

SBE 16*plus*-IM V2 SEACAT

*Conductivity and Temperature Recorder (pressure optional)
with Inductive Modem Interface*



Note: NEW ADDRESS
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User's Manual

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16plus-IM Digital Firmware Version 2.3 & later
16plus-IM Modem Firmware Version 1.1c & later
SIM Firmware Version 3.0a & later
IMM firmwre version 1.00 & later
SeatermV2 Version 1.1e and later
SBE Data Processing Version 7.21d & later



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Section 1: Introduction

This section includes a Quick Start procedure, and photos of a standard SBE 16plus-IM V2 shipment.

About this Manual

This manual is to be used with the SBE 16plus-IM V2 SEACAT Conductivity and Temperature (pressure optional) Recorder with Inductive Modem. It is organized to guide the user from installation through operation and data collection. We have included detailed specifications, command descriptions, maintenance and calibration information, and helpful notes throughout the manual.

Sea-Bird welcomes suggestions for new features and enhancements of our products and/or documentation. Please contact us with any comments or suggestions (seabird@seabird.com or 425-643-9866). Our business hours are Monday through Friday, 0800 to 1700 Pacific Standard Time (1600 to 0100 Universal Time) in winter and 0800 to 1700 Pacific Daylight Time (1500 to 0000 Universal Time) the rest of the year.

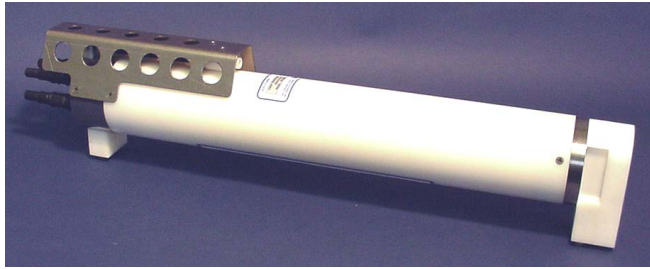
Quick Start

Follow these steps to get a Quick Start using the SBE 16plus-IM V2. The manual provides step-by-step details for performing each task:

1. Perform pre-check (*Section 3: Preparing for Deployment*):
 - A. Test power and communications.
 - B. Set 16plus-IM V2 ID.
2. Deploy (*Section 4: Deploying and Operating SBE 16plus-IM V2*):
 - A. Install new batteries if necessary.
 - B. Ensure all data has been uploaded, and then send **#iiNitLogging** to make entire memory available for recording if desired.
 - C. Set date and time (**#iiDateTime=**) and establish setup and logging parameters.
 - D. Check status (**#iiDS**) and calibration coefficients (**#iiDCal**) to verify setup.
 - E. Set 16plus-IM V2 to start logging now (**#iiStartNow**) or in the future (**#iiStartDateTime=** and **#iiStartLater**).
 - F. Remove protective plugs from anti-foulant device cups, and verify AF24173 Anti-Foulant Devices are installed. Leave protective plugs off for deployment.
 - G. Install dummy plugs and/or cable connectors, and locking sleeves.
 - H. Install 16plus-IM V2 on mooring cable.
 - I. (optional) Install Inductive Cable Coupler on mooring cable.
 - J. Wire system.

Unpacking SBE 16plus-IM V2

Shown below is a typical SBE 16plus-IM V2 shipment.



SBE 16plus-IM V2



Spare o-ring and hardware kit



Conductivity cell filling and storage kit



Conductivity cell cleaning solution (Triton-X)

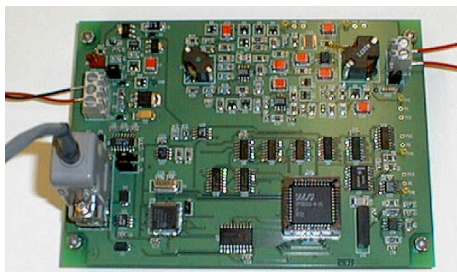


SBE 16plus-IM V2 manual



Software, and Electronic Copies of Software Manuals and User Manual

Note:
SBE 16plus-IM V2 can be used with SIM or with IMM; IMM not shown.



Surface Inductive Modem (SIM) PCB
(one per mooring, optional)



I/O Cable
(included with SIM)



Inductive Cable Coupler (ICC)
(optional with SIM, one per mooring)

Section 2: Description of SBE 16plus-IM V2

This section describes the functions and features of the SBE 16plus-IM V2 SEACAT, including:

- system description
- specifications
- dimensions and end cap connectors
- data storage
- batteries and battery endurance
- configuration options and plumbing
- Surface Inductive Modem (SIM), Inductive Cable Coupler (ICC), and mooring requirements

System Description

Note:

For detailed information on inductive modem systems, see *Real-Time Oceanography with Inductive Moorings*, at www.seabird.com under Technical Papers.

The SBE 16plus-IM V2 SEACAT is designed to measure conductivity, temperature, and (optional) pressure in marine or fresh-water environments in moored applications. The 16plus-IM V2 has internal batteries and non-volatile memory. It uses an Inductive Modem (IM) to transmit data and receive commands over a plastic-jacketed steel mooring cable (or other insulated conductor), using differential-phase-shift-keyed (DPSK) telemetry. No electrical cables or connectors are required. The 16plus-IM V2's built-in inductive coupler (split toroid) and cable clamp provide easy and secure attachment to the mooring cable.

Note:

Half-duplex communication is **one-direction** at a time (i.e., you cannot send commands and receive data at the same time). For example, if the IMM or SIM commands a 16plus-IM V2 to upload data, nothing else can be done while the data is being sent – the data upload cannot be stopped, and commands cannot be sent to other 16plus-IM V2s on the line.

Communicating with one or more 16plus-IM V2s requires the use of a Sea-Bird Inductive Modem Module (IMM) or Surface Inductive Modem (SIM). These devices provide a standard serial interface between the user's computer or other controlling device and up to 100 16plus-IM V2s (or other IM-compatible sensors), coupled to a single cable. The user can communicate with these devices via full-duplex RS-232C or half-duplex RS-485. Commands and data are transmitted half-duplex between these devices and the 16plus-IM V2.

Commands sent to the 16plus-IM V2 provide status display, data acquisition setup, data retrieval, and diagnostic tests. User-selectable operating modes include:

- **Polled sampling** – On command, the 16plus-IM V2 takes one sample and transmits data.
- **Autonomous sampling** – At pre-programmed intervals, the 16plus-IM V2 wakes up, samples, stores data in its FLASH memory, and powers off.
- **Combo sampling** – Autonomous sampling is in progress, and the 16plus-IM V2 can be commanded to transmit the last stored data.

The 16plus-IM V2 features the proven Sea-Bird conductivity and temperature sensors. Nine D-size alkaline batteries provide power for approximately 290,000 samples (with no pressure sensor, pump, or auxiliary sensors), depending on the sampling and telemetry schedule. The 64 Mbyte FLASH RAM memory records 2 years of conductivity, temperature, and date/time data while sampling every 10 seconds (other configurations/setups vary). User-selectable output format is raw data or engineering units, in hexadecimal or decimal form; XML output is also available. Setup, diagnostics, and data extraction are performed without opening the housing. The 16plus-IM V2 can power external sensors and acquire their outputs.

A standard 16*plus*-IM V2 is supplied with:

- Plastic housing for depths to 600 meters (1950 feet)
- Bulkhead connectors (Impulse glass-reinforced epoxy):
 - one 2-pin pump connector;
 - three 6-pin connectors, for two differential auxiliary A/D inputs each;
 - one 4-pin connector, for RS-232 auxiliary sensor (SBE 38 secondary temperature sensor, SBE 50 pressure sensor, WET Labs sensor [single, dual, or triple channel ECO sensor; WETStar; or C-Star], up to two Pro-Oceanus Gas Tension Devices, or Aanderaa Oxygen Optode 4330 or 4835)
- 64 Mbyte FLASH RAM memory
- 9 D-size alkaline batteries (Duracell MN1300, LR20)
- Anti-foulant device attachments and expendable AF24173 Anti-Foulant Devices. These are attached to each end of the conductivity cell, so that any water that enters the cell is treated.

16*plus*-IM V2 options include:

- Titanium housing for use to 7000 or 10500 meters (22,900 or 34,440 feet)
- Internally mounted pressure sensor -
 - Strain gauge pressure sensor, or
 - Quartz pressure sensor
- Pump -
 - SBE 5M (plastic or titanium housing) for pumped conductivity, or
 - SBE 5P (plastic housing) or 5T (titanium housing) for pumped conductivity **and** pumped auxiliary sensors
- Sensors for dissolved oxygen, fluorescence, light (PAR), light transmission, and turbidity
- Wet-pluggable (MCBH) connectors in place of standard connectors
- Battery pack kit for lithium batteries for longer deployments (lithium batteries **not** supplied by Sea-Bird).

Note:

The lithium battery pack cannot be used with a 16*plus*-IM V2 that is integrated with an SBE 5T or 5P pump.

Data upload can be accomplished without opening the 16*plus*-IM V2 housing, using the inductive modem telemetry (baud rate between 16*plus*-IM V2 and SIM or IMM is always 1200 baud). Alternatively, by opening the 16*plus*-IM V2 electronics chamber to access the internal RS-232 serial connector, fast upload of large data sets can be performed at rates up to 115,200 baud, using the optional data I/O cable (PN 801880).

Future upgrades and enhancements to the SBE 16*plus*-IM V2 firmware can be easily installed in the field through a computer serial port and the internal RS-232 serial connector inside the 16*plus*-IM V2, without the need to return the 16*plus*-IM V2 to Sea-Bird, using the optional data I/O cable (PN 801880).

The 16*plus*-IM V2 is supplied with a powerful Win 2000/XP software package, SEASOFT V2, which includes:

Notes:

- Help files provide detailed information on the software.
- A separate software manual contains detailed information on SBE Data Processing.
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site. See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

- **Deployment Endurance Calculator** – program for determining deployment length based on user-input deployment scheme, instrument power requirements, and battery capacity.
- **SeatermV2** – terminal program for easy communication and data retrieval. SeatermV2 is a *launcher*. Depending on the instrument selected it launches **SeatermIM** (inductive modem instruments, such as this 16*plus*-IM V2), **Seaterm232** (RS-232 instruments), or **Seaterm485** (RS-485 instruments).
- **SBE Data Processing** - program for calculation and plotting of conductivity, temperature, pressure, auxiliary sensor data, and derived variables such as salinity and sound velocity.

Specifications

	Temperature (°C)	Conductivity (S/m)	Pressure (optional)
Measurement Range	-5 to +35	0 to 9	0 to full scale range: • <i>Strain gauge sensor</i> : 20 / 100 / 350 / 600 / 1000 / 2000 / 3500 / 7000 meters • <i>Quartz sensor</i> : 20 / 60 / 130 / 200 / 270 / 680 / 1400 / 2000 / 4200 / 7000 / 10500 meters
Initial Accuracy	0.005	0.0005	• <i>Strain gauge sensor</i> : 0.1% of full scale range • <i>Quartz sensor</i> : 0.02% of full scale range
Typical Stability	0.0002/month	0.0003/month	• <i>Strain gauge sensor</i> : 0.1% of full scale range/year • <i>Quartz sensor</i> : 0.02% of full scale range/year
Resolution	0.0001	• 0.00005 (most oceanic water; resolves 0.4 ppm in salinity). • 0.00007 (high salinity water; resolves 0.4 ppm in salinity). • 0.00001 (fresh water; resolves 0.1 ppm in salinity).	• <i>Strain gauge sensor</i> : 0.002% of full scale range • <i>Quartz sensor</i> : 0.0006% of full scale range for 1-second integration; depends on sample integration time (see notes below)
Sensor Calibration (measurement outside these ranges may be at slightly reduced accuracy due to extrapolation errors)	+1 to +32	0 to 9; physical calibration over the range 2.6 to 6 S/m, plus zero conductivity (air)	Ambient pressure to full scale range in 5 steps

***Notes on Internally Mounted Quartz Pressure Sensor Resolution:**

Pressure Sensor Resolution = Sensitivity * Counter Resolution

- Sensitivity = Δ pressure / Δ frequency
 where Δ pressure is change in pressure in desired units (psia, db, meters, etc.) = pressure sensor full scale range
 Δ frequency is change in frequency in Hz \approx 3000 Hz over sensor's full scale range
- Counter Resolution = pressure sensor output frequency / (#iiParosIntegration * 1,843,200)
 where pressure sensor output frequency \approx 35,000 Hz
 #iiParosIntegration = user-input integration time (seconds)
- To convert pressure units: db = psia / 1.45

Example:

What resolution can be obtained for a 7000 meter (10,000 psia) Quartz pressure sensor?

Sensitivity = Δ pressure / Δ frequency = 7000 m / 3000 Hz = 2.333 m / Hz

Counter Resolution = pressure sensor output frequency / (#iiParosIntegration * 1,843,200)
 = 35,000 Hz / (#iiParosIntegration * 1,843,200)

Resolution = Sensitivity * Counter Resolution = 2.333 db/Hz * 35,000 Hz / (#iiParosIntegration * 1,843,200)

Looking at the resolution that can be obtained with a range of values for the integration time:

Integration time (#iiParosIntegration=)	Resolution
1 second	0.044 m (44 mm)
2.2 seconds	0.02 m (20 mm)
4.4 seconds	0.01 m (10 mm)
44 seconds	0.001 m (1 mm)

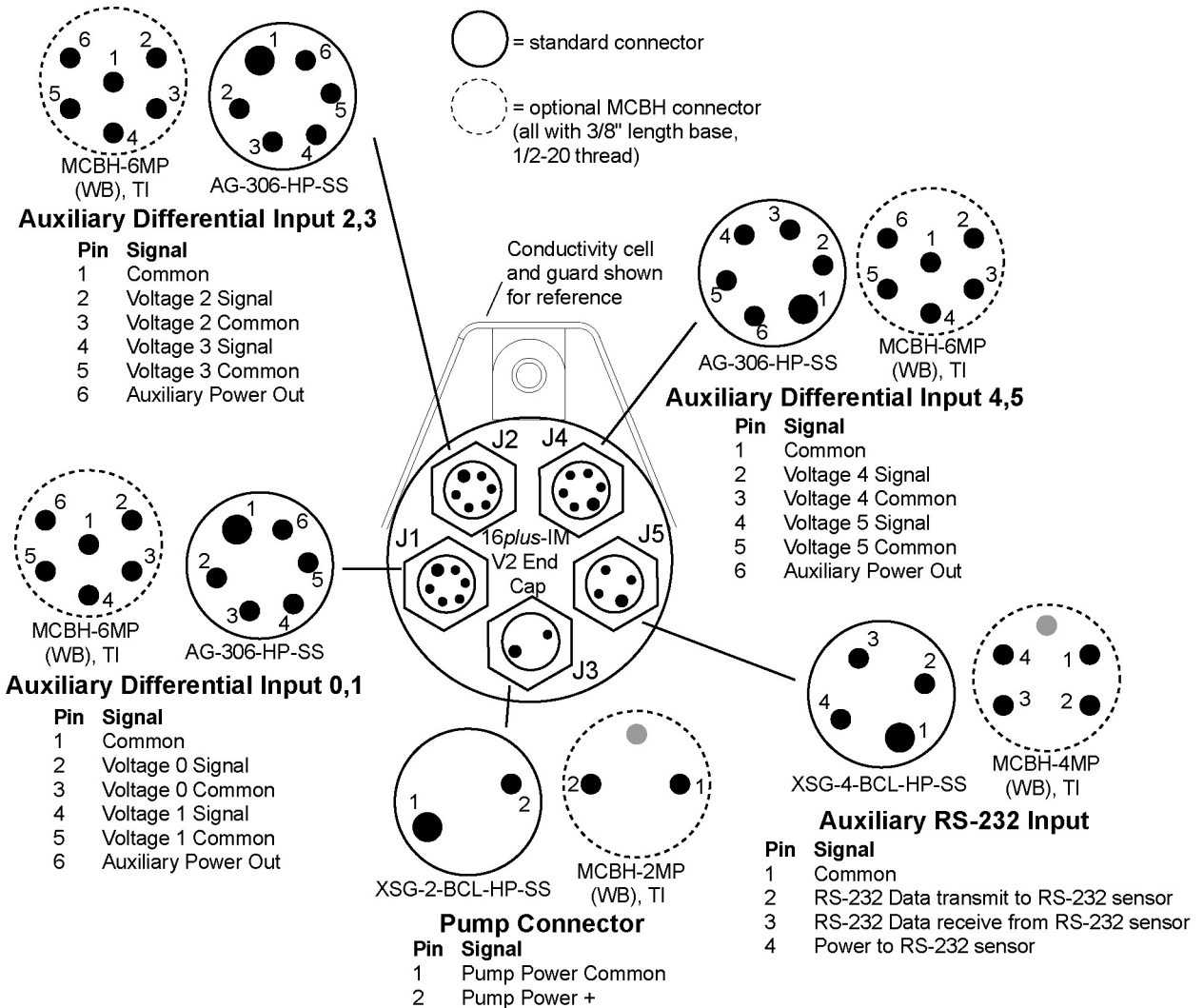
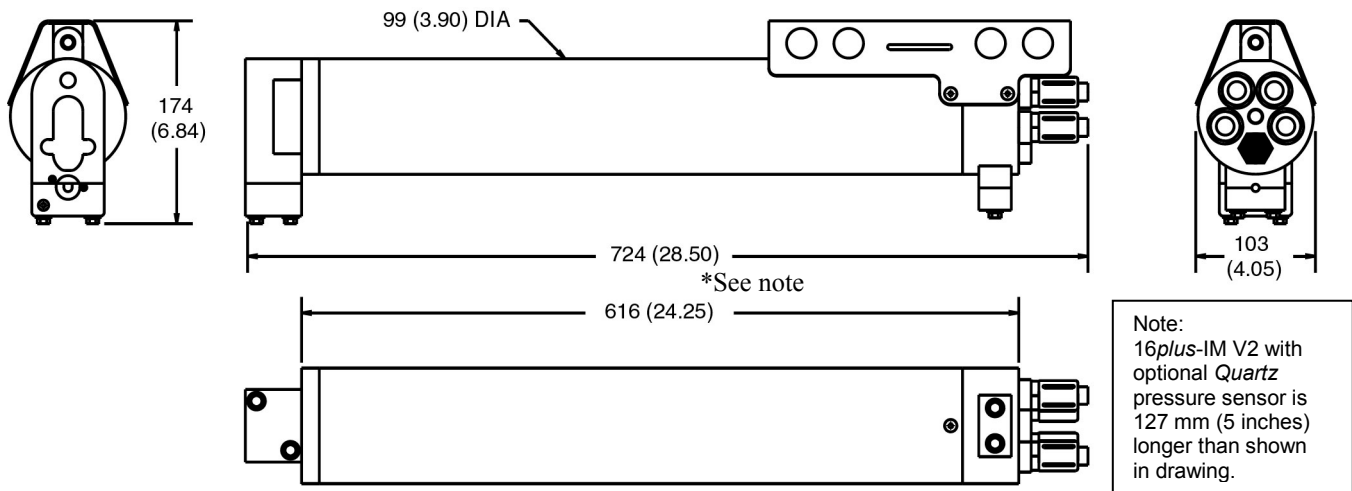
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Memory	64 Mbyte non-volatile FLASH memory																				
Data Storage	<table border="0"> <thead> <tr> <th>Recorded Parameter</th> <th>Bytes/sample</th> </tr> </thead> <tbody> <tr> <td>temperature + conductivity</td> <td>6 (3 each)</td> </tr> <tr> <td>internally mounted strain gauge or Quartz pressure</td> <td>5</td> </tr> <tr> <td>each external voltage</td> <td>2</td> </tr> <tr> <td>SBE 38 secondary temperature</td> <td>3</td> </tr> <tr> <td>SBE 50 pressure</td> <td>3</td> </tr> <tr> <td>WET Labs RS-232 sensor</td> <td>6</td> </tr> <tr> <td>Each Pro-Oceanus GTD</td> <td>4 (pressure) + 3 (temperature)</td> </tr> <tr> <td>Aanderaa Optode</td> <td>3</td> </tr> <tr> <td>date and time</td> <td>4</td> </tr> </tbody> </table>	Recorded Parameter	Bytes/sample	temperature + conductivity	6 (3 each)	internally mounted strain gauge or Quartz pressure	5	each external voltage	2	SBE 38 secondary temperature	3	SBE 50 pressure	3	WET Labs RS-232 sensor	6	Each Pro-Oceanus GTD	4 (pressure) + 3 (temperature)	Aanderaa Optode	3	date and time	4
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date and time	4																				
Real-Time Clock	32,768 Hz TCXO accurate to ± 1 minute/year.																				
Internal Batteries	Nine alkaline D-cells (Duracell MN 1300, LR20; nominal capacity 14 amp-hours).																				
Power Requirements	<p><i>Sampling:</i> no pressure sensor 55 mA with internally mounted pressure sensor 70 mA</p> <p><i>Optional Pump:</i> SBE 5M 100 mA SBE 5P or 5T 150 mA</p> <p><i>Communications:</i> 4 mA</p> <p><i>Quiescent:</i> 140 μA</p> <p>Sampling time (see <i>Sample Timing</i> for example calculations):</p> <ul style="list-style-type: none"> • Minimum 2.2 seconds/sample (no pump, no pressure sensor, 1 measurement/sample, and no delays). • Add 0.3 seconds with internally mounted strain gauge pressure sensor. • Add integration time with internally mounted Quartz pressure sensor (#iiParosIntegration=; minimum 1 second). • Add 0.25 seconds for each additional measurement/sample (#iiNCycles \geq 2). • Add pump on-time (0.5 second) if pump running before taking sample (#iiPumpMode=1). • Add time for user-programmed delay before sampling (#iiDelayBeforeSampling=). <p>Approximate Battery Endurance ¹:</p> <p>CT only: 290,000 samples CTD only: 200,000 samples CTD & 5M pump: 110,000 samples</p> <p>¹ With Duracell MN 1300 (LR20) cells. Dependent on sampling and telemetry scheme; see <i>Battery Endurance</i> for example calculations.</p>																				
Auxiliary Voltage and RS-232 Sensors	<p><i>Auxiliary power out:</i> up to 500 mA at 10.5 - 11 VDC</p> <p><i>Voltage sensor A/D resolution:</i> 14 bits</p> <p><i>Voltage sensor Input range:</i> 0 - 5 VDC</p>																				
Housing Depth Range and Materials	<p>600 meter (1950 ft): acetal copolymer (plastic)</p> <p>7000 meter (22,900 ft): 3AL-2.5V titanium</p> <p>10,500 meter (34,400 ft): 6AL-4V titanium</p>																				
Weight (without pump)	<p>With plastic housing: <i>in air</i> - 9 kg (20 lbs) <i>in water</i> - 4 kg (9 lbs)</p> <p>With 3AL-2.5V titanium housing: <i>in air</i> - 17 kg (38 lbs) <i>in water</i> - 12 kg (27 lbs)</p>																				

Dimensions and End Cap Connectors

Dimensions in millimeters (inches)



Data Storage

Note:

See *Battery Endurance* for power limitations.

The SBE 16plus-IM V2 has a 64 Mbyte FLASH memory. Shown below are examples of available data storage for several configurations. See *Specifications* for storage space required for each parameter.

Example 1: internally mounted strain gauge pressure and no auxiliary sensors
T & C = 6 bytes/sample
Strain gauge P = 5 bytes/sample
Date/Time = 4 bytes/sample
Storage space $\approx 64,000,000 / (6 + 5 + 4) \approx 4,266,000$ samples

Example 2: internally mounted Quartz pressure, 6 external voltages, and SBE 38 secondary temperature sensor
T & C = 6 bytes/sample
Quartz P = 5 bytes/sample
External voltages = 2 bytes/sample * 6 voltages = 12 bytes/sample
SBE 38 = 3 bytes/sample
Date/Time = 4 bytes/sample
Storage space $\approx 64,000,000 / (6 + 5 + 12 + 3 + 4) \approx 2,133,000$ samples

Sample Timing

Notes:

- See sampling times in *Specifications*.
- Sample timing information is approximate.
- See *Battery Endurance* for power limitations.

Sample timing is dependent on a number of factors, including whether the 16plus-IM V2 has an optional pressure sensor and the pressure sensor type – strain gauge or Quartz, setup for a Quartz pressure sensor (**#iiParosIntegration=**), setup for the optional pump (**#iiPumpMode=**), and user-programmable sampling parameters for number of samples per measurement (**#iiNCycles=**) and delay before sampling to allow time for auxiliary sensors to stabilize (**#iiDelayBeforeSampling=**).

For autonomous sampling (logging), the 16plus-IM V2 requires a minimum of 5 seconds from the end of one sample to the beginning of the next sample. After it takes each sample, it checks the time for the start of the next sample, based on the user-programmable sampling interval (**#iiSampleInterval=**). If there is less than 5 seconds remaining until the programmed start of the next sample, the 16plus-IM V2 provides a 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 16plus-IM V2 performs this check after each sample; because of small variations in sampling time, this can cause samples to be taken at uneven intervals. Therefore, best practice is to check the sample timing before you set up the instrument, to ensure that the sample interval is long enough.

Examples are shown below:

Example 1 - pump on for 0.5 sec before each sample (**#iiPumpMode=1**), no internally mounted pressure sensor, 1 measurement/sample (**#iiNCycles=1**):

Sampling time = 0.5 sec (pump before sampling) + 2.2 sec (basic sampling time) = 2.7 sec
 Minimum sample interval (**#iiSampleInterval=**) = 2.7 sec + 5 (sec between samples) = 7.7 sec < 10 sec minimum,
 so **minimum #iiSampleInterval=10**.

Example 2 - pump on during sample (**#iiPumpMode=2**), 15 sec delay before sampling (**#iiDelayBeforeSampling=15**), internally mounted Quartz pressure sensor integrating for 3 sec/sample (**#iiParosIntegration=3**), and 4 measurements/sample (**#iiNCycles=4**):

Sampling time = 15 (delay before sampling) + 2.2 (basic sampling time) + 3 (Quartz integration) +
 (4 – 1) * 0.25 (additional measurements/sample for **#iiNCycles**) = 20.95 sec
 Minimum sample interval (**#iiSampleInterval=**) = 20.95 sec + 5 (sec between samples) = 25.95 sec,
 so **minimum #iiSampleInterval=28** (round up by a few seconds, to account for any small differences in sample timing).

Batteries

Note:

The lithium battery pack cannot be used with a 16plus-IM V2 that is integrated with an SBE 5T or 5P pump.

For the main battery, the SBE 16plus-IM V2 uses nine D-cell alkaline batteries (Duracell MN 1300, LR20). An optional battery pack kit for lithium batteries is available (lithium batteries **not** supplied by Sea-Bird).

On-board lithium batteries (non-hazardous units which are unrestricted for shipping purposes) are provided to back-up the buffer and the real-time clock in the event of main battery failure or exhaustion. The main batteries may be replaced without affecting either the real-time clock or memory.

Battery Endurance

Notes:

- If the 16plus-IM V2 is logging data and the battery voltage is less than 7.5 volts, the 16plus-IM V2 halts logging and displays a low battery indication in the data.
- See *Data Storage and Specifications* for data storage limitations.

The standard alkaline battery pack has a nominal capacity of 14 amp-hours. For planning purposes, Sea-Bird recommends using a conservative value of:

- 12.2 amp-hours for a 16plus-IM V2 with no pump or auxiliary sensors
- 10.5 amp-hours for a 16plus-IM V2 drawing more current because of optional pump and/or auxiliary sensors

Current consumption and sampling times vary greatly, depending on the instrument configuration (inclusion of pressure sensor, pump, and/or auxiliary sensors) as well as user-programmed sampling parameters (pump operating mode, number of measurements per sample, delay before sampling). Examples are shown below for several sampling schemes. **You can use the Deployment Endurance Calculator** to determine the maximum deployment length, instead of performing the calculations by hand.

- Assuming the fastest practical interrogation scheme (wake all 16plus-IM V2s on mooring, send **GData**, send **Dataii** or **!iiData** to each 16plus-IM V2, and power off all 16plus-IM V2s), the communications current is drawn for approximately 0.5 seconds **per 16plus-IM V2 on the mooring**. Each 16plus-IM V2 on the mooring draws this current while any 16plus-IM V2 is being queried to transmit data. Other interrogation schemes require more time.

Ten 16plus-IM V2s with standard alkaline batteries are set up to sample autonomously every 10 minutes (6 samples/hour), and the last data sample will be requested by the computer every hour. How long can the instruments be deployed?

Example 1 – no pump, pressure sensor, or auxiliary sensors; 1 measurement/sample (**#iiNCycles=1**):

Sampling current = 55 mA * 2.2 sec = 0.12 amp-sec/sample

In 1 hour, sampling current = 6 samples * 0.12 amp-sec/sample = 0.72 amp-sec/hour

Quiescent current = 140 microamps = 0.140 mA

In 1 hour, quiescent current ≈ 0.140 mA * 3600 sec/hour = 0.50 amp-sec/hour

Communication current / query = 4 mA * 0.5 sec / 16plus-IM V2 to be queried * 10 instruments = 0.02 amp-sec/hour

Current consumption / hour = 0.72 + 0.50 + 0.02 = 1.24 amp-sec/hour

Capacity = (12.2 amp-hours * 3600 sec/hr) / (1.24 amp-sec/hour) = 35,419 hours = 1475 days = 4.0 years

However, Sea-Bird recommends that batteries should not be expected to last longer than 2 years in the field.

Example 2 - with 5M pump on for 0.5 sec/sample (**#iiPumpMode=1**), no pressure sensor or auxiliary sensors, 1 measurement/sample (**#iiNCycles=1**):

Sampling current = 55 mA * (2.2 sec + 0.5 sec) = 0.148 amp-sec/sample

In 1 hour, sampling current = 6 * 0.135 amp-sec/sample = 0.89 amp-sec/hour

Pump current = 100 mA * 0.5 sec = 0.05 amp-seconds/sample

In 1 hour, pump current = 6 * 0.05 amp-sec/sample = 0.3 amp-sec/hour

Quiescent current = 140 microamps = 0.140 mA

In 1 hour, quiescent current ≈ 0.140 mA * 3600 sec/hour = 0.50 amp-sec/hour

Communication current / query = 4 mA * 0.5 sec / 16plus-IM V2 to be queried * 10 instruments = 0.02 amp-sec/hour

Current consumption / hour = 0.89 + 0.3 + 0.50 + 0.02 = 1.71 amp-sec/hour

Capacity = (10.5 amp-hours * 3600 seconds/hr) / (1.71 amp-seconds/hour) = 22,105 hours = 921 days = 2.5 years

However, Sea-Bird recommends that batteries should not be expected to last longer than 2 years in the field.

Example 3 – with 5T pump on during sample (**#iiPumpMode=2**), internally mounted Quartz pressure sensor integrating for 3 sec/sample (**#iiParosIntegration=3**), 15 sec delay before sampling (**#iiDelayBeforeSampling=15**), auxiliary sensors drawing 100 mA, 4 measurements/sample (**#iiNCycles=4**):

On-time = 2.2 + 3 (Quartz integration) + 15 (delay before sampling) + (4 – 1) * 0.25 (additional measurements/sample) = 20.95 sec

Sampling current = 70 mA * 20.95 sec = 1.47 amp-sec/sample

In 1 hour, sampling current = 6 * 1.47 amp-sec/sample = 8.8 amp-sec/hour

5T Pump current = 150 mA * 20.95 sec = 3.14 amp-sec/sample

In 1 hour, pump current = 6 * 3.14 amp-sec/sample = 18.9 amp-sec/hour

Auxiliary sensor current = 100 mA * 20.95 sec = 2.10 amp-sec/sample

In 1 hour, auxiliary sensor current = 6 * 2.10 amp-sec/sample = 12.6 amp-sec/hour

Quiescent current = 140 microamps = 0.140 mA

In 1 hour, quiescent current ≈ 0.140 mA * 3600 sec/hour = 0.50 amp-sec/hour

Communication current / query = 4 mA * 0.5 sec / 16plus-IM V2 to be queried * 10 instruments = 0.02 amp-sec/hour

Current consumption / hour = 8.8 + 18.9 + 12.6 + 0.50 + 0.02 = 40.8 amp-sec/hour

Capacity = (10.5 amp-hours * 3600 sec/hr) / (40.8 amp-sec/hour) = 926 hours = 38 days = 0.1 years

Configuration Options and Plumbing

The SBE 16*plus*-IM V2 is available with an optional, externally mounted, submersible pump. The pump is required for a 16*plus*-IM V2 configured with an optional dissolved oxygen sensor or pumped fluorometer, but also provides the following benefits for conductivity data:

- Improved conductivity response - The pump flushes the previously sampled water from the conductivity cell and brings a new water sample quickly into the cell.
- Improved anti-foulant protection - Water does not freely flow through the conductivity cell between samples, allowing the anti-foulant concentration inside the cell to build up.

Several pump models are available:

- SBE 5M miniature pump (available in plastic or titanium) - for pumped conductivity
- SBE 5P (plastic) or 5T (titanium) pump - a more powerful pump for use if the 16*plus*-IM V2 is configured with a dissolved oxygen sensor and/or pumped fluorometer

In all cases, the pump is powered via a cable connected to the standard 2-pin Pump bulkhead connector on the sensor end cap.

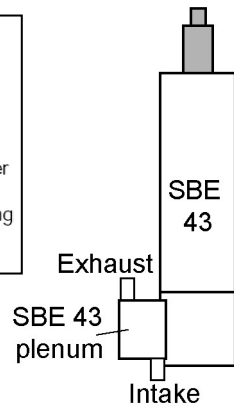
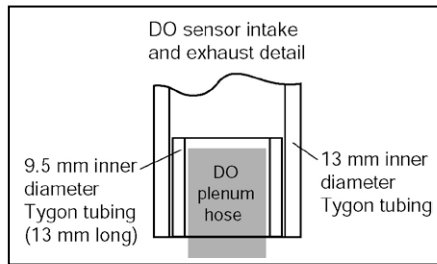
The 16*plus*-IM V2 can be configured with a wide range of auxiliary sensors. Three standard 6-pin bulkhead connectors on the sensor end cap serve as the input ports for the auxiliary sensor signal voltages and provide power to the sensors.

Additionally, a standard 4-pin bulkhead connector on the sensor end cap is provided for interfacing with one of the following RS-232 sensors:

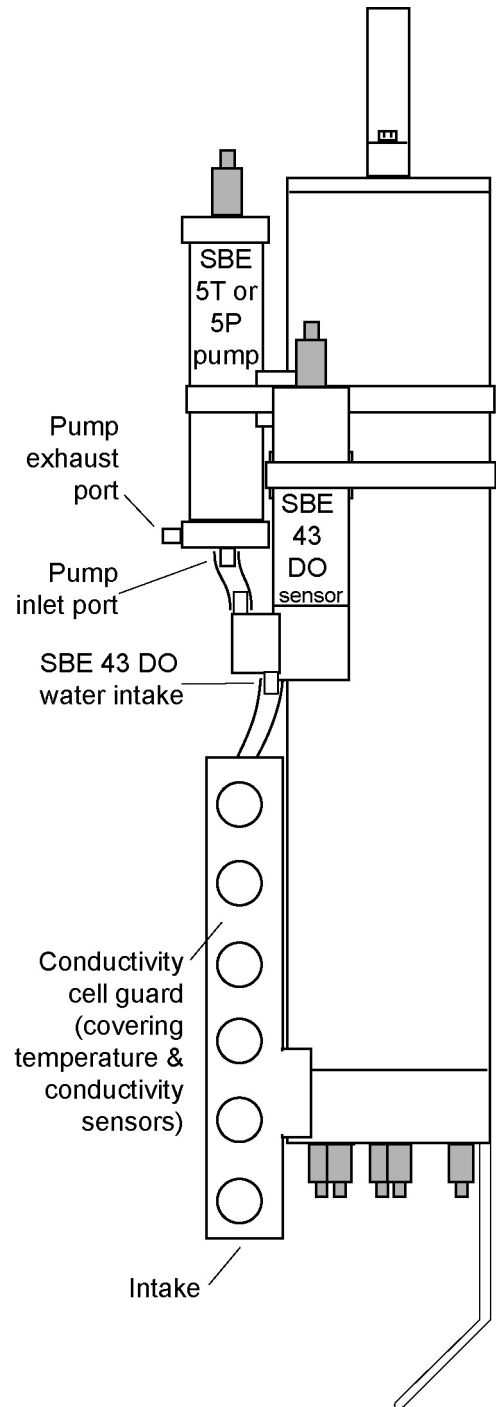
- SBE 38 secondary temperature sensor
- SBE 50 secondary strain-gauge pressure sensor
- WET Labs sensor - single, dual, or triple channel ECO sensor; WETStar; or C-Star
- Pro-Oceanus Gas Tension Devices (up to two GTDs can be integrated)
- Aanderaa Optode 4330 or 4835

Shown below is the plumbing arrangement of an SBE 16plus-IM V2 equipped with a pump and the optional SBE 43 Dissolved Oxygen sensor. See Section 4: *Deploying and Operating SBE 16plus-IM V2* for pump setup and operation details.

- Main plumbing is 13 mm ID x 19 mm OD (1/2 inch x 3/4 inch) Tygon tubing.
- A 13 mm (0.5 inch) long piece of 9.5 mm ID x 13 mm OD (3/8 inch x 1/2 inch) Tygon tubing to fit to the main plumbing is installed:
 - on the conductivity cell exhaust, and
 - on the SBE 43 intake and exhaust



Place DO sensor with plenum intake closer than exhaust to SBE 43 housing, as shown.
 Note: SBE 43 housing orientation (connector end up or down) does not affect operation. Plenum can be reversed on housing by removing and replacing 2 screws.



Inductive Modem Module (IMM) or Surface Inductive Modem (SIM)

An Inductive Modem Module or Surface Inductive Modem is required for communication with the SBE 16plus-IM V2. These devices impress (*modulate*) the mooring cable with a DPSK signal that is encoded with commands received from the computer/controller. The encoded signals are *demodulated* by inductive modem instruments coupled to the cable. Replies from inductive modem instruments are similarly coupled to the cable and *demodulated* by these devices.

Inductive Modem Module (IMM)

The IMM must be supplied with 7 to 24 volts DC power. The maximum operating current is approximately 15 milliamps.

The user's computer or buoy controller is interfaced via RS-232 (optional RS-485) serial port to the IMM. The standard interface protocol between the computer/controller and IMM is 1200, 2400, 4800, 9600, 19200, or 38400 baud (user-selectable); 8 data bits; no parity; RS-232C.

The DPSK communication link between the IMM and IM instrument(s) is half-duplex, so talking and listening is sequential only. Although the data link between the IMM and the user's computer/controller is established at 1200, 2400, 4800, 9600, 19200, or 38400, the DPSK modem communication between IMM and IM instruments always operates at 1200 baud.

See the IMM Manual for details.

Surface Inductive Modem (SIM)

The SIM must be supplied with 7 to 25 volts DC power. The operating current is approximately 30 milliamps.

The user's computer or buoy controller is interfaced via RS-232 (optional RS-485) serial port to the SIM. The standard interface protocol between the computer/controller and SIM is 1200, 2400, 4800, or 9600 baud (user-selectable); 8 data bits; no parity; RS-232C; with echoing of characters.

The DPSK communication link between the SIM and IM instrument(s) is half-duplex, so talking and listening is sequential only. Although the data link between the SIM and the user's computer/controller is established at 1200, 2400, 4800, or 9600 baud, the DPSK modem communication between SIM and IM instruments always operates at 1200 baud.

Mooring Cable and Wiring Requirements

Note:

For wiring, see applicable document:

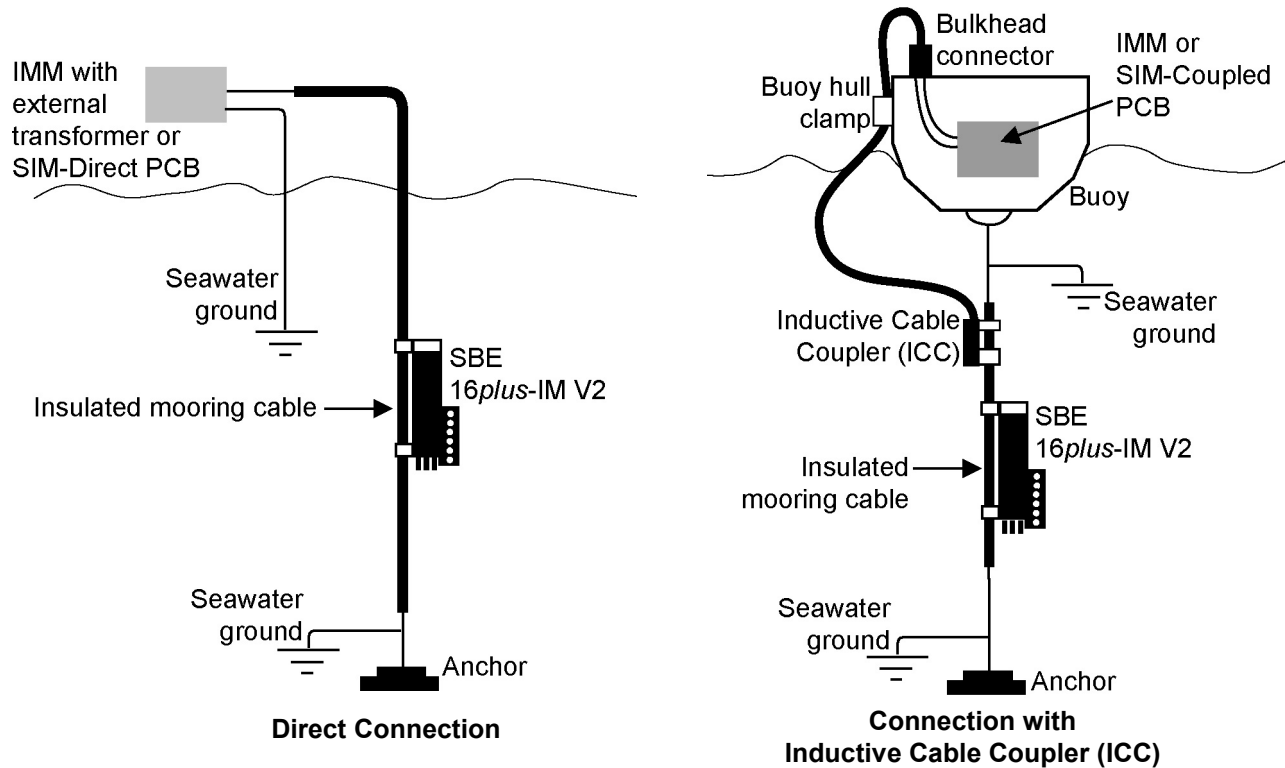
- IMM manual. **OR**
- *Appendix IV: SIM Hookup and Configuration.*

The SBE 16plus-IM V2 can mechanically accommodate mooring cables up to 16 mm (0.63 inches) in diameter. Clamps for specific cable diameters are available, or can be supplied on a custom basis. Suitable mooring cables use steel wire rope with a polypropylene or polyethylene-insulating jacket. The SIM operates without data errors using up to 8000 meters (26,200 feet) of 3 mm (0.12 inches) or larger cable.

The mooring cable must provide for connection to seawater ground below the deepest IM instrument. Terminating the wire with a metallic eye or clevis readily provides this connection.

The mooring cable must also provide for connection to the IMM or SIM.

- In a direct connection (typical cable-to-shore applications), the bottom end of the wire is grounded to seawater, and the top end remains insulated to the connection to the IMM or SIM. A second wire from the IMM or SIM connects to seawater ground, completing the circuit.
- In typical surface buoys it is often preferable to connect the jacketed mooring wire to the buoy with a length of chain, grounding the jacketed wire to seawater at each end. An Inductive Cable Coupler (ICC) connects the IMM or SIM to the jacketed wire above the uppermost IM instrument and below the point where the wire is grounded.



Section 3: Preparing for Deployment

This section describes:

- Installation and use of SeatermV2 terminal program
- Power and communications test to verify that the system works prior to deployment
- Setting SBE 16plus-IM V2 ID - each 16plus-IM V2 on a mooring must have a unique ID for communicating with the SIM and computer/controller

Software Installation

Notes:

- Help files provide detailed information on the software. A separate software manual on the CD-ROM contains detailed information on SBE Data Processing.
- It is possible to use the 16plus-IM V2 without the SeatermV2 terminal program by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our FTP site. See our website (www.seabird.com) for the latest software version number, a description of the software changes, and instructions for downloading the software from the FTP site.

Sea-Bird recommends the following minimum system requirements for SEASOFT V2 software: Windows 2000 or later, 500 MHz processor, 256 MB RAM, and 90 MB free disk space for installation. Although SEASOFT V2 was designed to work with a PC running Win 2000/XP; extensive testing has not shown any compatibility problems when using the software with a PC running Windows Vista.

If not already installed, install Sea-Bird software programs on your computer using the supplied software CD:

1. Insert the CD in your CD drive.
2. Install software: Double click on **SeasoftV2_date.exe** (*date* is the date that version of the software was created). Follow the dialog box directions to install the software. The installation program allows you to install the desired components. Install all the components, or just install Deployment Endurance Calculator (battery endurance calculator), SeatermV2 (terminal program *launcher* for the 16plus-IM V2), and SBE Data Processing (data processing).

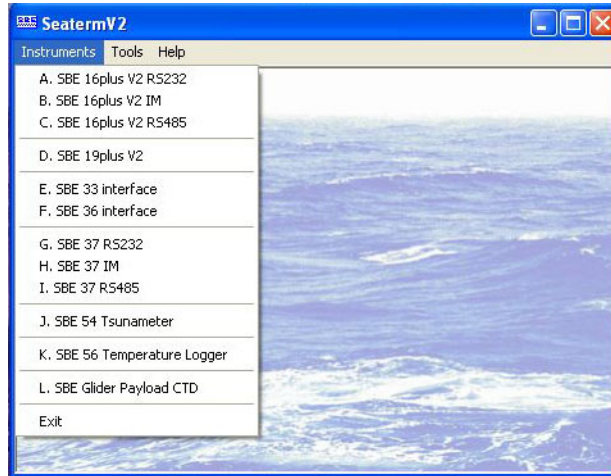
The default location for the software is c:\Program Files\Sea-Bird. Within that folder is a sub-directory for each program.

SeatermV2 Use

Note:

See SeatermV2's Help files.

1. Double click on **SeatermV2.exe**. The main screen looks like this:

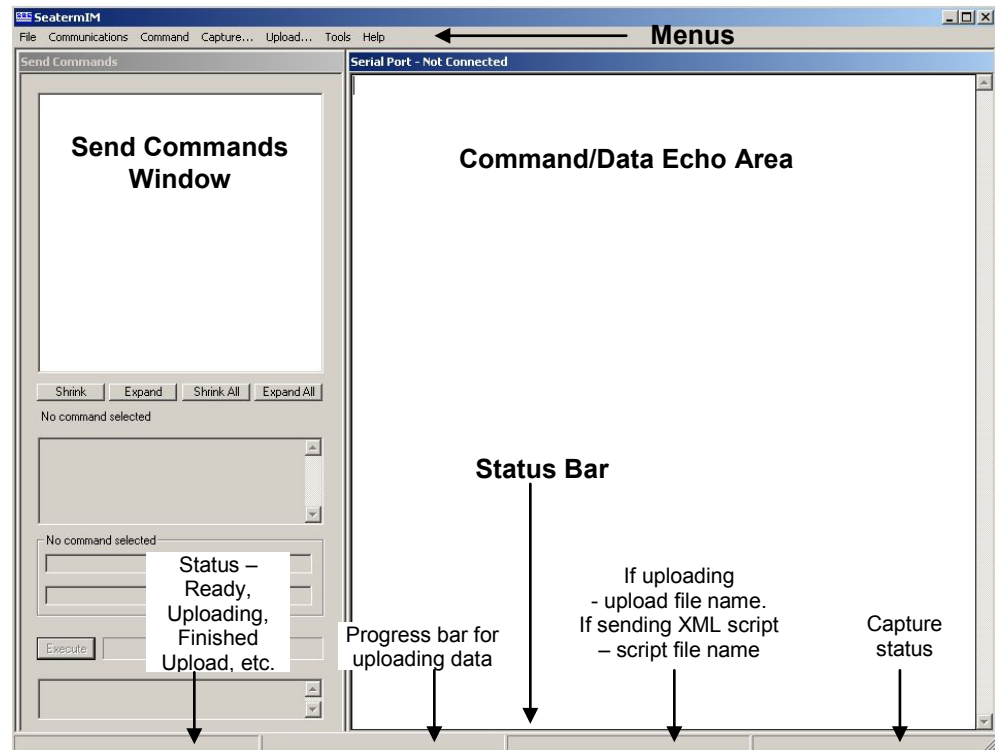


SeatermV2 is a *launcher*. Depending on the instrument selected, it launches SeatermIM (inductive modem instruments), Seaterm232 (RS-232 instruments), or Seaterm485 (RS-485 instruments).

Notes:

- See SeatermIM's Help files.
- If using the 16plus-IM V2 internal RS-232 connector to set up and/or upload data: select *SBE 16plus V2 RS232* instead of *SBE 16plus V2 IM*. This launches Seaterm232 instead of SeatermIM. Seaterm232 is similar to SeatermIM, but is optimized for RS-232 communications.

2. In the Instruments menu, select *SBE 16plus V2 IM*. **SeatermIM** opens; the main screen looks like this:



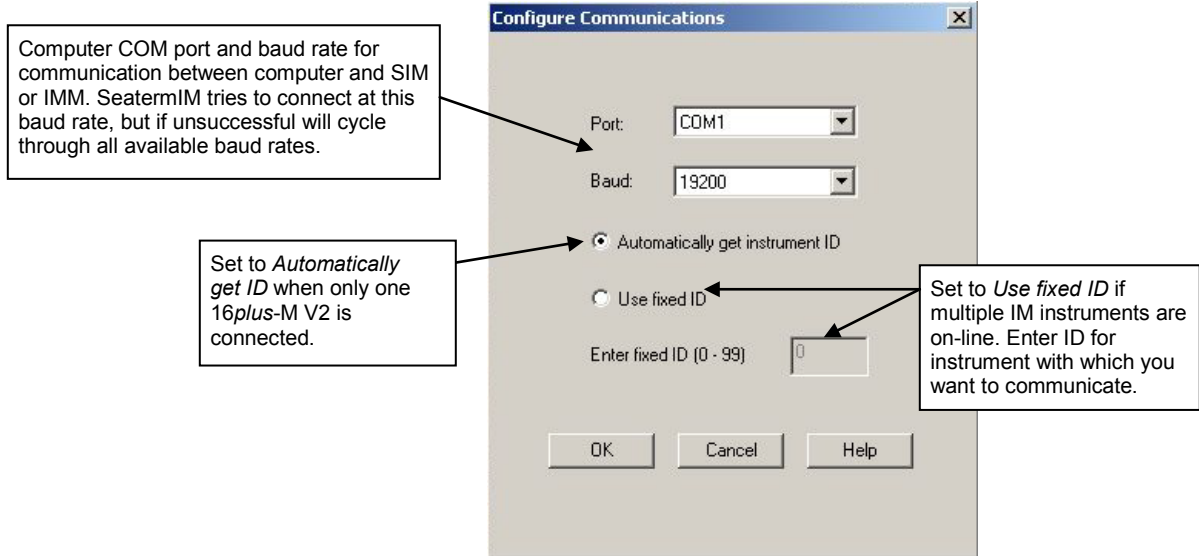
- **Menus** – For tasks and frequently executed instrument commands.
- **Send Commands window** – Contains commands applicable to your 16plus-IM V2. The list appears after you connect to the 16plus-IM V2.
- **Command/Data Echo Area** – Title bar of this window shows SeatermIM's current comm port and baud rate. Commands and the 16plus-IM V2 responses are echoed here. Additionally, a command can be manually typed or pasted (ctrl + V) here. Note that the 16plus-IM V2 must be *connected* and *awake* for it to respond to a command.
- **Status bar** – Provides connection, upload, script, and capture status information.

Following is a description of the menus:

Menu	Description	Equivalent Command*
File	<ul style="list-style-type: none"> • Load command file – opens selected .XML command file, and fills Send Commands window with commands. • Unload command file – closes command file, and removes commands from Send Commands window. • Exit - Exit program. 	-
Communications	<ul style="list-style-type: none"> • Configure – Establish communication parameters (comm port, baud rate, ID). • Connect – connect to comm port. Re-establish communications by sending wakeup tone to all IM instruments on line. Inductive modem instruments <i>go to sleep</i> after 2 minutes without communication from computer have elapsed. • Disconnect – disconnect from comm port • Disconnect and reconnect – may be useful if instrument has stopped responding. 	<ul style="list-style-type: none"> • PwrOn
Command	<ul style="list-style-type: none"> • Abort – interrupt and stop 16plus-IM V2's attempt to connect or to upload data, or sending of a script. • Send stop command – to stop logging. • Set local time– Set date and time to time sent by timekeeping software on your computer; accuracy ± 25 msec of time provided by computer. • Set UTC Time (Greenwich Mean Time) – Set date and time to time sent by timekeeping software on your computer; accuracy ± 25 msec of time provided by computer. 	<ul style="list-style-type: none"> • (press Esc key several times for Abort) • #iiStop • #iiDateTime= • #iiDateTime=
Capture	Capture instrument responses on screen to file, to save real-time data or use for diagnostics. File has .cap extension. Click Capture menu again to turn off capture. Capture status displays in Status bar.	—
Upload	Upload data stored in memory, in a format that Sea-Bird's data processing software can use (raw hex). Uploaded data has .xml extension, and is then automatically converted to a file with .hex extension. Before using Upload: stop logging by sending #iiStop .	Several status commands and appropriate data upload command as applicable to user selection of range of data to upload (use Upload menu if you will be processing data with SBE Data Processing or viewing archived data with Seasave)
Tools	<ul style="list-style-type: none"> • Diagnostics log - Keep a diagnostics log. • Convert .XML data file – Using Upload menu automatically does this conversion; tool is available if there was a problem with the automatic conversion. • Send script – Send XML script to 16plus-IM V2. May be useful if you have a number of 16plus-IM V2s to program with same setup. 	-

*See *Command Descriptions* in Section 4: *Deploying and Operating SBE 16plus-IM V2*.

3. If this is the first time SeatermIM is being used, the configuration dialog box displays:



Make the desired selections, and click OK.

4. SeatermIM tries to automatically connect to the 16plus-IM V2. It first sends commands to determine if it is connected to a SIM or an IMM, and sends the appropriate command to wake up all IM instruments on the line. The remaining connection attempt varies, depending on the configuration setting the last time SeatermIM was used:

Note:

!iiDS and **#iiGetHD** provide factory-set data such as instrument type, serial number, and firmware version for the 16plus-IM V2's communication microcontroller and acquisition microcontroller.

- If SeatermIM was set to *Automatically get instrument ID* the last time it was used – SeatermIM sends **id?** and waits for a response from the 16plus-IM V2. Once the ID response is received, SeatermIM sends **!iiDS** and **#iiGetHD**, using the ID provided by the 16plus-IM V2.
- If SeatermIM was set to *Use fixed ID* the last time it was used – SeatermIM sends **!iiDS** and **#iiGetHD**, using the fixed ID that was entered the last time the software was used.

SeatermIM then fills the Send Commands window with the correct list of commands for your 16plus-IM V2.

Notes:

- SeatermIM's baud rate must be the same as the IMM or SIM baud rate, as applicable. For both the SIM and the IMM, baud is factory-set to 9600, but can be changed by the user.
- Set to *Use fixed ID* to designate the appropriate 16plus-IM V2 if there are multiple 16plus-IM V2s on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16plus-IM V2 on the IM line. Note that the ID is stored in the 16plus-IM V2's EEPROM and can be changed so that multiple 16plus-IM V2s on a single IM line each have a unique ID. See the Configuration Sheet for the factory-set ID.

If there is no communication (no response to **id?** and/or no response to **!iiDS** and/or **#iiGetHD**):

- A. In the Communications menu, select *Configure*. The Configure Communications dialog box appears. Select the Comm port and baud rate for communication. Note that the factory-set baud rate is documented on the Configuration Sheet. If using a fixed ID, verify that the designated ID is correct for the 16plus-IM V2 with which you want to communicate. Click OK.
- B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). SeatermIM will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.
- C. If there is still no communication, check cabling between the computer, SIM or IMM, and 16plus-IM V2, and try to connect again.
- D. If there is still no communication, repeat Step A with a different comm port and/or different fixed ID, and try to connect again.

Taking a look at the Send Commands window:

The screenshot shows the 'Send Commands' window with a tree view of command categories. Callouts provide the following information:

- SIM Commands:** These commands are directed to SIM and are not preceded by any prefix. Note: If connecting to 16plus-IM V2 through IMM, IMM Commands appear in window instead of SIM Commands.
- SBE 16plus Modem Commands:** These commands are preceded by no prefix or #ii prefix, and are directed to a specific 16plus-IM V2's communication microcontroller.
- SBE 16plus Instrument Commands:** These commands are preceded by #ii prefix, and are directed to a specific 16plus-IM V2's acquisition microcontroller.

The tree view includes the following sub-items:

- SIM Commands:** Power-On, Status, Communications
- SBE 16plus Modem Commands:** Global, Get Data, ID, Status, Timeout
- SBE 16plus Instrument Commands:** Status, General Setup, Pressure Sensor Setup, Voltage Sensor Setup, RS-232 Sensor Setup, Output Format Setup, Autonomous Sampling (logging), Polled Sampling, Data Upload (with sub-items: Upload data from FLASH memory, Upload headers), Testing, Calibration Coefficients, Hardware Configuration

Buttons at the bottom include Shrink, Expand, Shrink All, and Expand All. A help box for the selected 'GetSamples' command reads: 'Upload selected data from FLASH memory with format specified by #iiOutputFormat=. If starting and ending sample numbers are omitted, all data is uploaded. Equivalent to #iiDD.' Below the help box are input fields for 'Starting sample number' and 'Ending sample number'. An 'Execute' button is present, and a preview box shows the command '#03GetSamples:'.

You can use the Send Commands window to send commands, or simply type the commands in the Command/Data Echo area if desired.

Power and Communications Test and Setting SBE 16plus-IM V2 IDs – Using Surface Inductive Modem (SIM)

The power and communications test will verify that the system works, prior to deployment.

Note:

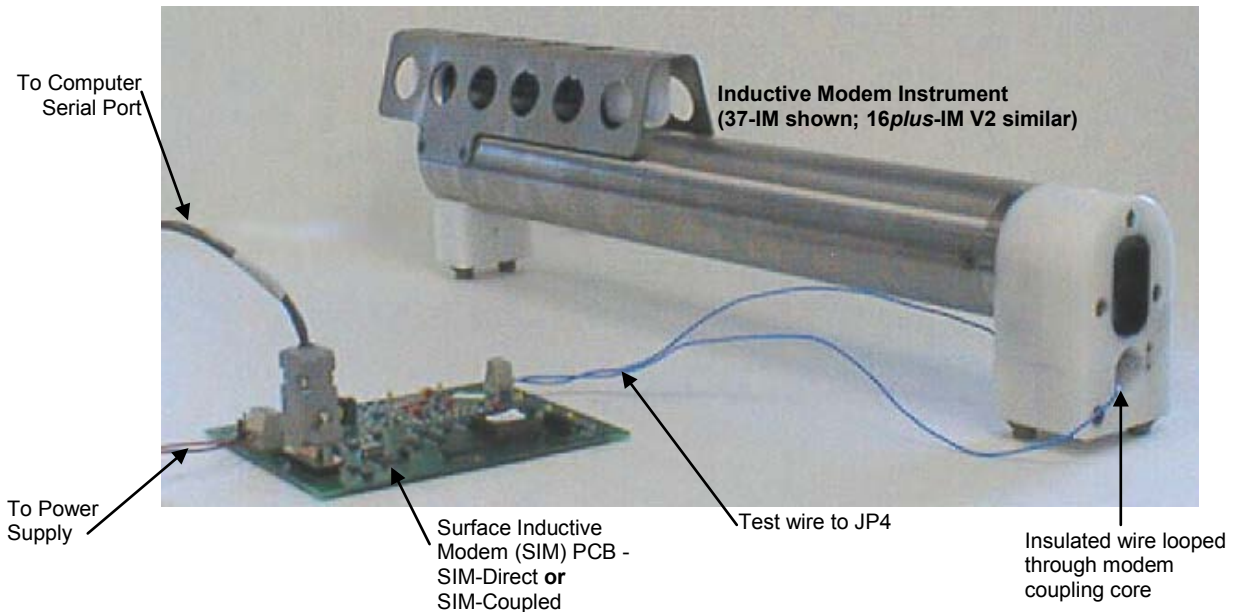
For testing and setup, an ICC is not required, even if using SIM-Coupled.

Notes:

- **If more than one IM instrument is on-line when you set the ID, all IM instruments will be set to the same ID.** The inductive modem receivers in IM instruments are very sensitive; two IM instruments that are side-by-side will take the same ID, even if one of them is not on the IM loop. **Therefore, separate IM instruments by at least 2 meters when setting IDs.**
- **Important! For Normal Deployed operation, reinstall the jumper across J5.**

Test Setup with SIM

1. Loop insulated wire through the 16plus-IM V2 modem coupling core to simulate a mooring cable. Connect the test wire ends to the SIM's mooring cable terminals (JP4). (See *Appendix IV: SIM Hookup and Configuration* for detailed information.)
2. On the SIM, remove the jumper on J5 (see *Appendix IV*). This inserts a 1K resistor in series with the inductive loop and reduces signal amplitude, preventing 16plus-IM V2s that are near but not attached to the inductive loop from responding to commands (especially important when sending the *ID= command).
3. Sea-Bird recommends a minimum of 20 ohms impedance to reduce noise during testing.
4. Connect the SIM to a 7-25 VDC power supply. A minimum of 30 milliamps are required. **Do not turn on the power supply yet.**
5. Connect the SIM to your computer's serial port using the 9-pin to 9-pin cable supplied with the SIM.

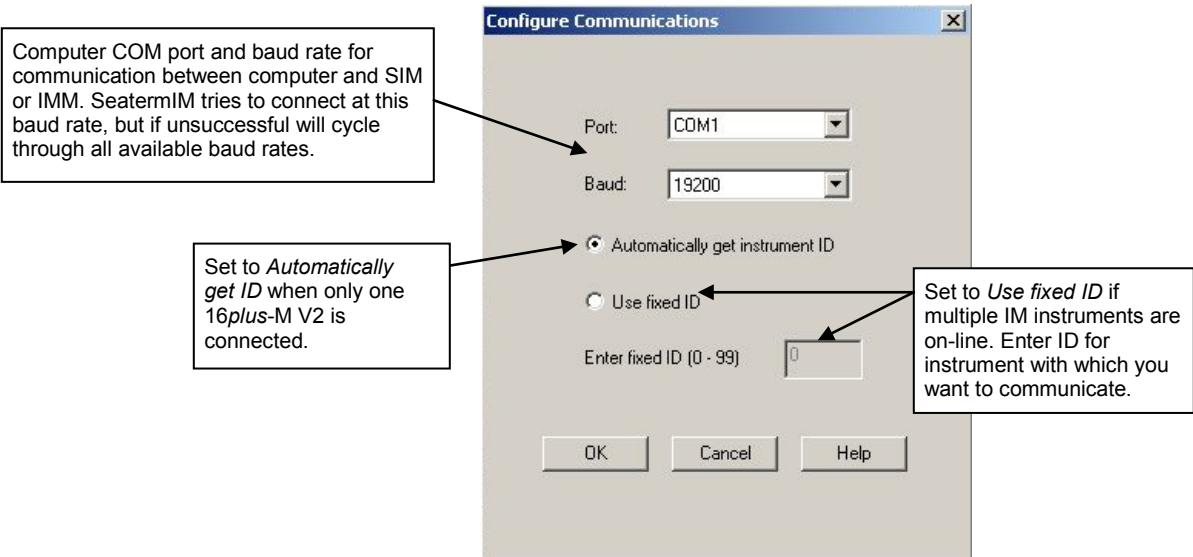


Test and Set SBE 16plus-IM V2 ID Using SIM

Note:

See SeatermV2 and SeatermIM Help files.

1. Double click on **SeatermV2.exe**. In the Instruments menu, select *SBE 16plus V2 IM*. **SeatermIM** opens.
2. If this is the first time SeatermIM is being used, the configuration dialog box displays:



Make the desired selections, and click OK.

3. SeatermIM tries to automatically connect to the 16plus-IM V2. It sends **DS** to get SIM status information, and **PwrOn** to wake up all IM instruments on the line. The remaining connection attempt varies, depending on the configuration setting the last time SeatermIM was used:
 - If SeatermIM was set to *Automatically get instrument ID* the last time it was used – SeatermIM sends **id?** and waits for a response from the 16plus-IM V2. Once the ID response is received, SeatermIM sends **!iiDS** and **#iiGetHD**, using the ID provided by the 16plus-IM V2.
 - If SeatermIM was set to *Use fixed ID* the last time it was used – SeatermIM sends **!iiDS** and **#iiGetHD**, using the fixed ID that was entered the last time the software was used.

Note:

!iiDS and **#iiGetHD** provide factory-set data such as instrument type, serial number, and firmware version for the 16plus-IM V2's communication microcontroller and acquisition microcontroller.

SeatermIM then fills the Send Commands window with the correct list of commands for your 16plus-IM V2.

Notes:

- SeatermIM's baud rate must be the same as the IMM or SIM baud rate, as applicable. For both the SIM and the IMM, baud is factory-set to 9600, but can be changed by the user.
- Set to *Use fixed ID* to designate the appropriate 16plus-IM V2 if there are multiple IM instruments on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16plus-IM V2 on the IM line. Note that the ID is stored in the 16plus-IM V2's EEPROM and can be changed so that multiple IM instruments on a single IM line each have a unique ID. See the Configuration Sheet for the factory-set ID.

If there is no communication (no response to **id?** and/or no response to **!iiDS** and **#iiGetHD**):

- A. In the Communications menu, select *Configure*. The Configure Communications dialog box appears. Select the Comm port and baud rate for communication. Note that the factory-set baud rate is documented on the Configuration Sheet. If using a fixed ID, verify that the designated ID is correct for the 16plus-IM V2 with which you want to communicate. Click OK.
- B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). SeatermIM will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.
- C. If there is still no communication, check cabling between the computer, SIM or IMM, and 16plus-IM V2, and try to connect again.
- D. If there is still no communication, repeat Step A with a different comm port and/or different fixed ID, and try to connect again.

Note:

Sending the status command causes the optional pump to turn on for a moment, so that the 16plus-IM V2 can measure and output the pump current. Because the pump is designed to be water lubricated, you may hear a noise when the impeller spins in air. Running the pump *dry* for **short** periods (for example, when sending the status command) will not harm the pump.

Note:

The SIM and 16plus-IM V2 have timeout algorithms designed to:

- restore control to the computer if an illegal command is sent
- conserve battery energy if too much time elapses between commands

If the system does not appear to respond, see *Timeout Descriptions* in Section 4: *Deploying and Operating SBE 16plus-IM V2*.

Note:

If more than one IM instrument is on-line when you set the ID, all IM instruments will be set to the same ID. The inductive modem receivers in IM instruments are very sensitive; two IM instruments that are side-by-side will take the same ID, even if one of them is not on the IM loop. **Therefore, separate IM instruments by at least 2 meters when setting IDs.**

4. Display 16plus-IM V2 status information by typing **#iiDS** (ii = 16plus-IM V2 ID) and pressing the Enter key. The display looks like this:

```
SBE 16plus-IM V 2.3 SERIAL NO. 0001 01 Oct 2011 14:02:13
vbatt = 10.3, vlith = 8.5, ioper = 62.5 ma, ipump = 21.6 ma,
iext01 = 76.2
status = not logging
samples = 0, free = 3870479
sample interval = 15 seconds, number of measurements per sample = 1
run pump for 0.5 sec, delay before sampling = 0.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38=no, SBE 50 = no, OPTODE = no, Gas 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. Command the 16plus-IM V2 to take a sample by typing **#iiTS** (ii = 16plus-IM V2 ID) and pressing the Enter key. The display looks like this (if 16plus-IM V2 includes optional internally mounted pressure sensor, and is set up for converted decimal output format, output sample number, no output salinity or sound velocity, and auxiliary voltage sensor on channel 0):

```
4000, 23.7658,0.00019, 0.062, 0.5632, 01 Oct 2011, 14:10:10, 5
where 0001 = 16plus-IM V2 serial number 4000 (16pxxxx-0001)
23.7658 = temperature in degrees Celsius
0.00019 = conductivity in S/m
0.062 = pressure in db
0.5632 = voltage for auxiliary sensor channel 0
01 Oct 2011 = date
14:10:10 = time
5 = sample number in memory
```

These numbers should be reasonable; i.e., room temperature, zero conductivity, barometric pressure (gauge pressure), current date and time (set at factory to Pacific Daylight or Standard Time), expected number of samples in memory.

6. Each IM instrument on a mooring must have a unique ID for communicating with the SIM and computer. Set the ID as described below, first verifying that only one 16plus-IM V2 is on-line before you set the ID:
- A. Set the 16plus-IM V2 ID by typing ***ID=ii** (ii= user-assigned ID number) and pressing the Enter key.
 - B. The computer responds by requesting verification, requiring you to again type ***ID=ii** and press the Enter key.
 - C. Record the ID for future reference.
 - D. In the Communications menu, select *Configure*. Set to *Use fixed ID*, enter the new ID, and click OK. This provides SeatermIM with the correct ID information for sending commands listed in the Send Commands window.
7. Command the 16plus-IM V2 to go to sleep (quiescent state) by typing **PwrOff** and pressing the Enter key.

The SBE 16plus-IM V2 is ready for programming and deployment.

Important! When testing and ID setting is complete for all IM instruments, reinstall the J5 jumper on the SIM PCB. The jumper must be installed for Normal Deployed operation.

Power and Communications Test and Setting SBE 16plus-IM V2 IDs – Using Inductive Modem Module (IMM)

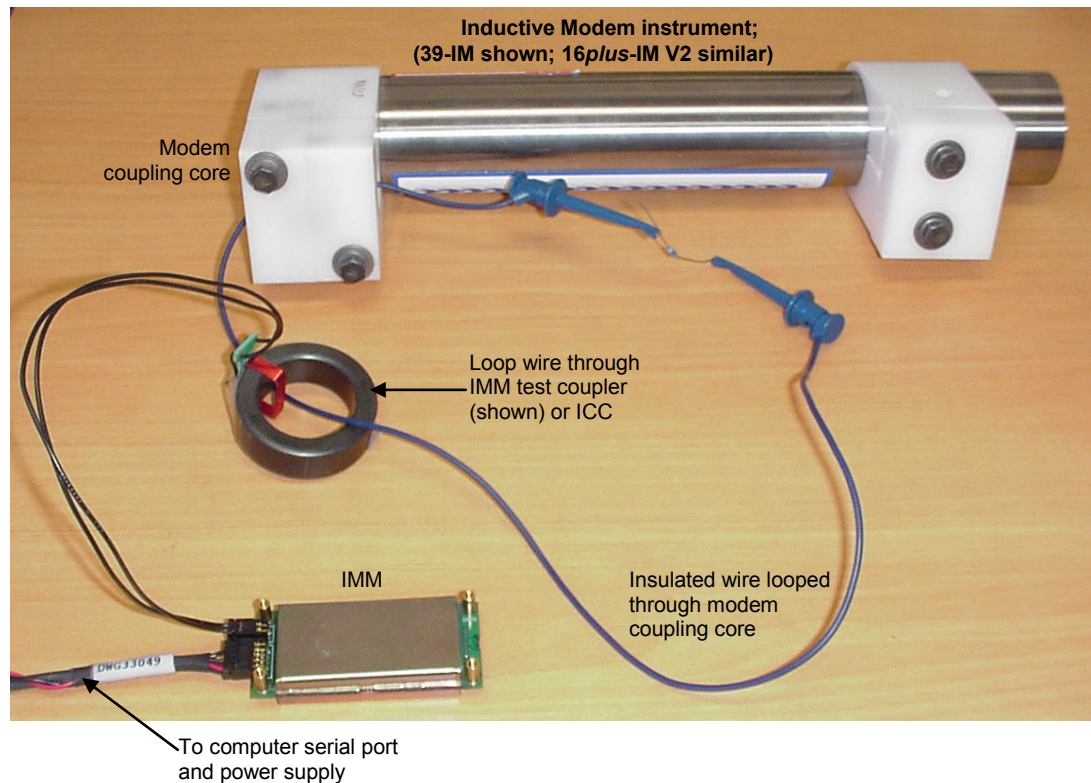
The power and communications test will verify that the system works, prior to deployment.

Test Setup with IMM

Note:

If more than one IM instrument is on-line when you set the ID, all IM instruments will be set to the same ID. The inductive modem receivers in IM instruments are very sensitive; two IM instruments that are side-by-side will take the same ID, even if one of them is not on the IM loop. **Therefore, separate IM instruments by at least 2 meters when setting IDs.**

1. Loop insulated wire through the 16plus-IM V2's modem coupling core to simulate a mooring cable. Place the other end of the loop through the IMM test coupler (supplied with the IMM) or the ICC. Connect the wire ends from the IMM test coupler or ICC to the IMM's mooring cable terminals (J1) (see IMM Manual).
2. Sea-Bird recommends a minimum of 20 ohms impedance to reduce noise during testing.
3. Connect the IMM to your computer's serial port and to a 7 – 24 VDC power supply using the cable supplied with the IMM. A maximum of 15 mA is required.



Setup of IMM for use with 16plus-IM V2

Note:

See the IMM manual for complete details on the use and setup of the IMM.

Sea-Bird recommends **one** of the following setups of the IMM for use with the SBE 16plus-IM V2:

To make full use of IMM capabilities:

***Init**

***Init** (Resets IMM to factory default state [must be sent twice])

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

To have the IMM emulate the SIM:

***Init**

***Init** (Resets IMM to factory default state [must be sent twice])

SetConfigType=1

SetEnableBinaryData=0

Verify that the IMM is set up as described by sending the **GetCD** command before proceeding with the 16plus-IM V2 setup.

A script including one of the above setups should be included in the buoy controller, to allow the IMM to be reset to the appropriate state if it becomes corrupted.

Test and Set SBE 16plus-IM V2 ID Using IMM

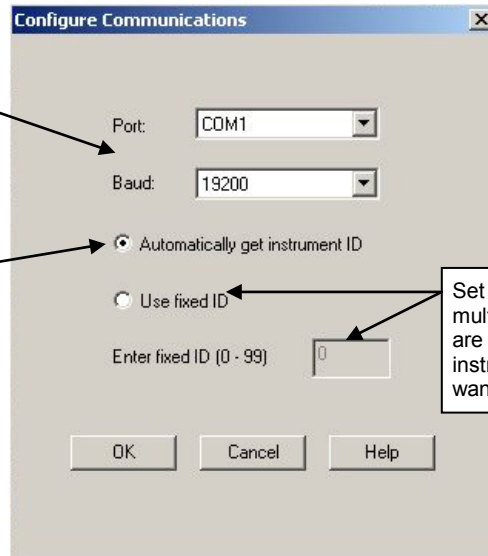
Note:

See SeatermV2 and SeatermIM Help files.

1. Double click on **SeatermV2.exe**. In the Instruments menu, select *SBE 37 IM*. **SeatermIM** opens:
2. If this is the first time SeatermIM is being used, the configuration dialog box displays:

Computer COM port and baud rate for communication between computer and IMM. SeatermIM tries to connect at this baud rate, but if unsuccessful will cycle through all available baud rates.

Set to *Automatically get ID* when only one 16plus-IM V2 is connected.



Set to *Use fixed ID* if multiple IM instruments are on-line. Enter ID for instrument with which you want to communicate.

Make the desired selections, and click OK.

3. SeatermIM tries to automatically connect to the 16plus-IM V2. It sends **DS** to determine if it is communicating with a SIM. If there is no response to **DS**, it assumes it is communicating with an IMM and proceeds as follows.
 - A. It sends **GetHD** to get IMM status information.
 - B. If **ConfigType=1**, it sends **PwrOn** to wake up all IM instruments on the line. If **ConfigType=2**, it sends **ForceCaptureLine** to reserve the IM line by transmitting a carrier signal, and **SendWakeuptone** to wake up all IM instruments on the line.
 - C. The remaining connection attempt varies, depending on the configuration setting the last time SeatermIM was used:
 - If SeatermIM was set to *Automatically get instrument ID* – It sends **id?** and waits for a response from the 16plus-IM V2. It then sends **!iiDS** and **#iiGetHD**, using the ID provided by the 16plus-IM V2.
 - If SeatermIM was set to *Use fixed ID* – It sends **!iiDS** and **#iiGetHD**, using the fixed ID that was entered the last time SeatermIM was used.

SeatermIM then fills the Send Commands window with the correct list of commands for your 16plus-IM V2.

Note:

!iiDS and **#iiGetHD** provide factory-set data such as instrument type, serial number, and firmware version for the 16plus-IM V2's communication microcontroller and acquisition microcontroller.

Notes:

- SeatermIM's baud rate must be the same as the IMM baud rate. Baud is factory-set to 9600, but can be changed by the user.
- Set to *Use fixed ID* to designate the appropriate 16plus-IM V2 if there are multiple IM instruments on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16plus-IM V2 on the IM line. Note that the ID is stored in the 16plus-IM V2's EEPROM and can be changed so that multiple IM instruments on a single IM line each have a unique ID. See the Configuration Sheet for the factory-set ID.

4. **If there is no communication** (no response to **id?** and/or no response to **!iiDS** and/or **#iiGetHD**):
 - A. In the Communications menu, select *Configure*. The Configure Communications dialog box appears. Select the Comm port and baud rate for communication. Note that the factory-set baud rate is documented on the Configuration Sheet. If using a fixed ID, verify that the designated ID is correct for the 16plus-IM V2 with which you want to communicate. Click OK.
 - B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). SeatermIM will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.
 - C. If there is still no communication, check cabling between the computer, IMM, and 16plus-IM V2, and try to connect again.
 - D. If there is still no communication, repeat Step A with a different comm port and/or different fixed ID, and try to connect again.

Note:

The IMM and 16plus-IM V2 have timeout algorithms designed to:

- restore control to the computer if an illegal command is sent
- conserve battery energy if too much time elapses between commands

If the system does not appear to respond:

- If **ConfigType=1**: send **PwrOn**.
- If **ConfigType=2**: wait at least 1 second, send **ForceCaptureLine**, and send **SendWakeUpTone**.

See *Timeout Descriptions* in Section 4: *Deploying and Operating 16plus-IM V2* and the IMM manual.

Note:

Sending the status command causes the optional pump to turn on for a moment, so that the 16plus-IM V2 can measure and output the pump current. Because the pump is designed to be water lubricated, you may hear a noise when the impeller spins in air. Running the pump *dry* for **short** periods (for example, when sending the status command) will not harm the pump.

Note:

The IMM and 16plus-IM V2 have timeout algorithms designed to:

- restore control to the computer if an illegal command is sent
- conserve battery energy if too much time elapses between commands

If the system does not appear to respond, see:

- *Timeout Descriptions* in Section 4: *Deploying and Operating SBE 16plus-IM V2* in this manual, and
- IMM manual.

5. Display 16plus-IM V2 status information by typing **#iiDS** (ii = 16plus-IM V2 ID) and pressing the Enter key. The display looks like this:

```
SBE 16plus-IM V 2.3 SERIAL NO. 0001 01 Oct 2011 14:02:13
vbatt = 10.3, vlith = 8.5, ioper = 62.5 ma, ipump = 21.6 ma,
iext01 = 76.2
status = not logging
sample interval = 15 seconds, number of measurements per sample = 1
samples = 0, free = 3870479
run pump for 0.5 sec, delay before sampling = 0.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38=no, SBE 50 = no, OPTODE = no, Gas 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
```

6. Command the 16plus-IM V2 to take a sample by typing **#iiTS** (ii = 16plus-IM V2 ID) and pressing the Enter key. The display looks like this (if 16plus-IM V2 includes optional internally mounted pressure sensor, and is set up for converted decimal output format, output sample number, no output salinity or sound velocity, and auxiliary voltage sensor on channel 0):

```
4000, 23.7658,0.00019, 0.062, 0.5632, 01 Oct 2011, 14:10:10, 5
```

where 0001 = 16plus-IM V2 serial number 4000 (16pxxxx-0001)
 23.7658 = temperature in degrees Celsius
 0.00019 = conductivity in S/m
 0.062 = pressure in db
 0.5632 = voltage for auxiliary sensor channel 0
 01 Oct 2011 = date
 14:10:10 = time
 5 = sample number in memory

These numbers should be reasonable; i.e., room temperature, zero conductivity, barometric pressure (gauge pressure), current date and time (set at factory to Pacific Daylight or Standard Time), expected number of samples in memory.

Note:

If more than one IM instrument is on-line when you set the ID, all IM instruments will be set to the same ID. The inductive modem receivers in IM instruments are very sensitive; two IM instruments that are side-by-side will take the same ID, even if one of them is not on the IM loop. **Therefore, separate IM instruments by at least 2 meters when setting IDs.**

7. Each IM instrument on a mooring must have a unique ID for communicating with the IMM and computer. Set the ID as described below, first verifying that only one 16plus-IM V2 is on-line before you set the ID:
 - A. Set the 16plus-IM V2 ID by typing ***ID=ii** (ii= user-assigned ID number) and pressing the Enter key.
 - B. The computer responds by requesting verification, requiring you to again type ***ID=ii** and press the Enter key.
 - C. Record the ID for future reference.
 - D. In the Communications menu, select *Configure*. Set to *Use fixed ID*, enter the new ID, and click OK. This provides SeatermIM with the correct ID information for sending commands listed in the Send Commands window.
8. Send additional commands, as desired.
9. Command the 16plus-IM V2 to go to sleep (quiescent state) by typing **PwrOff** and pressing the Enter key.

The SBE 16plus-IM V2 is ready for programming and deployment.

Section 4: Deploying and Operating SBE 16plus-IM V2

Note:

Separate software manuals and Help files contain detailed information on installation, setup, and use of Sea-Bird's software.

This section provides instructions for deploying the SBE 16plus-IM V2. It includes discussions of:

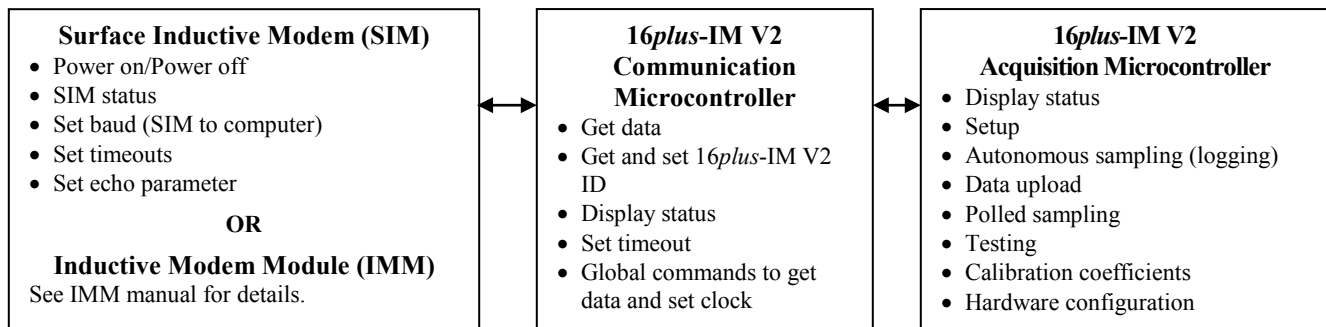
- System operation and timeout descriptions
- Sampling modes with example sets of commands
- Pump operation
- Command descriptions
- Data formats
- Deployment
- System installation and wiring
- Recovery - physical handling and uploading data
- Processing data with SBE Data Processing
- Editing a raw data file

Operation Description

The SBE 16plus-IM V2 internal functions are supervised by two internal microcontrollers. The acquisition microcontroller supervises measurement acquisition, and setup and sampling functions. The communication microcontroller supervises communication between the 16plus-IM V2 and IMM/SIM. These two microcontrollers allows for independent control of power usage by the communication and acquisition circuits. Acquisition consumes more power, but for shorter duration. Communication protocols take proportionately more time, but can be controlled separately and operate at lower power, thus maximizing battery life. This also prevents communication protocols from interfering with measurement acquisition timing.

Commands can be directed to the IMM or SIM (typically at the surface), the 16plus-IM V2 communication microcontroller (with a ! prefix), or the 16plus-IM V2 acquisition microcontroller (with a # prefix).

- An ID command prefix (#**ii** or !**ii**) is used to direct commands to a 16plus-IM V2 with the same ID.
- A Group command prefix (#**Gn:** or !**Gn:**) is used to direct commands to all instruments in a Group. **All 16plus-IM V2s have been factory assigned to Group 0 and Group 9.**
- Global commands do not require a prefix and are recognized by all 16plus-IM V2s attached to the same inductive cable.



Timeout Descriptions

For **IMM timeouts**, see the IMM manual.

SIM timeouts restore control to the computer if no reply is received from the 16plus-IM V2 (for example, upon sending an illegal command) within a specified length of time. This allows new commands to be sent. There are two user-programmable SIM timeouts:

- **DataNNMax** – timeout for **!iiData** and **Dataii** only.
Default 1000 milliseconds.

- **RelayMax** – timeout for all other commands. Default 20 seconds.

When using RS-232 between the SIM and computer, control of the SIM can be re-established sooner than the timeout by pressing the Esc key and then the Enter key. When the S> prompt is displayed, new commands can be sent.

The **16plus-IM V2 timeout** powers down the 16plus-IM V2 communication circuits if the 16plus-IM V2 does not receive a command for 2 minutes, to prevent exhaustion of its batteries. **To re-establish control:**

- Select *Connect* in SeatermIM's Communications menu. or
- (if using the SIM) Send **PwrOn**. or
- (if using the IMM) Wait at least 1 second, send **ForceCaptureLine**, and then send **SendWakupTone**.

The 16plus-IM V2 also has a user-programmable timeout (**!iiWait=**) that provides the maximum amount of time for the communication microcontroller to wait for a response from the acquisition microcontroller.

Sampling Modes

Note:

The 16plus-IM V2 communications microcontroller automatically enters quiescent state after 2 minutes without receiving a command.

The SBE 16plus-IM V2 has three basic sampling modes for obtaining data:

- Polled Sampling
- Autonomous Sampling (logging)
- Combo Sampling

Sampling commands can be used in various combinations to provide a high degree of operating flexibility. Review the operation of the three basic sampling modes and the commands described in *Command Descriptions* before setting up your system.

Descriptions and examples of the sampling modes follow for a system with three 16plus-IM V2s (IDs 01, 02, and 03) on a mooring cable. Note that the 16plus-IM V2 response to each command is not shown in the examples.

Polled Sampling

On command, the SBE 16plus-IM V2 takes one sample of data and sends the data to the SIM or IMM. Storing of data in the 16plus-IM V2 FLASH memory is dependent on the particular command used. Note that it is not possible to synchronize the data samples from each 16plus-IM V2 in polled sampling.

Example: Polled Sampling (user input in bold)

Send wakeup tone to all IM instruments. Globally set date and time to September 1, 2011 at 9:05 am.

Set up each 16plus-IM V2 with 1 voltage sensor, no pump, take and average 4 measurements for each sample, and output data in converted decimal format. After all parameters are entered, verify setup. Send power-off command to all 16plus-IM V2s.

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16plus-IM V2s.)

DATE TIME=09012011090500

#01VOLT0=Y

#01PUMPMODE=0

#01NCYCLES=4

#01OUTPUTFORMAT=3

#01GETCD (to verify setup)

(Repeat **#iiPTYPE=** through **#iiGETCD** for 16plus-IM V2s 02 and 03.)

PWROFF

Send wakeup tone to all 16plus-IM V2s. Command each 16plus-IM V2 to take a sample, and send data to SIM/IMM. Send power-off command to all 16plus-IM V2s.

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16plus-IM V2s.)

#01TS (16plus-IM V2 with ID=01 takes and transmits a sample.)

#02TS (16plus-IM V2 with ID=02 takes and transmits a sample.)

#03TS (16plus-IM V2 with ID=03 takes and transmits a sample.)

PWROFF

Autonomous Sampling (logging)

At pre-programmed intervals, the SBE 16plus-IM V2 wakes up, samples data, stores the data in its FLASH memory, and enters quiescent (sleep) state. The 16plus-IM V2 goes to sleep for a minimum of 5 seconds between each sample. The 16plus-IM V2 does not transmit data to the SIM or IMM. Autonomous sampling is started with **#iiStartNow** or **#iiStartLater**, and is stopped with **#iiStop**.

To synchronize the data samples for each 16plus-IM V2 in Autonomous Sampling (see *Specifications in Section 2: Description of SBE 16plus-IM V2* for the real-time clock specifications):

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

The 16plus-IM V2 has a *lockout* feature to prevent unintended interference with sampling. If the 16plus-IM V2 is sampling or is waiting to start sampling (**#iiStartLater** has been sent, but logging hasn't started yet), only the following commands will be accepted:

- All SIM or IMM commands,
- These 16plus-IM V2 Communication Microcontroller commands: **GData** (send **SendGData** if using IMM), **Dataii**, **!iiData**, **ID?**, and **!iiDS**
- These 16plus-IM V2 Acquisition Microcontroller commands: **#iiGetCD**, **#iiGetSD**, **#iiGetCC**, **#iiGetEC**, **#iiResetEC**, **#iiGetHD**, **#iiDS**, **#iiDCal**, **#iiTS**, **#iiSL**, **#iiSLT**, and **#iiStop**.

Note:

Use **#iiStop** to:

- stop autonomous sampling
- stop waiting to start autonomous sampling (after **#iiStartLater** has been sent)

Once **#iiStop** is sent, the 16plus-IM V2 accepts all commands again.

Example: Autonomous Sampling (user input in bold)

Send wakeup tone to all 16plus-IM V2s. Globally set date and time to September 1, 2011 at 9:05 am. For each 16plus-IM V2: initialize logging to overwrite previous data in memory, set up with 1 voltage sensor, take a sample every 120 seconds, take and average 4 measurements for each sample, and output data in raw hex format. Set up pump to run for 0.5 seconds before each sample. Set up to start logging on 15 September 2011 at 12:00:00. Send command to start logging at designated date and time. After all parameters are entered, verify setup. Send power-off command to all 16plus-IM V2s.

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16plus-IM V2s.)

```
DATETIME=09012011090500
#01INITLOGGING
#01VOLT0=Y
#01SAMPLEINTERVAL=120
#01NCYCLES=4
#01OUTPUTFORMAT=0
#01PUMPMODE=1
#01STARTDATETIME=09152011120000
#01STARTLATER
#01GETCD (to verify setup)
(Repeat #iiINITLOGGING through #iiGETCD for 16plus-IM V2s 02 and 03.)
PWROFF
```

Deploy 16plus-IM V2. Logging starts automatically at designated date and time.

When ready to upload all data to computer, wake up all 16plus-IM V2s, stop sampling, and upload data:

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16plus-IM V2s.)

```
#01STOP
```

(Click Upload menu – SeatermIM leads you through screens to define data to be uploaded and where to store it.)

(Repeat **#iiSTOP** through Upload for 16plus-IM V2s 02 and 03.)

```
PWROFF
```

Combo Sampling

Combo Sampling combines Autonomous Sampling with the ability to retrieve the last data sample from each SBE 16plus-IM V2, to look at data without stopping the sampling. As in Autonomous Sampling, the 16plus-IM V2 wakes up, samples data at pre-programmed intervals, stores the data in its FLASH memory, and powers-off (enters quiescent state).

When desired, the user can request the last stored data sample from a particular 16plus-IM V2. There are two ways to get the last stored sample:

- From a specific 16plus-IM V2 - use **#iiSL**.
- From all 16plus-IM V2s - use **GData** (send **SendGData** if using IMM), which is a global command to each 16plus-IM V2 to hold the last data sample in its buffer. Then, send **!iiData** to each 16plus-IM V2 to transmit the last data sample from its buffer.

Example: Combo Sampling (user input in bold)

Set up all 16plus-IM V2s as shown above for Autonomous Sampling.

After logging begins, look at data from last sample to check results:

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16plus-IM V2s.)

```
#01SL
#02SL
#03SL
PWROFF
```

OR

If using the **IMM** and want to retrieve data from all IM instruments on line:

(send **FCL** to reserve the IM line by transmitting a carrier signal, and send **SWT** to send a wake-up tone to all instruments on line.)

```
SENDGDATA
!01DATA
!02DATA
!03DATA
PWROFF
```

OR

If using the **SIM** and want to retrieve data from all IM instruments on line:

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16plus-IM V2s.)

```
GDATA
!01DATA
!02DATA
!03DATA
PWROFF
```

Upload all data as shown above for Autonomous Sampling.

Pump Operation

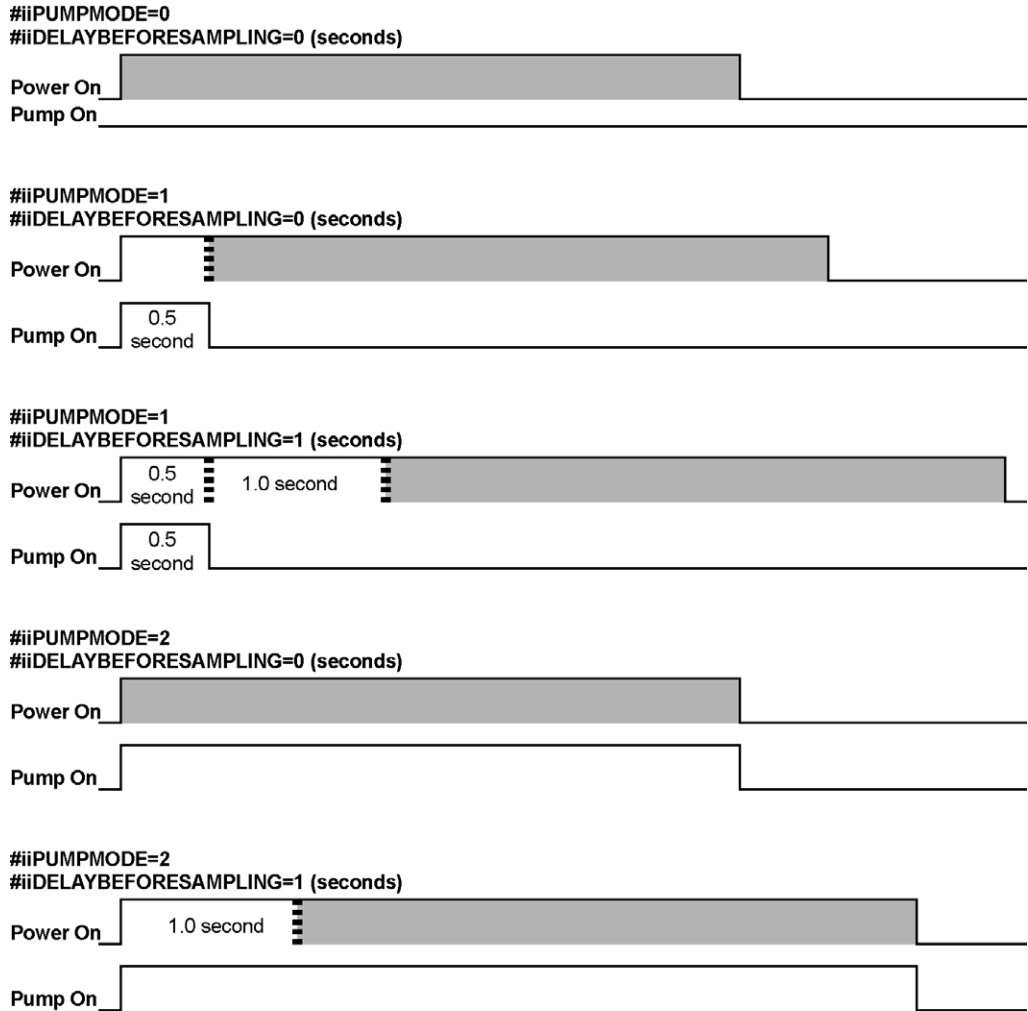
Do not run the pump dry. The pump is water lubricated; running it without water will damage it. If briefly testing your system in dry conditions, fill the inside of the pump head with water via the pump exhaust port. This will provide enough lubrication to prevent pump damage during brief testing.

Pump operation is governed by two user-programmable parameters:

- **#iiPumpMode=0, 1, or 2**
The 16plus-IM V2 can be set up to operate with no pump (0), with the pump running for 0.5 seconds before each sample (1), or with the pump running during each sample (2).
- **#iiDelayBeforeSampling=**
The 16plus-IM V2 can be set up to delay sampling after turning on external voltage and RS-232 sensors. Some instruments require time to equilibrate or stabilize after power is applied, to provide good quality data.

Note:
For the SIM: Set **RelayMax=** greater than **#iiDelayBeforeSampling=** to prevent the SIM from timing out during polled sampling.

#iiPumpMode= and **#iiDelayBeforeSampling=** interact in the operation of the pump, as shown below. Recommendations for settings are provided on the next page.



Note: ■ = sampling time (≥ 2.2 seconds)
Sampling time includes time for instrument to warm up as well as time to actually measure parameters. The 2.2 second sampling time is for 16plus-IM V2 with no pressure sensor, and 1 measurement / sample (**#iiNCycles=1**). See *Specifications* in Section 2: Description of SBE 16plus-IM V2 for sampling times for other setups.

Pump Setting Recommendations

Sea-Bird provides the following recommendations for pump settings. Note that longer pump times increase power usage, reducing battery endurance. See *Battery Endurance* in *Section 2: Description of SBE 16plus-IM V2* for sample battery endurance calculations.

Pump through Conductivity Cell Only (SBE 5M, 5P, or 5T pump)

For most deployments, set **#iiPumpMode=1** and **#iiDelayBeforeSampling=0**. The pump operates for 0.5 seconds before the conductivity measurement is made, providing enough time to ventilate the cell and bring in a new sample of water.

If the 16plus-IM V2 is moored in an area with large thermal gradients, it may be necessary to pump for a longer period of time, to eliminate any cell thermal mass effects on the measurement. In this case, set **#iiPumpMode=2** and set **#iiDelayBeforeSampling=** to a non-zero value, providing additional ventilation time (allowing the conductivity cell temperature to equilibrate to the water temperature) before taking the measurement.

Pump through Conductivity Cell and SBE 43 Dissolved Oxygen Sensor (requires SBE 5P or 5T pump)

Set **#iiPumpMode=2**.

As the pump brings new water into the SBE 43 plenum, some time is required for the sensor to equilibrate to the new oxygen level. The time required is dependent on the sensor's membrane thickness, and on the water temperature. Prior to 2007, all SBE 43s were sold with a 0.5 mil thick membrane. Beginning in 2007, Sea-Bird began offering two membrane thicknesses – 0.5 mil (faster response, typically for profiling applications) and 1.0 mil (slower response but more durable, typically for moored applications).

Note:

See *Application Note 64: SBE 43 Dissolved Oxygen Sensor – Background Information, Deployment Recommendations, and Cleaning and Storage* for the response time curves.

- For a **0.5 mil thick** membrane – Recommended **#iiDelayBeforeSampling=** varies in a non-linear fashion, from 15 seconds at 15 °C to 30 seconds at 0 °C.
- For a **1.0 mil thick** membrane – Recommended **#iiDelayBeforeSampling=** varies in a non-linear fashion, from 25 seconds at 15 °C to 40 seconds at 0 °C.

Pump through Conductivity Cell and Beckman- or YSI-type Dissolved Oxygen Sensor (requires SBE 5P or 5T pump)

Set **#iiPumpMode=2**. Set **#iiDelayBeforeSampling=** to 120 to 180 seconds, allowing time for the oxygen sensor to polarize before taking the measurement.

Command Descriptions

Notes:

- If using the 16plus-IM V2 with an **Inductive Modem Module (IMM)**, see the IMM manual for details on IMM commands.
- If using the 16plus-IM V2 with a **Surface Inductive Modem (SIM)**, the SIM commands are included in this manual.

This section describes commands and provides sample outputs.

See *Appendix III: Command Summary* for a summarized command list.

When entering commands:

- Input commands in upper or lower case letters and register commands by pressing the Enter key.
- The 16plus-IM V2 sends an error message if an invalid command is entered.
- (If **#iiOutputExecutedTag=N**) If the system does not return an S> prompt after executing a command, press the Enter key to get the S> prompt.
- Commands to enable a parameter or output (such as enabling a voltage channel) can be entered with the *argument* as Y or 1 for yes, and N or 0 for no (for example, **#iiVolt0=y** and **#iiVolt0=1** are equivalent; both enable voltage channel 0).
- If a new command is not received within 2 minutes after completion of a command, the 16plus-IM V2 communications microcontroller returns to the quiescent (sleep) state.
- If in quiescent state, re-establish communications by selecting *Connect* in SeatermIM's Communications menu, or
 - (if using SIM) entering **PwrOn**.
 - (if using IMM set to **ConfigType=1**) sending **PwrOn**.
 - (if using IMM set to **ConfigType=2**) waiting at least 1 second, sending **ForceCaptureLine**, and sending **Send WakeupTone**.
- The 16plus-IM V2 cannot have samples with different scan lengths (more or fewer data fields per sample) in memory. If the scan length is changed by commanding it to add or subtract a data field (such as an external voltage), the 16plus-IM V2 must initialize logging. Initializing logging sets the sample number and header number to 0, so the entire memory is available for recording data with the new scan length. **Initializing logging should only be performed after all previous data has been uploaded.** Therefore, do not send the following commands, which change the scan length, unless all previous data has been uploaded: **#iiPType=**, **#iiVolt0=**, **#iiVolt1=**, **#iiVolt2=**, **#iiVolt3=**, **#iiVolt4=**, **#iiVolt5=**, **#iiSBE38=**, **#iiSBE50=**, **#iiGTD=**, **#iiDualGTD=**, **#iiOptode=**.
- When sampling autonomously, the 16plus-IM V2 responds only to commands that do not change its setup or interfere with sampling (see *Autonomous Sampling* for command list). If you wake it while sampling (for example, to send **#iiDS** to check sampling progress), it temporarily stops sampling. Sampling resumes when it goes back to sleep again (after 2-minute timeout).
- While *waiting to start autonomous sampling* (if you sent **#iiStartLater** but sampling has not started yet), the 16plus-IM V2 responds only to commands that do not change its setup or interfere with sampling (see *Autonomous Sampling* for a list of commands). To send any other commands, send **#iiStop**, send the desired commands to modify the setup, and then send **#iiStartLater** again.

Note:

All 16plus-IM V2s are factory assigned to Group 0 and Group 9.

- When you send a group command (**#Gn:** or **!Gn:**), the IMM or SIM connected to the controller will not get a response from the instruments, because only 1 instrument can communicate at a time (IM telemetry is half-duplex). The IMM and SIM have been programmed to not wait for a response from a group command.
- If desired, you can upload data from the 16plus-IM V2 using the internal RS-232 connector (see *Appendix II: Electronics Disassembly/Reassembly* to access the connector) and the optional data I/O cable (PN 801880). If used in this way, omit the **#ii** prefix in the Acquisition Microcontroller commands, and use Seaterm232 instead of SeatermIM (select *SBE 16plus V2 IM RS232* in SeatermV2's Instrument menu).

Entries made with the commands are permanently stored in the SBE 16plus-IM V2 and remain in effect until you change them.

- The only exception occurs if the electronics are removed from the housing and disconnected from the battery Molex connector (see *Appendix II: Electronics Disassembly/Reassembly*). Upon reassembly, reset date and time (**DateTime=** or **#iiDateTime=**) and initialize logging (**#iiInitLogging**).

SIM Commands

SIM commands are directed to the Surface Inductive Modem, to set it up for operation with the 16plus-IM V2.

Power-On Commands

PwrOn	Send wakeup tone to all IM instruments on-line.
PwrOff	Send power-off command to all IM instruments on-line. Main power turned off and IM instruments placed in quiescent (sleep) state. Autonomous sampling and memory retention not affected.
AutoPwrOn=x	<p>x=Y (default): Automatically send PwrOn to all IM instruments on-line when power applied to SIM. This wakes up all IM instruments on-line.</p> <p>x=N: Do not send PwrOn when power applied to SIM.</p>

Note:

AutoPwrOn=N is not typically used with the 16plus-IM V2.

Note:

The **DS** response shows SBE 37 because the SIM was originally developed for the SBE 37-IM MicroCAT.

Status Command

DS	Display SIM firmware version and setup. Example includes commands used to modify parameters [in parentheses].
-----------	---

Example (user input in bold)

```

DS
SBE 37 SURFACE MODEM V 3.0a
wait time for dataNN response = 1000 msec           [DataNNMax=]
wait time for relay command response = 20 seconds   [RelayMax=]
binary relay character timeout = 1000 msec [not applicable to 16plus-IM V2]
echo = yes                                           [EchoOn or EchoOff]
execute pwrn command on powerup = yes              [AutoPwrOn=]

```

Communications Commands

Note:

The SIM's baud rate (set with **Baud=**) must be the same as SeatermIM's baud rate (set in *Configure* in the Communications menu). After you send **Baud=**, you must disconnect and reconnect (in the Communications menu, select *Disconnect and reconnect*) to communicate at the new baud rate.

Baud=x

x= baud rate between SIM and computer/controller (1200, 2400, 4800, or 9600). Default 9600.

Note:

If outputting data in XML format (**#iiOutputFormat=5**), Sea-Bird recommends setting **DataNNmax=** to 4000 milliseconds.

DataNNMax=x

x= timeout (0 – 32767 milliseconds; SIM rounds down to nearest 50 milliseconds) that applies to **!iiData** or **Dataii** only. If no reply is received within **DataNNMax**, control is returned to computer and other commands can be sent. Default 1000 milliseconds.

Note:

Set **RelayMax=** greater than **#iiDelayBeforeSampling=**. See *Pump Operation*.

RelayMax=x

x= timeout (0-3276 seconds) that applies to all commands other than **Dataii** or **!iiData**. If no reply is received within **RelayMax**, control is returned to computer and other commands can be sent. Default 20 seconds.

EchoOn

Echo characters received from computer (default) - computer monitor will show entered commands as you type.

EchoOff

Do not echo characters.

16plus-IM V2 Communication Microcontroller Commands

The following Communication Microcontroller commands can be sent as group commands: **GData**, **DateTime=**, **DS**, and **Wait=**. For example, **!G9:GData** sends **GData** to all instruments on-line that are in Group 9.

Note:

All 16plus-IM V2s are factory assigned to Group 0 and Group 9.

Global Commands

Note:

If the 16plus-IM V2 batteries have been removed, the date and time must be reset.

DateTime=mmddyyyyhhmmss Set real-time clock month, day, year, hour, minute, second for **all** 16plus-IM V2s.

When using IMM with either ConfigType:
Use **#iiDateTime=** to set clock in each individual 16plus-IM V2. **DateTime=** does not work.

Note:

The 16plus-IM V2 has a buffer that stores the most recent data sample. Unlike data in the FLASH memory, data in the buffer is erased upon removal or failure of power.

GData

Command **all** communication microcontrollers to get last data sample from acquisition microcontrollers. Communication microcontrollers hold data in a buffer until receiving **!iiData** or **Dataii**.

When using IMM with ConfigType=2:
Use **SendGData** instead; this results in IMM sending **GData** to all IM instruments online.

Get Data Command

!iiData or **Dataii**

Get data obtained with **GData** from 16plus-IM V2 with ID = ii (ii = 0-99).

When using IMM with either ConfigType:
Use **!iiData**. **Dataii** does not work.

16plus-IM V2 ID Command

Note:

If more than one IM instrument is on-line when you set the ID, all IM instruments will be set to the same ID. The inductive modem receivers in IM instruments are very sensitive; two IM instruments that are side-by-side will take the same ID, even if one of them is not on the IM loop. **Therefore, separate IM instruments by at least 2 meters when setting IDs.**

Only one IM instrument can be on line when sending these commands.

ID?

Display ID (ID = ii, where ii= 0-99).

***ID=ii**

Set 16plus-IM V2 ID to ii (ii= 0-99). Must be sent twice, because verification requested. **If more than one IM instrument is on-line, all IM instruments will be set to same ID.**

16*plus*-IM V2 Communication Microcontroller Status Command

!iiDS Display communication microcontroller firmware version and timeout parameter for 16*plus*-IM V2 with ID=ii.

Example (user input in bold, command used to modify parameter in parentheses)

!01DS

SCplus IM V2 1.1c

Response wait time 10 seconds

[**!iiWait=**]

16*plus*-IM V2 Communication Microcontroller Timeout Command

Note:

Set **!iiWait=** longer than (10 sec + **#iiDelayBeforeSampling=**).

!iiWait=x

x= maximum time (seconds) for communication microcontroller to wait for response from acquisition microcontroller. Range 2 – 600 seconds.

16plus-IM V2 Acquisition Microcontroller Commands

Notes:

- All 16plus-IM V2s are factory assigned to Group 0 and Group 9.
- If using the 16plus-IM V2's internal RS-232 connector to upload data: n SeatermV2's Instruments menu, select *SBE 16plus V2 RS232* instead of *SBE 16plus V2 IM*. This launches Seaterm232 instead of SeatermIM. Seaterm232 is similar to SeatermIM, but is optimized for RS-232 communications.

- When using inductive modem telemetry, all 16plus-IM V2 Acquisition Microcontroller commands are preceded by **#ii** (ii= 16plus-IM V2 ID), as shown in the command listings below. All Acquisition Microcontroller commands can also be sent as group commands (substitute **#Gn:** for **#ii** in the command). For example, **#G9:StartNow** sends **StartNow** to all instruments on-line that are in Group 9.
- When using RS-232 telemetry (connecting directly to the 16plus-IM V2's internal RS-232 serial connector), omit the **#ii** prefix shown in the command listings.

Status Commands

#iiGetCD

Get and display configuration data, which includes all parameters related to setup of 16plus-IM V2, including communication settings and sampling settings. Most of these parameters can be user-input/modified. List below includes, where applicable, command used to modify parameter:

Notes:

- **#iiGetCD** output does not include calibration coefficients. To display calibration coefficients, use the **#iiGetCC** command.
- The **#iiDS** response contains similar information as the combined responses from **#iiGetSD** and **#iiGetCD**, but in a different format.

- Device type, Serial number
- Sample interval [**#iiSampleInterval=**]
- Number of measurements to take and average per sample [**#iiNCycles=**]
- Integration time for Quartz pressure sensor [**#iiParosIntegration=**]
(only appears if **#iiPType=3**)
- Reference pressure to use if no internally mounted pressure sensor [**#iiRefPress=**]
(only appears if **#iiPType=0**)
- Pump turn-on parameter [**#iiPumpMode=**]?
- Pump turn-on delay [**#iiDelayBeforeSampling=**]
- Sample external voltages 0, 1, 2, 3, 4, and 5 [**#iiVolt0=** through **#iiVolt5=**]?
- Sample SBE 38 secondary temperature sensor [**#iiSBE38=**]?
- Sample SBE 50 secondary pressure sensor [**#iiSBE50=**]?
- Sample WET Labs RS-232 sensor [**WetLabs=**]?
- Sample Optode [**#iiOptode=**]?
- Sample Gas Tension Device [**#iiGTD=**], or dual Gas Tension Devices [**#iiDualGTD=**]?
- Output Executing and Executed tags [**#iiOutputExecutedTag=**]?
- Output format [**#iiOutputFormat=**]
- Output salinity [**#iiOutputSal=**]?
(only if output format = converted decimal or converted XML UVIC)
- Output sound velocity [**#iiOutputSV=**]?
(only if output format = converted decimal or converted XML UVIC)
- Output sigma-t, voltage, and current with each sample [**#iiOutputUCSD=**]?
(only if output format = converted decimal or converted XML UVIC)
- Output sample number with each sample [**#iiOutputSampleNumber=**]?

Status Commands (continued)

Example: 16plus-IM V2 with ID=01 (user input in bold, command used to modify parameter in parentheses)

#01getcd

```

<ConfigurationData DeviceType='SBE16plus-IM' SerialNumber='01606001'>
  <SamplingParameters>
    <SampleInterval>15</SampleInterval>                [#iiSampleInterval=]
    <MeasurementsPerSample>1</MeasurementsPerSample>   [#iiNCycles=]
    <Pump>run pump during sample</Pump>                [#iiPumpMode=]
    <DelayBeforeSampling>0.0</DelayBeforeSampling>     [#iiDelayBeforeSampling=]
  </SamplingParameters>
  <DataChannels>
    <ExtVolt0>yes</ExtVolt0>                            [#iiVolt0=]
    <ExtVolt1>no</ExtVolt1>                             [#iiVolt1=]
    <ExtVolt2>no</ExtVolt2>                             [#iiVolt2=]
    <ExtVolt3>yes</ExtVolt3>                            [#iiVolt3=]
    <ExtVolt4>no</ExtVolt4>                             [#iiVolt4=]
    <ExtVolt5>no</ExtVolt5>                             [#iiVolt5=]
    <SBE38>no</SBE38>                                   [#iiSBE38=]
    <SBE50>no</SBE50>                                   [#iiSBE50=]
    <WETLABS>no</WETLABS>                               [#iiWetLabs=]
    <OPTODE>no</OPTODE>                                 [#iiOptode=]
    <GTD>no</GTD>                                       [#iiGTD= or #iiDualGTD=]
  </DataChannels>
  <OutputExecutedTag>no</OutputExecutedTag>           [#iiOutputExecutedTag=]
  <OutputFormat>converted decimal</OutputFormat>      [#iiOutputFormat=]
  <OutputSalinity>no</OutputSalinity>                 [#iiOutputSal=]
  <OutputSoundVelocity>no</OutputSoundVelocity>       [#iiOutputSV=]
  <OutputSigmaT-V>no</OutputSigmaT-V>                 [#iiOutputUCSD=]
  <OutputSampleNumber>no</OutputSampleNumber>        [#iiOutputSampleNumber=]
</ConfigurationData>

```

Status Commands (continued)**Notes:**

- The **#iDS** response contains similar information as the combined responses from **#iiGetSD** and **#iiGetCD**, but in a different format.
- If configured with a pump, sending **#iiGetSD** causes the pump to turn on for a moment, so that the 16plus-IM V2 can measure and output the pump current. Because the pump is designed to be water lubricated, you will hear a noise when the impeller spins in air. Running the pump *dry* for such a **short** time will not harm the pump.
- In the example below, only voltage channel 0 is enabled, so external voltage current `ixt2345=` (for channels 2, 3, 4, and 5) is not shown.
- In the example below, no RS-232 sensor is enabled, so RS-232 sensor current `iserial=` is not shown.
- If the 16plus-IM V2 is set up with a WET Labs ECO-FL fluorometer with Bio-Wiper (**#iiBiowiper=Y**) and if **#iiOutputExecutedTag=**, the **#iiGetSD** response shows:
`<Executing/>` to allow time for the Bio-Wiper to close before it measures the enabled external voltage currents.

#iiGetSD

Get and display status data, which contains data that changes while deployed. List below includes, where applicable, command used to modify parameter:

- Device type, Serial number
- Date and time [**#iiDateTime=**] in ISO8601-2000 extended format (yyyy – mm-ddThh:mm:ss)
- Logging status (not logging, logging, waiting to start at . . ., or unknown status)
- Number of recorded events in event counter [reset with **#iiResetEC**]
- Voltages and currents -
 - Main battery voltage
 - Back-up lithium battery voltage
 - Operating current
 - Pump current
 - External voltage sensor current (channels 0 and 1) – displays only if 1 or more channels enabled
 - External voltage sensor current (channels 2, 3, 4, and 5) – displays only if 1 or more channels enabled
 - RS-232 sensor current – displays only if channel enabled
- Memory - [reset with **#iiInitLogging**]
 - Number of bytes in memory
 - Number of samples in memory
 - Number of additional samples that can be placed in memory
 - Length (number of bytes) of each sample
 - Number of headers in memory

Example: 16plus-IM V2 with ID=01 (user input in bold, command used to modify parameter in parentheses)

#01getsd

```

<StatusData DeviceType = 'SBE16plus-IM' SerialNumber = '01606001'>
  <DateTime>2011-07-24T10:53:03</DateTime>                                [#iiDateTime=]
  <LoggingState>not logging</LoggingState>
  <EventSummary numEvents = '0'/>                                        [can clear with #iiResetEC]
  <Power>
    <vMain>10.1</vMain>
    <vLith>8.9</vLith>
    <iMain>61.9</iMain>
    <iPump>20.6</iPump>
    <iExt01>67.2</iExt01>
  </Power>
  <MemorySummary>
    <Bytes>0</Bytes>                                                    [can clear with #iiInitLogging]
    <Samples>0</Samples>                                              [can clear with #iiInitLogging]
    <SamplesFree> 3870479</SamplesFree>                               [can clear with #iiInitLogging]
    <SampleLength>17</SampleLength>
    <Headers>0</Headers>                                             [can clear with InitLogging]
  </MemorySummary>
</StatusData>

```

Notes:

- **#iiDCal** and **#iiGetCC** responses contain similar information, but in different formats.
- Dates shown are when calibrations were performed.

Status Commands (*continued*)**#iiGetCC**

Get and display calibration coefficients, which are initially factor-set and should agree with Calibration Certificates shipped with 16plus-IM V2.

Example: 16plus-IM V2 with ID=01, strain gauge pressure sensor (user input in bold, command used to modify coefficient in parentheses)

#01getcc

```

<CalibrationCoefficients DeviceType = 'SBE16plus-IM' SerialNumber = '01606001'>
  <Calibration format = 'TEMP1' id = 'Main Temperature'>
    <SerialNum>01600001</SerialNum>
    <CalDate>19-Mar-11</CalDate>
    <TA0>1.155787e-03</TA0>
    <TA1>2.725208e-04</TA1>
    <TA2>-7.526811e-07</TA2>
    <TA3>1.716270e-07</TA3>
    <TOFFSET>0.000000e+00</TOFFSET>
  </Calibration>
  <Calibration format = 'WBCOND0' id = 'Main Conductivity'>
    <SerialNum>01600001</SerialNum>
    <CalDate>19-Mar-11</CalDate>
    <G>-1.006192e+00</G>
    <H>1.310565e-01</H>
    <I>-2.437852e-04</I>
    <J>3.490353e-05</J>
    <CPCOR>-9.570000e-08</CPCOR>
    <CTCOR>3.250000e-06</CTCOR>
    <CSLOPE>1.000000e+00</CSLOPE>
  </Calibration>
  <Calibration format = 'STRAIN0' id = 'Main Pressure'>
    <SerialNum>01600001</SerialNum>
    <CalDate>07-Mar-11</CalDate>
    <PA0>-5.137085e-02</PA0>
    <PA1>1.550601e-03</PA1>
    <PA2>7.210415e-12</PA2>
    <PTCA0>5.154159e+05</PTCA0>
    <PTCA1>2.560262e-01</PTCA1>
    <PTCA2>-8.533080e-02</PTCA2>
    <PTCB0>2.426612e+01</PTCB0>
    <PTCB1>-7.750000e-04</PTCB1>
    <PTCB2>0.000000e+00</PTCB2>
    <PTEMPA0>-7.667877e+01</PTEMPA0>
    <PTEMPA1>4.880376e+01</PTEMPA1>
    <PTEMPA2>-4.555938e-01</PTEMPA2>
    <POFFSET>0.000000e+00</POFFSET>
    <PRANGE>1.000000e+03</PRANGE>
  </Calibration>
  <Calibration format = 'VOLT0' id = 'Volt 0'>
    <OFFSET>0.000000e+00</OFFSET>
    <SLOPE>1.260977e+00</SLOPE>
  </Calibration>
  <Calibration format = 'VOLT0' id = 'Volt 1'>
    <OFFSET>-4.728750e-02</OFFSET>
    <SLOPE>1.259474e+00</SLOPE>
  </Calibration>
  <Calibration format = 'VOLT0' id = 'Volt 2'>
    <OFFSET>-4.715313e-02</OFFSET>
    <SLOPE>1.259946e+00</SLOPE>
  </Calibration>
  <Calibration format = 'VOLT0' id = 'Volt 3'>
    <OFFSET>-4.772396e-02</OFFSET>
    <SLOPE>1.260486e+00</SLOPE>
  </Calibration>
  <Calibration format = 'VOLT0' id = 'Volt 4'>
    <OFFSET>-4.765417e-02</OFFSET>
    <SLOPE>1.260014e+00</SLOPE>
  </Calibration>
  <Calibration format = 'VOLT0' id = 'Volt 5'>
    <OFFSET>-4.744167e-02</OFFSET>
    <SLOPE>1.260255e+00</SLOPE>
  </Calibration>
  <Calibration format = 'FREQ0' id = 'external frequency channel'>
    <EXTFREQSF>1.000000e+00</EXTFREQSF>
  </Calibration>
</CalibrationCoefficients>

```

[#iiTCalDate=]
 [#iiTA0=]
 [#iiTA1=]
 [#iiTA2=]
 [#iiTA3=]
 [#iiTOffset=]

[#iiCCalDate=]
 [#iiCG=]
 [#iiCH=]
 [#iiCI=]
 [#iiCJ=]
 [#iiCPCor=]
 [#iiCTCor=]
 [#iiCSlope=]

[#iiPCalDate=]
 [#iiPA0=]
 [#iiPA1=]
 [#iiPA2=]
 [#iiPTCA0=]
 [#iiPTCA1=]
 [#iiPTCA2=]
 [#iiPTCB0=]
 [#iiPTCB1=]
 [#iiPTCB2=]
 [#iiPTempA0=]
 [#iiPTempA1=]
 [#iiPTempA2=]
 [#iiPOffset= (decibars)]
 [#iiPRange= (psia)]

[#iiVOffset0=]
 [#iiVSlope0=]

[#iiVOffset1=]
 [#iiVSlope1=]

[#iiVOffset2=]
 [#iiVSlope2=]

[#iiVOffset3=]
 [#iiVSlope3=]

[#iiVOffset4=]
 [#iiVSlope4=]

[#iiVOffset5=]
 [#iiVSlope5=]

[#iiExtFreqSF=]

Status Commands (*continued*)**#iiGetEC**

Get and display event counter data, which can help to identify root cause of a malfunction. Event counter records number of occurrences of common timeouts, power-on resets, etc. Can be cleared with **#iiResetEC**. Possible events that may be logged include:

- Power fail – main batteries and/or external voltage below voltage cutoff
- EEPROM read or EEPROM write – all power removed (main batteries removed, and back-up lithium batteries are dead)
- Alarm short – woke up 16plus-IM V2 to send a command while logging
- Alarm long – sent **#iiStartLater**, but **#iiStartDateTime=** is more than 1 month in future
- AD7730 timeout – response from temperature and pressure A/D converter delayed; typically if woke up to send a command while logging
- AD7714 timeout – response from voltage channel A/D converter delayed; typically if woke up to send a command while logging
- FLASH out of memory – all available memory space is used; autonomous sampling continues, but no additional data written to FLASH (does not overwrite)
- FLASH correctable error – single bit error in a page, corrects itself, does not affect data
- FLASH ECC error – does not affect data
- FLASH timeout – problem with FLASH
- FLASH ready – problem with FLASH; timeout error
- FLASH erase failed – problem with FLASH
- FLASH write failed – problem with FLASH
- FLASH uncorrectable – problem with FLASH; 2 or more bits of errors in a page
- FLASH block overrun – problem with FLASH
- New bad block – problem with FLASH; FLASH write or erase failed, or a FLASH uncorrectable error

Example 16plus-IM V2 with ID=01 (user input in bold, command used to modify parameter in parentheses)

```
#01getec
<EventCounters DeviceType = 'SBE16plus-IM' SerialNumber = '01606001'>
  <EventSummary numEvents = '1' />
  <Event type='alarm short' count='1' />
</EventCounters>
```

[can clear with **#iiResetEC**]

#iiResetEC

Delete all events in event counter (number of events displays in **#iiGetSD** response, and event details display in **#iiGetEC** response).

Status Commands (continued)**#iiGetHD**

Get and display hardware data, which is fixed data describing 16plus-IM V2:

- Device type, Serial number
- Manufacturer
- Firmware version
- Firmware date
- Command set version
- PCB serial number and assembly number
- Manufacture date
- Internal sensor types and serial numbers
- External voltage sensor types (DO, fluorometer, etc.) and serial numbers
- External RS-232 sensor types (SBE 38, ET Labs, etc.) and serial numbers

Note:

External sensor types and serial numbers can be changed in the field, to accommodate changes in auxiliary sensors cabled to the 16plus-IM V2. Other hardware data is typically not changed by the user.

Example: 16plus-IM V2 with ID=01 (user input in bold, command used to modify parameter in parentheses)

#01gethd

```
<HardwareData DeviceType = 'SBE16plus-IM' SerialNumber = '01600003'>
  <Manufacturer>Sea-Bird Electronics, Inc.</Manufacturer>
  <FirmwareVersion>2.3</FirmwareVersion>
  <FirmwareDate>21 March 2011 15:00</FirmwareDate>
  <CommandSetVersion>2.1</CommandSetVersion>
  <PCBAssembly PCBSerialNum = 'not assigned' Version = '41054F' />
  <PCBAssembly PCBSerialNum = 'not assigned' Version = '41580' />
  <PCBAssembly PCBSerialNum = 'not assigned' Version = '41056E' />
  <PCBAssembly PCBSerialNum = 'not assigned' Version = '41059D' />
  <MfgDate>03 march 2011</MfgDate>
  <InternalSensors>
    <Sensor id = 'Main Temperature'>
      <type>temperature0</type>
      <SerialNumber>01606003</SerialNumber>
    </Sensor>
    <Sensor id = 'Main Conductivity'>
      <type>conductivity-0</type>
      <SerialNumber>01606003</SerialNumber>
    </Sensor>
    <Sensor id = 'Main Pressure'>
      <type>strain-0</type>
      <SerialNumber>2580011</SerialNumber>
    </Sensor>
  </InternalSensors>
  <ExternalSensors>
    <Sensor id = 'volt 0'>
      <type>not assigned</type>
      <SerialNumber>not assigned</SerialNumber>
    </Sensor>
    <Sensor id = 'volt 1'>
      <type>not assigned</type>
      <SerialNumber>not assigned</SerialNumber>
    </Sensor>
    <Sensor id = 'volt 2'>
      <type>not assigned</type>
      <SerialNumber>not assigned</SerialNumber>
    </Sensor>
    <Sensor id = 'volt 3'>
      <type>not assigned</type>
      <SerialNumber>not assigned</SerialNumber>
    </Sensor>
    <Sensor id = 'volt 4'>
      <type>not assigned</type>
      <SerialNumber>not assigned</SerialNumber>
    </Sensor>
    <Sensor id = 'volt 5'>
      <type>not assigned</type>
      <SerialNumber>not assigned</SerialNumber>
    <Sensor id = 'serial'>
      <type>not assigned</type>
      <SerialNumber> not assigned </SerialNumber>
    </Sensor>
  </ExternalSensors>
</HardwareData>
```

[#iiSetPcbSerialNum1=, #iiSetPCBAssembly1=]
 [#iiSetPcbSerialNum2=, #iiSetPCBAssembly2=]
 [#iiSetPcbSerialNum3=, #iiSetPCBAssembly3=]
 [#iiSetPcbSerialNum4=, #iiSetPCBAssembly4=]
 [#iiSetMfgDate=]

[#iiPType=]

[#iiSetVoltType0=]
 [#iiSetVoltSN0=]

[#iiSetVoltType1=]
 [#iiSetVoltSN1=]

[#iiSetVoltType2=]
 [#iiSetVoltSN2=]

[#iiSetVoltType3=]
 [#iiSetVoltSN3=]

[#iiSetVoltType4=]
 [#iiSetVoltSN4=]

[#iiSetVoltType5=]
 [#iiSetVoltSN5=]

[#iiSetSerialType=]
 [#iiSetSerialSN=]

Status Commands (*continued*)**Notes:**

- The **#iiDS** response contains similar information as the combined responses from **#iiGetSD** and **#iiGetCD**, but in a different format.
- If configured with a pump, sending **#iiDS** causes the pump to turn on for a moment, so that the 16plus-IM V2 can measure and output the pump current. Because the pump is designed to be water lubricated, you will hear a noise when the impeller spins in air. Running the pump *dry* for such a **short** time will not harm the pump.
- In the example below, only voltage channel 0 is enabled, so external voltage current `iext2345=` (for channels 2, 3, 4, and 5) is not shown.
- In the example below, no RS-232 sensor is enabled, so RS-232 sensor current `iserial=` is not shown.
- If the 16plus-IM V2 is set up for dual GTDs, the **#iiDS** shows:
Dual Gas Tension Device = Yes
- If the 16plus-IM V2 is set up with a WET Labs ECO-FL fluorometer with Bio-Wiper (**#iiBiowiper=Y**), the **#iiDS** reply shows: `wait 4 seconds for biowiper to close` before it measures the enabled external voltage currents.

#iiDS

Display operating status and setup parameters.

List below includes, where applicable, command used to modify parameter.

- Firmware version, serial number, date and time [**DateTime=** or **#iiDateTime=**]
- Voltages and currents (main and back-up lithium battery voltages; currents – operating, pump, external voltage sensors, RS-232 sensor)
- Logging status (not logging, logging, waiting to start at . . ., or unknown status)
- Number of samples and available sample space in memory
- Sample interval [**#iiSampleInterval=**] and number of measurements to take and average per sample [**#iiNCycles=**]
- Integration time [**#iiParosIntegration=**] (only appears if pressure sensor = quartz with temp comp)
- Pump turn-on parameter [**#iiPumpMode=**], and turn-on delay [**#iiDelayBeforeSampling=**]
- Battery cut-off voltage
- Internally mounted pressure sensor type [**#iiPType=**] and range [**#iiPRange=**]
- Sample RS-232 sensor - SBE 38 secondary temperature sensor [**#iiSBE38=**], SBE 50 pressure sensor [**#iiSBE50=**], WET Labs [**#iiWetLabs=**], Optode [**#iiOptode=**], Gas Tension Device or Dual Gas Tension Devices [**#iiGTD=** or **#iiDualGTD=**]?
- Sample external voltages 0, 1, 2, 3, 4, and 5? [**#iiVolt0=** through **#iiVolt5=**]
- Output format [**#iiOutputFormat=**]
- Output salinity [**#iiOutputSal=**], sound velocity [**#iiOutputSV=**], and sample number [**#iiOutputSampleNumber=**] with each sample? (only if output format = converted decimal or converted XML UVIC)
- Output sigma-t, voltage, and current with each sample [**#iiOutputUCSD=**]? (only if output format = converted decimal or converted XML UVIC; and if set to Y)

Example: 16plus-IM V2 with ID=01 (user input in bold, command used to modify parameter in parentheses)

#01DS

```
SBE 16plus-IM V 2.3 SERIAL NO. 0001 01 Jul 2011 14:02:13 [ #iiDateTime= ]
vbatt = 9.6, vlith = 8.5, ioper = 61.2 ma, ipump = 25.5 ma
iext01 = 78.4 ma
status = not logging
samples = 0, free = 3870479
sample interval = 15 seconds, number of measurements per sample = 1 [ #iiSampleInterval=, #iiNCycles= ]
run pump during sample, delay before sampling = 2.0 seconds [ #iiPumpMode=, #iiDelayBeforeSampling= ]
pressure sensor = strain gauge, range = 1000.0 [ #iiPType=, #iiPRange= ]
SBE 38=no, SBE 50=no, WETLABS = no, OPTODE=no, Gas Tension Device=no
[ #iiSBE38=, #iiSBE50=, #iiWetLabs=, #iiOptode=, #iiGTD=, #iiDualGTD= ]
Ext Volt 0=yes, Ext Volt 1=no, [ #iiVolt0= and #iiVolt1= ]
Ext Volt 2=no, Ext Volt 3=no, [ #iiVolt2= and #iiVolt3= ]
Ext Volt 4 = no, Ext Volt 5 = no [ #iiVolt4= and #iiVolt5= ]
output format = raw HEX [ #iiOutputFormat= ]
```

Status Commands (continued)**Notes:**

- The **#iiDCal** and **#iiGetCC** responses contain the same information, but in different formats.
- Dates shown are when calibrations were performed.

#iiDCal

Display calibration coefficients, which are initially factory-set and should agree with Calibration Certificates shipped with 16plus-IM V2.

Example: 16plus-IM V2 with ID=01 with internally mounted strain gauge pressure sensor (user input in bold, command used to modify coefficient in parentheses).

#01dcal

```
SBE 16plus-IM V 2.3 SERIAL NO. 0001 24 Jul 2011 14:46:05
temperature: 20-mar-11
  TA0 = -3.178124e-06
  TA1 = 2.751603e-04
  TA2 = -2.215606e-06
  TA3 = 1.549719e-07
  TOFFSET = 0.000000e+00
conductivity: 20-mar-11
  G = -9.855242e-01
  H = 1.458421e-01
  I = -3.290801e-04
  J = 4.784952e-05
  CPCOR = -9.570000e-08
  CTCOR = 3.250000e-06
  CSLOPE = 1.000000e+00
pressure S/N 2580011, range = 2000 psia: 14-mar-11
  PA0 = 0.000000e+00
  PA1 = 0.000000e+00
  PA2 = 0.000000e+00
  PTEMPA0 = 0.000000e+00
  PTEMPA1 = 0.000000e+00
  PTEMPA2 = 0.000000e+00
  PTCA0 = 0.000000e+00
  PTCA1 = 0.000000e+00
  PTCA2 = 0.000000e+00
  PTCB0 = 0.000000e+00
  PTCB1 = 0.000000e+00
  PTCB2 = 0.000000e+00
POFFSET = 0.000000e+00
volt 0: offset = 0.000000e+00, slope = 1.000000e+00
volt 1: offset = 0.000000e+00, slope = 1.000000e+00
volt 2: offset = 0.000000e+00, slope = 1.000000e+00
volt 3: offset = 0.000000e+00, slope = 1.000000e+00
volt 4: offset = 0.000000e+00, slope = 1.000000e+00
volt 5: offset = 0.000000e+00, slope = 1.000000e+00
EXTFREQSF = 1.000000e+00
```

```
[#iiDateTime=]
[#iiTCalDate=]
  [#iiTA0=]
  [#iiTA1=]
  [#iiTA2=]
  [#iiTA3=]
  [#iiTOffset=]
[#iiCCalDate=]
  [#iiCG=]
  [#iiCH=]
  [#iiCI=]
  [#iiCJ=]
  [#iiCPCor=]
  [#iiCTCor=]
  [#iiCSlope=]
[#iiPRange= (psia), #iiPCalDate=]
  [#iiPA0=]
  [#iiPA1=]
  [#iiPA2=]
  [#iiPTempA0=]
  [#iiPTempA1=]
  [#iiPTempA2=]
  [#iiPTCA0=]
  [#iiPTCA1=]
  [#iiPTCA2=]
  [#iiPTCB0=]
  [#iiPTCB1=]
  [#iiPTCB2=]
  [#iiPOffset= (decibars)]
[#iiVOffset0=, #iiVSlope0=]
[#iiVOffset1=, #iiVSlope1=]
[#iiVOffset2=, #iiVSlope2=]
[#iiVOffset3=, #iiVSlope3=]
[#iiVOffset4=, #iiVSlope4=]
[#iiVOffset5=, #iiVSlope5=]
[#iiExtFreqSF=]
```

General Setup Commands

#iiDateTime=
mmddyyyyhhmmss Set real-time clock month, day, year, hour, minute, second.

Example: Set current date and time for 16plus-IM V2 with ID=01 to 05 October 2011 12:05:00 (user input in bold).

#01DATETIME=10052011120500

#iiOutputExecutedTag=x **x=Y:** Display XML Executing and Executed tags (*default*). Executed tag displays at end of each command response; Executing tag displays one or more times if 16plus-IM V2 response to command requires additional time.
x=N: Do not.

Example: Set 16plus-IM V2 with ID=01 to output Executed and Executing tags (user input in bold).

#01outputexecutedtag=y
 <Executed/>**#01getcd**
 (**#iiGetCD** response)
 <Executed/>

Notes:

- Pump operation is affected by both **#iiPumpMode=** and **#iiDelayBeforeSampling=**. See *Pump Operation*.
- **#iiPumpMode=**, **#iiNCycles=**, **#iiParosIntegration=**, and **#iiDelayBeforeSampling=** affect the time required to sample. If the time required to sample is too high, the 16plus-IM V2 is unable to take the required number of measurements and do the calculations within **#iiSampleInterval=**. See *Sample Timing* in *Section 2: Description of SBE 16plus-IM V2*.

#iiPumpMode=x **x=0:** No pump.
x=1: Run pump for 0.5 seconds before each sample (typical for pumping through conductivity cell only, with no auxiliary sensors connected to plumbing).
x=2: Run pump during each sample (typical for pumping through conductivity cell and in-line auxiliary sensor).

#iiNCycles=x **x=** number of measurements to take and average for each sample. Range 1 – 100; *default 1*. 16plus-IM V2 takes and averages **#iiNCycles=** measurements (each 0.25 seconds apart). For autonomous sampling; averaged data is stored in FLASH memory.

General Setup Commands (*continued*)

Notes:

- When **#iiInitLogging** or **#iiSampleNumber=** are sent, the 16plus-IM V2 responds that it is initializing logging.
- **Do not initialize logging until all data has been uploaded.** These commands do not delete data; they reset the data pointer. **If you accidentally initialize logging before uploading**, recover data as follows:
 1. Set **#iiSampleNumber=a** and **#iiHeaderNumber=b**, where **a** and **b** are your estimate of number of samples and headers in memory.
 2. Upload data. If **a** is more than actual number of samples or **b** is more than actual number of headers in memory, data for non-existent samples/headers will be bad, random data. Review uploaded data file carefully and delete any bad data.
 3. If desired, increase **a** and/or **b** and upload data again, to see if there is additional valid data in memory.

#iiInitLogging

Initialize logging - after all previous data has been uploaded, initialize logging before starting to log again to make entire memory available for recording. **#iiInitLogging** sets sample number (**#iiSampleNumber=**) and header number (**#iiHeaderNumber=**) to 0 (sampling will start with sample 1 and header 1). If not set to 0, data will be stored after last recorded sample. **Do not send #iiInitLogging until all existing data has been uploaded.**

#iiSampleNumber=x

x= sample number for last sample in memory. Typically only used to recover data if you accidentally initialize logging (using **#iiInitLogging**) before uploading all existing data. **Do not send #iiSampleNumber=0 until all existing data has been uploaded.**

#iiHeaderNumber=x

x= header number for last header in memory. Typically only used to recover data if you accidentally initialize logging (using **#iiInitLogging** or **#iiSampleNumber=0**) before uploading all existing data. 16plus-IM V2 can have a maximum of 1000 stored headers. Note that 16plus-IM V2 writes a new header each time autonomous sampling is started and after every 2000 samples are stored in memory.

Note:

If an ECO-FL with Bio-Wiper is installed and **#iiBiowiper=N**, sending **#iiGetSD** or **#iiDS** will open the Bio-Wiper, but not provide enough powered time to close it again. If you then deploy the instrument with the Bio-Wiper open and with a delayed start time, it may become fouled because the Bio-Wiper will remain open until the first sample is completed.

#iiBiowiper=x

x=Y: Configuration includes WET Labs ECO-FL fluorometer with Bio-Wiper (voltage *or* RS-232 auxiliary sensor). With this setup, 16plus-IM V2 is powered longer for **#iiGetSD** and **#iiDS**, providing sufficient time for Bio-Wiper to open and then shut again if Bio-Wiper is set up to take 1 measurement for each sample (see *Application Note 72*).

x=N (default): No ECO-FL with Bio-Wiper.

Pressure Sensor Setup Commands

Notes:

- **Do not send #iiPType= unless all previous data has been uploaded from memory.** When #iiPType= is sent, the 16plus-IM V2 responds that it is initializing logging.
- The 16plus-IM V2 configuration (.xmlcon or .con) file must match the #iiPType= selection of internally mounted pressure sensor when processing uploaded data. View and edit the configuration file in SBE Data Processing. #iiPType= is factory-set to match the ordered configuration.

#iiPType=x

Internally mounted pressure sensor type (set at factory):

x=0: No internally mounted pressure sensor.

x=1: Strain gauge.

x=3: Quartz with temperature compensation.

#iiRefPress=x

x= reference pressure (gauge) in decibars to use if 16plus-IM V2 does not include internally mounted pressure sensor; 16plus-IM V2 uses reference pressure in conductivity, salinity, and sound velocity calculation. Value entered for #iiRefPress= is displayed in #iiGetCD and #iiDS responses if 16plus-IM V2 does not include internally mounted pressure sensor. Entry ignored if 16plus-IM V2 includes internally mounted pressure sensor. If 16plus-IM V2 interfaces with an SBE 50 pressure sensor, it does **not** use SBE 50 data in conductivity, salinity, and sound velocity calculation.

Notes:

- The 16plus-IM V2 does the integration for the Quartz pressure sensor *after* #iiNCycles= measurements have been taken.
- #iiPumpMode=, #iiNCycles=, #iiParosIntegration=, and #iiDelayBeforeSampling= affect the time required to sample. If the time required to sample is too high, the 16plus-IM V2 is unable to take the required number of measurements and do the calculations within #iiSampleInterval=. See *Sample Timing* in Section 2: Description of SBE 16plus-IM V2.

#iiParosIntegration=x

x= integration time for optional internally mounted Quartz pressure sensor (not applicable for strain gauge pressure sensor). Range 1 – 600 seconds; default 1 second. Increasing integration time increases resolution. See *Specifications* in Section 2: Description of SBE 16plus-IM V2 to determine resolution for Quartz pressure sensor.

Voltage Sensor Setup Commands

Notes:

- Do not send #iiVolt0 = through #iiVolt5= unless all previous data has been uploaded from memory. When one of these commands is sent, the 16plus-IM V2 responds that it is initializing logging.
- The 16plus-IM V2 configuration (.xmlcon or .con) file must match this selection of number of external voltages when processing uploaded data. View and edit the configuration file in SBE Data Processing. These parameters are factory-set to match the ordered instrument configuration.
- External voltage numbers 0, 1, 2, 3, 4, and 5 correspond to wiring of sensors to a voltage channel on the 16plus-IM V2 end cap (see *Dimensions and End Cap Connectors* in Section 2: *Description of 16plus-IM V2*). However, in the .xmlcon or .con file, voltage 0 is the first external voltage in the data stream, voltage 1 is the second, etc.

Notes:

- Set **RelayMax=** (time SIM waits for reply from 16plus-IM V2 before it times out) longer than **#iiDelayBeforeSampling=**.
- Set **liiWait=** longer than (10 sec + **#iiDelayBeforeSampling=**).
- **#iiPumpMode=**, **#iiNCycles=**, **#iiParosIntegration=**, and **#iiDelayBeforeSampling=** affect the time required to sample. If the time required to sample is too high, the 16plus-IM V2 is unable to take the required number of measurements and do the calculations within **#iiSampleInterval=**. See *Sample Timing* in Section 2: *Description of SBE 16plus-IM V2*.
- Pump operation is affected by both **#iiDelayBeforeSampling=** and **#iiPumpMode=**. See *Pump Operation*.
- **#iiDelayBeforeSampling=** does not apply to the RS-232 Aanderaa Optode, because turning on power to the Optode causes it to sample. The 16plus-IM V2 turns on power to the Optode when the 16plus-IM V2 is ready to acquire Optode data.

#iiVolt0=x

x=Y: Enable external voltage 0.
x=N: Do not enable external voltage 0.

#iiVolt1=x

x=Y: Enable external voltage 1.
x=N: Do not enable external voltage 1.

#iiVolt2=x

x=Y: Enable external voltage 2.
x=N: Do not enable external voltage 2.

#iiVolt3=x

x=Y: Enable external voltage 3.
x=N: Do not enable external voltage 3.

#iiVolt4=x

x=Y: Enable external voltage 4.
x=N: Do not enable external voltage 4.

#iiVolt5=x

x=Y: Enable external voltage 5.
x=N: Do not enable external voltage 5.

Example: Enable voltage sensors wired to channels 0 and 3 on end cap; ID=01 (user input in bold).

```
#01VOLT0=Y
#01VOLT1=N
#01VOLT2=N
#01VOLT3=Y
#01VOLT4=Y
#01VOLT5=Y
```

There will be 2 external sensor voltages in data stream. In .xmlcon or .con file (in SBE Data Processing), indicate 2 external voltage channels. Voltage 0 corresponds to sensor wired to external voltage channel 0; voltage 1 corresponds to sensor wired to external voltage channel 3.

#iiDelayBeforeSampling=x

x= time (seconds) to wait after switching on external voltages and RS-232 sensors before sampling (0-600 seconds). **Default 0 seconds.** Typical value if using:

- SBE 43 oxygen sensor – time is dependent on membrane thickness and water temperature (see *Pump Operation*). Use with **#iiPumpMode=2**.

- Beckman- or YSI-type oxygen sensor – 120 to 180 seconds required to provide time for sensor to polarize. Use with **#iiPumpMode=2**.

- Sea Tech fluorometer - 15 seconds required to provide time for sensor to stabilize.

RS-232 Sensor Setup Commands**Notes:**

- **Do not send #iiSBE38=, #iiSBE50=, #iiGTD=, #iiDualGTD=, or #iiOptode= unless all previous data has been uploaded from memory.** When one of these commands is sent, the 16plus-IM V2 responds that it is initializing logging.
- The 16plus-IM V2 configuration (.xmlcon or .con) file must match this selection of RS-232 sensor when processing uploaded data. View and edit the configuration file in SBE Data Processing. These parameters are factory-set to match the ordered instrument configuration.
- See the appropriate sensor manual for command details for the RS-232 instruments.

The 16plus-IM V2 can interface with one of the following RS-232 instruments (connected to the 4-pin *Auxiliary RS-232 Input* bulkhead connector on the 16plus-IM V2 end cap):

- SBE 38 secondary temperature sensor,
- SBE 50 pressure sensor
- WET Labs single, dual, or triple channel ECO sensor; WETStar; or C-Star
- Pro-Oceanus Gas Tension Devices (up to two GTDs can be integrated)
- Aanderaa Oxygen Optode 4330 or 4835

Setup for SBE 38:

Set up SBE 38 to interface with SBE 16plus-IM V2, **before** you connect it to 16plus-IM V2. Connect SBE 38 directly to computer, power with an external power supply, and (using SEATERM or Seaterm232) set:

- **Baud rate** to 1200 (**Baud=1200**)
- **Interface** to RS-232 (**Interface=232**)
- **Sampling** to begin when power applied (**AutoRun=Y**)
- **Output** to converted data (**Format=C**)

Connect SBE 38 to SBE 16plus-IM V2 *Auxiliary RS-232 Input* connector, using provided cable. In the 16plus-IM V2, set **#iiSBE38=Y** to enable interface.

#iiSBE38=x

x=Y: Enable SBE 38 secondary temperature sensor.

x=N: Do not enable SBE 38.

Setup for SBE 50:

Set up SBE 50 to interface with SBE 16plus-IM V2, **before** you connect it to 16plus-IM V2. Connect SBE 50 directly to computer, power with an external power supply, and (using SEATERM or Seaterm232) set:

- **Baud rate** to 1200 (**Baud=1200**).
- **Output** to converted data in psia, decibars, meters, or feet (**OutputFormat= 1, 2, 3, 4, 5, or 6**).

Note: **If you will be using SBE Data Processing**, you **must** set the SBE 50 format to psia (**OutputFormat=1**)

Connect SBE 50 to SBE 16plus-IM V2 *Auxiliary RS-232 Input* connector, using provided cable. In the 16plus-IM V2, set **#iiSBE50=Y** to enable interface.

#iiSBE50=x

x=Y: Enable SBE 50 pressure sensor.

x=N: Do not enable SBE 50.

RS-232 Sensor Setup Commands (*continued*)**Note:**

The 16plus-IM V2 sample interval (**#iiSampleInterval=**) must be greater than or equal to the sum of the times required to sample. Total time is affected by the following:

- Minimum time required for 16plus V2 to take a sample (≈ 2.5 sec).
- Time required for integration of optional Quartz pressure sensor (**#iiParosIntegration=**).
- Time required for 16plus V2 to take and average **#iiNCycles=** samples; samples are taken 0.25 sec apart.
- Delay after providing power to external sensors before sampling (**#iiDelayBeforeSampling=**); *minimum #iiDelayBeforeSampling= is 2 sec if using a WET Labs RS-232 sensor.*
- Time required to run pump before sampling (0.5 sec if **#iiPumpMode=1**).

Setup for WET Labs Sensor

(*single, dual, or triple ECO Sensor; WETStar, or C-Star*):

- **16plus-IM V2 #iiDelayBeforeSampling=** must be ≥ 2 sec if using a WET Labs RS-232 sensor. If **#iiWetLabs=Y** and **#iiDelayBeforeSampling** < 2 sec, 16plus-IM V2 automatically sets **#iiDelayBeforeSampling=2**.

Note that the SBE 16plus-IM V2 stores and outputs 6 bytes of WET Labs RS-232 data for each sample. If integrating an ECO Triplet, each sensor of the Triplet uses 2 bytes (for a total of 6 bytes). If integrating a dual ECO sensor (such as the FLNTU), the first 4 bytes contain the sensor data; the remaining 2 bytes are 0's. For single WET Labs RS-232 sensors, the first 2 bytes contain the sensor data; the remaining 4 bytes are 0's.

#iiWetLabs=x

x=Y: Enable WET Labs RS-232 sensor.

x=N: Do not enable WET Labs RS-232 sensor.

RS-232 Sensor Setup Commands (*continued*)**Note:**

The 16plus-IM V2 sample interval (**#iiSampleInterval=**) must be greater than or equal to the sum of the times required to sample. Total time is affected by the following:

- **Programmable pressure integration time for GTD.**
- **Programmable temperature integration time for GTD.**
- Minimum time required for 16plus-IM V2 to take a sample (≈ 2.5 sec).
- Time required for integration of optional Quartz pressure sensor (**#iiParosIntegration=**).
- Time required for 16plus-IM V2 to take and average **#iiNCycles=** samples; samples are taken 0.25 sec apart.
- Delay after providing power to external sensors before sampling (**#iiDelayBeforeSampling=**).
- Time required to run pump before sampling (0.5 sec if **#iiPumpMode=1**).

Setup for GTD:

Set up GTD to interface with SBE 16plus-IM V2, **before** you connect it to 16plus-IM V2. Connect GTD directly to computer, power with an external power supply, and (using software provided by Pro-Oceanus) set:

- **Baud rate** to 1200.
- **Output** to millibars.
- Sum of **pressure integration time** and **temperature integration time** so that the GTD responds to a *take pressure reading* command in 40 seconds or less (required so that 16plus-IM V2 does not *time out* while waiting for reply).

Connect GTD to SBE 16plus-IM V2 *Auxiliary RS-232 Input* connector, using provided cable (end labeled *Pro-Oceanus* to GTD and end labeled *Sea-Bird* to 16plus-IM V2). In the 16plus-IM V2, set:

- **#iiGTD=Y** or **#iiDualGTD=Y** to enable interface.
- **#iiSendGTD=** to change IDs if necessary.

The 16plus-IM V2 samples the GTD last, after **#iiDelayBeforeSampling=**, and after conductivity, temperature, and pressure, and all voltage channels have been sampled. To conserve power, the voltage to any other external sensors and the pump are turned off before acquiring the GTD sample.

Each time a sample is to be taken, SBE 16plus-IM V2 sends following commands to GTD (ID= 01, 02, etc.):

- ***ID00VR** <CR><LF> - get GTD firmware version; wait up to 3 seconds for reply.
- ***ID00SN** <CR><LF> - get GTD serial number; wait up to 5 seconds for reply.
- ***9900P5** <CR><LF> - command all GTDs to sample pressure; hold data in GTD.
- ***ID00DB** <CR.<LF> - get held pressure; wait up to 90 seconds for reply.
- ***9900Q5** <CR><LF> - command all GTDs to sample temperature; hold data in GTD.
- ***ID00DB** <CR.<LF> - get held temperature; wait up to 90 seconds for reply.

#iiGTD=x

x=Y: Enable GTD.

x=N: Do not enable GTD.

#iiDualGTD=x

x=Y: Enable dual (2) GTDs.

x=N: Do not enable dual GTDs.

#iiTGTD

Measure GTD(s), output 1 sample of data from each GTD (firmware version, serial number, pressure, and temperature).

Notes:

- A 16plus-IM V2 with dual GTDs is shipped with a Y-cable installed for the GTDs. The GTD ends are labeled GTD #1 and #2, and Sea-Bird set the GTD IDs to match.
- If **#iiDualGTD=Y**, setting for **#iiGTD=** has no effect.

Example: Output GTD data for 16plus-IM V2 (ID=01) with dual GTDs (user input in bold):

```
#01TGTD
GTD#1 VR reply = *0001VR=s2.03 (GTD firmware version)
GTD#2 VR reply = *0002VR=s2.03 (GTD firmware version)
GTD#1 SN reply = *0001SN = 75524 (GTD serial number)
GTD#2 SN reply = *0002SN = 81440 (GTD serial number)
GTD#1 pressure reply = *00011010.04661, p = 101004661 (millibars x 105)
GTD#2 pressure reply = *00021010.01580, p = 101001580 (millibars x 105)
GTD#1 temperature reply = *000123.49548, t = 23.4955 (°C)
GTD#2 temperature reply = *000223.0357038, t = 23.0357 (°C)
```

RS-232 Sensor Setup Commands (*continued*)**Setup for GTD** (*continued*):

#iiSendGTD=command Command 16plus-IM V2 to send **command** to GTD and receive response; **command** can be any command recognized by GTD (see GTD manual).

Examples: (user input in bold)

Send firmware version command from 16plus-IM V2 (ID=01) to GTD #1:

```
#01SENDGTD=*0100vr
Sending GTD: **0100vr
GTD RX = *0001VR=s2.03
```

Send serial number command from 16plus-IM V2 (ID=01) to GTD #2:

```
#01SENDGTD=*0200sn
Sending GTD: **0200sn
GTD RX = *0002SN=81440
```

Notes:

- When setting up the configuration (.xmlcon or .con) file In Seasave and/or SBE Data Processing, select *Oxygen, Optode* for the Serial RS-232C sensor. Enter the serial number, calibration date, and information required for salinity and depth corrections. The *internal salinity* must match the value you programmed into the Optode (the value is ignored if you do not enable the *Salinity correction*). If you enable *Salinity correction*, our software corrects the oxygen output from the Optode based on the actual salinity (calculated from the CTD data). If you enable *Depth correction*, our software corrects the oxygen output from the Optode based on the depth (calculated from the CTD data).
- Power turn-on defined by **#iiDelayBeforeSampling=** does not apply to the RS-232 Aanderaa Optode, because turning on power to the Optode causes it to sample. The 16plus-IM V2 turns on power to the Optode when the 16plus-IM V2 is ready to acquire the Optode data, after all CTD and other external sensor data is acquired.

Setup for Aanderaa Optode:

Set up Optode to interface with 16plus-IM V2, **before** you connect it to 16plus-IM V2. Connect Optode directly to computer, power with an external power supply, and (following directions provided by Aanderaa) set:

- Communication** to RS-232.
- Sample interval** to 5.
- Output** to model number, serial number, and oxygen concentration (micromoles/liter) in decimal format. Disable all other output (air saturation, temperature, raw data, and text).

Connect Optode to SBE 16plus-IM V2 *Auxiliary RS-232 Input* connector. In 16plus-IM V2, set **#iiOptode=Y** to enable interface.

#iiOptode=x **x=Y:** Enable RS-232 Optode.
 x=N: Do not enable Optode.

Output Format Setup Commands

See *Data Format* after the command descriptions for complete details on all formats.

Note:

Output format does not affect how data is stored in FLASH memory. Sea-Bird's data processing software (SBE Data Processing) requires data in raw hexadecimal (**#iiOutputFormat=0**).

Typical use of the output format command is:

- Before beginning logging, set the output format to converted decimal (**#iiOutputFormat=3**) for ease in viewing data in SeatermIM (if you will be transmitting occasional data samples while logging).
- After stopping sampling, use SeatermIM's Upload menu to upload data from memory. This automatically uploads the data in raw hex (regardless of the **#iiOutputFormat=** setting), so the data is compatible with SBE Data Processing for processing and with Seasave for viewing archived data.

#iiOutputFormat=x

x=0: Output raw frequencies and voltages in hexadecimal; required for data that will be processed with Sea-Bird software. When using SeatermIM's Upload menu, SeatermIM sends **#iiOutputFormat=0**, causing 16plus-IM V2 to upload data in memory in raw hex, regardless of user-programmed **#iiOutputFormat=**.

x=1: Output converted (engineering units) data in hexadecimal.

x=2: Output raw frequencies and voltages in decimal.

x=3: Output converted (engineering units) data in decimal.

x=4: Not a valid output format.

x=5: Output converted (engineering units) data in decimal, in XML.

#iiOutputSal=x

x=Y: Calculate and output salinity (psu). Only applies if **#iiOutputFormat=3** or **5**.

x=N: Do not.

#iiOutputSV=x

x=Y: Calculate and output sound velocity (m/sec), using Chen and Millero formula (UNESCO Technical Papers in Marine Science #44). Only applies if **#iiOutputFormat=3** or **5**.

x=N: Do not.

#iiOutputUCSD=x

x=Y: Calculate and output density sigma-t (kg/m^3), battery voltage, and operating current (mA) with data polled while logging. Voltage and current measured after delay before sampling, but before sampling. Only applies if **#iiOutputFormat=3** or **5**.

x=N: Do not.

Note:

#iiOutputSampleNumber=Y could be used to verify that logging is occurring at the correct rate. For example, while logging:

1. Send **#iiSL**.
2. After some interval, send **#iiSL** again. Compare change in output sample numbers to expected change based on **#iiSampleInterval=**.

#iiOutputSampleNumber=x

x=Y: Output 6-character sample number (number of samples in memory at time sample was taken) with data from **Dataii**, **!iiData**, **#iiSL**, **#iiSLT**, **#iiTS**, and **#iiTSS**. Only applies if **#iiOutputFormat=3** or **5**.

x=N: Do not.

Autonomous Sampling (logging) Commands**Notes:**

- In SeatermIM, to save data to a file (if you will be transmitting occasional data samples while logging), click the Capture menu before beginning logging.
- If the FLASH memory is filled to capacity, data sampling continues, but excess data is not saved in memory. **The 16plus-IM V2 will not overwrite data stored in memory.**
- If the maximum number of headers is reached but there is still room for samples in FLASH memory, the 16plus-IM V2 continues to sample and store sample data in FLASH memory without writing additional headers.
- If the 16plus-IM V2 is sampling and the voltage is less than the cut-off voltage (7.5 volts), the 16plus-IM V2 halts logging and displays
WARNING: LOW BATTERY
VOLTAGE.

Note:

#iiPumpMode=, **#iiNCycles=**, **#iiParosIntegration=**, and **#iiDelayBeforeSampling=** affect the time required to sample. If the time required to sample is too high, the 16plus-IM V2 is unable to take the required number of measurements and do the calculations within **#iiSampleInterval=**. See *Sample Timing* in *Section 2: Description of SBE 16plus-IM V2*.

Notes:

- After receiving **#iiStartLater**, the 16plus-IM V2 displays *waiting to start at ...* in reply to **#iiGetSD** or **#iiDS**. Once logging has started, the reply displays *logging*.
- If the delayed start time has already passed when **#iiStartLater** is received, 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 16plus-IM V2 assumes that the user made an error in setting the delayed start date and time, and it executes **#iiStartNow**.

Notes:

- You may need to send **#iiStop** several times to get the 16plus-IM V2 to respond.
- You must stop logging before uploading data.

Autonomous sampling commands direct the 16plus-IM V2 to sample at a pre-programmed interval. When commanded to start sampling with **#iiStartNow** or **#iiStartLater**, the 16plus-IM V2 takes samples, stores the data in its FLASH memory, and enters quiescent (sleep) state between samples.

To start sampling, use **#iiStartNow**; sampling starts **#iiSampleInterval=** seconds after receipt of **#iiStartNow**. Alternatively, use **#iiStartDateTime=** and **#iiStartLater** to start sampling at a designated date and time. The first time sampling starts after receipt of the initialize logging command (**#iiInitLogging**), data recording starts at the beginning of memory and any previously recorded data is written over. When **#iiStop** is sent, recording stops. Each time **#iiStartNow** or **#iiStartLater** is sent again, recording continues, with new data stored after the previously recorded data. A new header is written each time logging starts and every 2000 samples thereafter. A maximum of 1000 headers can be written.

The 16plus-IM V2 responds only to **#iiGetCD**, **#iiGetSD**, **#iiGetCC**, **#iiGetEC**, **#iiResetEC**, **#iiGetHD**, **#iiDS**, **#iiDCal**, **#iiTS**, **#iiSL**, **#iiSLT**, **#iiGetLastSamples:x**, and **#iiStop** while logging or waiting to start logging. If you wake the 16plus-IM V2 (for example, to send **#iiDS** to check logging progress), it temporarily stops sampling. Sampling resumes when the Acquisition microcontroller goes back to sleep (as soon as it finishes processing the command).

#iiSampleInterval=x x= interval (seconds) between samples
(10 – 14,400 seconds).

*Example: If **#iiSampleInterval=10** and **#iiNCycles=4**, every 10 seconds 16plus-IM V2 takes 4 samples (each 0.25 seconds apart), averages data from 4 samples, and stores averaged data in FLASH memory.*

#iiStartNow Start autonomous sampling now.

#iiStartDateTime=
mmddyyhhmmss Set delayed start month, day, year, hour, minute, second.

#iiStartLater Start autonomous sampling at time set with **#iiStartDateTime=**. If you need to change 16plus-IM V2 setup after **#iiStartLater** has been sent (but before logging has started), send **#iiStop**, change setup as desired, and then send **#iiStartLater** again.

Example: Program 16plus-IM V2 with ID=01 to start logging on 20 January 2011 12:00:00 (user input in bold).
#01STARTDATETIME=01202011120000
#01STARTLATER

#iiStop Stop autonomous sampling or stop waiting to start autonomous sampling (if **#iiStartLater** was sent but sampling has not begun yet). Connect to 16plus-IM V2 (*Connect* in SeatermIM's Communications menu) before sending **#iiStop**.

Polled Sampling Commands

Note:

The 16plus-IM V2 has a buffer that stores the most recent data sample. Unlike data in the FLASH memory, data in the buffer is erased upon removal or failure of power.

These commands request a single sample (with the exception of **#iiGetLastSamples:x**). The 16plus-IM V2 always stores data for the most recent sample in its buffer. Some Sampling commands also store data in FLASH memory - the 16plus-IM V2 will not execute the *store data in FLASH memory* portion of those commands while sampling autonomously.

#iiSL	Output last sample from buffer (sample obtained with polled sampling command, or latest sample from logging).
#iiSLT	Output last sample from buffer, then take new sample and store data in buffer. Data is not stored in FLASH memory.
#iiTS	Take new sample, store data in buffer, and output data. Data is not stored in FLASH memory.
#iiTSS	Take new sample, store data in buffer and FLASH memory , and output data.
#iiGetLastSamples:x	Output last x samples from FLASH memory. If x is greater than the number of samples in memory, 16plus-IM V2 outputs all samples in memory. If x is omitted, 16plus-IM V2 outputs just the last sample. You do not need to stop logging (#iiStop) before sending #iiGetLastSamples:x.

Data Upload Commands

Stop sampling autonomously (send **#iiStop**) before uploading data. If manually sending a data upload command, data is uploaded in the format defined by **#iiOutputFormat=**.

Notes:

- The uploaded data format is the same, regardless of the choice of upload telemetry (IM or RS-232).
- **Use SeatermIM's or Seaterm232's Upload menu to upload data that will be processed by SBE Data Processing.** Manually entering a data upload command does not produce data with the required header information for processing by our software. These commands are included here for reference for users who are writing their own software.
- **If not using the Upload menu -** To save data to a file, click the Capture menu before entering a data upload command.
- See *Data Format* after these *Command Descriptions*.

Upload data using one of these telemetry methods:

- **RS-232 (serial mode)** - Much faster upload (up to 115,200 baud) is available in serial mode; however, you must open the 16plus-IM V2 housing to access the internal RS-232 serial connector. When using RS-232 telemetry, select *SBE 16plus V2 RS232* in SeatermV2's Instrument menu; this launches **Seaterm232**.
Note: When uploading in Seaterm232, the Upload Data dialog box allows you to select *Text* or *Binary* as the Upload format. However, **Binary is not compatible** with the 16plus-IM V2.
- **Inductive modem** – Data can be uploaded while the 16plus-IM V2 is deployed, or is wired in the lab as shown in *Test Setup with SIM* or *Test Setup with IMM* in *Section 3: Preparing 16plus-IM V2 for Deployment*. Upload speed is limited by the baud rate between the 16plus-IM V2 and IMM/SIM, which is 1200 baud.

#iiGetSamples:b,e or **#iiDDb,e** Upload data from sample **b** to sample **e**. If **b** and **e** are omitted, all data is uploaded. First sample is number 1.

Examples: 16plus-IM V2 with ID=01, upload samples 1-1000 to a file (user input in bold):
(Click Capture menu and enter desired filename in dialog box.)

#01GETSAMPLES:1,1000

or

#01DD1,1000

#iiGetHeaders:b,e or **#iiDHb,e** Upload header **b** to header **e** (a maximum of 500 headers can be uploaded at one time). If **b** and **e** are omitted, the first 500 headers are uploaded. First header number is 1. Header includes:

- header number
- month, day, hour, minute, and second when header was written
- first and last sample for header
- interval between samples (**#iiSampleInterval=**)
- reason logging was halted (batfail = battery voltage too low; stop cmd = received **#iiStop** or Home or Ctrl Z character; timeout = error condition; unknown = error condition; ?????? = error condition)

Example: 16plus-IM V2 with ID=01, upload second header to a file (user input in bold):
(Click Capture menu and enter desired filename in dialog box.)

#01GETHEADERS:2,2

or

#01DH2,2

16plus-IM V2 responds:

hdr 2 30 Aug 2011 12:30:33 samples 35 to 87, int=60, stop=stop cmd

Testing Commands

The 16plus-IM V2 takes and outputs **30 samples** for each test (except as noted); data is **not** stored in FLASH memory.

Note:
If your 16plus-IM V2 includes an optional pump:
 Testing commands do not automatically turn the pump on. Thus, for instruments plumbed with the pump, they report data from essentially the same sample of water for all 30 measurements, because the pump does not run but the pump and associated plumbing prevent water from freely flowing through the conductivity cell and other plumbed sensors (for example, dissolved oxygen sensor). To get data from fresh samples, send **#iiPumpOn** before sending a testing command, and then send **#iiPumpOff** when the test is complete.

- #iiTC Measure conductivity, output converted data.
- #iiTCR Measure conductivity, output raw data.
- #iiTT Measure temperature, output converted data.
- #iiTTR Measure temperature, output raw data.
- #iiTP Measure internally mounted pressure (strain gauge or Quartz), output converted data.
- #iiTPR Measure internally mounted pressure (strain gauge or Quartz), output raw data.
- #iiTV Measure 6 external voltage channels, output converted data.
- #iiTVR Measure voltages read by A/D converter, output raw data:

Column	Output
1 – 6	External voltages
7	Main battery voltage / 11
8	Back-up lithium battery voltage / 3.741
9	External current / 333.33
10	Pressure temperature voltage

- #iiTF Measure frequency (internally mounted Quartz pressure sensor), output converted data.
- #iiTFR Measure frequency (internally mounted Quartz pressure sensor), output raw data.
- #iiT38 Measure SBE 38 (secondary temperature), output converted data.
- #iiT50 Measure SBE 50 pressure, output converted data.

Testing Commands *continued***TWetLabs**

Measure WET Labs RS-232 sensor. Output varies, depending on sensor type.

ECO triple sensor:

Column	Output
1 – 2	Date and time
3	Wavelength sensor 1
4	Raw signal counts sensor 1
5	Wave length sensor 2
6	Raw signal counts sensor 2
7	Wave length sensor 3
8	Raw signal counts sensor 3
9	Thermistor counts

ECO dual sensor:

Column	Output
1 – 2	Date and time
3	Wavelength sensor 1
4	Raw signal counts sensor 1
5	Wave length sensor 2
6	Raw signal counts sensor 2
7	Thermistor counts

ECO single sensor:

Column	Output
1 – 2	Date and time
3	Wavelength sensor 1
4	Raw signal counts sensor 1
5	Thermistor counts

WETStar: Counts***C-Star:***

Column	Output
1	Sensor serial number
2	Reference counts
3	Signal counts
4	Corrected signal raw counts
5	Calculated beam c, inverse meters
6	Internal thermistor, counts

#iiTOptode

Measure Aanderaa Optode, output product number, serial number, and dissolved oxygen (micromoles/liter).

#iiPumpOn

Turn pump on for testing purposes. Use this command:

- Before sending testing command to obtain pumped data from sensors plumbed with the pump, or
- To test pump.

#iiPumpOff

Turn pump off for testing purposes.

Calibration Coefficients Commands

Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with the 16plus-IM V2.

Notes:

- F = floating point number
S = string with no spaces
- If using an SBE 38 secondary temperature sensor or SBE 50 pressure sensor, its calibration coefficients are not stored in the 16plus-IM V2 EEPROM. View and/or modify the instrument's calibration coefficients by connecting the instrument to the computer directly and using SEATERM or Seaterm232.

Temperature

#iiTCalDate=S	S=calibration date
#iiTA0=F	F=A0
#iiTA1=F	F=A1
#iiTA2=F	F=A2
#iiTA3=F	F=A3
#iiTOffset=F	F=offset correction

Conductivity

#iiCCalDate=S	S=calibration date
#iiCG=F	F=G
#iiCH=F	F=H
#iiCI=F	F=I
#iiCJ=F	F=J
#iiCPCor=F	F=pcor
#iiCTCor=F	F=tcor
#iiCSlope=F	F=slope correction

Internally Mounted Pressure - General

#iiPCalDate=S	S=calibration date
#iiPRange=F	F=sensor full scale range (psia)
#iiPOffset=F	F=offset correction (decibars)

Internally Mounted Strain Gauge Pressure

#iiPA0=F	F=A0
#iiPA1=F	F=A1
#iiPA2=F	F=A2
#iiPTempA0=F	F=pressure temperature A0
#iiPTempA1=F	F=pressure temperature A1
#iiPTempA2=F	F=pressure temperature A2
#iiPTCA0=F	F=pressure temperature compensation ptca0
#iiPTCA1=F	F=pressure temperature compensation ptca1
#iiPTCA2=F	F=pressure temperature compensation ptca2
#iiPTCB0=F	F=pressure temperature compensation ptcb0
#iiPTCB1=F	F=pressure temperature compensation ptcb1
#iiPTCB2=F	F=pressure temperature compensation ptcb2

Internally Mounted Quartz Pressure

#iiPC1=F	F=C1
#iiPC2=F	F=C2
#iiPC3=F	F=C3
#iiPD1=F	F=D1
#iiPD2=F	F=D2
#iiPT1=F	F=T1
#iiPT2=F	F=T2
#iiPT3=F	F=T3
#iiPT4=F	F=T4
#iiPSlope=F	F=slope correction

External Frequency

#iiExtFreqSF=F	F=external frequency scale factor (applies to Quartz pressure sensor)
----------------	---

Voltage Channels

The following commands set voltage channel offsets and slopes **at the factory**. These are properties of the 16plus-IM V2's electronics, and are not calibration coefficients for the auxiliary sensors. These commands are included here for completeness, **but should never be used by the customer**.

#iiVOffset0=	#iiVSlope0=
#iiVOffset1=	#iiVSlope1=
#iiVOffset2=	#iiVSlope2=
#iiVOffset3=	#iiVSlope3=
#iiVOffset4=	#iiVSlope4=
#iiVOffset5=	#iiVSlope5=

Note:

If using auxiliary A/D sensors (**#iiVolt0=** through **#iiVolt5=**), their calibration coefficients are not stored in the 16plus-IM V2 EEPROM, but are stored in the 16plus-IM V2 configuration (.xmlcon or .con) file. View and/or modify the calibration coefficients using the Configure menu in SBE Data Processing.

Hardware Configuration Commands

The following commands are used to set manufacturing date, PCB serial numbers, PCB assembly numbers, and auxiliary channel sensor types (description such as *oxygen*, *fluorometer*, etc.) and serial number.

Factory Settings – do not modify in the field

```
#iiSetMfgDate=  
#iiSetPcbSerialNum1=  
#iiSetPcbSerialNum2=  
#iiSetPcbSerialNum3=  
#iiSetPcbSerialNum4=  
#iiSetPcbAssembly1=  
#iiSetPcbAssembly2=  
#iiSetPcbAssembly3=  
#iiSetPcbAssembly4=
```

Auxiliary Voltage Sensor Settings – can be modified in the field to accommodate changes in auxiliary voltage sensors cabled to the 16plus-IM V2

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

Auxiliary RS-232 Sensor Settings – can be modified in the field to accommodate changes in auxiliary RS-232 sensors cabled to the 16plus-IM V2

```
#iiSetSerialType=  
#iiSetSerialSN=
```

Data Format

Note:

For the date and time output with the data, time is the time at the **start** of the sample, after:

- a small amount of time (1 to 2 seconds) for the 16*plus*-IM V2 to wake up and prepare to sample, and
- any programmed **#iiDelayBeforeSampling=**.

For example, if the 16*plus*-IM V2 is programmed to wake up and sample at 12:00:00, and

#iiDelayBeforeSampling=20, the output time for the first sample will be 12:00:21 or 12:00:22.

The SBE 16*plus*-IM V2 stores data in a compact machine code. Data is converted and output in the user-selected format without affecting data in memory. Because memory data remains intact until deliberately overwritten, you can upload in one format, then choose another format and upload again.

Output format is dependent on **#iiOutputFormat= (0, 1, 2, 3, or 5)** and on the command used to retrieve the data, as detailed below. The inclusion of some data is dependent on system configuration - if the system does not include the specified sensor, the corresponding data is not included, shortening the data string. RS-232 sensors always output data in the same format, regardless of **#iiOutputFormat=**:

- SBE 38, SBE 50, GTD, and Optode data is always output in engineering units.
- WET Labs RS-232 sensor data is always output in raw counts.

#iiOutputFormat=0 (raw frequencies and voltages in Hex)

Data is output in the order listed, with no spaces or commas between parameters. Shown with each parameter is the number of digits, and how to calculate the parameter from the data (use the decimal equivalent of the hex data in the equations).

Uploaded Data (from #iiGetSamples:b,e, #iiDDb,e, or Upload menu) or Polled Data (from #iiSL, #iiSLT, #iiTS, or #iiTSS):**Notes:**

- When using SeatermIM's Upload menu, SeatermIM sends **#iiOutputFormat=0**. This causes the 16plus-IM V2 to upload data in memory in raw hex, regardless of the user-programmed format, providing the data in a format that SBE Data Processing can use.
- Our software uses the equations shown to perform these calculations; alternatively, you can use the equations to develop your own processing software.
- The pressure sensor is an absolute sensor, so its **raw** output includes the effect of atmospheric pressure (14.7 psi). As shown on the Calibration Sheet, Sea-Bird's calibration (and resulting calibration coefficients) is in terms of psia. However, when outputting pressure in **engineering units**, the 16plus-IM V2 outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). The 16plus-IM V2 uses the following equation to convert psia to decibars:
pressure (db) =
[pressure (psia) - 14.7] * 0.689476
- SBE 50 units are dependent on **OutputFormat=** programmed into the SBE 50; if you will be using SBE Data Processing, you must set the SBE 50 format to psia (**OutputFormat=1**).

1. Temperature A/D counts = ttttt
2. Conductivity frequency (Hz) = cccccc / 256
3. (if #iiPType=1) Internally mounted strain gauge pressure sensor pressure A/D counts = pppppp
4. (if #iiPType=1) Internally mounted strain gauge pressure sensor pressure temperature compensation voltage = vvvv / 13,107
5. (if #iiPType=3) Internally mounted Quartz pressure sensor pressure frequency (Hz) = pppppp / 256
6. (if #iiPType=3) Internally mounted Quartz pressure sensor temperature compensation voltage = vvvv / 13,107
7. (if #iiVolt0=Y) External voltage 0 = vvvv / 13,107
8. (if #iiVolt1=Y) External voltage 1 = vvvv / 13,107
9. (if #iiVolt2=Y) External voltage 2 = vvvv / 13,107
10. (if #iiVolt3=Y) External voltage 3 = vvvv / 13,107
11. (if #iiVolt4=Y) External voltage 4 = vvvv / 13,107
12. (if #iiVolt5=Y) External voltage 5 = vvvv / 13,107
13. (if #iiSBE38=Y) SBE 38 secondary temperature (°C, ITS-90)
= (ttttt / 100,000) - 10
14. (if #iiSBE50=Y) SBE 50 pressure (decibars, psia, meters, or feet)
= (pppppp / 10,000) - 100
15. (if #iiWetLabs=Y) WET Labs RS-232 sensor = wwwwwwxyyyy
where wwww, 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
16. (if #iiGTD=Y or #iiDualGTD=Y)
GTD #1 pressure (millibars) = pppppppp / 100,000
17. (if #iiGTD=Y or #iiDualGTD=Y)
GTD #1 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
18. (if #iiDualGTD=Y)
GTD #2 pressure (millibars) = pppppppp / 100,000
19. (if #iiDualGTD=Y)
GTD #2 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
20. (if #iiOptode=Y)
Optode oxygen (micromoles/liter) = (oooooo / 10,000) - 10
21. Time
seconds since January 1, 2000 = sssssss

Example: 16plus-IM V2 with strain gauge pressure sensor and 2 external voltages sampled,
example scan = tttttccceceppppvvvvvvvvvvvsssssss
= 0A53711BC7220C14C17D82030505940EC4270B

- Temperature = ttttt = 0A5371 (676721 decimal);
temperature A/D counts = 676721
- Conductivity = 1BC722 (1820450 decimal);
conductivity frequency = 1820450 / 256 = 7111.133 Hz
- Internally mounted strain gauge pressure = pppppp = 0C14C1 (791745 decimal);
Strain gauge pressure A/D counts = 791745
- Internally mounted strain gauge temperature compensation =
vvvv = 7D82 (32,130 decimal);
Strain gauge temperature = 32,130 / 13,107 = 2.4514 volts
- First external voltage = vvvv = 0305 (773 decimal);
voltage = 773 / 13,107 = 0.0590 volts
- Second external voltage = vvvv = 0594 (1428 decimal);
voltage = 1428 / 13,107 = 0.1089 volts
- Time = sssssss = 0EC4270B (247,736,075 decimal)
seconds since January 1, 2000 = 247,736,075

Polled Data from Dataii or !iiData:

Data is preceded by the 16plus-IM V2 two-character decimal ID and a comma.
The rest of the data stream is as described above.

Example: 16plus-IM V2 with strain gauge pressure sensor and 2 external voltages sampled.

DATA01

01, 0A53711BC7220C14C17D82030505940EC4270B

Same as example above, but hex data stream is preceded by 16plus-IM V2 ID (01).

#iiOutputFormat=1 (engineering units in Hex)

Data is output in the order listed, with no spaces or commas between the parameters. Shown with each parameter is the number of digits, and how to calculate the parameter from the data (use the decimal equivalent of the hex data in the equations).

Uploaded Data (from #iiGetSamples:b,e or #iiDDB,e) or Polled Data (from #iiSL, #iiSLT, #iiTS, or #iiTSS):

1. Temperature (°C, ITS-90) = (ttttt / 100,000) - 10
2. Conductivity (S/m) = (ccccc / 1,000,000) - 1
3. (strain gauge or Quartz) - #iiPType=1 or 3)
Internally mounted pressure (decibars) = (pppppp / 1,000) - 100
4. (if #iiVolt0=Y) External voltage 0 = vvvv / 13,107
5. (if #iiVolt1=Y) External voltage 1 = vvvv / 13,107
6. (if #iiVolt2=Y) External voltage 2 = vvvv / 13,107
7. (if #iiVolt3=Y) External voltage 3 = vvvv / 13,107
8. (if #iiVolt4=Y) External voltage 4 = vvvv / 13,107
9. (if #iiVolt5=Y) External voltage 5 = vvvv / 13,107
10. (if #iiSBE38=Y)
SBE 38 secondary temperature (°C, ITS-90) = (ttttt / 100,000) - 10
11. (if #iiSBE50=Y)
SBE 50 pressure (decibars, psia, meters, or feet) = (pppppp / 10,000) - 100
12. (if #iiWetLabs=Y) WET Labs RS-232 sensor = wwwwwwxyyyy
where wwww, 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
13. (if #iiGTD=Y or #iiDualGTD=Y)
GTD #1 pressure (millibars) = pppppppp / 100,000
14. (if #iiGTD=Y or #iiDualGTD=Y)
GTD #1 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
15. (if #iiDualGTD=Y)
GTD #2 pressure (millibars) = pppppppp / 100,000
16. (if #iiDualGTD=Y)
GTD #2 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
17. (if #iiOptode=Y)
Optode oxygen (micromoles/liter) = (oooooo / 10,000) - 10
18. Time
seconds since January 1, 2000 = ssssssss

Note:

SBE 50 units are dependent on **OutputFormat=** programmed into the SBE 50.

Example: 16plus-IM V2 with strain gauge pressure sensor and 2 external voltages sampled,
example scan = tttttccccppppppvvvvvvvsssssss = 3385C40F42FE0186DE030505940EC4270B

- Temperature = ttttt = 3385C4 (3376580 decimal); temperature (°C, ITS-90) = (3376580 / 100,000) - 10 = 23.7658
- Conductivity = ccccc = 0F42FE (1000190 decimal); conductivity (S/m) = (1000190 / 1,000,000) - 1 = 0.00019
- Internally mounted pressure = pppppp = 0186DE (100062 decimal); pressure (decibars) = (100062 / 1,000) - 100 = 0.062
- First external voltage = vvvv = 0305 (773 decimal); voltage = 773 / 13,107 = 0.0590 volts
- Second external voltage = vvvv = 0594 (1428 decimal); voltage = 1428 / 13,107 = 0.1089 volts
- Time = ssssssss = 0EC4270B (247,736,075 decimal); seconds since January 1, 2000 = 247,736,075

Polled Data from Dataii or !iiData:

Data is preceded by the 16*plus*-IM V2 two-character decimal ID and a comma.
The rest of the data stream is as described above.

Example: 16*plus*-IM V2 with strain gauge pressure sensor and 2 external voltages sampled.

DATA01

01, 3385C40F42FE0186DE0305059425980600

Same as example above, but hex data stream is preceded by 16*plus*-IM V2 ID (01).

#iiOutputFormat=2 (raw frequencies and voltages in decimal)

Data is output in the order listed, with a comma followed by a space between each parameter. Shown with each parameter are the number of digits and the placement of the decimal point. Leading zeros are suppressed, except for one zero to the left of the decimal point.

Uploaded Data (from #iiGetSamples:b,e or #iiDDB,e) or Polled Data (from #iiSL, #iiSLT, #iiTS, or #iiTSS):

1. Temperature A/D counts = ttttt
2. Conductivity frequency (Hz) = cccc.ccc
3. (if #iiPType=1) Internally mounted strain gauge pressure sensor pressure A/D counts = pppppp
4. (if #iiPType=1) Internally mounted strain gauge pressure sensor temperature compensation voltage = v.vvvv
5. (if #iiPType=3) Internally mounted Quartz pressure frequency (Hz) = ppppp.ppp
6. (if #iiPType=3) Internally mounted Quartz pressure sensor temperature compensation voltage = v.vvvv
7. (if #iiVolt0=Y) External voltage 0 = v.vvvv
8. (if #iiVolt1=Y) External voltage 1 = v.vvvv
9. (if #iiVolt2=Y) External voltage 2 = v.vvvv
10. (if #iiVolt3=Y) External voltage 3 = v.vvvv
11. (if #iiVolt4=Y) External voltage 4 = v.vvvv
12. (if #iiVolt5=Y) External voltage 5 = v.vvvv
13. (if #iiSBE38=Y) SBE 38 secondary temperature (°C, ITS-90) = ttt.ttt
14. (if #iiSBE50=Y) SBE 50 pressure (decibars, psia, meters, or feet) = pppp.ppp
15. (if #iiWetLabs=Y) WET Labs RS-232 sensor = wwww, xxxx, yyyy where wwww, 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
16. (if #iiGTD=Y or #iiDualGTD=Y) GTD #1 pressure GTD #1 pressure (millibars) = pppppppp / 100,000
17. (if #iiGTD=Y or #iiDualGTD=Y) GTD #1 temperature (°C, ITS-90) = tt.ttt
18. (if #iiDualGTD=Y) GTD #2 pressure (millibars) = pppppppp / 100,000
19. (if #iiDualGTD=Y) GTD #2 temperature (°C, ITS-90) = tt.ttt
20. (if #iiOptode=Y) Optode oxygen (micromoles/liter) = oooo.ooo
21. Time date, time = dd Mmm yyyy, hh:mm:ss (day month year hour:minute:second)

Note:

SBE 50 units are dependent on **OutputFormat=** programmed into the SBE 50.

Example: 16plus-IM V2 with strain gauge pressure sensor and 2 external voltages sampled, example scan = 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 Nov 2007, 07:34:35

- Temperature = ttttt = 676721; temperature A/D counts = 676721
- Conductivity = cccc.ccc = 7111.133; conductivity frequency = 7111.133 Hz
- Internally mounted strain gauge pressure = pppppp = 791745; Strain gauge pressure A/D counts = 791745
- Internally mounted strain gauge temperature compensation = v.vvvv = 2.4514; Strain gauge temperature = 2.4514 volts
- First external voltage = v.vvvv = 0.0590; voltage = 0.0590 volts
- Second external voltage = v.vvvv = 0.1089; voltage = 0.1089 volts
- Date, time = dd Mmm yyyy, hh:mm:ss = 7 Nov 2007, 07:34:35; Date, time = 7 November 2007, 07:34:35

Polled Data from Dataii or !iiData:

Data is preceded by the 16*plus*-IM V2 two-character decimal ID and a comma.
The rest of the data stream is as described above.

Example: 16*plus*-IM V2 with strain gauge pressure sensor and 2 external voltages sampled.

DATA01

01, 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089, 7 Nov 2007, 07:34:35

Same as example above, but data stream is preceded by 16*plus*-IM V2 ID (01).

#iiOutputFormat=3 (engineering units in decimal)

Data is output in the order listed, with a comma followed by a space between each parameter. Shown with each parameter are the number of digits and the placement of the decimal point. Leading zeros are suppressed, except for one zero to the left of the decimal point.

Uploaded Data (from #iiGetSamples:b,e or #iiDDB,e):

1. Temperature(°C, ITS-90) = ttt.tttt
2. Conductivity (S/m) = cc.ccccc
3. (strain gauge or Quartz - #iiPType=1 or 3)
Internally mounted pressure (decibars) = pppp.ppp
4. (if #iiVolt0=Y) External voltage 0 = v.vvvv
5. (if #iiVolt1=Y) External voltage 1 = v.vvvv
6. (if #iiVolt2=Y) External voltage 2 = v.vvvv
7. (if #iiVolt3=Y) External voltage 3 = v.vvvv
8. (if #iiVolt4=Y) External voltage 4 = v.vvvv
9. (if #iiVolt5=Y) External voltage 5 = v.vvvv
10. (if #iiSBE38=Y) SBE 38 secondary temperature (°C, ITS-90) = ttt.tttt
11. (if #iiSBE50=Y)
SBE 50 pressure (decibars, psia, meters, or feet) = pppp.ppp
12. (if #iiWetLabs=Y) WET Labs RS-232 sensor = wwwww, xxxx, yyyy
where wwwww, 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
13. (if #iiGTD=Y or #iiDualGTD=Y)
GTD #1 pressure (millibars) = ppppppppp / 100,000
14. (if #iiGTD=Y or #iiDualGTD=Y)
GTD #1 temperature (°C, ITS-90) = tt.ttt
15. (if #iiDualGTD=Y)
GTD #2 pressure (millibars) = ppppppppp / 100,000
16. (if #iiDualGTD=Y)
GTD #2 temperature (°C, ITS-90) = tt.ttt
17. (if #iiOptode=Y) Optode oxygen (micromoles/liter) = oooo.ooo
18. (if #iiOutputSal=Y) Salinity (psu) = sss.ssss
19. (if #iiOutputSV=Y) Sound velocity (meters/second) = vvvv.vvv
20. Time
date, time = dd mmm yyyy, hh:mm:ss (day month year hour:minute:second)

Note:

SBE 50 units are dependent on **OutputFormat=** programmed into the SBE 50.

Example: 16plus-IM V2 with strain gauge pressure sensor and 2 external voltages sampled, example scan = 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 Nov 2007, 07:34:35

- Temperature = ttt.tttt = 23.7658; temperature (°C, ITS-90) = 23.7658
- Conductivity = cc.ccccc = 0.00019; conductivity (S/m) = 0.00019
- Internally mounted pressure = pppp.ppp = 0.062; pressure (decibars) = 0.062
- First external voltage = v.vvvv = 0.0590; voltage = 0.0590 volts
- Second external voltage = v.vvvv = 0.1089; voltage = 0.1089 volts
- Date, time = dd mmm yyyy, hh:mm:ss = 7 Nov 2007, 07:34:35
Date, time = 7 November 2007, 07:34:35

Polled Data from #iiSL, #iiSLT, #iiTS, or #iiTSS:

- If **#iiOutputUCSD=Y** and the 16plus-IM V2 is logging (autonomous sampling is in progress), data is followed by density sigma-t in kg/m³(ddd.dddd), battery voltage (vv.v), and operating current in mA (ccc.c), each separated by a comma and a space. The rest of the data stream is as described above for uploaded data.
Note: 16plus-IM V2 does not respond to **#iiTSS** while logging.
- If **#iiOutputSampleNumber=N**, data is preceded by the 16plus-IM V2 four-character serial number and a comma. The rest of the data stream is as described above for uploaded data.
- If **#iiOutputSampleNumber=Y**, data is preceded by the 16plus-IM V2 four-character serial number and a comma, and is followed at the very end (after **#iiOutputUCSD** data if applicable) by the six-character sample number (number of samples in memory at the time the sample was taken). The rest of the data stream is as described above for uploaded data.

Example: Serial number 4000 16plus-IM V2 with pressure sensor and 2 external voltages sampled, and with **#iiOutputSampleNumber=Y**. Command instrument to send output from last sample taken, which was sample 11.

#01SL

4000, 23.7658, 0.00019, 0.062, 0.0590, 0.1089, 7 Nov 2007, 07:34:35, 11

(same as example above for uploaded data, but data stream is preceded by serial number and followed by sample number)

Polled Data from Dataii or !iiData:

- If **#iiOutputUCSD=Y**, data is followed by density sigma-t in kg/m³(ddd.dddd), battery voltage (vv.v), and operating current in mA (ccc.c), each separated by a comma and a space. The rest of the data stream is as described above for uploaded data.
- If **#iiOutputSampleNumber=N**, data is preceded by the 16plus-IM V2 two-character ID and a comma and four-character serial number and a comma. The rest of the data stream is as described above for uploaded data.
- If **#iiOutputSampleNumber=Y**, data is preceded by the 16plus-IM V2 two-character ID and a comma and four-character serial number and a comma, and is followed at the very end (after **#iiOutputUCSD** data if applicable) by the six-character sample number (number of samples in memory at the time the sample was taken). The rest of the data stream is as described above for uploaded data.

Example: Serial number 4000 16plus-IM V2 with pressure sensor and 2 external voltages sampled, and with **#iiOutputSampleNumber=Y**. Command instrument to send output from last sample taken, which was sample 11.

DATA01

01, 4000, 23.7658, 0.00019, 0.062, 0.0590, 0.1089, 7 Nov 2007, 07:34:35, 11

(same as example above for uploaded data, but data stream is preceded by ID and serial number and followed by sample number)

#iiOutputFormat=5 (engineering units in decimal, in XML)**Note:**

#iiOutputFormat=5 is listed in the #iiGetCD and #iiDS response as converted XML UVIC.

Data is output in the order listed, with **no** carriage return or line feed between each parameter (however, there is a carriage return and line feed at the end of the data stream, after the </datapacket> closing tag). Shown with each parameter are the number of digits and the placement of the decimal point. Leading zeroes are suppressed, except for one zero to the left of the decimal point.

Note:

For ease in reading, the data structure is shown with each XML tag on a separate line. However, there are no carriage returns or line feeds between tags (see example below).

Uploaded Data (from #iiGetSamples:b,e or #iiDDb,e):

```
<?xml?>
<datapacket>
<hdr>
<mfg>Sea-Bird</mfg>
<model>16plus</model>
<sn>nnnn</sn>
</hdr>
<data>
<t1>ttt.tttt</t1>
<c1>cc.ccccc</c1>
<p1>pppp.ppp </p1> (if #iiPType=1 or 3)
<v0>v.vvvv</v0> (if #iiVolt0=Y)
<v1>v.vvvv</v1> (if #iiVolt1=Y)
<v2>v.vvvv</v2> (if #iiVolt2=Y)
<v3>v.vvvv</v3> (if #iiVolt3=Y)
<v4>v.vvvv</v4> (if #iiVolt4=Y)
<v5>v.vvvv</v5> (if #iiVolt5=Y)
<ser1>
<type>sbe38, sbe50, wetlabs, gtd, or optode</type> (indicates type of RS-232 sensor)
<t38>ttt.tttt</t38> (if #iiSBE38=Y)
<p2>pppp.ppp</p2> (if #iiSBE50=Y)
<w10>www</w10> (if WetLabs=Y)
<w11>xxxx</w11> (if WetLabs=Y)
<w12>yyyy</w12> (if WetLabs=Y)
<p1>pppppppp</p1> (if #iiGTD=Y or #iiDualGTD=Y)
<t1>tt.ttt</t1> (if #iiGTD=Y or #iiDualGTD=Y)
<p2>pppppppp</p2> (if #iiDualGTD=Y)
<t2>tt.ttt</t2> (if #iiDualGTD=Y)
<oox>oooo.ooo</oox> (if #iiOptode=Y)
</ser1>
<sal>sss.ssss</sal> (if #iiOutputSal=Y)
<sv>vvvv.vvv</sv> (if #iiOutputSV=Y)
<dt>yyyy-mm-ddThh:mm:ss</dt>
<smpl>xxxxxxx</smpl> (if #iiOutputSampleNumber=Y)
</data>
</datapacket>
```

where

Serial number = nnnn

Temperature (°C, ITS-90) = ttt.ttt

Conductivity (S/m) = cc.ccccc

Internally mounted pressure (decibars) = pppp.ppp

External voltage = v.vvvv (for voltage 0, 1, 2, 3, 4, and 5)

SBE 38 temperature (°C, ITS-90) = ttt.ttt

SBE 50 pressure (decibars, psia, meters, or feet) = pppp.ppp

WET Labs

sensor 0 (raw signal counts) = wwwww

sensor 1 (raw signal counts) = xxxx (= 0 unless using dual or triple sensor)

sensor 2 (raw signal counts) = yyyy (= 0 unless using triple sensor)

GTD pressure (millibars) = ppppppppp / 100,000 (for GTD #1 and #2)

GTD temperature (°C, ITS-90) = tt.ttt (for GTD #1 and #2)

Optode oxygen (micromoles/liter) = ooooo.ooo

Salinity (psu) = sss.ssss

Sound velocity (meters/second) = vvvv.vvv

Date, time = year month day T hour:minute:second (yyyy-mm-ddThh:mm:ss)

Sample number = xxxxxxx

Note:

SBE 50 units are dependent on **OutputFormat=** programmed into the SBE 50.

Example: 16plus-IM V2 with internally mounted strain gauge pressure sensor and 2 external voltages sampled, example scan =

```
<?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><dt>2007-11-07T07:34:35</dt></data></datapacket>CRLF
```

Serial number = 1234, Temperature (°C, ITS-90) = 23.7658, Conductivity (S/m) = 0.00019, Internally mounted pressure (decibars) = 0.062, First external voltage = 0.0590 volts, Second external voltage = 0.1089 volts, and Date, time = November 7, 2007, 07:34:35

Polled Data from #iiSL, #iiSLT, #iiTS, or #iiTSS:

If #iiOutputUCSD=Y and the 16plus-IM V2 is logging (autonomous sampling is in progress), 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

operating current (mA) = ccc.c

The rest of the data stream is as described above for uploaded data.

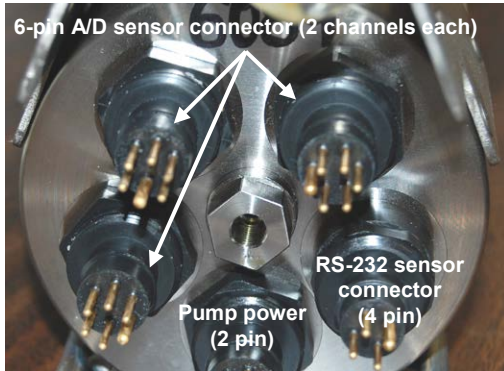
Setup for Deployment

1. Install new batteries (see *Replacing Alkaline Batteries* in *Section 5: Routine Maintenance and Calibration*) or ensure the existing batteries have enough capacity to cover the intended deployment.
2. Program the 16plus-IM V2 for the intended deployment using SeatermIM (see *Section 3: Preparing for Deployment* for connection information; see this section for setup/configuration, sampling modes, pump operation, and commands):
 - A. Ensure all data has been uploaded, and then send **#iiInitLogging** to make the entire memory available for recording.
If **#iiInitLogging** is not sent, data will be stored after the last recorded sample.
 - B. Set the date and time. Date and time can be set globally for all 16plus-IM V2s online (**DateTime=**) or individually for each 16plus-IM V2 (**#iiDateTime=**) To synchronize autonomous sampling for a system with multiple 16plus-IM V2s on a mooring cable, set the date and time globally, with all the 16plus-IM V2s online (see *Autonomous Sampling* for synchronization details).
 - C. Establish setup and logging parameters.
 - D. If the system will have multiple 16plus-IM V2s (or other IM instruments) on the mooring cable, verify that SeatermIM is set to *Use fixed ID* to allow use of SeatermIM's Send Commands window:
 - 1) In the Communications menu, select *Configure*.
 - 2) Click on *Use fixed ID*. Enter the 16plus-IM V2's ID.
 - 3) Click OK.
 - E. Send **#iiGetCD** or **#iiDS** to verify the setup.
 - F. Use **one** of the following sequences to initiate logging:
 - **#iiStartNow** to start logging now.
 - **#iiStartDateTime=** and **#iiStartLater** to start logging at the specified date and time.
3. If you will be using SeatermIM to view occasional data samples while logging, click the Capture menu to save the data to a file. Note that this file **cannot be processed by SBE Data Processing, as it does not have the required headers and format for Sea-Bird's processing software.**

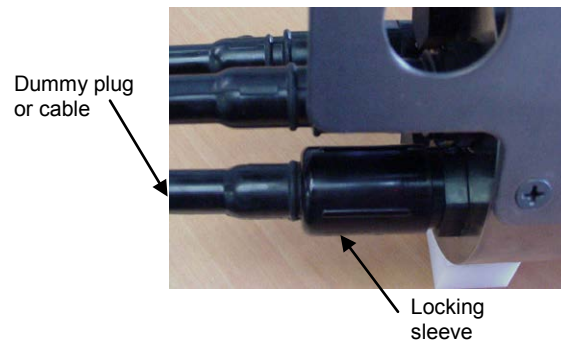
Deployment

CAUTION:

Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.

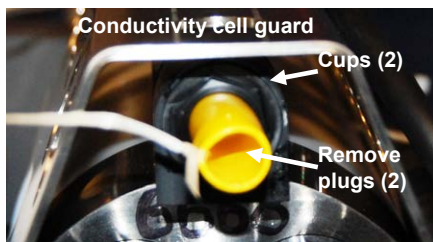


1. Install a cable or dummy plug for each connector on the 16plus-IM V2 sensor end cap:
 - A. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).
 - B. **Standard Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the 16plus-IM V2. Remove any trapped air by *burping* or gently squeezing the plug/connector near the top and moving your fingers toward the end cap. **OR**
MCBH Connector – Install the plug/cable connector, aligning the pins.
 - C. Place the locking sleeve over the plug/cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**



2. Connect the other end of the cables installed in Step 1 to the appropriate sensors.

3. As applicable, remove the plug(s) from the anti-foulant device cap(s), or remove the Tygon tubing (and associated barbed anti-foulant device caps) that is looped end-to-end around the conductivity cell (see *Conductivity Cell Maintenance* in *Section 5: Routine Maintenance and Calibration*). Verify that the two plastic cups contain AF24173 Anti-Foulant Devices (see *Section 5: Routine Maintenance and Calibration* for Anti-Foulant Device replacement). If using the 16plus-IM V2 with a pump, verify that the system plumbing is correctly installed (see *Configuration Options and Plumbing* in *Section 2: Description of SBE 16plus-IM V2*).



Mounting clamp, with opening sized to specified cable diameter – cable **clamped** by this bracket. Note: Installing clamp on larger cable than specified may cause damage to cable and/or modem and prevent IM communications.



For both mounting brackets – loosen hardware to separate bracket halves and mount on mooring cable

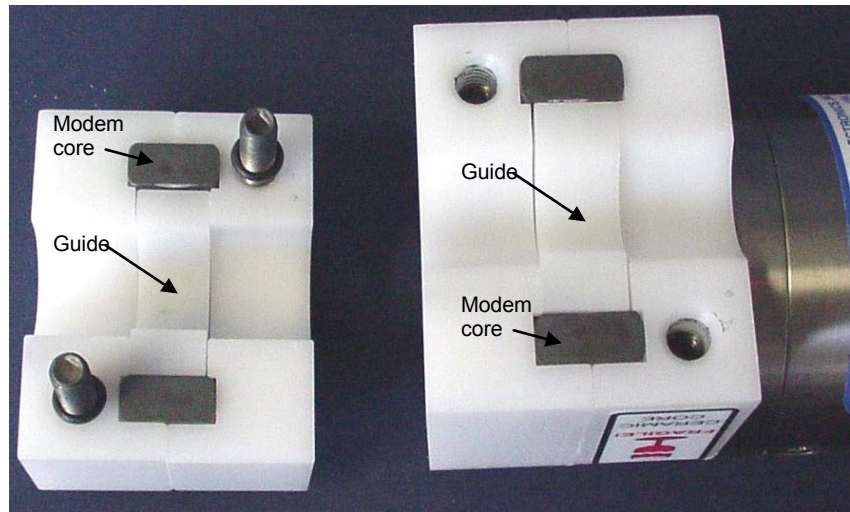
Mounting guide / inductive modem coupler – contains modem coupling toroid core. Cable goes through here but is **not clamped**, to avoid putting through tension on end cap (which could pull off end cap).

For proper communications, 2 halves of modem coupling toroid core must mate, with no gaps

4. Attach the mounting brackets to the insulated mooring cable:
 - A. Open each mounting bracket by unthreading the two large titanium hex bolts.
 - B. Place the insulated mooring cable inside the brackets' grooves.
 - C. Reinstall each bracket half with the hex bolts.
 - D. Verify that the two halves of the modem coupling toroid have come together evenly, and that the mounting clamp is secure.

5. Verify that the hardware and external fittings are secure.

Mounting guide / Inductive Modem Coupler Detail
 (Note: Photo is 37-IMP; detail similar for 16plus-IM V2)
 Guide is sized *slightly* bigger than specified cable diameter, to allow cable to pass through freely but limit vibration of 16plus-IM V2 on cable



The SBE 16plus-IM V2 is ready to go into the water.

System Installation and Wiring

For system installation and wiring details, refer to:

- *Mooring Cable and Wiring Requirements* in *Section 2: Description of SBE 16plus-IM V2*
- *Appendix IV: SIM Hookup and Configuration* or *IMM Manual*.

Installing Optional Inductive Cable Coupler (ICC)

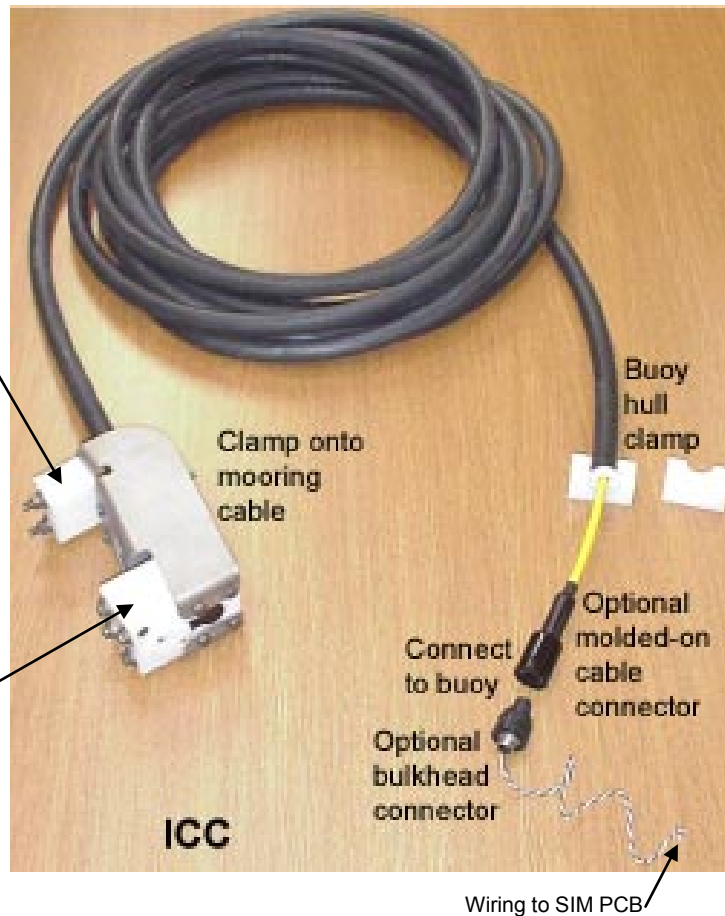
1. Loosen the titanium hex head bolts connecting the two halves of each of the ICC brackets. Pull the halves apart.
2. Place the insulated mooring cable inside the brackets' grooves.
3. Reinstall each bracket half with the hex bolts.
4. Verify that the two halves of the modem coupling toroid have come together evenly, and that the mounting clamp is secure.

Note:

See *Application Note 85: Handling of Ferrite Core on Instruments with Inductive Modem Telemetry* for more detailed information on handling and installation.

Mounting clamp, with opening sized to specified cable diameter – cable **clamped** by this bracket. Note: Installing clamp on larger cable than specified may cause damage to cable and/or modem and prevent IM communications.

Mounting guide / inductive modem coupler – contains modem coupling toroid. Cable goes through here but is **not clamped**, to avoid putting through tension on end cap (which could pull off end cap). **Detail of guide and core is similar to shown above for the 16plus-IM V2 guide and core.**



Recovery

WARNING!

If the 16plus-IM V2 stops working while underwater, is unresponsive to commands, or shows other signs of flooding or damage, carefully secure it away from people until you have determined that abnormal internal pressure does not exist or has been relieved. Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals. When a sealed pressure housing floods at great depths and is subsequently raised to the surface, water may be trapped at the pressure at which it entered the housing, presenting a danger if the housing is opened before relieving the internal pressure. Instances of such flooding are rare. However, a housing that floods at 5000 meters depth holds an internal pressure of more than 7000 psia, and has the potential to eject the end cap with lethal force. A housing that floods at 50 meters holds an internal pressure of more than 85 psia; this force could still cause injury.

If you suspect the 16plus-IM V2 is flooded, point the 16plus-IM V2 in a safe direction away from people, and loosen 1 end cap bulkhead connector very slowly, at least 1 turn. This opens an o-ring seal under the connector. Look for signs of internal pressure (hissing or water leak). If internal pressure is detected, let it bleed off slowly past the connector o-ring. Then, you can safely remove the end cap.

1. Rinse the instrument and conductivity cell with fresh water. (See *Section 5: Routine Maintenance and Calibration* for cell cleaning and storage.)
2. Reinsert the protective plugs in the anti-foulant device cups.
3. If the batteries are exhausted, new batteries must be installed before the data can be extracted. Stored data will not be lost as a result of exhaustion or removal of batteries. See *Section 5: Routine Maintenance and Calibration* for replacement of batteries.
4. If immediate redeployment is not required, it is best to leave the 16plus-IM V2 with batteries in place and in a quiescent (sleep) state (**PwrOff**). Because the quiescent current required is only 140 microamps, the batteries can be left in place without significant loss of capacity. If the 16plus-IM V2 is to be stored for a long time, **replace the batteries yearly to prevent battery leakage** (which could damage the 16plus-IM V2).

Uploading Data

Upload data using one of these telemetry methods:

Notes:

- The uploaded data format is the same, regardless of the choice of upload telemetry (IM or RS-232).
- In Seaterm232 (used to upload data in Serial Mode), the Upload Data dialog box allows you to select *Text* or *Binary* upload. **However, binary upload is not a valid selection for the 16plus-IM V2.**

- **Inductive modem** – Data can be uploaded while the SBE 16plus-IM V2 is deployed, or is wired in the lab as shown in *Test Setup with SIM* or *Test Setup with IMM* in *Section 3: Preparing for Deployment*. Upload speed is limited by the baud rate between the 16plus-IM V2 and IMM/SIM, which is 1200 baud.
- **RS-232 (Serial Mode)** – Much faster upload (up to 115,200 baud) is available in serial mode; however, you must open the 16plus-IM V2 housing and access the internal RS-232 serial connector on the electronics. When using RS-232 telemetry, select *SBE 16 V2 RS232* in SeatermV2's Instrument menu; this launches **Seaterm232**.

Each upload method is detailed separately below.

Upload Using Inductive Modem Telemetry

Note:

Data may be uploaded during deployment or after recovery. If uploading after recovery. Wire the 16plus-IM V2 and SIM or IMM as described in *Section 3: Preparing for Deployment*.

1. Double click on **SeatermV2.exe**. The main screen appears.
2. In the Instruments menu, select *SBE 16plus V2 IM*. **SeatermIM** opens.
3. SeatermIM first sends commands to determine if it is connected to a SIM or an IMM, and sends the appropriate command to wake up all IM instruments on the line. The remaining connection attempt varies, depending on the configuration setting the last time SeatermIM was used:
 - If SeatermIM was set to *Automatically get instrument ID* the last time it was used – SeatermIM sends **id?** and waits for a response from the 16plus-IM V2. Once the ID response is received, SeatermIM sends **!iIDS** and **#iiGetHD**, using the ID provided by the 16plus-IM V2.
 - If SeatermIM was set to *Use fixed ID* the last time it was used – SeatermIM sends **!iIDS** and **#iiGetHD**, using the fixed ID that was entered the last time the software was used.

SeatermIM then fills the Send Commands window with the correct list of commands for your 16plus-IM V2.

Notes:

- SeatermIM's baud rate must be the same as the IMM or SIM baud rate, as applicable. For both the SIM and the IMM, baud is factory-set to 9600, but can be changed by the user.
- Set to *Use fixed ID* to designate the appropriate 16plus-IM V2 if there are multiple 16plus-IM V2s on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16plus-IM V2 on the IM line. Note that the ID is stored in the 16plus-IM V2's EEPROM and can be changed so that multiple 16plus-IM V2s on a single IM line each have a unique ID. See the Configuration Sheet for the factory-set ID.

If there is no communication (no response to **id?** and/or no response to **!iIDS** and/or **#iiGetHD**):

- A. In the Communications menu, select *Configure*. The Configure Communications dialog box appears. Select the Comm port and baud rate for communication. Note that the factory-set baud rate is documented on the Configuration Sheet. If using a fixed ID, verify that the designated ID is correct for the 16plus-IM V2 with which you want to communicate. Click OK.
 - B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). SeatermIM will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.
 - C. If there is still no communication, check cabling between the computer, SIM or IMM, and 16plus-IM V2, and try to connect again.
 - D. If there is still no communication, repeat Step A with a different comm port and/or different fixed ID, and try to connect again.
4. If you have not already done so, command the 16plus-IM V2 to stop autonomous sampling by typing **#iiStop** (ii= 16plus-IM V2 ID) and pressing the Enter key.

Note:

You may need to send **#iiStop** several times to get the 16plus-IM V2 to respond.

5. Display 16plus-IM V2 status information by typing **#iiDS** (ii = 16plus-IM V2 ID) and pressing the Enter key. The display looks like this:

```
SBE 16plus-IM V 2.3 SERIAL NO. 0001 01 Aug 2011 14:11:48
vbatt = 10.3, vlith = 8.5, ioper = 62.5 ma, ipump = 21.6 ma,
iext01 = 76.2 ma
status = not logging
samples = 162, free = 3870317
sample interval = 15 seconds, number of measurements per sample = 2
run pump during sample, delay before sampling = 2.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38 = no, SBE 50 = no, OPTODE = no, Gas 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 = raw HEX
```

Verify that the status shows **status = not logging**.

6. Click the Upload menu to upload stored data in a form that Sea-Bird's data processing software can use. SeatermIM responds as follows:
 - A. SeatermIM sends a wake-up tone.
 - B. SeatermIM sends **#iiOutputExecutedTag=Y**, which is necessary for the upload process.
 - C. SeatermIM sends **#iiGetSD** and displays the response. **#iiGetSD** provides information on the instrument status, and the number of samples in memory.
 - D. In the Save As dialog box, enter the desired upload file name and click OK. The upload file has a .XML extension.
 - E. An Upload data dialog box appears.

Note:

SeatermIM sends a wake-up tone several times during the upload process, to ensure communications if the 16plus-IM V2 has gone to sleep.

The screenshot shows the 'Upload Data' dialog box with the following fields and options:

- Block size [bytes]:** A text box containing '800'. A callout box explains: 'Select number of bytes uploaded in each block. SeatermIM uploads data in blocks, and calculates a checksum at end of each block. If block fails checksum verification, SeatermIM tries to upload block of data again, cutting block size in half.'
- Memory summary:** A table showing:

Bytes	108
Samples	4
SamplesFree	2436964
SampleLength	27
Profiles	0
- Upload data options:** A group of radio buttons:
 - All data as a single file
 - All data separated by cast
 - By scan number range
 - By address range
 - By cast number range
 - From a single cast
- Address range:** A section with two text boxes:
 - Beginning with byte #: 0
 - Number of bytes to upload: 108
- Upload file:** A text box containing 'C:\UploadTest.xml' and a 'Browse...' button. A callout box explains: 'To change upload file name selected in Step D above, click Browse to navigate to desired upload path and name. Upload file has a .xml extension. After Seaterm232 uploads data into .xml file, it automatically converts .xml file to .hex file (same file name, different extension), which is compatible with Seasave and SBE Data Processing.'

At the bottom of the dialog are four buttons: Help, Start, Save & Exit, and Cancel.

Make the desired selections.

7. Click the Header Form tab to customize the header:

Defines header information included with uploaded data:

- Prompt for header information – As data is uploaded, user is prompted to fill out user-defined header form.
- Include default header form in upload file – User-defined default header form included in upload file. User is not prompted to add any information when data is uploaded.
- Don't include default header form in upload file – Header information not included in upload file.

The entries are free form, 0 to 12 lines long. This dialog box establishes:

- the header prompts that appear for the user to fill in when uploading data, if *Prompt for header information* was selected
- the header included with the uploaded data, if *Include default header form in upload file* was selected

Enter the desired header/header prompts.

8. Click Start; the Status bar at the bottom of the window displays the upload progress.

- SeatermIM sends a wake-up tone. It then sends **#iiGetHD** (get hardware data), **#iiGetSD** (get status data), **#iiGetCD** (get configuration data), **#iiGetCC** (get calibration coefficients), **#iiGetEC** (get event counter), and **#iiGetHeaders:b,e**, and writes the responses to the upload file. These commands provide information regarding the number of samples in memory, calibration coefficients, etc.
- If you selected *Prompt for header information in the Upload Data dialog box*** – a dialog box with the header form appears. Enter the desired header information, and click OK. SeatermIM writes the header information to the upload file.
- SeatermIM sends the data upload command, based on your selection of upload range in the Upload Data dialog box, writes the data to the upload .xml file, and then creates the .hex file from the .xml file. The .hex file contains the data in raw hexadecimal, for compatibility with SBE Data Processing and Seasave.

Note:

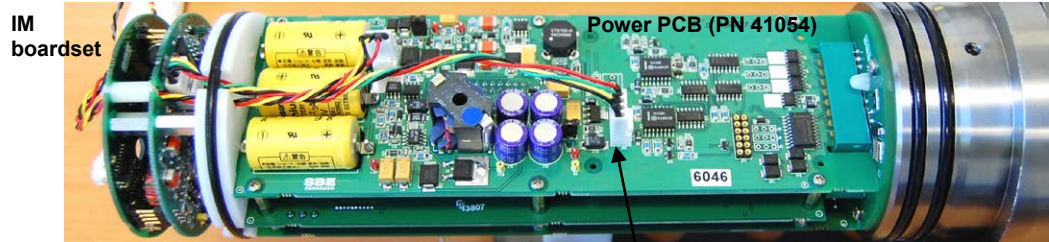
To prepare the 16plus-IM V2 for re-deployment:

1. After all data has been uploaded, send **#iilnitLogging**. If this command is not sent and logging is started, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
2. Send **PwrOff** to put the 16plus-IM V2 in quiescent (sleep) state until ready to redeploy. The quiescent current is only 140 microamps, so the batteries can be left in place without significant loss of capacity.

9. Ensure all data has been uploaded by reviewing and processing the data.
 - A. Use **Seasave** to display and plot the *raw* hexadecimal data in engineering units (see *Verifying Contents of Configuration (.xmlcon or .con) File* and Seasave manual / Help files).
 - B. Use **SBE Data Processing** to process and plot the data (see *Processing Data Using SBE Data Processing* and SBE Data Processing manual / Help files).

Upload Using RS-232 (Serial Mode) at Higher Baud Rates

1. Remove the sensor end cap and electronics from the housing (see *Appendix II: Electronics Disassembly/Reassembly* for details).
2. Unplug the IM boardset from JP6 on the PN 41054 PCB. Attach the RS-232 cable (supplied by Sea-Bird) to JP6 on the PN 41054 PCB and to the computer, using the optional data I/O cable (PN 801880).



JP6 internal RS-232 connector, for firmware update and/or fast upload. Unplug IM boardset, and connect JP6 to computer with optional data I/O cable (PN 801880).

3. Double click on **SeatermV2.exe**. The main screen appears.
4. In the Instruments menu, select *SBE 16plus V2 RS232* (not *SBE 16plus V2 IM*). **Seaterm232** opens.
5. **Seaterm232** will try to automatically connect to the 16plus-IM V2. In the Command menu, select *Abort* to interrupt the communication attempt.
6. In the Communications menu, select *Configure*. The Serial Port Configuration dialog box appears.
 - A. Select the Comm port, and select **1200** as the baud rate.
 - B. Click OK.
7. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). **Seaterm232** sends **GetHD** and displays the response. **Seaterm232** also fills the Send Commands window with the correct list of commands for your 16plus-IM V2.
8. Command the 16plus-IM V2 to stop logging by pressing the Enter key, typing **Stop**, and pressing the Enter key again.
9. Type **Baud=38400** or **Baud=115200**, and press Enter. The 16plus-IM V2 should respond:
Switching to <38400 or 115200> for 5 minutes.
10. In the Communications menu, select *Configure*. The Serial Port Configuration dialog box appears.
 - A. Select the Comm port, and select 38400 or 115200 as the baud rate (match the baud rate entered in Step 9).
 - B. Click OK.

Notes:

- The 16plus-IM V2 uses 1200 baud for IM telemetry; you must initially connect at 1200 baud using RS-232 telemetry. You can increase the baud rate once you are connected.
- You may need to send **Stop** several times to get the 16plus-IM V2 to respond.
- Check your computer's capabilities before resetting the baud. The 16plus-IM V2 will remain at the specified higher baud rate (38400 or 115200) while communicating (i.e., if you are sending commands to it, or it is responding). **After 5 minutes with no communication, the 16plus-IM V2 automatically switches back to 1200 baud.**

11. **SeatermV2** begins communicating at the new baud. Display status by typing **DS** and pressing the Enter key. The display looks like this:

```
SBE 16plus-IM V 2.3 SERIAL NO. 0001 01 Aug 2011 14:11:48
vbatt = 10.3, vlith = 8.5, ioper = 62.5 ma, ipump = 21.6 ma,
iext01 = 76.2 ma
status = not logging
samples = 162, free = 3870317
sample interval = 15 seconds, number of measurements per sample = 2
run pump during sample, delay before sampling = 2.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38 = no, SBE 50 = no, OPTODE = no, Gas 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 = raw HEX
```

Verify that the status shows **status = not logging**.

12. Click Upload to upload stored data. Seaterm232 responds as follows:
 - A. Seaterm232 sends **GetSD** and displays the response. **GetSD** provides information on the instrument status, and number of samples in memory.
 - B. Seaterm232 sends **DH** and displays the response. **DH** provides information on the headers in memory.
 - C. In the Save As dialog box, enter the desired upload file name and click OK. The upload file has a .XML extension.
 - D. An Upload Data dialog box appears:

Select to enable ASCII text. **Binary is not compatible with the 16plus-IM V2.**

Select number of bytes uploaded in each block. Seaterm232 uploads data in blocks, and calculates a checksum at end of each block. If block fails checksum verification, Seaterm232 tries to upload block of data again, cutting block size in half.

Defines data upload type and range:

- All data as a single file – All data is uploaded into 1 file.
- By scan number range – Enter beginning scan (sample) number and total number of scans. All data within range is uploaded into 1 file.
- By address range – Enter beginning byte number and total number of bytes. Note that first byte in memory is byte 0. All data within range is uploaded into 1 file.

To change upload file name selected in Step C above, click Browse to navigate to desired upload file path and name. Upload file has a .xml extension. After Seaterm232 uploads data into .xml file, it automatically converts .xml file to .hex file (same file name, different extension), which is compatible with Seasave and SBE Data Processing.

Upload Data

Upload Data
Header Form

Upload format
 Text Binary

Block size [bytes]

Upload data options
 All data as a single file
 All data separated by cast
 By scan number range
 By address range
 By cast number range
 From a single cast

Address range
 Beginning with byte #
 Number of bytes to upload

Baud rate for upload

Not applicable unless device type = SBE54.

Upload file

Memory summary

Bytes	3078
Samples	162
SamplesFree	3462898
SampleLength	19
Profiles	0

Help
Start
Save & Exit
Cancel

Make the desired selections.

13. Click the Header Form tab to customize the header:

Defines header information included with uploaded data:

- Prompt for header information – As data is uploaded, user is prompted to fill out user-defined header form.
- Include default header form in upload file – User-defined default header form included in upload file. User is not prompted to add any information when data is uploaded.
- Don't include default header form in upload file – Header information not included in upload file.

The entries are free form, 0 to 12 lines long. This dialog box establishes:

- the header prompts that appear for the user to fill in when uploading data, if *Prompt for header information* was selected
- the header included with the uploaded data, if *Include default header form in upload file* was selected

Enter the desired header/header prompts.

14. Click Start; the Status bar at the bottom of the window displays the upload progress:

- Seaterm232 sends **GetHD** (get hardware data), **GetSD** (get status data), **GetCD** (get configuration data), **GetCC** (get calibration coefficients), and **GetEC** (get event counter), and writes the responses to the upload file. These commands provide information regarding the number of samples in memory, header numbers, calibration coefficients, etc.
- If you selected *Prompt for header information* in the Upload Data dialog box** – a dialog box with the header form appears. Enter the desired header information, and click OK. Seaterm232 writes the header information to the upload file.
- Seaterm232 sends the data upload command, based on your selection of upload range in the Upload Data dialog box, writes the data to the upload .xml file, and then creates the .hex file from the .xml file. The .hex file contains the data in raw hexadecimal, for compatibility with Seasave and SBE Data Processing.
- When the data has been uploaded, Seaterm232 shows the S> prompt (if **OutputExecutedTag=N**).

15. Ensure all data has been uploaded by reviewing and processing the data:
 - A. Use **Seasave** to display and plot the *raw* hexadecimal data in engineering units (see *Verifying Contents of .xmlcon or .con File* and Seasave manual / Help files).
 - B. Use **SBE Data Processing** to process and plot the data (see *Processing Data Using SBE Data Processing* and SBE Data Processing manual / Help files).
16. Remove the PN 801880 data I/O cable from JP6 on the PN 41054 PCB. Plug the IM boardset into JP6.
17. Reinstall the electronics and sensor end cap (see *Appendix II: Electronics Disassembly/Reassembly* for details).

Note:

To prepare for re-deployment (using IM telemetry):

1. After all data has been uploaded, send **#iilnitLogging**. If this command is not sent and sampling is started, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
2. Send **PwrOff** to put the 16plus-IM V2 in quiescent (sleep) state until ready to redeploy. The quiescent current is only 140 microamps, so the batteries can be left in place without significant loss of capacity.

Processing Data Using SBE Data Processing

Notes:

- Seasave and SBE Data Processing versions 7.20a introduced .xmlcon files (in XML format). Versions 7.20a and later allow you to open a .con or .xmlcon file, and to save it to a .con or .xmlcon file. Seasave and SBE Data Processing use the same file.
- A new or recalibrated CTD ships with a configuration file that reflects the current configuration as *we know it*. The file is named with the instrument serial number, followed by a .con extension. For example, for a CTD with serial number 2375, Sea-Bird names the file *2375.con*. You may rename the file (but not the extension) if desired; this will not affect the results.
- In the 16plus-IM V2 setup commands, external voltage numbers 0, 1, 2, 3, 4, and 5 correspond to wiring of sensors to a voltage channel on the end cap (see *Dimensions and End Cap Connectors* in *Section 2: Description of SBE 16plus-IM V2*). However, in the .xmlcon or .con file, voltage 0 is the first external voltage in the data stream, voltage 1 is the second, etc.

1. Convert the .hex (raw data) file (uploaded from 16plus-IM V2 memory) to a .cnv (engineering units) file in SBE Data Processing's Data Conversion module.
2. Once the data is converted: perform further processing (remove bad data, etc.), calculate derived variables, and plot data using SBE Data Processing's other modules.

Verifying Contents of Configuration (.xmlcon or .con) File

To convert the .hex (raw data) file, you need a .xmlcon or .con configuration file, which defines the instrument – integrated sensors, and channels, serial numbers, and calibration dates and coefficients for all sensors (conductivity, temperature, and pressure as well as auxiliary sensors). SBE Data Processing uses the configuration file information to interpret and process the raw data. **If the configuration file does not match the actual instrument configuration, the software will be unable to interpret and process the data correctly.**

To view or modify the .xmlcon or .con file:

1. Double click on SBEDataProc.exe.
2. In the Configure menu, select *SBE 16plus V2 Seacat CTD*. The configuration dialog box appears. In the configuration dialog box, click Open.

- In the Open dialog box, select the .xmlcon or .con file and click Open. Verify that the sensors match those on your 16plus-IM V2, and that auxiliary sensors are assigned to the correct voltage channels. Verify that calibration coefficients for all sensors are up-to-date.

Channel/Sensor table reflects this choice (0, 1, 2, 3, 4, 5, or 6). Must agree with 16plus-IM V2 setup for #iiVoltN= (N=0, 1, 2, 3, 4, and 5); see reply from #iiGetCD or #iiDS. Voltage channel 0 in .xmlcon or .con file corresponds to first external voltage in data stream, voltage channel 1 to second, etc.

Interval between scans. Must agree with 16plus-IM V2 setup (#iiSampleInterval=); see reply from #iiGetCD or #iiDS.

Not applicable to 16plus-IM V2.

Configuration for the SBE 16plus Se

Configuration file opened: None

Pressure sensor type: Strain Gauge

External voltage channels: 2

Serial RS-232C sensor: Temperature, SBE 38

Sample interval seconds: 10

NMEA position data added

Channel	Sensor
1. Count	Temperature
2. Frequency	Conductivity
3. Count	Pressure, Strain Gauge
4. A/D voltage 0	Oxygen, SBE 43
5. A/D voltage 1	pH
6. Serial RS-232	Temperature, SBE 38

Buttons: New, Open..., Save, Save As..., Select..., Modify..., Report..., Help..., Exit, Cancel

Internally mounted pressure sensor: strain gauge, Digiquartz with temperature compensation, or none. If no pressure sensor is selected, Data button accesses dialog box to input additional parameter needed to process data. Must agree with 16plus-IM V2 setup (#iiPType=); see reply from #iiGetCD or #iiDS. Applies only to internally mounted pressure sensor; if 16plus-IM V2 has no internally mounted pressure but is interfacing with SBE 50 pressure sensor, select No pressure sensor here and then select SBE 50 in Serial RS-232C sensor field. Note: Digiquartz without temperature compensation is not applicable.

SBE 38 (secondary temperature), SBE 50 (pressure), WET Labs sensor (up to 3 channels), up to 2 GTDs (dissolved oxygen or nitrogen), or Optode. Must agree with 16plus-IM V2 setup; see reply from #iiGetCD or #iiDS. Channel/Sensor table lists RS-232 sensor below voltage channels.

Shaded sensors cannot be removed or changed to another type of sensor. All others are optional.

New to create new .xmlcon or .con file for this CTD. Open to select different .xmlcon or .con file. Save or Save As to save current .xmlcon or .con file settings.

Click a (non-shaded) sensor and click Select to pick a different sensor for that channel. A dialog box with a list of sensors appears. Select sensors after number of voltage channels have been specified above.

Click a sensor and click Modify to change calibration coefficients for that sensor.

- Click Save or Save As to save any changes to the .xmlcon or .con file. Click Exit when done reviewing / modifying the configuration.

Editing Raw Data File

Sometimes users want to edit the raw .hex data file before beginning processing, to remove data at the beginning of the file corresponding to instrument *soak* time, to remove blocks of bad data, to edit the header, or to add explanatory notes about the cast. **Editing the raw .hex file can corrupt the data, making it impossible to perform further processing using Sea-Bird software.** We strongly recommend that you first convert the data to a .cnv file (using Data Conversion in SBE Data Processing), and then use other SBE Data Processing modules to edit the .cnv file as desired.

Note:

Although we provide this technique for editing a raw .hex file, **Sea-Bird's strong recommendation, as described above, is to always convert the raw data file and then edit the converted file.**

The procedure for editing a .hex data file described below has been found to work correctly on computers running Windows 98, 2000, and NT. **If the editing is not performed using this technique, SBE Data Processing may reject the edited data file and give you an error message.**

1. Make a back-up copy of your .hex data file before you begin.
2. Run WordPad.
3. In the File menu, select Open. The Open dialog box appears. For *Files of type*, select *All Documents (*.*)*. Browse to the desired .hex data file and click Open.
4. Edit the file as desired, **inserting any new header lines after the System Upload Time line**. Note that all header lines must begin with an asterisk (*), and *END* indicates the end of the header. An example is shown below (for an SBE 21), with the added lines in bold:

```
* Sea-Bird SBE 21 Data File:
* FileName = C:\Odis\SAT2-ODIS\oct14-19\oc15_99.hex
* Software Version Seasave Win32 vl.10
* Temperature SN = 2366
* Conductivity SN = 2366
* System UpLoad Time = Oct 15 1999 10:57:19
* Testing adding header lines
* Must start with an asterisk
* Place anywhere between System Upload Time & END of header
* NMEA Latitude = 30 59.70 N
* NMEA Longitude = 081 37.93 W
* NMEA UTC (Time) = Oct 15 1999 10:57:19
* Store Lat/Lon Data = Append to Every Scan and Append to .NAV
File When <Ctrl F7> is Pressed
** Ship:          Sea-Bird
** Cruise:        Sea-Bird Header Test
** Station:
** Latitude:
** Longitude:
*END*
```

5. In the File menu, select Save (**not Save As**). If you are running Windows 2000, the following message displays:
You are about to save the document in a Text-Only format, which will remove all formatting. Are you sure you want to do this?
Ignore the message and click *Yes*.
6. In the File menu, select Exit.

Section 5: Routine Maintenance and Calibration

This section reviews:

- corrosion precautions
- connector mating and maintenance
- battery replacement
- conductivity cell storage and cleaning
- pressure sensor maintenance
- pump maintenance
- AF24173 Anti-Foulant Device replacement
- sensor calibration

The accuracy of the SBE 16plus-IM V2 is sustained by the care and calibration of the sensors and by establishing proper handling practices.

Corrosion Precautions

Rinse the SBE 16plus-IM V2 with fresh water after use and prior to storage.

For both the plastic and titanium housing, all exposed metal is titanium (the plastic housing has a titanium end cap). No corrosion precautions are required, but direct electrical connection of the titanium to dissimilar metal hardware should be avoided.

Connector Mating and Maintenance

Note:

See *Application Note 57: Connector Care and Cable Installation*.

Clean and inspect connectors, cables, and dummy plugs before every deployment and as part of your yearly equipment maintenance. Inspect connectors that are unmated for signs of corrosion product around the pins, and for cuts, nicks or other flaws that may compromise the seal.

CAUTION:

Do not use WD-40 or other petroleum-based lubricants, as they will damage the connectors.

1. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).
2. **Standard Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the 16plus-IM V2. Remove any trapped air by *burping* or gently squeezing the plug/connector near the top and moving your fingers toward the end cap. **OR**
MCBH Connector – Install the plug/cable connector, aligning the pins.
3. Place the locking sleeve over the plug/cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**

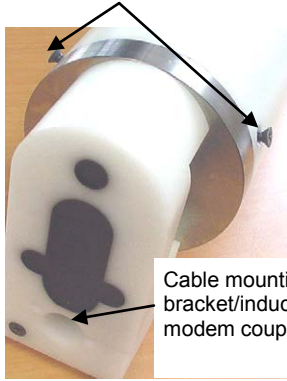
Verify that a cable or dummy plug is installed for each connector on the system before deployment.

Replacing Alkaline Batteries

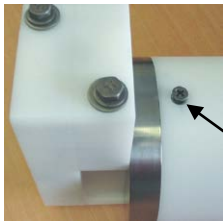
Alkaline D-cell
(MN1300, LR20)



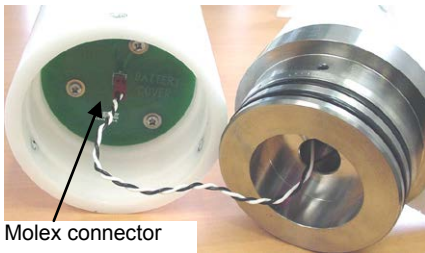
Screws securing end cap
(shown partially removed)



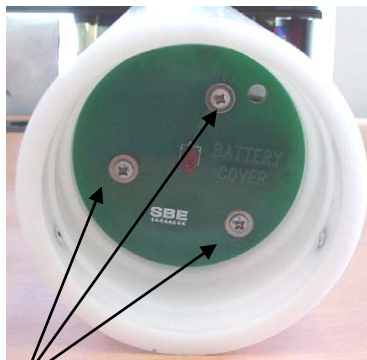
Cable mounting
bracket/inductive
modem coupler



Screw securing
end cap (shown
partially removed)



Molex connector



Remove Phillips-head screws
and washers from battery cover plate

The SBE 16plus-IM V2 uses alkaline D-cells (Duracell MN1300, LR20), dropped into the battery compartment.

Leave the batteries in place when storing the SBE 16plus-IM V2 to prevent depletion of the back-up lithium batteries by the real-time clock. Even *exhausted* main batteries will power the clock almost indefinitely. If the 16plus-IM V2 is to be stored for long periods, **replace the batteries yearly to prevent battery leakage** (which could damage the 16plus-IM V2).

1. Remove the modem end cap (end cap without connectors):
 - A. Wipe the outside of the end cap and housing dry, being careful to remove any water at the seam between them.
 - B. Remove the three flat Phillips-head screws. Do not remove any other screws from the housing.
 - C. Remove the end cap by pulling firmly and steadily on the plastic cable mounting bracket/inductive modem coupler. It may be necessary to twist or rock the end cap back and forth or use a non-marring tool on the edge of the cap to loosen it.
 - D. The end cap is electrically connected to the electronics with a 2-pin Molex connector. Holding the wire cluster near the connector, pull gently to detach the female end of the connector from the pins.
 - E. Remove any water from the O-ring mating surfaces inside the housing with a lint-free cloth or tissue.
 - F. Put the end cap aside, being careful to protect the O-rings from damage or contamination.
2. Remove the battery cover plate from the housing:
 - A. Remove the three Phillips-head screws and washers from the battery cover plate inside the housing.
 - B. The battery cover plate will pop out. Put it aside.
3. Turn the 16plus-IM V2 over and remove the batteries.
4. Install the new batteries, with the + terminals against the flat battery contacts and the - terminals against the spring contacts.
5. Reinstall the battery cover plate in the housing:
 - A. Align the battery cover plate with the housing. The posts inside the housing are not placed symmetrically, so the cover plate fits into the housing only one way. Looking at the cover plate, note that one screw hole is closer to the edge than the others, corresponding to the post that is closest to the housing.
 - B. Reinstall the three Phillips-head screws and washers, while pushing hard on the battery cover plate to depress the spring contacts at the bottom of the battery compartment. **The screws must be fully tightened, or battery power to the circuitry will be intermittent.**
6. Check the battery voltage at BAT + and BAT - on the battery cover plate. It should be approximately 13.5 volts.
7. Reinstall the end cap:
 - A. Remove any water from the O-rings and mating surfaces with a lint-free cloth or tissue. Inspect the O-rings and mating surfaces for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of o-ring lubricant (Parker Super O Lube) to O-rings and mating surfaces.
 - B. Plug the female end of the 2-pin Molex connector onto the pins. Verify the connector is properly aligned - a backward connection will prevent communication with the computer.
 - C. Carefully fit the end cap into the housing until the O-rings are fully seated.
 - D. Reinstall the three flat Phillips-head screws to secure the end cap.

Conductivity Cell Maintenance

CAUTIONS:

- **Do not put a brush or any object inside the conductivity cell to dry it or clean it.** Touching and bending the electrodes can change the calibration. Large bends and movement of the electrodes can damage the cell.
- **Do not store the 16plus-IM V2 with water in the conductivity cell.** Freezing temperatures (for example, in Arctic environments or during air shipment) can break the cell if it is full of water.

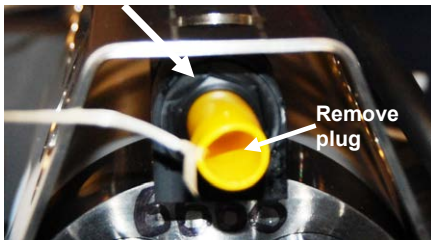
The SBE 16plus-IM V2's conductivity cell is shipped dry to prevent freezing in shipping. Refer to *Application Note 2D: Instructions for Care and Cleaning of Conductivity Cells* for conductivity cell cleaning procedures and cleaning materials.

- The Active Use (after each cast) section of the application note is not applicable to the 16plus-IM V2, which is intended for use as a moored instrument.

The 16plus-IM V2 is shipped with a kit for cell filling and storage. The kit includes a syringe and tubing assembly, and two anti-foulant device caps with hose barbs. The tubing cannot attach to an anti-foulant device cap that is not barbed.

- If your 16plus-IM V2 does not include a pump - the installed anti-foulant device caps at both ends of the conductivity cell are not barbed.
- If your 16plus-IM V2 includes a pump - the installed anti-foulant device cap at the pump end of the cell is barbed; the installed anti-foulant device cap at the intake end of the cell is not barbed.

Unscrew cap, and replace with barbed cap for cleaning and storage



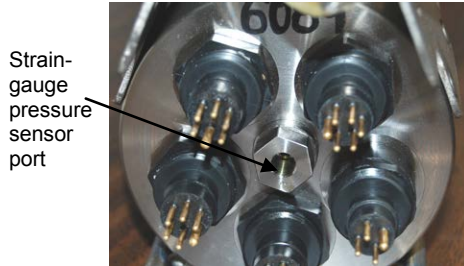
Cleaning and storage instructions below require use of the syringe and tubing assembly at the intake end of the cell (requiring one barbed cap), and looping Tygon tubing from end to end of the cell (requiring two barbed caps). Remove the installed anti-foulant device cap(s) and replace them with the anti-foulant device cap(s) with hose barbs **for cleaning and storage only**. Remember to reinstall the original anti-foulant device cap(s) before deployment. **Deploying an SBE 16plus-IM V2 with barbed anti-foulant device cap(s) in place of the installed caps is likely to produce undesirable results in your data.** See *Replacing Anti-Foulant Devices* for safety precautions when handling the AF24173 Anti-Foulant Devices.

Internally Mounted Pressure Sensor (optional) Maintenance

CAUTION:

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

Pressure sensor maintenance varies, depending on the type of pressure sensor in your SBE 16plus-IM V2.



Strain-gauge pressure sensor port

Strain Gauge Pressure Sensor

Periodically (approximately once a year) inspect the pressure port for particles and debris. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc.

Quartz Pressure Sensor



Nylon pressure capillary fitting for 16plus-IM V2 with Quartz pressure sensor

At the factory, the pressure sensor and pressure port were filled with a silicon oil, and a nylon pressure capillary fitting – which includes a pressure port fitting and an external capillary tube – were used to retain the oil. The oil transmits hydrostatic pressure via internal, stainless steel, capillary tubing to the pressure sensor inside the instrument, and prevents corrosion that might occur if the sensor diaphragm was exposed to water. The internal tubing and nylon capillary fitting are vacuum back-filled at the factory.

Because of the viscosity of the silicone oil and capillary action, the silicone oil does not run out of the external capillary tube. However, due to temperature and pressure cycling over long periods, it is normal for some oil to slowly leak out of the external capillary tube. **When the oil is not visible or is receding inside the translucent tube, or if the fitting has been damaged, refill the oil** using the supplied pressure sensor oil refill kit. See *Application Note 12-1: Pressure Port Oil Refill Procedure & Nylon Capillary Fitting Replacement*.

Pump (optional) Maintenance

See *Application Note 75: Maintenance of SBE 5T, 5P, and 5M Pumps*.

Replacing Anti-Foulant Devices (SBE 16plus, SBE 19plus)



AF24173
Anti-Foulant
Device

The SBE 16plus and 19plus (moored option) have an anti-foulant device cup and cap on each end of the conductivity cell. A new SBE 16plus (or moored option 19plus) is shipped with an Anti-Foulant Device and a protective plug pre-installed in each cup.

Wearing rubber or latex gloves, follow this procedure to replace each Anti-Foulant Device (two):

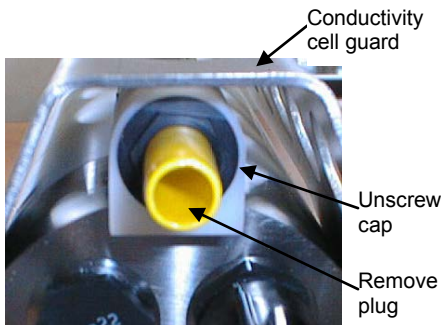
1. Remove the protective plug;
2. Unscrew the cap with a $5/8$ -inch socket wrench;
3. Remove the old Anti-Foulant Device. If the old Anti-Foulant Device is difficult to remove:
 - Use needle-nose pliers and carefully break up material;
 - If necessary, remove the conductivity cell guard to provide easier access;
4. Place the new Anti-Foulant Device in the cup;
5. Rethread the cap onto the cup. Do not over tighten;
6. Replace the protective plug if not ready to redeploy.

WARNING!

AF24173 Anti-Foulant Devices contain bis(tributyltin) oxide. Handle the devices only with rubber or latex gloves. Wear eye protection. Wash with soap and water after handling.

Read precautionary information on product label (see Appendix V) before proceeding.

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



CAUTION:

One of the anti-foulant device cups is attached to the guard and connected to the conductivity cell. **Removing the guard without disconnecting the cup from the guard will break the cell.** If the guard must be removed:

1. Remove the two screws connecting the anti-foulant device cup to the guard;
2. Remove the four Phillips-head screws connecting the guard to the housing and sensor end cap;
3. Gently lift the guard away.

Sensor Calibration

Note

After recalibration, Sea-Bird enters the new calibration coefficients in the 16*plus*-IM V2 EEPROM, and ships the instrument back to the user with Calibration Certificates showing the new coefficients. We also ship a new instrument configuration (.con) file, which includes the new coefficients.

Sea-Bird sensors are calibrated by subjecting them to known physical conditions and measuring the sensor responses. Coefficients are then computed, which may be used with appropriate algorithms to obtain engineering units. The conductivity, temperature, and (optional) pressure sensors on the SBE 16*plus*-IM V2 are supplied fully calibrated, with coefficients stored in EEPROM in the 16*plus*-IM V2 and printed on their respective Calibration Certificates.

We recommend that the 16*plus*-IM V2 be returned to Sea-Bird for calibration.

Conductivity Sensor

The conductivity sensor incorporates a fixed precision resistor in parallel with the cell. When the cell is dry and in air, the sensor's electrical circuitry outputs a frequency representative of the fixed resistor. This frequency is recorded on the Calibration Certificate and should remain stable (within 1 Hz) over time.

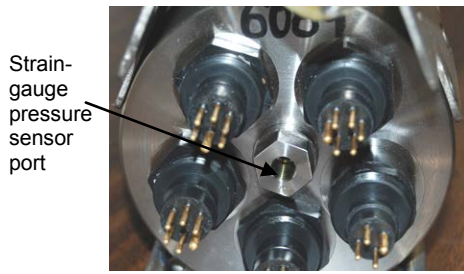
The primary mechanism for calibration drift in conductivity sensors is the fouling of the cell by chemical or biological deposits. Fouling changes the cell geometry, resulting in a shift in cell constant.

Accordingly, the most important determinant of long-term sensor accuracy is the cleanliness of the cell. We recommend that the conductivity sensors be calibrated before and after deployment, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

Temperature Sensor

The primary source of temperature sensor calibration drift is the aging of the thermistor element. Sensor drift will usually be a few thousandths of a degree during the first year, and less in subsequent intervals. Sensor drift is not substantially dependent upon the environmental conditions of use, and — unlike platinum or copper elements — the thermistor is insensitive to shock.

Internally Mounted Pressure Sensor



The SBE 16plus-IM V2 is available with an internally mounted strain-gauge or Quartz pressure sensor. These sensors are capable of meeting the 16plus-IM V2 error specification with some allowance for aging and ambient-temperature induced drift.

Pressure sensors show most of their error as a linear offset from zero. A technique is provided below for making small corrections to the pressure sensor calibration using the *offset* (**#iiPOffset=**) calibration coefficient term by comparing 16plus-IM V2 pressure output to readings from a barometer.

Allow the 16plus-IM V2 to equilibrate in a reasonably constant temperature environment for at least 5 hours before starting. Pressure sensors exhibit a transient change in their output in response to changes in their environmental temperature. Sea-Bird instruments are constructed to minimize this by thermally decoupling the sensor from the body of the instrument. However, there is still some residual effect; allowing the 16plus-IM V2 to equilibrate before starting will provide the most accurate calibration correction.

Note:

The pressure sensor is an absolute sensor, so its **raw** output includes the effect of atmospheric pressure (14.7 psi). As shown on the Calibration Sheet, Sea-Bird's calibration (and resulting calibration coefficients) is in terms of psia. However, when outputting pressure in **engineering units**, the 16plus-IM V2 outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). The 16plus-IM V2 uses the following equation to convert psia to decibars: pressure (db) = [pressure (psia) - 14.7] * 0.689476

1. Place the 16plus-IM V2 in the orientation it will have when deployed.
2. In SeatermIM:
 - A. Set the pressure offset to 0.0 (**#iiPOffset=0**).
 - B. Send **#iiTP** to measure the 16plus-IM V2 pressure 30 times and transmit converted data in engineering units (decibars).
3. Compare the 16plus-IM V2 output to the reading from a good barometer at the same elevation as the 16plus-IM V2 pressure sensor. Calculate *offset* = barometer reading – 16plus-IM V2 reading
4. Enter the calculated offset (positive or negative) in two places:
 - In the 16plus-IM V2 EEPROM, using **#iiPOffset=** in SeatermIM, **and**
 - In the configuration (.xmlcon or .con) file, using SBE Data Processing or Seasave.

Offset Correction Example

Absolute pressure measured by a barometer is 1010.50 mbar. Pressure displayed from 16plus-IM V2 is -2.5 dbars. Convert barometer reading to dbars using the relationship: mbar * 0.01 = dbar
 Barometer reading = 1010.50 mbar * 0.01 = 10.1050 dbar
 The 16plus-IM V2's internal calculations and our processing software output gage pressure, using an assumed value of 14.7 psi for atmospheric pressure. Convert 16plus-IM V2 reading from gage to absolute by adding 14.7 psia to the 16plus-IM V2 output:
 $-2.5 \text{ dbars} + (14.7 \text{ psi} * 0.689476 \text{ dbar/psia}) = -2.5 + 10.13 = 7.635 \text{ dbars}$
 Offset = 10.1050 – 7.635 = + 2.47 dbars
 Enter offset in 16plus-IM V2 and in .xmlcon or .con file.

For demanding applications, or where the sensor's air ambient pressure response has changed significantly, calibration using a dead-weight generator is recommended. The end cap's 7/16-20 straight thread permits mechanical connection to the pressure source. Use a fitting that has an O-ring tapered seal, such as Swagelok-200-1-4ST, which conforms to MS16142 boss.

Section 6: Troubleshooting

This section reviews common problems in operating the SBE 16plus-IM V2, and provides the most common causes and solutions.

Problem 1: Unable to Communicate with SBE 16plus-IM V2

The `S>` prompt indicates that communications between the 16plus-IM V2 and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by selecting *Connect* in the Communications menu in SeatermIM, or pressing the Enter key several times.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the SIM or IMM and computer for a loose connection.

Cause/Solution 2: The instrument communication settings may not have been entered correctly in SeatermIM. Verify the settings in the Configure Communications dialog box (Communications menu -> *Configure*). The settings should match those on the instrument Configuration Sheet.

Cause/Solution 3: The I/O cable between the SIM or IMM and computer may not be the correct one. The I/O cable supplied with the SIM or IMM permits connection to standard 9-pin RS-232 interfaces.

Cause/Solution 4: The modem core in the 16plus-IM V2 (and/or the ICC, if applicable) may have a gap, be misaligned, or be damaged. See *Application Note 85: Handling of Ferrite Core in Instruments with Inductive Modem Telemetry* for details on inspecting the modem core and proper installation of the 16plus-IM V2 and the ICC (if applicable) on the cable.

Problem 2: No Data Recorded

Cause/Solution 1: The memory may be full; once the memory is full, no further data will be recorded. Verify that the memory is not full using `#iiGetSD` or `#iiDS` (*free* = 0 or 1 if memory is full). Sea-Bird recommends that you upload all previous data before beginning another deployment. Once the data is uploaded, send `#iiInitLogging` to reset the memory. After the memory is reset, `#iiGetSD` or `#iiDS` will show *samples* = 0.

Problem 3: Nonsense or Unreasonable Data

The symptom of this problem is an uploaded file that contains nonsense values (for example, 9999.999) or unreasonable values (for example, values that are outside the expected range of the data).

Cause/Solution 1: An uploaded data file with nonsense values may be caused by incorrect instrument configuration:

- Bad data may be caused by incorrect configuration in the 16plus-IM V2. Send **#iiGetCD** or **#iiDS** to verify the setup of the 16plus-IM V2 matches the instrument Configuration Sheet (correct pressure sensor, voltage sensors assigned to correct channels, etc).
- Bad data may be caused by incorrect configuration in the instrument .xmlcon or .con configuration file. Verify the settings in the configuration file match the instrument Configuration Sheet.

Note:

Each 16plus-IM V2 is shipped with a configuration (.con) file that matches the configuration of the instrument (number and type of auxiliary sensors, etc.) and includes the instrument calibration coefficients.

Cause/Solution 2: An uploaded data file with unreasonable (i.e., out of the expected range) values for temperature, conductivity, etc. may be caused by incorrect calibration coefficients:

- If you manually uploaded data in engineering units (**#iiOutputFormat=1, 3, or 5**) – Bad data may be caused by incorrect calibration coefficients in the 16plus-IM V2. Send **#iiGetCC** or **#iiDCal** to verify the calibration coefficients in the 16plus-IM V2 match the instrument Calibration Certificates. Note that calibration coefficients do not affect the raw data stored in 16plus-IM V2 memory. If you have not yet overwritten the memory with new data, you can correct the coefficients and then upload the data again.
- If you manually uploaded data in raw hexadecimal (**#iiOutputFormat=0**), or used SeatermIM's Upload menu to upload data and are processing the data in SBE Data Processing or viewing it in Seasave - Bad data may be caused by incorrect calibration coefficients in the instrument .xmlcon or .con configuration file. Verify the calibration coefficients in the configuration file match the instrument Calibration Certificates.
- For RS-232 sensors interfacing to the 16plus-IM V2: Bad data may be caused by incorrect calibration coefficients programmed into the RS-232 sensor. Connect the sensor directly to the computer and use Seaterm232 or SEATERM to verify the calibration coefficients match the instrument Calibration Certificate.

Problem 4: Program Corrupted

Note:

Using the reset switch does not affect the 16plus-IM V2 memory - data in memory and user-programmable parameter values are unaffected.

Cause/Solution 1: In rare cases, a severe static shock or other problem can corrupt the program that controls the SBE 16plus-IM V2 microprocessor. This program can be initialized by using the reset switch. Proceed as follows to initialize:

1. Open the battery end cap and remove the batteries (see *Replacing Alkaline Batteries* in *Section 5: Routine Maintenance and Calibration*).
2. There is a small, pushbutton switch on the battery compartment bulkhead, which is visible after the batteries are removed. The switch is used to disconnect the internal back-up lithium batteries from the electronics. Push the switch in for 1 second.
3. Reinstall or replace the batteries, and close the battery end cap.
4. Establish communications with the 16plus-IM V2 (see *Section 3: Preparing for Deployment*). Send **#iiGetSD** or **#iiDS** to verify that the date and time and sample number are correct.

Glossary

Batteries – Nine alkaline D-cells (Duracell MN1300, LR20) standard.

Deployment Endurance Calculator – Sea-Bird’s Windows 2000/XP software used to calculate deployment length for moored instruments, based on user-input deployment scheme, instrument power requirements, and battery capacity.

Fouling – Biological growth in the conductivity cell during deployment.

ICC – Inductive Cable Coupler, which clamps to the insulated mooring cable and transfers the inductive signal on wire to the SIM PCB installed inside the buoy or elsewhere.

IMM – Inductive Modem Module PCB, used to interface between the computer serial port and 16plus-IM V2s or other compatible IM instruments. Either an IMM or SIM is required to interface with the 16plus-IM V2.

PCB – Printed Circuit Board.

SBE Data Processing – Sea-Bird’s 2000/XP data processing software, which calculates and plots temperature, conductivity, and optional pressure, data from auxiliary sensors, and derives variables such as salinity and sound velocity.

Scan – One data sample containing temperature, conductivity, optional pressure, date and time, and optional auxiliary inputs.

SEACAT – High-accuracy conductivity, temperature, and pressure recorder. The SEACAT is available as the SBE 16plus (moored applications), and SBE 19plus (moored or profiling applications).

The 16plus is available in three versions:

- 16plus with **RS-232** interface (standard)
- 16plus with **RS-485** interface
- 16plus-IM with **inductive modem** interface (**this manual**)

Version 2 (V2) of each of these instruments became available in late 2007 / early 2008, and have 2 additional A/D channels (for a total of 6), a standard channel for an RS-232 sensor, and larger memory (64 MB).

A plus version of the SBE 21 SEACAT (thermosalinograph) is under development.

Seasave V7 – Sea-Bird’s Win 2000/XP software used to acquire, convert, and display real-time or archived raw data. **Seasave cannot be used to acquire data from the 16plus-IM V2, but can be used to display in engineering units the raw hexadecimal data uploaded from the 16plus-IM V2.**

SEASOFT V2 – Sea-Bird’s complete Win 2000/XP software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT V2 includes **Deployment Endurance Calculator, SeatermV2, SBE Data Processing, Seasave V7.**

SeatermV2 – Win 2000/XP terminal program *launcher*. Depending on the instrument selected, it launches SeatermIM (inductive modem instruments), Seaterm232 (RS-232 instruments), or Seaterm485 (RS-485 instruments).

SeatermIM – Win 2000/XP terminal program used with Sea-Bird instruments that communicate via an Inductive Modem (IM) interface, and that were developed or redesigned in 2006 and later. The common feature of these instruments is the ability to output data in XML. Instruments currently supported by SeatermIM include: SBE 16*plus*-IM V2 (IM interface, version 2 or later digital firmware) and 37-IM/-IMP (IM interface, version 3 or later digital firmware).

SIM – Surface Inductive Modem PCB, used to interface between computer serial port and SBE 16*plus*-IM V2 or other compatible IM instruments. Either an IMM or SIM is required to interface with the 16*plus*-IM V2.

Super O-Lube – Silicone lubricant used to lubricate O-rings and O-ring mating surfaces. Super O-Lube can be ordered from Sea-Bird, but should also be available locally from distributors. Super O-Lube is manufactured by Parker Hannifin (www.parker.com/ead/cm2.asp?cmid=3956)

TCXO – Temperature Compensated Crystal Oscillator.

Triton X-100 – Reagent grade non-ionic surfactant (detergent), used for cleaning the conductivity cell. Triton can be ordered from Sea-Bird, but should also be available locally from chemical supply or laboratory products companies. Triton is manufactured by Mallinckrodt Baker (www.mallbaker.com/changecountry.asp?back=/Default.asp)

Appendix I: Functional Description and Circuitry

Sensors

The SBE16*plus*-IM V2 embodies the same sensor elements (3-electrode, 2-terminal, borosilicate glass cell, and pressure-protected thermistor) previously employed in Sea-Bird's modular SBE 3 and SBE 4 sensors and in the original SEACAT design. The SBE 16*plus*-IM V2 differs from the SBE 16 in that it uses three independent channels to digitize temperature, conductivity, and pressure concurrently. Multiplexing is not used for these channels.

The optional internally mounted pressure sensor is a strain-gauge or Quartz sensor.

Sensor Interface

Temperature is acquired by applying an AC excitation to a bridge circuit containing an ultra-stable aged thermistor with a drift rate of less than 0.002 °C per year. The other elements in the bridge are VISHAY precision resistors. A 24-bit A/D converter digitizes the output of the bridge. AC excitation and ratiometric comparison avoids errors caused by parasitic thermocouples, offset voltages, leakage currents, and reference errors.

Conductivity is acquired using an ultra-precision Wein-Bridge oscillator to generate a frequency output in response to changes in conductivity.

Strain-gauge pressure is acquired by applying an AC excitation to the pressure bridge. A 24-bit A/D converter digitizes the output of the bridge. AC excitation and ratiometric comparison avoids errors caused by parasitic thermocouples, offset voltages, leakage currents, and reference errors. A silicon diode embedded in the pressure bridge is used to measure the temperature of the pressure bridge. This temperature is used to perform offset and span corrections on the measured pressure signal.

The six external 0 to 5 volt DC voltage channels are processed by differential amplifiers with an input resistance of 50K ohms and are digitized with a 14-bit A/D converter.

Real-Time Clock

To minimize power and improve clock accuracy, a temperature-compensated crystal oscillator (TCXO) is used as the real-time-clock frequency source. The TCXO is accurate to ± 1 minute per year (0 °C to 40 °C).

Battery Wiring

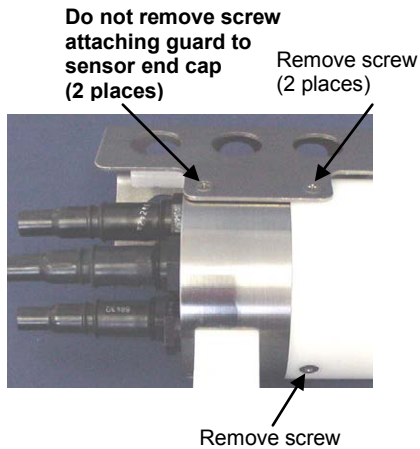
SBE 16plus-IM V2 main battery is a series connection of D-cells that drop into the battery compartment as a cluster of end-to-end stacks, three batteries each (standard 9-cell battery pack has three stacks). The positive battery connections are contact areas on double-thick printed circuit disks that form the internal bulkhead and battery retainer plates. Battery negative contacts are heavy beryllium-copper springs. The three cell stacks are aligned by plastic insulated aluminum spacers which also serve as electrical interconnects. The battery-to-circuit card connection is made by means of a Molex-type 3-pin pc board connector (JP3 on the power PCB).

The Power PCB contains three series-connected Panasonic BR-2/3A lithium cells (non-hazardous) which are diode OR'd with the main battery. The back-up lithium supply is capable of maintaining the buffer and the real-time clock if the main batteries are removed. If the back-up lithium battery voltage (*Vlith* in the #iGetSD or #iIDS response) falls below 7 volts, replace the back-up batteries.

Appendix II: Electronics Disassembly/Reassembly

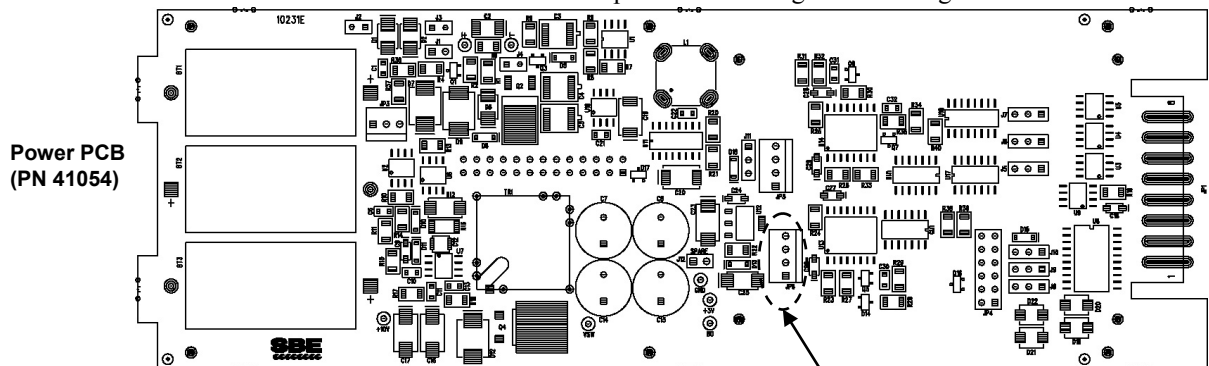
CAUTION:

Use caution during disassembly and reassembly to avoid breaking the conductivity cell.



Disassembly:

1. As a precaution, upload any data in memory before beginning.
2. Remove the two Phillips-head screws holding the conductivity cell guard to the housing. **Do not remove the two screws holding the conductivity cell guard to the sensor end cap.**
3. Remove the Phillips-head screw holding the sensor end cap to the housing on the side opposite the conductivity cell guard.
4. Remove the sensor end cap (with attached conductivity cell and cell guard) and electronics:
 - A. Wipe the outside of the sensor end cap and housing dry, being careful to remove any water at the seam between them.
 - B. Slide the end cap and attached electronics out of the housing.
 - C. The electronics are electrically connected to the battery compartment bulkhead with a Molex connector. Disconnect the Molex connector.
 - D. Remove any water from the O-rings and mating surfaces inside the housing with a lint-free cloth or tissue.
 - E. Be careful to protect the O-rings from damage or contamination.



JP6 internal RS-232 connector, for firmware update and/or fast upload. Unplug IM boardset, and connect JP6 to computer with optional data I/O cable (PN 801880).

Reassembly:

1. Reinstall the sensor end cap, conductivity cell and guard, and electronics:
 - A. Remove any water from the O-rings and mating surfaces in the housing with a lint-free cloth or tissue. Inspect the O-rings and mating surfaces for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to the O-rings and mating surfaces.
 - B. Plug the Molex connector onto the pins on the battery compartment bulkhead. Verify the connector holes and pins are properly aligned.
 - C. Carefully fit the end cap and electronics into the housing until the O-rings are fully seated.
2. Reinstall the three screws to secure the end cap.
3. Reset the date and time (**#iiDateTime=**) and initialize logging (**#iiInitLogging**) before redeploying. No other parameters should have been affected by the electronics disassembly (send **#iiGetCD** or **#iiDS** to verify).

Note:

Before delivery, a desiccant package is placed in the electronics chamber, and the electronics chamber is filled with dry Argon gas. These measures help prevent condensation.

If the electronics are exposed to the atmosphere, dry gas backfill with Argon and replace the desiccant package.

See *Application Note 71: Desiccant Use and Regeneration (drying)* for desiccant information.

Battery replacement does not affect desiccation of the electronics, as no significant gas exchange is possible unless the electronics PCBs are actually removed from the housing.

Appendix III: Command Summary

Note:
See *Command Descriptions* in Section 4: *Deploying and Operating SBE 16plus-IM V2* for detailed information and examples.

FUNCTION	CATEGORY	COMMAND	DESCRIPTION	
IMM Commands	-	See the IMM manual for a complete list of IMM commands.		
SIM Commands	Power-On	PwrOn	Send wakeup tone to all 16plus-IM V2s.	
		PwrOff	Send power off command to all 16plus-IM V2s. SBE 16plus-IM V2s enter quiescent (sleep) state. Main power turned off, but data logging and memory retention unaffected.	
		AutoPwrOn=x	x=Y (default): Send PwrOn to 16plus-IM V2s when power applied to SIM. This wakes up all 16plus-IM V2s on line. x=N : Do not send PwrOn when power applied to SIM.	
	Status	DS	Display SIM firmware version and setup parameters.	
	Communications	Communications	Baud=x	x = baud rate between SIM and computer/controller (1200, 2400, 4800, or 9600). Default 9600.
			DataNMax=x	x = timeout (milliseconds) that applies to !iiData or Dataii only. If no reply received within x (0-32767), control returned to computer and other commands can be sent. Default 1000 milliseconds.
			RelayMax=x	x = timeout (seconds) that applies to all other commands. If no reply received within x (0-3276), control returned to computer and other commands can be sent. Default 20 seconds.
			EchoOn	Echo characters received from computer (default).
			EchoOff	Do not echo characters.
	16plus-IM V2 Communication Microcontroller Commands	Global	DateTime=mmddyyyyhhmmss	Set real-time clock month, day, year, hour, minute, second for all 16plus-IM V2s.
GData			Command all 16plus-IM V2 communication microcontrollers to get last data sample from acquisition units. 16plus-IM V2 communication microcontrollers hold data in a buffer until receiving !iiData or Dataii .	
Get Data		!iiData or Dataii	Get data obtained with GData from 16plus-IM V2 with ID=ii.	
16plus-IM V2 ID Only 1 16plus-IM V2 can be on line when sending these commands.		ID?	Display 16plus-IM V2 ID (ID=ii, where ii=0 to 99)	
		*ID=ii (If more than 1 16plus-IM V2 on line when setting ID, all will have same ID)	Set 16plus-IM V2 ID to ii (ii=0 to 99). Command must be sent twice, because verification requested.	
16plus-IM V2 communication microcontroller status		!iiDS	Display firmware version and timeout parameter.	
16plus-IM V2 communication microcontroller timeout		!iiWait=x	x = maximum time (seconds) for communication microcontroller to wait for response from acquisition microcontroller. Range 2 – 600 seconds.	

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
16plus-IM V2 Acquisition Microcontroller Commands (ii = 16plus-IM V2 ID)	Status	#iiGetCD	Get and display configuration data (setup parameters).
		#iiGetSD	Get and display status data.
		#iiGetCC	Get and display calibration coefficients.
		#iiGetEC	Get and display event counter data.
		#iiResetEC	Delete all events in event counter
		#iiGetHD	Get and display hardware data.
		#iiDS	Get and display configuration data (setup parameters) and status data.
		#iiDCal	Get and display calibration coefficients.
	General Setup	#iiDateTime=mmddyyyyhhmmss	Set real-time clock month, day, year, hour, minute, second.
		#iiOutputExecutedTag=x	x=Y : Display XML Executing and Executed tags. x=N : Do not.
		#iiPumpMode=x	x=0 : No pump. x=1 : Run pump for 0.5 seconds before each sample. x=2 : Run pump during each sample.
		#iiNCycles=x	x = number of measurements to take and average for each sample. Default 1.
		#iiInitLogging	After all previous data has been uploaded, send this before starting to sample to make entire memory available for recording. If not sent, data stored after last sample. Equivalent to #iiSampleNumber=0 .
		#iiSampleNumber=x	x = sample number for last sample in memory. #iiSampleNumber=0 is equivalent to #iiInitLogging .
		#iiHeaderNumber=x	x = header number for last header in memory.
	Pressure Sensor Setup	#iiPType=x	Internally mounted pressure sensor type - x=0 : No internally mounted pressure sensor. x=1 : Strain gauge. x=3 : Quartz with temperature compensation.
		#iiRefPress=x	x = reference pressure (gauge) in db to use if 16plus-IM V2 does not include internally mounted pressure sensor.
		#iiParosIntegration=x	x = integration time (seconds) for optional internally mounted Quartz pressure sensor (1 - 600 seconds; default 1 second).
	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 (seconds) to wait after switching on external voltages and RS-232 sensors before sampling (0-600 sec). Default 0 sec.	

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
16plus-IM V2 Acquisition Microcontroller Commands (ii = 16plus-IM V2 ID) <i>(continued)</i>	RS-232 Sensor Setup	#iiSBE38=x	x=Y: Enable SBE 38. x=N: Do not.
		#iiSBE50=x	x=Y: Enable SBE 50. x=N: Do not.
		#iiWetLabs=x	x=Y: Enable WET Labs RS-232 sensor. x=N: Do not.
		#iiGTD=x	x=Y: Enable GTD. x=N: Do not.
		#iiDualGTD=x	x=Y: Enable dual (2) GTDs. x=N: Do not.
		#iiTGTD	Measure GTD(s), output 1 converted data sample for each GTD.
		#iiSendGTD=command	Command 16plus-IM V2 to send command to GTD and receive response (command can be any command recognized by GTD).
	#iiOptode=x	x=Y: Enable Aanderaa Optode. x=N: Do not.	
	Output Format Setup	#iiOutputFormat=x	x=0: output raw frequencies and voltages in Hex (required if using SBE Data Processing or Seasave). x=1: output converted data in Hex. x=2: output raw frequencies and voltages in decimal. x=3: output converted data in decimal. x=5: output converted data in decimal XML.
		#iiOutputSal=x	x=Y: Calculate and output salinity (psu) if #iiOutputFormat=3 or 5. x=N: Do not.
		#iiOutputSV=x	x=Y: Calculate and output sound velocity (m/sec) if #iiOutputFormat=3 or 5. x=N: Do not.
		#iiOutputUCSD=x	x=Y: Calculate and output sigma-t (kg/m ³), battery voltage, and operating current (mA) with data polled while logging. Only applies if #iiOutputFormat=3 or 5. x=N: Do not.
		#iiOutputSampleNumber=x	x=Y: Output sample number with data from Dataii , #iiData, #iiSL, #iiSLT, #iiTS, and #iiTSS if #iiOutputFormat=3 or 5. x=N: Do not.
	Autonomous Sampling	#iiSampleInterval=x	x= interval (seconds) between samples (10 – 14,400).
		#iiStartNow	Start autonomous sampling now.
		#iiStartDateTime =mmddyyyhhmmss	Delayed start: month, day, year, hour, minute, second.
		#iiStartLater	Start autonomous sampling at delayed start date and time.
		#iiStop	Stop autonomous sampling or stop waiting to start autonomous sampling. Must stop sampling before uploading data.
	Polled Sampling	#iiSL	Output last sample from buffer.
		#iiSLT	Output last sample from buffer, then take new sample and store in buffer.
		#iiTS	Take sample, store in buffer, output data.
		#iiTSS	Take sample, store in buffer and FLASH memory , output data.
		#iiGetLastSamples:x	Output last x samples from FLASH memory.
	Data Upload	GetSamples:b,e or #iiDDb,e	Upload data from scan b to scan e . Stop autonomous sampling before sending.
		GetHeaders:b,e or #iiDHb,e	Upload header b to header e .

Note:
Use SeatermIM's Upload menu to upload data that will be processed by SBE Data Processing. Manually entering the data upload command does not produce data with the required header information for processing by SBE Data Processing.

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
16plus-IM V2 Acquisition Microcontroller Commands (ii = 16plus-IM V2 ID) (continued)	Testing Takes and outputs 30 samples for each test.	#iiTC	Measure conductivity, output converted data.
		#iiTCR	Measure conductivity, output raw data.
		#iiTT	Measure temperature, output converted data.
		#iiTTR	Measure temperature, output raw data
		#iiTP	Measure pressure, output converted data.
		#iiTPR	Measure pressure, output raw data.
		#iiTV	Measure 6 external voltage channels, output converted data.
		#iiTVR	Measure 6 external voltage channels, main battery voltage, lithium battery voltage, external current, pressure temperature, output raw data.
		#iiTF	Measure frequency (Quartz pressure sensor), output converted data.
		#iiTFR	Measure frequency (Quartz pressure sensor), output raw data.
		#iiT38	Measure SBE 38, output converted data.
		#iiT50	Measure SBE 50, output converted data.
		#iiTWetLabs	Measure WET Labs RS-232 sensor, output raw data.
		#iiTOptode	Measure Aanderaa Optode, output converted data.
#iiPumpOn	Turn pump on for testing purposes.		
#iiPumpOff	Turn pump off for testing purposes.		

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
<p>16plus-IM V2 Acquisition Microcontroller Commands (ii = 16plus-IM V2 ID) (continued)</p>	<p>Coefficients (F=floating point number; S=string with no spaces)</p> <p>Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with 16plus-IM V2. View all coefficients with #iiGetCC or #iiDCal.</p>	#iiTCalDate=S	S=Temperature calibration date.
		#iiTAO=F	F=Temperature A0.
		#iiTA1=F	F=Temperature A1.
		#iiTA2=F	F=Temperature A2.
		#iiTA3=F	F=Temperature A3.
		#iiTOffset=F	F=Temperature offset correction.
		#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.
		#iiCPCor=F	F=Conductivity pcor.
		#iiCTCor=F	F=Conductivity tcor.
		#iiCSlope=F	F=Conductivity slope correction.
		#iiPCalDate=S	S=Pressure calibration date.
		#iiPRange=F	F=Pressure sensor full scale range (psia).
		#iiPOffset=F	F=Pressure offset correction (decibars).
		#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 temperature compensation ptca0.
		#iiPTCA1=F	F=Strain gauge pressure temperature compensation ptca1.
		#iiPTCA2=F	F=Strain gauge pressure temperature compensation ptca2.
		#iiPTCB0=F	F=Strain gauge pressure temperature compensation ptcb0.
		#iiPTCB1=F	F=Strain gauge pressure temperature compensation ptcb1.
		#iiPTCB2=F	F=Strain gauge pressure temperature compensation 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=Pressure slope correction.		
#iiExtFreqSF=F	F=External frequency (Quartz pressure sensor) scale factor.		
<p>#iiVOffset0=, #iiVSlope0=, #iiVOffset5=, #iiVSlope5=</p>	<p>Voltage channel offsets and slopes are all factory set, and should never be modified by customer. These are properties of 16plus-IM V2 electronics, and are not calibration coefficients for auxiliary sensors. Enter calibration coefficients for auxiliary sensors in .xml con or .con file in SBE Data Processing.</p>		

FUNCTION	CATEGORY	COMMAND
	<p align="center">Hardware Configuration</p>	<p><i>Factory Settings – do not modify in the field</i> #iiSetMfgDate= #iiSetPcbSerialNum1=, #iiSetPcbSerialNum2=, #iiSetPcbSerialNum3=, #iiSetPcbSerialNum4= #iiSetPcbAssembly1=, #iiSetPcbAssembly2=, #iiSetPcbAssembly3=, #iiSetPcbAssembly4=</p> <p><i>Auxiliary Sensor Settings – can be modified in the field to accommodate changes in auxiliary sensors cabled to 16plus-IM V2</i> #iiSetVoltType0=, #iiSetVoltSN0= #iiSetVoltType1=, #iiSetVoltSN1= #iiSetVoltType2=, #iiSetVoltSN2= #iiSetVoltType3=, #iiSetVoltSN3= #iiSetVoltType4=, #iiSetVoltSN4= #iiSetVoltType5=, #iiSetVoltSN5= #iiSetSerialType=, #iiSetSerialSN=</p>

Appendix IV: SIM Hookup and Configuration

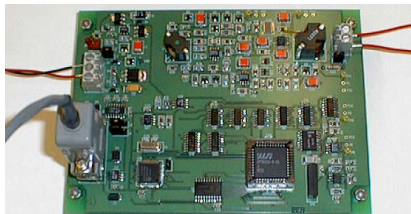
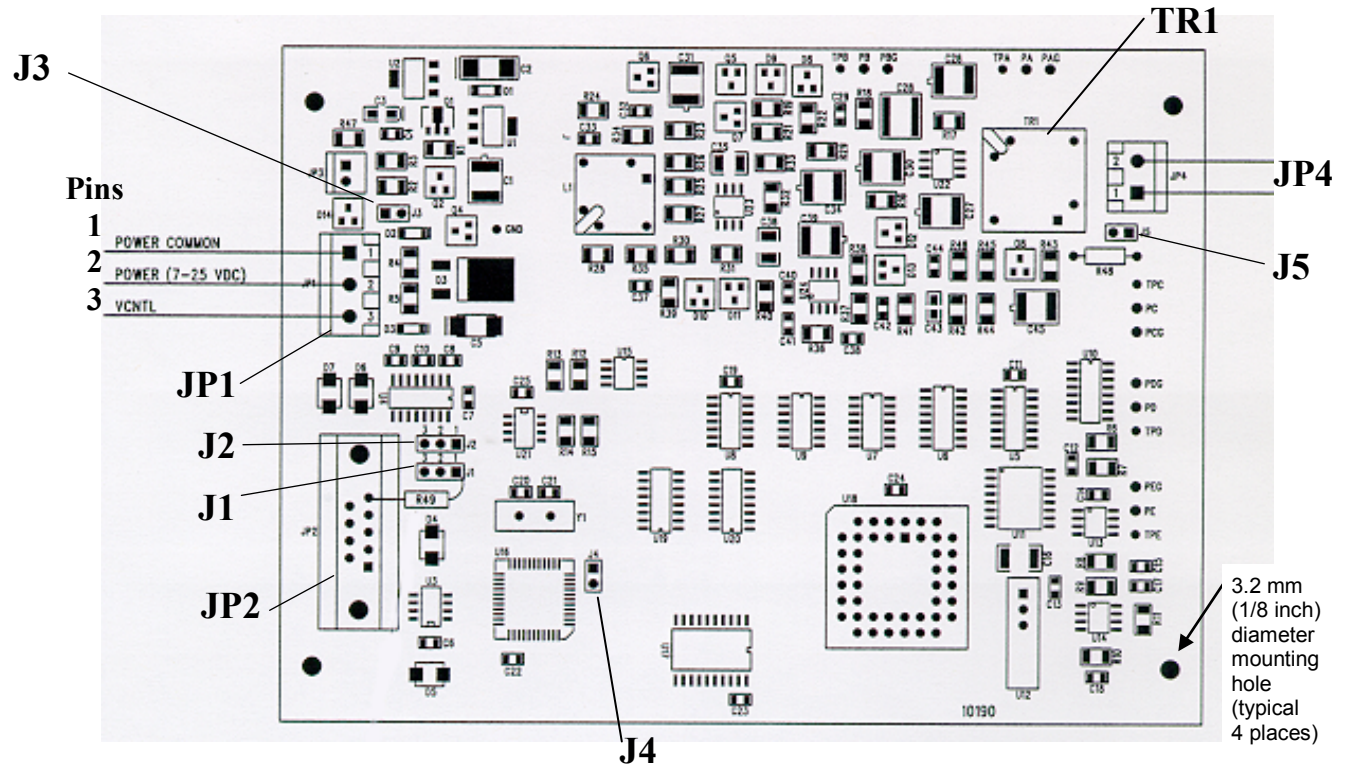


Photo shows SIM-Direct for use without Inductive Cable Coupler. SIM-Coupled for use with Inductive Cable Coupler is similar, but does not include TR1.

Dimensions:

PCB: 109 mm x 147.5 mm (4 1/4 x 5 3/4 inches)

Mounting holes: 90.5 mm x 138.1 mm (3 9/16 x 5 7/16 inches)

Power Connection

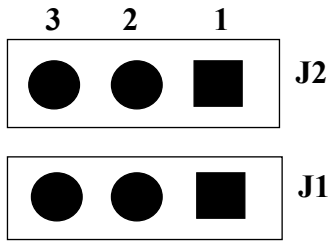
The SIM can be configured to power up in either of the following two modes:

- Normal Power Switching (factory setting)** – The SIM runs when power is applied. Set up the SIM as follows:
 1. Connect Power Common to JP1 pin 1.
 2. Connect 7-25 VDC to JP1 pin 2.
 3. Verify there is no connection to JP1 pin 3.
 4. Verify jumper is across J3.
- Logic Level Controlled Power Switching** – Power is always applied to JP1, pins 1 and 2. Voltage applied to JP1 pin 3 (VCNTL) switches power to the SIM. Set up the SIM as follows:
 1. Connect Power Common to JP1 pin 1.
 2. Connect 7-25 VDC to JP1 pin 2.
 3. Remove jumper on J3.

Note:

If VCNTL < 1 volt, SIM is Off (consuming < 100 microamps).
If VCNTL > 2 volts, SIM is On.

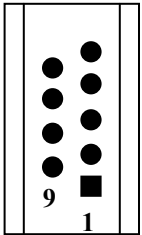
Interface Option Connection (J1, J2, and J4)



The SIM can be configured to accept RS-232 or RS-485:

- **RS-232 (factory setting)**
 1. Verify jumper is on J1 pins 2 and 3.
 2. Verify jumper is on J2 pins 2 and 3.
 3. Remove jumper on J4.
- **RS-485**
 1. Install jumper on J1 pins 1 and 2.
 2. Install jumper on J2 pins 1 and 2.
 3. Install jumper on J4.

I/O Connector Wiring (JP2)



Connect wires to JP2 as follows:

- **RS-232**
 1. **Pin 2** - RS-232 transmit from SIM to computer
 2. **Pin 3** - RS-232 transmit from computer to SIM
 3. **Pin 5** - Power Common
- **RS-485**
 1. **Pin 4** - RS-485 'A'
 2. **Pin 5** - Power Common
 3. **Pin 6** - RS-485 'B'

Inductive Mooring Cable Connection (JP4)

Note:

ICC version 4 may have 3 wires in the cable. If you ordered the ICC with a pigtail termination, solder the white and white/black wires together and attach to 1 terminal of JP4. Attach the white/red wire to the other terminal.

- **SBE 16plus-IM V2 installed with Inductive Cable Coupler (ICC)** - Connect wires from the ICC to JP4 on SIM-Coupled.
- **SBE 16plus-IM V2 installed without Inductive Cable Coupler (ICC)** - Connect wires from the mooring cable and seawater ground to JP4 on SIM-Direct.

Normal Deployed Operation (J5)

Note:

If more than one IM instrument is on-line when you set the ID, all IM instruments will be set to the same ID. The inductive modem receivers in IM instruments are very sensitive; two IM instruments that are side-by-side will take the same ID, even if one of them is not on the IM loop. **Therefore, separate IM instruments by at least 2 meters when setting IDs.**

- **Normal Deployed Operation** - Ensure jumper on J5 is installed.
- **Instrument Setup and Lab Testing** - Remove jumper on J5. Removing this jumper inserts a 1K resistor in series with the inductive loop, reducing the signal amplitude. This prevents the SBE 16plus-IM V2s in close proximity from responding to commands, which is especially important when sending the *ID= command.

Appendix V: 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 IN SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.

ACTIVE INGREDIENT:

Bis(tributyltin) oxide.....	53.0%
OTHER INGREDIENTS:	<u>47.0%</u>
Total.....	100.0%

DANGER

See the complete label within the Conductivity Instrument Manual for Additional Precautionary Statements and Information on the Handling, Storage, and Disposal of this Product.

Net Contents: Two anti-foulant devices

Sea-Bird Electronics, Inc.
13431 NE 20th Street
Bellevue, WA 98005

EPA Registration No. 74489-1
EPA Establishment No. 74489-WA-1

AF24173 Anti-Foulant Device

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

ACTIVE INGREDIENT:

Bis(tributyltin) oxide.....	53.0%
OTHER INGREDIENTS:	47.0%
Total.....	100.0%

DANGER

See Precautionary Statements for additional information.

FIRST AID	
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.
If in eyes	<ul style="list-style-type: none"> Hold 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.
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 Street
 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. Harmful if swallowed. Harmful if absorbed through the skin or inhaled. Prolonged or frequently repeated contact may cause allergic reactions in some individuals. Wash thoroughly with soap and water after handling.

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Wear protective gloves (rubber or latex), goggles or other eye protection, and clothing to minimize contact.
- Follow 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.
- Wash hands with soap and water before eating, drinking, chewing gum, using tobacco or using the toilet.

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.

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 to 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 purpose. Offer for recycling, if available.

Appendix VI: Replacement Parts

Part Number	Part	Application Description	Quantity in 16plus-IM V2
22018	Batteries, alkaline D-cell, Duracell MN 1300 (LR20)	Power 16plus-IM V2	9
801294	Battery cover plate	Retains batteries	1
801483	9D (10.8V / 42 amp-hour) lithium battery pack kit	For longer deployments; batteries not included in kit, and not available from Sea-Bird. Cannot use if 16plus-IM V2 integrated with 5T / 5P pump.	-
801479	3DD (10.8V / 30 amp-hour) lithium battery pack kit	For longer deployments; batteries not included in kit, and not available from Sea-Bird. Cannot use if 16plus-IM V2 integrated with 5T / 5P pump.	-
30411	Triton X-100	Octyl Phenol Ethoxylate – Reagent grade non-ionic cleaning solution for conductivity cell (100% strength; dilute as directed)	1
801542	AF24173 Anti-Foulant Device	bis(tributyltin) oxide device inserted into anti-foulant device cup, for moored applications	1 (set of 2)
231505	Anti-foulant device cap	Secures AF24173 Anti-Foulant Device in cup	2
30984	Anti-foulant device plug	Seals end of anti-foulant assembly when not deployed	2
30900	Machine screw, 1/4-20 x 2" hex head, titanium	Secures mounting clamp	4
30633	Washer, 1/4" split ring lock, titanium	For screw 30900 (secures mounting clamp)	4
30634	Washer 1/4" flat, titanium	For screw 30900 (secures mounting clamp)	4
31019	O-ring 2-088 N674-70	For screw 30900 (retains mounting clamp hardware)	4
801880	4-pin Molex to 9-pin DB-9S I/O cable, 0.9 m (3 ft) long	From internal RS-232 connector to computer, for fast upload and/or for updating firmware	-
171887	9-pin DB-9P to 9-pin DB-9S I/O cable, 3 m (10 ft) long	From SIM to computer	1
171888	25-pin DB-25S to 9-pin DB-9P cable adapter	For use with computer with DB-25 connector	1
17133*	2-pin RMG-4FS to 2-pin RMG-4FS cable, 1.1 m (3.7 ft) long	From 16plus-IM V2 to optional pump	1
17044.1*	2-pin RMG-2FS dummy plug and locking sleeve	For unused pump connector	1
17046.1 *	4-pin RMG-4FS dummy plug and locking sleeve	For unused RS-232 connector	1
17047.1*	6-pin AG-206 dummy plug and locking sleeve	For unused auxiliary differential input sensor connector	3
171503	2-pin MCIL-2FS to 2-pin MCIL-2FS (wet-pluggable connector) cable, 1.1 m (3.7 ft) long	From 16plus-IM V2 to optional pump	1
171497.1	2-pin MCDC-2-F wet-pluggable dummy plug and locking sleeve	For unused pump connector	1
171398.1	4-pin MCDC-4-F wet-pluggable dummy plug and locking sleeve	For unused RS-232 auxiliary sensor connector	1
171498.1	6-pin MCDC-6-F wet-pluggable dummy plug and locking sleeve	For unused auxiliary differential input sensor connector	3
30388	Tygon tube, 1/2 inch ID x 3/4 inch OD	Main plumbing tubing for pumped configuration	-
30579	Tygon tube, 3/8 inch ID x 1/2 inch OD	13 mm (0.5 inch) long pieces used for pumped configurations on conductivity cell exhaust cap and for SBE 43 intake and exhaust to fit to main plumbing	-

* For standard bulkhead connectors

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Part Number	Part	Application Description	Quantity in 16plus-IM V2
22009	Panasonic BR-2/3A lithium batteries	Back-up lithium cells on Power PCB	3
60021	Spare battery end cap hardware and o-rings	O-rings and hardware, including: <ul style="list-style-type: none"> • 30145 Screw, 6-32 x 1/2 Phillips-head, stainless steel (secures battery cover plate to battery posts) • 30242 Washer, #6 flat, stainless steel (for 30145) • 30816 Parker 2-234E603-70 (battery end cap to housing piston seals, sensor end cap to housing seals) 	-
50274	Spare o-ring kit	Assorted o-rings, including: <ul style="list-style-type: none"> • 30816 Parker 2-234E603-70 (battery end cap to housing piston seals, sensor end cap to housing seals) • 30507 Parker 2-206N674-70 (each end of conductivity cell) • 30802 Parker 2-110DUR070, ethylene (titanium conductivity cell tray face seal, groove surface) • 30809 Morrison seal, .047" hole, NIT (temperature probe Morrison seal) • 30072 Parker 2-017N674-70 (bulkhead connector seal) • 30070 Parker 3-904N674-70 (pressure sensor mounting seal) • 30087 Parker 2-232N674-70 (buffer for top retainer of PCB sandwich assembly) • 30801 Parker 5-374E603-70 (base of battery bulkhead seal) 	-
50273	Spare hardware kit	Assorted hardware, including: <ul style="list-style-type: none"> • 30145 Screw, 6-32 x 1/2 Phillips-head, stainless steel (secures battery cover plate to battery posts) • 30242 Washer, #6 flat, stainless steel (for 30145) • 30414 Washer, #12, internal tooth (secures battery bulkhead retainer) • 30954 Screw 4-40 x 3/16 Phillips-head, stainless steel (securing screw for PCB retainer rod) • 31119 Screw 6-32 x 5/8 Truss Head (secures battery bulkhead retainer to bulkhead bottom plate) • 30176 Screw, 10-24 x 3/4, Phillips-head, stainless steel (secures Celcon threaded ring inside titanium battery end cap) • 30249 Washer #10, Flat, stainless steel (for 30176) • 30447 Bolt, 1/4-20 x 1 1/4 Hex, titanium (secures lift eye to battery end cap) • 31089 Screw, 10-32 x 1/2 flat Phillips-head, titanium (secures sensor end cap to housing - side opposite conductivity cell guard) • 31090 Screw, 10-32 x 5/8 flat Phillips-head, titanium (secures conductivity cell guard to housing) • 31118 Screw, 10-32 x 3/8 Phillips-head, titanium (secures conductivity cell guard to sensor end cap) • 30875 Bolt 1/4-20 x 5/8 Hex, titanium (secures connector guard to sensor end cap) • 30633 Washer, 1/4" split ring lock, titanium (for 30875) • 30919 Screw, 6-32 x 3/8 flat slotted, titanium (secures anti-foulant device cup to conductivity cell guard) • 31066 Screw, 8-32 x 3/4 socket, titanium (secures conductivity cell and TC duct to sensor end cap) 	-
50323	Seaspares kit, standard connectors	Includes o-rings, hardware, bulkhead connectors, dummy plugs, etc.: <ul style="list-style-type: none"> • 50087 Conductivity cell filling and storage kit • 50273 Spare hardware kit (see above) • 50274 Spare o-ring kit (see above) • 801294 Battery cover plate • 17044.1 2-pin RMG-2FS dummy plug with locking sleeve • 17047.1 6-pin AG-206 dummy plug with locking sleeve • 17652 2-pin XSG-2-BCL-HP-SS bulkhead connector • 17628 6-pin AG-306-HP-SS bulkhead connector • 30388 Vinyl tube, 3/4" x 1/2" (main sensor plumbing tubing) • 30409 Teflon tape (for insides of hose clamps) • 30411 Triton X100 (for cell cleaning) • 30457 Parker O-Lube (o-ring lubricant) 	-

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Part Number	Part	Application Description	Quantity in 16plus-IM V2
50324	Seaspares kit, wet-pluggable connectors	Includes o-rings, hardware, bulkhead connectors, dummy plugs, etc.: <ul style="list-style-type: none"> • 50087 Conductivity cell filling and storage kit • 50273 Spare hardware kit (see above) • 50274 Spare o-ring kit (see above) • 801294 Battery cover plate • 171192 Locking sleeve • 171497 2-pin MCDC-2-F wet-pluggable dummy plug • 171498 6-pin MCDC-6-F wet-pluggable dummy plug • 172019 2-pin MCBH-2MP(WB) ½-20 bulkhead connector • 172022 6-pin MCBH-6MP(WB) ½-20 bulkhead connector • 30388 Vinyl tube, ¾" x ½" (main sensor plumbing tubing) • 30409 Teflon tape (for insides of hose clamps) • 30411 Triton X100 (for cell cleaning) • 30457 Parker O-Lube (o-ring lubricant) 	-

Appendix VII: Manual Revision History

Manual Version	Date	Description
001	03/08	<ul style="list-style-type: none"> Release of firmware version 2 (16plus-IM V2).
002	01/09	<ul style="list-style-type: none"> Update for SeatermV2 software. Firmware changes – Add CommandSetVersion tag to #iiGetHD reply, add Headers tag to #iiGetSD reply, set maximum #iiDH and #iiGetHeaders reply to 500, allow #iiStartLater maximum of 90 days instead of 1 month in future. Strain gauge pressure sensor maintenance: – design change, no port plug anymore. Add information on !iiWait=: set to (#iiDelaybeforeSampling + 10 sec), to make sure do not time out too quickly. Add J1, J2, etc. labeling on internal wiring showing what goes to what connector. SBE 50 setup: If using SBE Data Processing, must set SBE 50 format to psia (OutputFormat=1). Correct references to TSSOn (non-existent command in V2) to TSS Correct SIM firmware version to 3.0a (not 3.09).
003	07/09	<ul style="list-style-type: none"> Firmware 2.2: <ul style="list-style-type: none"> Add information related to use of Aanderaa Optode as auxiliary RS-232 sensor. Add information on ability to update firmware and/or upload data through internal RS-232 connector on electronics. Clarify and correct sleep time between samples. Remove PType= from setup examples, mention that factory-set. Update software name. Add statement about compatibility with Vista. Update SeatermV2 screen capture to show SBE 33 and 36 in instrument list. Add information about Deployment Endurance Calculator, which is installed with Seasoft.
004	12/09	<ul style="list-style-type: none"> Seasave and SBE Data Processing 7.20a: Add information about .xmlcon file. Add statement about not having other IM instruments nearby when setting ID. Add more information about operation with GTD auxiliary sensor. Add more information about #iiDelayBeforeSampling: does not apply to Optode. Add more information about #iiGetLastSamples:x; do not need to stop logging before sending command. Add CE mark. Update SBE address. Update anti-foul label in Appendix with new Container Handling requirement and new address.
005	04/11	<ul style="list-style-type: none"> Firmware 2.3: <ul style="list-style-type: none"> Add compatibility with WET Labs RS-232 sensors (#iiWetLabs=, #iiTWetLabs). Add commands for RS-232 sensor type and serial number (#iiSetSerialType=, #iiSetSerialSN=). #iiStartLater limitation is 1 month in future. Correct explanation of #iiSampleNumber=; does not reset #iiHeaderNumber=. Add information that lithium battery packs are not compatible with use with SBE 5T or 5P pump. Correct Diquartz pressure sensor stability specification to 0.02% of full scale range/year. Clarify that Optode data is acquired after all CTD and other external sensor data. Replacement parts list: update Seaspares kit contents Update SeatermV2 screen. Remove references to Druck pressure sensors. Update photo for conductivity cell maintenance. Correct typos.

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