab of the **Upload Data** window:
 - Enter any header information to be included with the transmitted data. This could include the start date of deployment, recovery date of deployment, latitude, mooring description, etc.
10. Select **Upload** in the *Upload Datatab*.
The software writes the data to the .xml file and then makes a .hex file from it. The hex file is compatible with the SBE Data Processing and Seasave software.
11. Use Seasave to show and make plots of the raw hexadecimal data to verify that all of the data has been transmitted.

7.3 Convert data

Look at the data with the Data Processing software to make sure that all of the data was transmitted to the PC. Use the Data Processing software to convert the raw data (.hex) to Engineering units (.cnv), which can be further processed by other software from the manufacturer.

1. After the data is transmitted, the Seaterm software opens a dialog box to start the data conversion module. Select **Yes** to start the module.
The software automatically completes the sensor configuration information.
2. Optional: to change any of the configuration settings, push **Modify...** in the "Instrument configuration file" area.
 - a. "Sample interval in seconds" must be the same value used with **SampleInterval=**. Use **GetCD** or **DS** to see this value.
 - b. Put a check in the box next to "Pressure sensor" if the sensor is so equipped. This is the value set with **ReferencePressure** and can be changed in the .xmlcon file if necessary.
 - c. Put a check in the box next to "Use deployment latitude in depth calculations" so that the latitude at which the sensor was deployed can be entered. The software uses this value to calculate local gravity and salt water depth.
 - d. Double-click on the sensor to look at or change its calibration coefficients.
 - e. Push **Save** to save any changes, then **Exit**.
3. Select the *Data Setup* tab.
 - a. Put a check in the "Process scans to end of file" check box.
 - b. Select **ASCII** output in the "Output format" drop-down area.
 - c. Select **Upcast** and **downcast** in the "Convert Data from" drop-down area.
 - d. Select **Create converted data (.cnv) file only** in the "Create file types" drop-down box.
 - e. Optional: put a check in the box next to "Prompt for start time and/or note." The software will ask the user to change the start time in the .cnv header and not use the sensor's time stamp in the "Source for start time in output .cnv header" area.
 - f. Push **Select Output Variables...** to see that window.

Transmit and convert data

4. Select Conductivity, Temperature, Pressure (optional), and other derived variables such as Salinity, Density, Sound Velocity, etc. Push **OK**.
5. Push **Start Process** in the *Data Setup* tab.
The software converts the .hex file to a .cnv file.

Section 8 Maintenance

⚠ WARNING



If the user thinks that a sensor has water in the pressure housing: Disconnect the sensor from any power supply. Put on safety glasses and make sure that the sensor is pointed away from the body and other people. In a well ventilated area, use the purge port (if the sensor is so equipped), or very SLOWLY loosen the bulkhead connector to let the pressure release.

8.1 Plastic sensor maintenance

Sensors with plastic or acetyl pressure housings are lighter and less expensive than the more durable titanium or aluminum housings, but require extra care.

- Plastic can become brittle in cold environments. It is possible for cracks to form around screw holes. Make sure that screws are tightened to 15 in-lbs., or finger-tight, then 45 degrees more.
- Plastic scratches easily. Do not use screwdrivers or metal tools to remove the end flange. Monitor the pressure housing for deep scratches that can become a point of weakness during deep deployments or very cold temperatures. Make sure that the O-ring surfaces are clean.

8.2 Replace alkaline batteries

⚠ WARNING



Explosion hazard. If the batteries are not installed correctly, explosive gases can be released. Make sure that the batteries are of the same approved chemical type and are inserted in the correct orientation.

⚠ WARNING



If the user thinks that the alkaline batteries have leaks, pressure may have built up inside of the pressure housing. Follow ESD protocols to release internal pressure. Put on safety glasses and protective gloves and make sure that the sensor is pointed away from the body and other people. In a well ventilated area very SLOWLY loosen the bulkhead connector to release the pressure. Keep away from heat, sparks, flame, and other sources of ignition. Do not smoke.

⚠ CAUTION



The pressure housing contains Electrostatic Discharge (ESD) sensitive parts and assemblies that are susceptible to damage from ESD. Follow ESD protocols:

- Put on protective eye wear before you open the pressure housing.
- Any electrostatic charge on the body of the human operator must be released before the pressure housing is opened: put a hand on a grounded surface, or better, wear a grounded antistatic wrist strap.
- At a minimum, wear short-sleeved antistatic clothing, such as cotton, or better, wear an antistatic smock for this service activity. *Do not wear a sweater, fleece or polyester-based clothing.*
- At a minimum, use a workstation with a wood or metal tabletop, or better, a tabletop that dissipates static. *Do not use a workstation with a synthetic or polymeric-based tabletop.*

NOTICE

Blue Moly™ and Dow Corning®4 lubricants are electrically conductive. Keep away from electrical components.

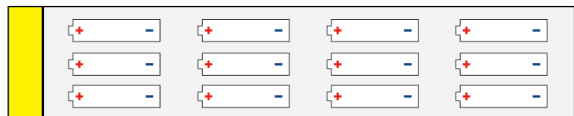
The instrument uses 12 Duracell® MN1300, LR20 D-cell alkaline batteries.

Remove the batteries if the sensor will be stored for longer than 3 months. Store batteries at a temperature between 5 °C and 30 °C.

1. Remove the battery end flange (opposite the end with connectors):
 - a. Clean the outside of the end flange and the housing. Make sure all parts are dry.
 - b. Remove the three flat Phillips-head screws from the end of the 16plus V2.
 - c. Pull firmly on the plastic bracket to remove the end flange. It may be necessary to turn the end flange or use a tool that will not cause damage to the plastic housing to loosen the end flange.
 - d. Use a lint-free cloth or tissue to remove any water from the O-ring surfaces inside the housing.
 - e. Make sure to protect the O-ring from damage or contamination.
2. Remove the three Phillips-head screws and washers from the green battery cover-plate inside the housing.
 - a. Turn the battery pack over and remove the batteries.
 - b. Install new batteries with the + terminals up. Refer to the marks on the side of the battery pack.



3. Turn the sensor over and remove the batteries.
4. Install new batteries. Make sure the polarity is correct.



5. Install the cover on the battery pack again:
 - a. The cover fits onto the battery pack only one way: one screw hole is closer to the edge than the others, which aligns with the post that is closest to the housing.
 - b. Push hard on the battery cover to compress the spring contacts and install the three Phillips-head screws and washers again.
 - c. Tighten the cover completely, or power to the sensor will be intermittent.
 - d. Use the **BAT +** and **BAT -** contacts to verify that the battery voltage is approximately 13.5 volts.
6. Carefully install the end flange again:
 - a. Make sure there is no water on any surface.
 - b. Connect the Molex connectors.
 - c. The O-rings must be pristine. Apply a small quantity of Parker Super O-Lube on any new O-rings, then carefully install the new ones.
 - d. Carefully push the end flange into the housing until it is against the O-rings.
 - e. Install the three flat Phillips-head screws in the sensor end flange.

8.3 Remove or replace anti-fouling devices

⚠ CAUTION

AF24173 anti-fouling devices contain bis(tributyltin) oxide. Wear rubber or latex gloves and eye protection to replace these devices on the sensor if it is so equipped. Wash hands with soap and water when finished.

Read the precautions on the product label.

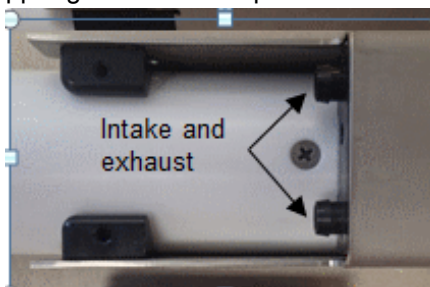
It is a violation of US federal law to use this product in a manner that is inconsistent with its label.

Remove the anti-fouling devices as a first maintenance task to save the anti-fouling material for deployments.

1. Use a 5/32 inch hex wrench to loosen the two captured cap screws that attach the copper anti-fouling assembly to the plastic assembly on the pressure housing. Carefully remove the copper anti-fouling assembly from the housing.



2. Remove the three Phillips-head screws from the copper anti-fouling assembly, and pull the copper guard off of the plastic anti-fouling holder.



3. Remove the protective plug from the anti-fouling device cup.
4. Use a toothpick to lift each of the anti-fouling devices out of the holder. If necessary, use needle-nose pliers to carefully break up the device.

Option	Procedure
To deploy sensor	Insert new anti-fouling devices into the cup, then install the cap onto the cup. Do not tighten too tight. Attach the copper assembly to the sensor again.
To clean or store sensor	Do not insert new anti-fouling devices. Install the protective plug. Make sure to remove the plug before the next deployment or pressurization of the sensor. Damage to the conductivity cells can be caused if the plugs are not removed.

8.4 Maintain pump

Sediment in the pump can cause data from the sensor to be of poor quality. To clean and maintain the pump, put the sensor in clean water and operate the pump for 15 minutes.

8.5 Clean pressure sensor

NOTICE

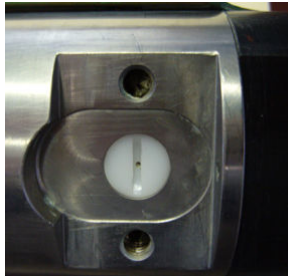
Do not put a brush or any object in the pressure port. It may damage or break the pressure sensor.

The nylon pressure capillary fitting has a pressure port fitting and an external capillary tube that is filled with silicone oil. The oil transmits hydrostatic pressure from the capillary tubing to the pressure sensor. The oil also prevents corrosion if the sensor is exposed to water.

Because of temperature and pressure changes over long time periods, some oil will slowly leak out of the external capillary tube. Use P/N 50025, Pressure Sensor Oil Refill Kit to refill the oil in the tube if no oil can be seen in the tube.

At regular intervals, or annually, inspect and clean the pressure port of sensors that are so equipped.

1. Use a flathead screwdriver to remove the pressure port plug.



2. Flush the pressure port with warm DI water to remove any contamination.
3. Replace the pressure port plug. Do not over-tighten the nylon screw.

8.6 Examine O-rings

NOTICE

Do not use petroleum-based lubricants on O-rings. It will cause damage to the O-rings. Damaged O-rings can cause the sensor to flood and make it unserviceable.

Examine the O-rings on the sensor every time they are exposed—on the connector end flange and other parts. O-rings must be pristine. If there is any question about whether an O-ring is clean and undamaged, replace it with a new one.

1. Dry the O-rings and O-ring grooves with a lint-free cloth or tissue.
2. Examine each O-ring to make sure there is no damage, dirt, lint or hair on it.
3. Replace an O-ring if necessary.
4. Apply a small quantity of silicone-based Parker Super O Lube® or Dow Corning® high vacuum grease to each O-ring.
 - The lubricant helps the O-ring move into its groove with no twist, which can compromise the seal.
 - Do NOT use petroleum-based lubricants on any O-ring.

8.7 Clean bulkhead connectors

NOTICE

Do not use WD-40® or petroleum-based lubricant on bulkhead connectors. It will cause damage to the rubber.






Damaged connectors can cause a loss of data and additional costs for service.

Damaged connectors can cause damage to the sensor and make it unserviceable.

Use silicone-based lubricants only.

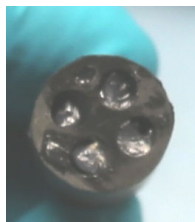
Examine, clean, and lubricate bulkhead connectors at regular intervals. Connectors that are not lubricated increase the damage to the rubber that seals the connector contacts. The incorrect lubricant will cause the failure of the bulkhead connector.

1. Apply isopropyl alcohol (IPA) as a spray or with a nylon brush or lint-free swab or wipes to clean the contacts.
2. Flush with additional IPA.
3. Shake the socket ends and wipe the pins of the connectors to remove the IPA.
4. Blow air into the sockets and on the pins to make sure they are dry.
5. Use a flashlight and a magnifying glass to look for:

Any corrosion.		
Cracks, scratches, or other damage on the rubber pins or in the sockets.		
Separation of the rubber from the pins.		
Swelled or bulging rubber pins.		

6. Use a silicone-based lubricant on each of the contacts of the bulkhead connector. The manufacturer recommends any of the products listed below.
 - 3M™ Spray Silicone Lubricant (3M ID# 62-4678-4930-3). Make sure to let it dry.
 - Dow Corning Molykote® III Compound (DC III)
 - Dow Corning High Vacuum Grease® (DC 976 V)
 - Dow Corning 4 Electrical Insulating Compound® (DC 4)
 - Dow Corning Molykote 44 High Temperature Grease® (DC 44)

Use a finger to put a small quantity (approximately 1 cm in diameter) of silicone grease on the socket end of the connector and push as much of the lubricant as possible into each socket. Do not use too much lubricant, as that will prevent a good seal.



7. Connect the connectors.
8. Use a lint-free wipe to clean any unwanted lubricant from the sides of the connectors.

8.8 CTD storage

When the plumbing is clean, the sensor can be prepared for storage:

- Make sure the anti-fouling devices are not installed.
- Make sure there is a dummy plug and lock collar attached to the bulkhead connector.

For short-term storage up to a week, make sure to put the manufacturer-supplied colored plugs on the intake and exhaust plumbing ports.

For long term storage:

- Attach one end of a Tygon hose section to the exhaust port, and the other end to the intake port to isolate the conductivity cell plumbing.
- Attach the yellow protective label over the intake and exhaust ports.



8.9 Calibration

The manufacturer calibrates every sensor to known conditions and measures the response of the sensor. Calibration coefficients are calculated and are used to get engineering units.

8.9.1 Conductivity

The conductivity sensor has a fixed resistor in parallel with the cell. When the cell is dry and in air, the output of the sensor is a frequency that is a reflection of the fixed resistor. This value is on the Calibration Certificate and should remain stable (within 1 Hz) over time.

The calibration changes as a result of fouling in the cell by chemical or biological deposits. Because of this, the long-term accuracy depends on how clean the cell is. The manufacturer recommends that the user has the conductivity sensor calibrated before and after a deployment, but also after the sensor has been deployed in contaminated water.

8.9.2 Temperature

As the thermistor element ages during the first year, the calibration of temperature sensor changes by a few thousandths of a degree. Change is less in subsequent years. Environmental conditions do not have much effect on the calibration.

8.9.3 Pressure

The strain-gauge pressure sensor has an initial static error band of 0.05%. Pressure sensors show most of their error as a linear offset from zero. Note that the pressure sensor is an "absolute" sensor, so the raw data includes the effect of atmospheric pressure of 14.7 psi. Engineering units, however, are relative to the ocean surface. The sensor uses the equations below to convert psia:

$$P(\text{db}) = P(\text{psi}) = P(\text{psia}) - 14.7$$

$$P(\text{dbar}) = [P(\text{psia}) - 14.7] \times 0.689476$$

The manufacturer recommends that the user applies the offset calibration coefficient to make small corrections to the pressure sensor calibration. Compare the pressure values to a barometer.

1. Let the sensor equilibrate in a constant temperature bath for at least 5 hours in the orientation in which it will be deployed.
2. Start the appropriate Seaterm software.
3. Set the pressure offset to 0.0 (POffset=0).
4. Set the output format to converted decimal (OutputFormat=1).
5. Set the pressure output to yes (OutputPress=y), and pressure units to decibars (SetPressUnits=0).
6. Take 100 samples and transmit data (TSN:100).
7. Compare the sensor output to what a barometer at the same elevation as the pressure sensor port shows.
 - Calculate the offset: the barometer value - pressure sensor value.
8. Set the calculated offset (POffset=).

8.10 Spare parts and accessories

Part number	Description	Qty
90087	Universal plumbing kit, pump air release valve, y-fitting, tubing (AN 64-1)	1
50087.1	Conductivity cell filling and storage hose, with barbs	1
171498	Dummy plug for MCBH6MP, with lock collar	1
60021	Spare battery end cap hardware kit, SBE16/19/25	1
801206	Data I/O cable, 2.4 m (DN 33447)	1
30411	500 ml bottle of non-ionic surfactant	1
801542.1	AF24173 anti-fouling device, pair	1

Section 9 Reference: command descriptions

This is a reference for advanced users. The values of these commands are stored in the sensor until the user changes them. Notes about terminal commands are listed below.

- Commands are not case-sensitive. Push **Enter** to store a command.
- The sensor sends an error message if a command is invalid.
- When #iiOutputExecutedTag=N and the 16plus V2 does not show an S> prompt after a command is executed, push Enter to see the S> prompt.
- The argument Y and 1 are both "Yes" and N and 0 are both "No." For example, Volt0=y and Volt0=1 are equivalent.
- The sensor will go into a low power mode if no command is sent for 2 minutes. Select *Connect* in the **Communications** menu to start communication again or push Enter.
- If the 16plus-IM V2 is in a low power mode, select *Connect* from the **Communications** menu in the SeatermIM software to start communications again.
 - With a SIM: send PwrOn
 - With an IMM set to ConfigType=1: send PwrOn
 - With an IMM set to ConfigType=2: wait 1 second then send ForceCaptureLine, then send WakeupTone.
- Samples must have the same number of data fields. If the number of data fields is changed, the sensor must start data collection again. This sets the sample number and cast number to 0, so all of the memory is available to record data with the new number of data fields. **Make sure to transmit all stored data to a PC before the 16plus-IM V2 starts again, or data will be lost.** Commands that change the number of data fields are #iiPType=, #iiVolt0=, #iiVolt1=, #iiVolt2=, #iiVolt3=, #iiVolt4=, #iiVolt5=, #iiSBE63=, #iiSBE38=, #iiWetLabs=, #iiGTD=, #iiDualGTD=, #iiOptode=. The user is prompted to verify the command so stored data is not overwritten.
- During data collection, the 16plus-IM V2 responds to commands that do not change the setup of the sensor. If for example, the user sends #iiDS while the sensor collects data, it will temporarily stop. Data collection starts again when the sensor goes into low power mode because 2 minutes have passed.
- If #iiStartLater was sent and the 16plus-IM V2 has not yet started to collect data, it will respond only to commands that do not change the setup of the sensor.
- To send any other commands, send #iiStop, then send any commands to change the setup and then send #iiStartLater.
- When a group command such as #Gn: or !Gn: is sent, the IMM or SIM connected to the controller will not get a response from the sensors because only one sensor can communicate at a time. The IMM and SIM are set up to not wait for a response from a group command.
- Data can be transmitted from the 16plus-IM V2 with the internal RS232 connector. Do not use the #ii prefix in the Acquisition Microcontroller commands, and use Seaterm232 and not SeatermIM.

9.1 SIM

PwrOn	Send "wakeup" tone to all IM sensors on-line.
PwrOff	Turn off power to all IM sensors on-line. Sensors go into low power mode. Has no effect on autonomous data collection.
AutoPwrOn=x	x=Y: Automatically send PwrOn to all sensors on-line when power is supplied to SIM. Default. x=N: do not (not typically used with the 16plus-IM v2).
DS	Show SIM firmware version and setup. (Response shows SBE 37 because the SIM was used in that sensor first.)
Baud=x	Baud rate between SIM and PC or controller. 1200, 2400, 4800 or 9600 available. Default = 9600.

Reference: command descriptions

	SIM and SeatermIM baud setting must agree. To change the baud rate, select <i>Disconnect and reconnect</i> to disconnect, then select it again to connect at the new baud rate.
DataNNMax=x	x= timeout, 0–32767 milliseconds that applies to !iiData or Dataii only. If no response is received within DataNNMax, the PC is in control and other commands can be sent. If #iiOutputFormat=5, set DataNNMax to 4000. Default = 1000.
RelayMax=x	x = timeout, 0–32767 seconds that applies to all commands other than !iiData or Dataii. If no response is received within RelayMax, the PC is in control and other commands can be sent. Default = 20. Set RelayMax= to a value greater than that set in #iiDelayBeforeSampling.
EchoOn	Show ("echo") characters as they are entered.
EchoOff	Dot not show characters.

9.2 Communications microcontroller

The manufacturer puts all 16plus-IM V2s in Group 0 and Group 9. Group commands are GData, DateTime=, DS, Wait=. For example, !G9:GData sends GData to all sensors on-line in group 9.

DateTime= mmddyyhhmmss	Set real-time clock for all 16plus-IM V2s. Use #iiDateTime to set time in each 16plus-IM V2. DateTime will not work. If the batteries have been removed from the sensor, date and time must be set again.
GData	Command all communication microcontrollers to get the last data sample from acquisition microcontrollers. The communication microcontrollers hold data in a buffer until !iiData or Dataii is received. When an IMM with ConfigType=2 is used, use SendGData instead. The IMM sends the GData command to all IM sensors on-line.
!iiData or Dataii	Get the data from the buffers of all on-line sensors. ii = 0–99. When an IMM with either ConfigType= is used, use !iiData. instead. Dataii will not work.
ID commands: Only one IM sensor can be on-line when the ID commands are used. If more than one is on-line when ID is set, all sensors will be set to the same ID. The inductive modem receivers are very sensitive and should be separated by a minimum of 2 meters when IDs are set.	
ID?	Show ID. ID = ii, where ii = 0–99.
*ID-ii	Set 16plus-IM V2 ID to ii, where ii = 0–99. Send command two times.
!iiDS	Show the communication microcontroller firmware version and timeout value for a 16plus-IM V2 with ID=ii.
!iiWait=x	x= maximum time in seconds for the communication microcontroller to wait for a response from the acquisition microcontroller. Range is 2–600. Make sure to set !iiWait= to #iiDelayBeforeSampling= plus 10 seconds.

9.3 Acquisition microcontroller

Use #Gn: in place of #ii to send acquisition microcontroller commands as group commands. For example, #G9:StartNow sends StartNow to all sensors on-line that are in group 9.

To use the 16plus-IM V2's internal RS232 to transmit data, select SBE 16plus-IM V2 RS232, not 16plus-IM V2 IM. Seaterm232 is designed for RS232 communications. Do not use the #ii prefix.

9.3.1 Status

#iiGetCD	Show configuration data
----------	-------------------------

Example for 16plus-IM V2with ID=01, user entries in **boldface**:

#iiGETCD

```

<ConfigurationData DeviceType='SBE16plus-IM' SerialNumber='01906003'>
    <SamplingParameters>
#iiSampleInterval=        <SampleInterval>15</SampleInterval>
#iiNCycles=              <MeasurementsPerSample>1</MeasurementsPerSample>
#iiDelayBeforeSampling=  <DelayBeforeSampling>0.0</DelayBeforeSampling>
#iiDelayAfterSampling=  <DelayAfterSampling>0.0</DelayAfterSampling>
    </SamplingParameters>
    <DataChannels>
#iiVolt0=                <ExtVolt0>yes</ExtVolt>
#iiVolt1=                <ExtVolt1>no</ExtVolt>
#iiVolt2=                <ExtVolt2>no</ExtVolt>
#iiVolt3=                <ExtVolt3>yes</ExtVolt>
#iiVolt4=                <ExtVolt4>no</ExtVolt>
#iiVolt5=                <ExtVolt5>no</ExtVolt>
#iiSBE38=                <SBE38>no</SBE38>
#iiSBE50=                <SBE50>no</SBE50>
#iiWetLabs=              <WETLABS>no</WETLABS>
#iiOptode=               <OPTODE>no</OPTODE>
#iiSBE63=                <SBE63>no</SBE63>
#iiGTD=                  <GTD>no</GTD>
    </DataChannels>
#iiOutputExecutedTag=    <OutputExecutedTag>no</OutputExecutedTag>
#iiOutputFormat=        <OutputFormat>converted decimal</OutputFormat>
#iiOutputSal=           <OutputSalinity>no</OutputSalinity>>
#iiOutputSV=            <OutputSoundVelocity>no</OutputSoundVelocity>
#iiOutputUCSD=          <OutputSigmaT_V_I>no</OutputSigmaT_V_I>
#iiOutputSampleNumber=  <OutSampleNumber>no</OutSampleNumber>
    </ConfigurationData>

```

#iiGetSD	Show status data
	Sensor model, S/N
	DateTime= format of date and time yyyy-mm-ddThh:mm:ss
	Data collection status
	Event counter, reset with #iiResetEC

Reference: command descriptions

	Voltages and current draw <ul style="list-style-type: none"> main battery voltage Back-up lithium battery voltage current draw during operation pump current draw external voltage sensor current for channels 0 and 1; shows if 1 or more channels are enabled external voltage sensor current for channels 2, 3, 4, 5; shows if 1 or more channels are enabled RS232 sensor current draw; shows if channel is enabled.
	Memory: number of bytes in memory, number of samples in memory, number of additional samples that can be saved in memory, number of bytes in each sample, number of casts in memory if in Profiling mode. Reset with InitLogging

#iiGetCC	Show calibration coefficients. Same as the Calibration Certificates from the manufacturer.
----------	--

#iiGetEC	Show event counter. Some events include:
	Power fail: main batteries or external voltage below cutoff.
	EEPROM read or EEPROM write: all power removed (main batteries removed, and back-up lithium batteries are dead)
	Alarm short: sample missed because "wake" command was sent during data collection in Moored mode
	Alarm long: #iiStartLater was sent, but #iiStartDateTime is more than 1 month in the future
	AD7730 timeout: delayed response from temperature and pressure A/D converter. Typical if a command is sent during data collection in Moored mode
	AD7714 timeout: delayed response from voltage channel A/D converter. Typical if a command is sent during data collection in Moored mode
Flash	Out of memory. Data collection continues but additional data is not stored
	Correctable error: single bit error in a page that self-corrects. Does not affect data
	ECC error: does not affect data
	Timeout: problem with flash
	Ready: problem with flash, timeout error
	Erase failed: problem with flash
	Write failed: problem with flash
	Uncorrectable: problem with flash. 2 or more bits of errors on a page
	Block overrun: problem with flash
	New bad block: problem with flash. Write or Erase failed, or an uncorrectable error

#iiResetEC	Erase all events in the event counter
------------	---------------------------------------

#iiGetHD	Show hardware data
	Sensor model, S/N
	Manufacturer
	Firmware version
	Firmware date
	PCB S/N and assembly numbers
	Manufacture date

	Sensor models and serial numbers
	Internal sensor models and serial numbers
	External voltage sensor models and S/N. Can be changed by the user.
	External RS232 sensor models and S/N. Can be changed by the user.
#iiDS	Show operation status and setup parameters
	Firmware version, S/N, date and time. DateTime=
	Voltages and current draw
	Data collection status—not started, started, no data collection, or unknown
	Number of samples saved and available space in memory
	#iiSampleInterval= and #iiNCycles=, the number of samples to collect and average for each sample
	#iiParosIntegration= integration time. Shows only for quartz pressure sensor
	#iiPumpMode, pump turn-on parameter. #iiDelayBeforeSampling= turn-on delay, #iiDelayAfterSampling= turn-off delay.
	Battery cut-off voltage
	#iiPType= pressure type and #iiPRange= pressure range, set by manufacturer
	#iiSBE38= secondary temperature sensor #iiSBE 50= pressure sensor #iiWETLabs= WET Labs sensor #iiOptode= optode #iiSBE63= optical dissolved oxygen sensor #iiGTD= gas tension device #iiDualGTD= dual gas tension devices
	#iiVolt0= through #iiVolt5= sample external voltages 0, 1, 2, 3, 4, 5
	#iiOutputFormat= format of data
	#iiOutputSal= salinity output, #iiOutputSV= sound velocity, #iiOutputSampleNumber= if format of output is converted decimal or converted XML UVIC
	#iiOutputUCSD= sigma-t, voltage, and current draw transmitted with each sample if output format is set to Y

Notes:

- The #iiDS command is equivalent to the responses from #iiGetSD and #iiGetCD, with a different format.
- Send #iiDS to briefly turn the pump on, so the 16plus-IM V2 will measure and show the pump current draw. It will not cause damage to the pump to operate it for a **short** period of time.
- If a WET Labs sensor with a Bio-wiper (Biowiper=y) is used, the #iiDS response shows wait 4 seconds for biowiper to close before it measures the enabled external voltage currents.

#iiDCal	Calibration coefficients in a different format from GetCC. Should agree with the calibration certificate.
---------	---

9.3.2 General setup

#iiDateTime=x	Set real-time clock. Format is mmddyyyyhhmmss.
#iiOutputExecutedTag=x	x=Y: show XML tags during and after execution x=N: do not show XML tags. Tags show one or more times during execution if the response to the command requires additional time.

Reference: command descriptions

#iiPumpMode=x	x=0: no pump x=1: Operate pump for 0.5 seconds before each sample (typical if no auxiliary sensors are connected to the plumbing). x=2: Operate pump during each sample (typical if auxiliary sensor are connected to the plumbing).
#iiNCycles=x	x=number of measurements to take and average for each sample, 1–100. Default = 1.
#iiInitLogging	transmit all stored data , then initialize the sensor before data collection starts again. All of the memory is available. #iiInitLogging sets the sample number #iiSampleNumber= and header and cast number #iiHeaderNumber= to 0. The first sample is 1 and the cast/header is 1. If not set to 0, data will be stored after the last recorded sample.
#iiSampleNumber=x*	x= sample number for last sample in memory. Typically only used to recover data if InitLogging is accidentally used before all stored data is transmitted to a PC. Do not send #iiSampleNumber=0 until all stored data has been transmitted.
#iiHeaderNumber=x*	x=header and cast number for last header or cast in memory. Typically only used to recover data if #iiInitLogging is accidentally used before all stored data is transmitted to a PC. Maximum stored headers is 1000. The 16plus-IM V2 writes a new header: each time data collection starts in Profiling mode each time data collection starts and after every 2000 samples are stored in memory in Moored mode.
#iiBiowiper=x	x=Y: used when the system includes a WET Labs sensor with Bio-wiper. The 16plus-IM V2 is on longer for #iiGetSD and #iiDS so there is enough time for the wiper to open and then close if the wiper is set up to take 1 measurement for each sample. x=N: no Bio-wiper. Default.

Notes:

- If #iiGetSD or #iiDS is sent when a WET Labs sensor with a Bio-wiper is installed and #iiBiowiper=N, the Bio-wiper will open but there will not be enough time to close it with the supplied power. If the system is deployed with the Bio-wiper open and a delayed start time, the sensor may become fouled because the Bio-wiper will stay open until the first sample is complete.
- The sensor goes into a low power mode to save battery power if no command is received within 2 minutes.

The 16plus-IM V2 requires verification when #iiInitLogging, #iiSampleNumber=, or #iiHeaderNumber= are sent. The sensor responds: `this command will change the scan length and/or initialize logging. Repeat the command to verify.` Enter the command again, then push **Enter**. The 16plus-IM V2 responds: `Scan length has changed, initializing logging` **Make sure that all data has been transmitted to a PC before #iiInitLogging is sent.** These commands do not erase data; they reset the data pointer. If #iiInitLogging is sent accidentally, do the steps below to recover data.

1. Set #iiSampleNumber=a and #iiHeaderNumber=b, where a and b are the estimate of the number of samples and casts in memory.
2. Transmit data. If a is more than the actual number of samples or b is more than the actual number of casts in memory, the data for the non-existent samples or casts will be nonsense. Examine the transmitted data and erase any bad, nonsense data.
3. Increase a or b and transmit the data again to see if there is additional valid data in memory.

9.3.3 Pressure sensor

#iiPType=x	x= type of pressure sensor, set by the manufacturer. x=1: strain gauge. x=3: quartz.
#iiRefPress=x	x= reference pressure, dbars. Use if there is no internal pressure sensor. Reference pressure is used to calculate conductivity, salinity, sound velocity. This entry is ignored if the 16plus-IM V2 does not have an internal pressure sensor. If an SBE 50 pressure sensor is connected, the 16plus-IM V2 does not use that data for calculations.
#iiParosIntegration=x	x= integration time for optional quartz pressure sensor. Range: 1–600 seconds. Default = 1.

Notes:

- The configuration file, .xmlcon or .con file must agree with the pressure sensor and external voltages to see real-time data in Seasave or to process data. Look at or edit the configuration file in Seasave or the SBE Data Processing software. These parameters are factory-set to agree with the system configuration that was purchased.
- The 16plus-IM V2 does the integration for the quartz pressure sensor after #iiNCycles= measurements.
- #iiPumpMode=, #iiNCycles, #iiDelayBeforeSampling and #iiDelayAfterSampling have an effect on the time required to sample. If the time is too high, the sensor can not take the required number of measurements and do calculations within #iiSampleInterval=.

9.3.4 Voltage sensor setup

#iiVolt0=x	x=Y: enable external voltage 0 x=N: do not
#iiVolt1=x	x=Y: enable external voltage 1 x=N: do not
#iiVolt2=x	x=Y: enable external voltage 2 x=N: do not
#iiVolt3=x	x=Y: enable external voltage 3 x=N: do not
#iiVolt4=x	x=Y: enable external voltage 4 x=N: do not
#iiVolt5=x	x=Y: enable external voltage 5 x=N: do not
#iiDelayBeforeSampling=x	x= time to wait before data collection after external voltage and RS232 sensors are turned on, 0–600 seconds. Default = 0. Typical: WET Labs sensor with Bio-wiper, approximately 4 seconds. SBE 43 or 63 oxygen change with the membrane thickness and water temperature. Use with #iiPumpMode=2. Beckman or YSI oxygen sensor, 120–180 seconds so the sensor can polarize. Use with #iiPumpMode=2.
#iiDelayAfterSampling=x	x= time to wait after data collection is complete before the power is turned off to external voltage and RS232 sensors, 0–100 seconds. Default = 0. Typical: WET Labs sensor with Bio-wiper, approximately 4 seconds.

Notes:

- Make sure to transmit all stored data from the 16plus-IM V2 to a PC before #iiVolt0= through #iiVolt5= are sent. When one of these commands is sent, the 16plus-IM V2 responds with #iiInitLogging, which erases all data stored in memory.

- External voltage numbers 0, 1, 2, 3, 4, and 5 are the same as the wiring of the sensors to a voltage channel on the 16plus-IM V2. However, in the .xmlcon or .con file, voltage 0 is the first external voltage in the data, voltage 1 is the second, etc.
- Set the time the SIM waits for a response, #iiRelayMax=, longer that #iiDelayBeforeSampling= so that the SeaCAT does not go into a low power mode.
- Set !iiWait= to #iiDelayBeforeSampling= + 10 seconds.
- #iiPumpMode=, #iiNCycles, #iiDelayBeforeSampling and #iiDelayAfterSampling have an effect on the time required to sample. If the time is too high, the sensor cannot take the required number of measurements and do calculations within #iiSampleInterval=.
- #iiDelayBeforeSampling=, #iiDelayAfterSampling= and #iiPumpMode= have an effect on pump operation.
- #iiDelayBeforeSampling= does not apply to the RS232 Aanderaa Optode. The 16plus-IM V2 turns on the power to the Optode when it is ready to collect data from the Optode.

9.3.5 RS232 sensor setup

Make sure that all of the stored data has been transmitted to a PC before any of these commands are sent or data will be erased: #iiSBE63=, #iiSBE38=, #iiSBE50=, #iiWetLabs=, #iiGTD=, #iiDualGTD, #iiOptode.

The 16plus-IM V2 sample interval (#iiSampleInterval=) must be greater than or equal to the sum of the times required to sample. #iiPumpMode=, #iiNCycles=, #iiParosIntegration=, #iiDelayBeforeSampling=, and #iiDelayAfterSampling= have an effect on the time required to sample. If the time required to sample is too high, the 16plus-IM V2 cannot make the required number of measurements and do the calculations in #iiSampleInterval=.

Setup for SBE 63

Use #iiDelayBeforeSampling= to set the delay to 25 seconds at 15 °C, and 40 seconds at 0 °C. This gives the SBE 63 enough time to equilibrate after the pump starts and before a measurement is made.

The minimum time required for the SeaCAT to collect a sample and to get a measurement from the SBE 63 is approximately 10 seconds.

Connect the SBE 63 to a PC and supply power externally. Use Seaterm232 to set the parameters below **before** it is connected to the 16plus-IM V2.

- Use SetBaud= to set the baud rate to 9600.
- Use SetEcho=1 to see the commands entered.
- Use SetAvg=2 to set the number of samples to be averaged. Values can be from 1-16; 2 (default) is recommended.
- Use SetFormat=1 so that the data format agrees with the 16plus-IM V2.
- Use SetAutoRun=0 to disable automatic operation when power is supplied.
- Use GetSD or GetHD to verify that <SerPause> is 0.

Connect the SBE 63 to the 16plus-IM V2 *auxiliary RS232* connector. In the 16plus-IM V2, set #iiSBE63=Y to enable communications.

#iiSBE63=x	x=Y: enable SBE 63 x=N: do not
#iiSend63=command	Command the 16plus-IM V2 to send [command] to the SBE 63 and get a response. The [command] is any command used by the SBE 63.

Setup for SBE 38

Connect the SBE 38 to a PC and supply power externally. Use Seaterm232 to set the parameters below **before** it is connected to the 16plus-IM V2.

- Use Baud=1200 to set the baud rate to 1200.

- Use Interface=232 to set the interface.
- Use AutoRun=y to start data collection when power is supplied.
- Use Format=C so that the data format is converted.

Connect the SBE 38 to the 16plus-IM V2 *auxiliary RS232* connector. In the 16plus-IM V2, set #iiSBE38=Y to enable communications.

#iiSBE38=x	x=Y: enable SBE 38 secondary temperature sensor x=N: do not
------------	--

Setup for SBE 50

Connect the SBE 50 to a PC and supply power externally. Use Seaterm232 to set the parameters below **before** it is connected to the 16plus-IM V2.

- Use Baud=1200 to set the baud rate to 1200.
- Use OutputFormat=1, 2, 3, 4, 5, 6 to see the data in psia, decibars, meters, or feet.

Connect the SBE 50 to the 16plus-IM V2 *auxiliary RS232* connector. In the 16plus-IM V2, set ii#SBE50=Y to enable communications.

#iiSBE50=x	x=Y: enable SBE 50 x=N: do not
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Setup for WET Labs sensors

The SeaCAT is compatible with ECO models, WETStar, C-Star, and SeaOWL UV-A sensors.

- #iiDelayBeforeSampling= must be > 2 seconds. If WetLabs=Y and #iiDelayBeforeSampling < 2 seconds, the SeaCAT automatically sets it to 2 seconds.
- If the WET Labs sensor has a Bio-wiper, set #iiDelayBeforeSampling= and #iiDelayAfterSampling= to 4 seconds so the Bio-wiper has time to open and close for each sample.
- The 16plus-IM V2 transmits 6 bytes of data for each sample:
 - 3-channel sensors (SeaOWL and ECO Triplet) use 6 bytes.
 - 2-channel sensors (ECO FLNTU) use the first 4 bytes; the last 2 are 0's.
 - Single-channel sensors use the first 2 bytes; the last 4 are 0's.

Connect the WET Labs sensor to the 16plus-IM V2 *auxiliary RS232* connector. In the 16plus-IM V2, set #iiWetLabs=Y to enable communications.

#iiWetLabs=x	x=Y: enable WET Labs sensor x=N: do not
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Setup for Gas Tension Device

Connect the GTD to a PC and supply power externally. Use the software from Pro-Oceanus to set the parameters below **before** it is connected to the 16plus-IM V2.

- Set the baud rate to 1200.
- Set the output to millibars.
- Set the sum of the pressure integration time and the temperature integration time to 40 seconds or less so that the 16plus-IM V2 does not go into low power mode while it waits for the GTD. Use the `take pressure reading` command to set this value.

Connect the GTD to the 16plus-IM V2 *auxiliary RS232* connector. In the 16plus-IM V2, set #iiGTD or #iiDualGTD=Y to enable communications.

Reference: command descriptions

#iiGTD=x	x=Y: enable GTD x=N: do not
#iiDualGTD=x	x=Y: enable two GTDs x=N: do not
#iiTGTD	Measure GTDs, transmit one sample of data from each GTD, with firmware version, serial number, pressure, temperature
#iiSendGTD=command	Command the 16plus-IM V2 to send [command] to GTD and get response. [command] is any used by the GTD

The 16plus-IM V2 communicates with the GTD last, after #iiDelayBeforeSampling=, conductivity, temperature, pressure, and all voltage channels. The voltage to all other external sensors and the pump are turned off before the SeaCAT communicates with the GTD.

Before each sample, the 16plus-IM V2 sends the commands below to the GTD:

- *ID00VR<CR><LF>—get GTD firmware version. Wait up to 3 seconds for response.
- *ID00SN<CR><LF>—get GTD serial number. Wait up to 5 seconds for response.
- *9900P5<CR><LF>—command all GTDs to take a sample of pressure and hold data in the GTD.
- *ID00DB<CR><LF>—get pressure. Wait up to 90 seconds for response.
- *9900Q5<CR><LF>—command all GTDs to take a sample of temperature and hold data in the GTD.
- *ID00DB<CR><LF>—get temperature. Wait up to 90 seconds for response.

Setup for Aanderaa Optode

Connect the Optode to a PC and supply power externally. Do the steps given by Aanderaa to set the parameters below **before** it is connected to the 16plus-IM V2.

- Set Communication to RS232.
- Set the Sample Interval to 5.
- Set the output to model number, serial number, and oxygen concentration (µmoles/L) in decimal format. Disable air saturation, temperature, raw data, and text.

Connect the Optode to the 16plus-IM V2 *auxiliary RS232* connector. In the 16plus-IM V2, set #iiOptode=Y to enable communications.

#iiOptode=x	x=Y: enable Optode x=N: do not
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Notes:

To set up the configuration file in the Seasave or SBE Data Processing software, select *Oxygen*, *Optode* for the serial sensor. Enter the serial number, calibration date, and information required for salinity and depth corrections. The *internal salinity* must agree with the value in the Optode. The value is ignored if *Salinity correction* is disabled. When *Salinity correction* is enabled, the software corrects the oxygen output from the Optode based on the actual salinity calculated from the CTD data.

Power on from #iiDelayBeforeSampling does not apply to the Optode. The 16plus-IM V2 turns on power to the Optode when it is ready to collect the Optode data—after all CTD and other external sensor data is collected.

9.3.6 Output format

#iiOutputFormat=x	x=0: raw hexadecimal data, required for data processed with the manufacturer's software. Use the SeatermIM Upload menu to upload data. x=1: converted hexadecimal data in engineering units x=2: raw frequencies and voltages in decimal x=3: converted decimal data in engineering units x=4: not a valid format x=5: converted decimal data in engineering units, in XML
#iiOutputSal=x	x=Y: calculate and show salinity, psu, if #iiOutputFormat=3 or 5. x=N: do not
#iiOutputSV=x	x=Y: calculate and show sound velocity, m/sec, if #iiOutputFormat=3 or 5. x=N: do not
#iiOutputUSCD=x	x=0: calculate and show density sigma-t (kg/m3), battery voltage and operation current (mA) with data polled during data collection. Voltage and current are measured after delay before data collection, but before actual data collection, if #iiOutputFormat=3 or 5. x=1: do not
#iiOutputSampleNum=x	x=Y: show 6-character sample number, the number of samples stored in memory at the time the sample was taken with Dataii, !iiData, #iiSL, #iiSLT, #iiTS, #iiTSS, if #iiOutputFormat=3 or 5. x=N: do not

Notes:

The output format has no effect on how data is stored in the flash memory. The data processing software requires data in #iiOutputFormat=0.

Typical use of the output format command:

- Before data collection, set #iiOutputFormat=3 to see data in SeatermIM, if data will be transmitted occasionally while data is collected.
- Use the SeatermIM **Upload** menu to automatically transmit data in raw hex, no matter what the #iiOutputFormat= is set to, so that data is compatible with the SBE Data Processing software to process data and with Seasave software to look at archived data.

9.3.7 Autonomous data collection

The first time data collection starts after the InitLogging command is sent, data is recorded at the start of memory. Any previously recorded data is overwritten. Each time data collection starts, the data is recorded, and a new header is written to identify the cast number, date, time, and sample numbers in the cast. Maximum casts is 1000.

#iiSampleInterval=x	x=interval in seconds between samples, 10–14,400 seconds
#iiStartNow	Start data collection now
#iiStartDateTime=	Start data collection. Format is mmddyyyyhhmmss
#iiStartLater	Start data collection at #iiStartDateTime=. To change the setup after #iiStartLater has been sent (but before data collection has started), send #iiStop, make the necessary changes, then send #iiStartLater again.
#iiStop	Stop data collection or stop the wait to collect data (if #iiStartLater was sent but data collection has not started). Connect the 16plus-IM V2 to a PC, and select <i>Connect</i> in SeatermIM Communications menu, then send #iiStop. It may be necessary to send #iiStop more than one time.

Notes:

- When the 16plus-IM V2 receives the #iiStartLater command, it shows *waiting to start at ...* in response to #iiGetSD or #iiDS.
- If the delayed start time has passed when #iiStartLater is sent, the 16plus-IM V2 executes #iiStartNow.

- If the delayed start date and time is more than 1 month in the future when #iiStartLater is received, the sensor executes #iiStartNow.

9.3.8 Controlled data collection

Use these commands to collect one sample. The 16plus-IM V2 always stores data for the most recent sample in its buffer. Some commands also store data in the flash memory: the 16plus-IM V2 will not execute the *store data in flash memory* part of those commands during data collection.

#iiSL	Show data from the buffer (sample from the polled sample command, or latest sample from data collection).
#iiSLT	Show data from the last sample stored in buffer, then collect a new sample and store data in buffer.
#iiTS	Collect new sample, store data in buffer, show data, leave power on.
#iiTSS	Collect one sample, store data in buffer and flash memory, show data.
#iiGetLastSamples:x	Show the last x samples from flash memory. If x is more than the number of samples in memory, the sensor shows all the samples in memory. If x is not entered, the 16plus-IM V2 shows only the last sample. It is not necessary to stop data collection to send this command.

9.3.9 Transmit data

To transmit data from the 16plus-IM V2 to a PC, make sure to stop data collection first. If a data transmit command is sent manually, the data is transmitted in the format defined by #iiOutputFormat=.

Transmit data to a PC with RS232 or Inductive Modem.

- RS232 is much faster, up to 115,200 baud. The pressure housing of the 16plus-IM V2 must be opened to access the RS232 connector. Use the SeatermV2 software to select *16plus V2 RS232* from the **Instrument** menu. When Seaterm232 is used, make sure to select *Text*, not *Binary* as the upload format. Binary is not compatible with the 16plus-IM V2.
- Inductive modem—data can be transmitted while the 16plus-IM V2 is deployed, or is connected for testing. The baud rate is limited to 1200.

#iiGetSamples:b,e or #iiDDb,e	transmit data from sample b to sample e . If b and e are not entered, all data is transmitted.
GetHeaders:b,e or DHb,e	transmit header b to header e. If b and e are not entered, all headers are transmitted.

A maximum of 500 headers can be transmitted at one time. The first header number is 1. Header information includes:

- Header number
- Month, day, hour, minute, second when header was written
- First and last sample for header
- Interval between samples
- Reason data collection stopped
 - batfail = battery voltage is too low
 - stop cmd = #iiStop, Home, or Ctrl-Z received
 - timeout = error condition
 - unknown = error condition
 - ?????? = error condition

Notes:

- The format of the transmitted data is the same for IM or RS232.

- Use the SeatermIM or Seaterm232 **Upload** menu to transmit data to be processed by the SBE Data Processing software. A manually entered data transmit command does not have the required header information for the software.
- To save data to a file, select the **Capture** menu before data upload (transmit) command is sent.

9.3.10 Test

The 16plus-IM V2 collects and transmits 30 samples for each test. Data is not stored in the flash memory. Push **Esc** or send a break character to stop a test.

Test commands do not automatically turn the pump on. Sensors that have a pump collect water from the same area for all 30 measurements because the pump and its plumbing do not let water flow freely through the conductivity cell. To get data from fresh samples, send #iiPumpOn and then send a test command. Then send #iiPumpOff when the test is complete.

#iiTC	Measure conductivity with converted data as the output.
#iiTCR	Measure conductivity with raw data as the output.
#iiTT	Measure temperature with converted data as the output.
#iiTTR	Measure temperature with raw data as the output.
#iiTP	Measure pressure with converted data as the output.
#iiTPR	Measure pressure with raw data as the output.
#iiTV	Measure 6 external voltage channels with converted data as the output.
#iiTVR	Measure voltages read by A/D converter with raw data as the output. Columns 1–6: external voltages Column 7: main battery voltage/11 Column 8: back-up lithium battery voltage/3.741 Column 9: external current/333.33 Column 10: pressure temperature voltage
#iiTF	Measure frequency (quartz pressure sensor) with converted data as the output.
#iiTFR	Measure frequency (quartz pressure sensor) with raw data as the output.
#iiT63	Measure SBE 63 optical dissolved oxygen with aa.aaaa, b.bbbb, o.oooo, tt.tttt as the output. aa.aaa=phase in µsec b.bbbb=temperature voltage o.oooo=dissolved oxygen, ml/L tt.tttt=temperature, °C
#iiT38	Measure SBE 38 secondary temperature with converted data as the output.
#iiT50	Measure SBE 50 pressure with converted data as the output
#iiTOptode	Measure Aanderaa Optode, product number, serial number, and dissolved oxygen µmoles/L as the output
#iiPumpOn	Turn pump on. Use this command to get pumped data from sensors with a pump, or to test the pump
#iiPumpOff	Turn pump off

ECO Triplet or SeaOWL UV-A	
Column	Output
1–2	date and time
3	wavelength sensor 1
4	raw signal counts sensor 1

Reference: command descriptions

5	wavelength sensor 2
6	raw signal counts sensor 2
7	wavelength sensor 3
8	raw signal counts sensor 3
9	thermistor counts

ECO dual channel	
Column	Output
1–2	date and time
3	wavelength sensor 1
4	raw signal counts sensor 1
5	wavelength sensor 2
6	raw signal counts sensor 2
7	thermistor counts

ECO single channel	
Column	Output
1–2	date and time
3	wavelength sensor 1
4	raw signal counts sensor 1
5	thermistor counts

C-Star	
Column	Output
1	serial number
2	reference counts
3	signal counts
4	corrected signal raw counts
5	calculated beam c, inverse meters
6	internal thermistor counts

9.3.11 Calibration coefficients

F = floating point number. S = String with no spaces.

Calibration coefficients are set by the manufacturer and should be the same as the Calibration Certificates that ship with the 16plus-IM V2. Send #iGetCC or #iDCal to see all coefficients.

Temperature	
#iTCalDate=S	S=temperature calibration date
#iTA0=F	F=temperature A0
#iTA1=F	F=temperature A1
#iTA2=F	F=temperature A2

#iiTA3=F	F=temperature A3
#iiTOffset=F	F=temperature offset correction
Conductivity	
#iiCCalDate=S	S=conductivity calibration date
#iiCG=F	F=conductivity G
#iiCH=F	F=conductivity H
#iiCI=F	F=conductivity I
#iiCJ=F	F=conductivity J
#iiCTCor=F	F=conductivity tcor
#iiCPCor=F	F=conductivity pcor
#iiCSlope=F	F=conductivity slope correction
Internal pressure	
#iiPCalDate=S	S=pressure calibration date
#iiPRange=F	F=pressure sensor full scale range, psia
#iiPOffset=F	F=pressure offset correction
#iiPA0=F	F=strain-gauge pressure A0
#iiPA1=F	F=strain-gauge pressure A1
#iiPA2=F	F=strain-gauge pressure A2
#iiPTempA0=F	F=strain-gauge pressure temperature A0
#iiPTempA1=F	F=strain-gauge pressure temperature A1
#iiPTempA2=F	F=strain-gauge pressure temperature A2
#iiPTCA0=F	F=strain-gauge pressure ptca0
#iiPTCA1=F	F=strain-gauge pressure ptca1
#iiPTCA2=F	F=strain-gauge pressure ptca2
#iiPTCB0=F	F=strain-gauge pressure ptcb0
#iiPTCB1=F	F=strain-gauge pressure ptcb1
#iiPTCB2=F	F=strain-gauge pressure ptcb2
#iiPC1=F	F=quartz pressure C1
#iiPC2=F	F=quartz pressure C2
#iiPC3=F	F=quartz pressure C3
#iiPD1=F	F=quartz pressure D1
#iiPD2=F	F=quartz pressure D2
#iiPT1=F	F=quartz pressure T1
#iiPT2=F	F=quartz pressure T2
#iiPT3=F	F=quartz pressure T3
#iiPT4=F	F=quartz pressure T4
#iiPSlope=F	F=quartz pressure slope correction

Notes:

- Auxiliary sensor calibration coefficients are not stored in the 16plus-IM V2 EEPROM.

- Calibration coefficients for sensors that have raw data as output are stored in the 16plus-IM V2 configuration file. Use the **Configure** menu in the SBE Data Processing software to see or change the coefficients.
- Some RS232 auxiliary sensors store their calibration coefficients internally and data is transmitted in engineering units.
- For the SBE 63, use the 16plus-IM V2 software to send #ii63= to see or change the calibration coefficients.
- For other auxiliary sensors such as the SBE 38 or SBE 50, connect the sensor to a PC and use Seaterm (not SeatermIM) to look at or change the calibration coefficients.

9.3.12 Hardware configuration

Auxiliary sensor settings can be modified in the field to change the sensors connected the 16plus-IM V2.

#iiSetVoltType0=
#iiSetVoltSN0=
#iiSetVoltType1=
#iiSetVoltSN1=
#iiSetVoltType2=
#iiSetVoltSN2=
#iiSetVoltType3=
#iiSetVoltSN3=
#iiSetVoltType4=
#iiSetVoltSN4=
#iiSetVoltType5=
#iiSetVoltSN5=
#iiSetSerialType=
#iiSetSerialSN=

Section 10 Troubleshooting

10.1 No communications with sensor

If the `OutputExecutedTag=N`, the `S>` prompt shows that there was communication between the sensor and PC. Select *Connect* in the **Communications** menu again, or push **Enter** several times.

Cause: The I/O cable is not connected correctly.

Solution: Make sure the cable is connected at the PC and the sensor.

Cause: The sensor communication settings were not entered correctly in the software.

Solution: From the **Communications** menu, go to *Configure*, then *Serial Port Configuration*. Make sure that the settings match the values on the Configuration Sheet that shipped with the sensor.

Cause: The I/O cable is not the correct cable.

Solution: Make sure the cable is a standard 9-pin RS232 cable.

10.2 No data recorded

Cause: The memory is full. No additional data can be recorded.

Solution: Send `GetSD` or `DS` to verify that the memory is not full. If full, *free = 0 or 1*. Transmit all stored data to a PC before the next deployment. Then send `InitLogging` to set the memory to 0. Send `GetSD` or `DS` to show that *samples = 0*.

10.3 Data looks incorrect

Cause: Data that looks incorrect, with values out of range, for example, may be caused by incorrect calibration coefficients in the sensor.

Solution: Send `GetCC` to verify that the calibration coefficients in the sensor are the same as the Calibration Sheet from the manufacturer. This does not affect the raw data stored in the sensor.

- If the memory is not overwritten with new data, correct the coefficients and upload the data again.
- If the memory is overwritten with new data, manually correct the coefficients in the `.xmlcon` configuration file, then process the data again in the Data Conversion module of the SBE Data Processing software.

Cause: Small changes in conductivity are an indication that the pump flow is incorrect. There are several causes, such as a clogged air bleed hole, sediment, or an incorrect `MinCondFreq` setting.

Solutions:

- Clean the air bleed hole.
- Make sure that the pump is oriented correctly.
- Use a wash bottle to flush the plumbing to remove sediment.
- Make sure `MinCondFreq` is not set too high.

10.4 Salinity spikes

Salinity is a derived value from conductivity, pressure, and depth. It is calculated by the sensor if `OutputSal=Y`. Salinity can also be calculated from sensor data (a hex file) in the Data Conversion module of the SBE Data Processing software, or in the Derive module from the converted (`.cnv`) file.

In profiling applications, salinity spikes can be the result of temperature and conductivity measurements that are not aligned because of conditions with sharp gradients. The

differences in response times for temperature and conductivity measurements can be corrected for post-processing if the response times are known.

In moored applications, the pump flushes the conductivity cell faster than the environment changes, so temperature and conductivity measurements stay aligned. Typical **causes** of salinity spikes include:

- External biofouling that limits the flow through the conductivity cell will cause the conductivity measurement to occur after the temperature measurement.
- Solar heating at shallow depths can cause the actual temperature inside the conductivity cell to be different from the temperature measured by the thermistor.
- Air bubbles from breaking waves can cause the conductivity cell measurement to read low.

Section 11 General information

⚠ WARNING

This product can expose the user to chemicals with silica, crystalline (airborne particles of respirable size), which is known to the State of California to cause cancer and birth defects or other reproductive harm. For more information, go to www.P65Warnings.ca.gov.

Revised editions of this user manual are on the manufacturer's website.

11.1 Warranty

Refer to the manufacturer's website for warranty information (seabird.com/warranty).

11.2 Service and support

The manufacturer recommends that sensors be sent back to the manufacturer annually to be cleaned, calibrated, and for standard maintenance.

Refer to the website for FAQs and technical notes, or contact the manufacturer for support at support@seabird.com. Do the steps below to send a sensor back to the manufacturer.

1. Complete the online Return Merchandise Authorization (RMA) form or contact the manufacturer.
Note: The manufacturer is not responsible for damage to the sensor during return shipment.
2. Remove all batteries from the sensor, if so equipped.
3. Remove all anti-fouling treatments and devices.
Note: The manufacturer will not accept sensors that have been treated with anti-fouling compounds for service or repair. This includes AF 24173 devices, tri-butyltin, marine anti-fouling paint, ablative coatings, etc.
4. Use the sensor's original ruggedized shipping case to send the sensor back to the manufacturer.
5. Write the RMA number on the outside of the shipping case and on the packing list.
6. Use 3rd-day air to ship the sensor back to the manufacturer. Do not use ground shipping.
7. The manufacturer will supply all replacement parts and labor and pay to send the sensor back to the user via 3rd-day air shipping.

11.3 AF24173 anti-foulant device

AF24173 Anti-Foulant Devices supplied for user replacement are supplied in polyethylene bags displaying the following label:

AF24173 ANTI-FOULANT DEVICE	
FOR USE ONLY WITH SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.	
ACTIVE INGREDIENT: Bis(tributyltin) oxide	52.1%
OTHER INGREDIENTS:	47.9%
TOTAL	100.0%
⚠ DANGER	
Refer to conductivity sensor manual for the complete label and additional precautionary statements and information on the handling, storage and disposal of these devices.	
Net contents: Two anti-foulant devices	EPA Registration No. 74489-1
Sea-Bird Electronics, Inc.	EPA Establishment No. 74489-WA-1
13431 NE 20 th St.	
Bellevue, WA 98005	

AF24173 ANTI-FOULANT DEVICE

FOR USE ONLY WITH SEA-BIRD ELECTRONICS CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT: Bis(tributyltin) oxide 52.1%

General information

OTHER INGREDIENTS: 47.9%

TOTAL 100.0%

DANGER

See Precautionary Statements for additional information.

FIRST AID	
If in eyes	<ul style="list-style-type: none">• Hold the eye open and rinse slowly and gently with water for 15–20 minutes.• Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.• Call a poison control center or doctor for treatment advice.
If on skin or clothing	<ul style="list-style-type: none">• Take off contaminated clothing.• Rinse skin immediately with plenty of water for 15–20 minutes.• Call a poison control center or doctor for treatment advice.
If swallowed	<ul style="list-style-type: none">• Call poison control center or doctor immediately for treatment advice.• Have person drink several glasses of water.• Do not induce vomiting.• Do not give anything by mouth to an unconscious person.
HOT LINE NUMBER	
Note to Physician	Probable mucosal damage may contraindicate the use of gastric lavage.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For further information, call National Pesticide Telecommunications Network (NPTN) at 1-800-858-7378.	

Net contents: Two anti-foulant devices

Sea-Bird Electronics, Inc.

13431 NE 20th St.

Bellevue, WA 98005

EPA Registration No. 74489-1

EPA Establishment No. 74489-WA-1

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

Danger:

Corrosive—Causes irreversible eye damage and skin burns. May be fatal if swallowed or absorbed through the skin. Do not get in eyes, on skin, or on clothing. Wash thoroughly with soap and water after handling and before eating, drinking, chewing gum, using tobacco, or using the toilet. Remove and wash contaminated clothing before reuse.

PERSONAL PROTECTIVE EQUIPMENT

Users must wear: protective gloves (rubber or latex), goggles or other eye protection, long-sleeved shirt, long pants, and shoes plus socks.

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Follow the manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.

ENVIRONMENTAL HAZARDS

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has

been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of EPA. This material is toxic to fish. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat or open flame. Avoid contact with acids and oxidizers.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling.

For use only in Sea-Bird Electronics conductivity sensors. Read installation instructions in the applicable Conductivity Instrument Manual.

Intended for professional use by military, government, academic, commercial, and scientific personnel.

STORAGE AND DISPOSAL

PESTICIDE STORAGE: Store in original container in a cool, dry place. Prevent exposure to heat or flame. Do not store near acids or oxidizers. Keep container tightly closed.

PESTICIDE SPILL PROCEDURE: In case of a spill, absorb spills with absorbent material. Put saturated absorbent material into a labeled container for treatment or disposal.

PESTICIDE DISPOSAL: Pesticide that cannot be used according to label instructions must be disposed of according to Federal or approved State procedures under Subtitle C of the Resource Conservation and Recovery Act.

CONTAINER HANDLING: Nonrefillable container. Do not reuse this container for any other purpose. Offer for recycling, if available.

Sea-Bird Electronics
13431 NE 20th Street
Bellevue WA 98005 U.S.A.
(425) 643-9866

