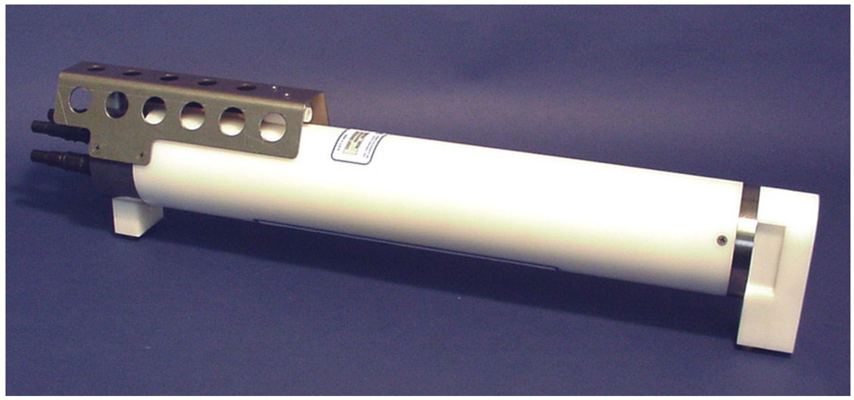
SBE 16*plus*-IM V2 SeaCAT

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



User's Manual

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Manual Version #007, 12/16/13
16*plus*-IM Digital Firmware Version 2.5.2 & later
16*plus*-IM Modem Firmware Version 1.1c & later
SIM Firmware Version 3.0a & later
IMM Firmware version 1.00 & later
SeatermV2 Version 2.3.0 and later
SBE Data Processing Version 7.23.1 & later

CE

Limited Liability Statement

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use or servicing of this system.

Declaration of Conformity

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

DECLARATION OF CONFORMITY

Manufacturer's Name: **Sea-Bird Electronics**
Manufacturer's Address: 13431 NE 20th Street
Bellevue, WA 98005, USA

The Authorized Representative located within the Community is:
OTT MESSTECHNIK GmbH & Co.KG
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Device Description: Various Data Acquisition Devices and Sensors

Model Numbers:

3S	3F	3plus	4C	4M	5T	5P	5M	7
8	9plus	11plus	14	16plus V2	16plus-IM V2		17plus V2	18
19plus V2	21	25plus	26plus	27	29	32	32C	32SC
33	35	35RT	36	37-IMP	37-IM	37-SMP	37-SM	37-SIP
37-SI	38	39	39-IM	39plus	41	41CP	43	43F
44	45	49	50	52-MP	53BPR	54	55	56
63	SIM	ICC	IMM	PDIM	AFM	90488	90204	90402
90504	Glider Payload CTD		NiMH Battery Charger and Battery Pack					

Applicable EU Directives: Machinery Directive 98 / 37 /EC
EMC Directive 2004 / 108 /EC
Low Voltage Directive (73 / 23 /EEC) as amended by (93 / 68 /EEC)

Applicable Harmonized Standards:
EN 61326-1:2006 Class A Electrical Equipment for Measurement, Control, and Laboratory Use, EMC Requirement – Part 1: General Requirements
(EN 55011:2007 Group 1, Class A)

EN 61010-1:2001, Safety Requirements for Electrical Equipments for Measurement, Control, and Laboratory Use – Part 1: General Requirements

Declaration based upon compliance to the Essential Requirements and Letter of Opinion from CKC Certification Services, LLC., Notified Body 0976

I, the undersigned, hereby declare that the equipment specified above conforms to the above European Union Directives and Standards.

Authorized Signature:
Name: Nordeen Larson
Title of Signatory: President
Date: 3 September 2013
Place: Bellevue, WA

Table of Contents

Section 1: Introduction

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

About this Manual

This manual is to be used with the SBE 16*plus*-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

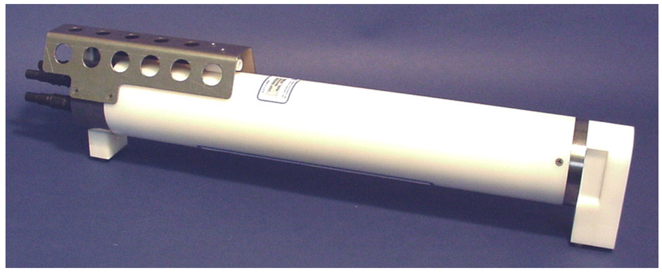
Follow these steps to get a Quick Start using the SBE 16*plus*-IM V2. The manual provides step-by-step details for performing each task:

1. Perform pre-check (*Section 3: Preparing for Deployment*):
   A. Test power and communications.
   B. Set 16*plus*-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 **#iiInitLogging** 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 16*plus*-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 16*plus*-IM V2 on mooring cable.
   I. (optional) Install Inductive Cable Coupler on mooring cable.
   J. Wire system.

Unpacking SBE 16*plus*-IM V2

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



SBE 16*plus*-IM V2

Spare o-ring and hardare kit

Conductivity cell filling and storage kit

Conductivity cell cleaning solution (Triton-X)

Software, and Electronic Copies of Software Manuals and User Manual

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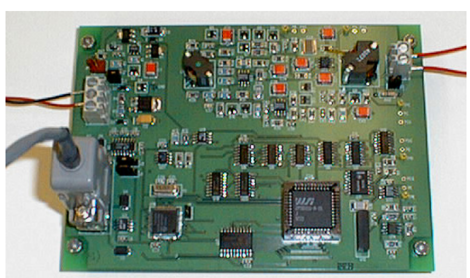
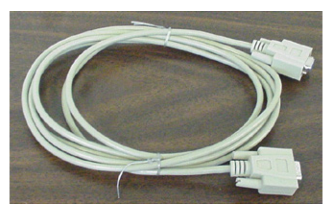
Note:
SBE 16*plus*-IM V2 can be used with SIM or with IMM; IMM not shown.



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 16*plus*-IM V2

This section describes the functions and features of the SBE 16*plus*-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.

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 16*plus*-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 16*plus*-IM V2s on the line.

The SBE 16*plus*-IM V2 SeaCAT is designed to measure conductivity, temperature, and (optional) pressure in marine or fresh-water environments in moored applications. The 16*plus*-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 16*plus*-IM V2's built-in inductive coupler (split toroid) and cable clamp provide easy and secure attachment to the mooring cable.

Communicating with one or more 16*plus*-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 16*plus*-IM V2s (or other IM-compatible sensors), coupled to a single cable. The user can communicate with these devices via full-duplex RS-232C (optional half-duplex RS-485 for SIM). Commands and data are transmitted half-duplex between these devices and the 16*plus*-IM V2.

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

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

The 16*plus*-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 16*plus*-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 63 optical dissolved oxygen 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.

Note:
Although 16*plus*-IM V2 is available with a 10,500 m housing, maximum transmission distance between the Surface Inductive Modem or Inductive Modem Module and 16*plus*-IM V2 is rated only to 8000 m.

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 software package, Seasoft V2, which includes:

- **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.

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.

Specifications

	Temperature (°C)	Conductivity (S/m)	Pressure (optional)
Measurement Range	-5 to +35	0 to 9	0 to full scale range: • *Strain gauge sensor:* 20/100/350/600/1000/2000/3500/7000 meters • *Quartz sensor:* 20/60/130/200/270/680/1400/2000/4200/7000/10500 meters Note: Although 16*plus*-IM V2 is available with a 10,500 m pressure sensor and housing, maximum transmission distance between SIM or IMM and 16*plus*-IM V2 is rated only to 8000 m.
Initial Accuracy	± 0.005	± 0.0005	• *Strain gauge sensor:* ± 0.1% of full scale range • *Quartz sensor:* ± 0.02% of full scale range
Typical Stability	0.0002/month	0.0003/month	• *Strain gauge sensor:* 0.1% of full scale range/year • *Quartz sensor:* 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).	• *Strain gauge sensor:* 0.002% of full scale range • *Quartz sensor:* 0.0006% of full scale range for 1-sec 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 ≈ 3000 Hz over sensor's full scale range
- Counter Resolution = pressure sensor output frequency / (**#iiParosIntegration** * 1,843,200)
  where pressure sensor output frequency ≈ 35,000 Hz
  #iiParosIntegration = user-input integration time (sec)
- 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 sec	0.044 m (44 mm)
2.2 sec	0.02 m (20 mm)
4.4 sec	0.01 m (10 mm)
44 sec	0.001 m (1 mm)

Continued on next page

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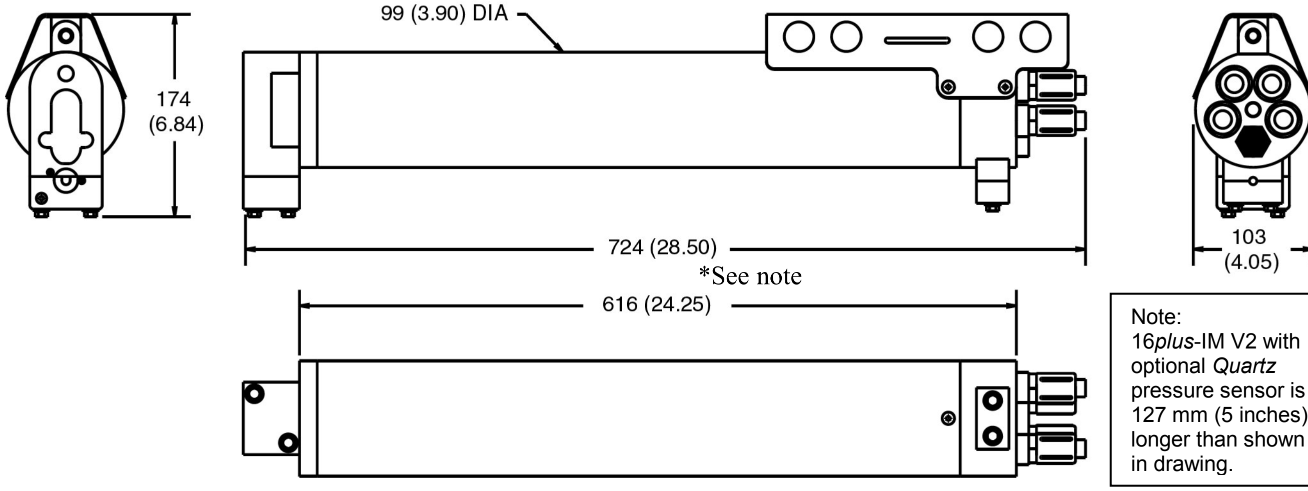
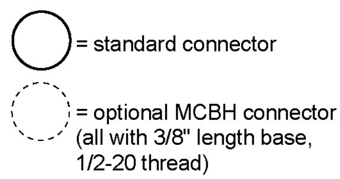
Memory	64 Mbyte non-volatile FLASH memory
Data Storage	**<u>Recorded Parameter</u>** **<u>Bytes/sample</u>** temperature + conductivity 6 (3 each) internally mounted strain gauge or Quartz pressure 5 each external voltage 2 SBE 63 optical dissolved oxygen 6 SBE 38 secondary temperature 3 SBE 50 pressure 3 WET Labs RS-232 sensor 6 Each Pro-Oceanus GTD 4 (pressure) + 3 (temperature) Aanderaa Optode 3 date and time 4
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	*Sampling*: no pressure sensor 55 mA with internally mounted pressure sensor 70 mA *Optional Pump:* SBE 5M 100 mA SBE 5P or 5T 150 mA *Communications:* 4 mA *Quiescent:* 140 µA Sampling time (see *Sample Timing* for example calculations): • Minimum 2.2 sec/sample (no pump, no pressure sensor, 1 measurement/sample, and no delays). • Add 0.3 sec with internally mounted strain gauge pressure sensor. • Add integration time with internally mounted Quartz pressure sensor (**#iiParosIntegration=**; minimum 1 sec). • Add 0.25 sec for each additional measurement/sample (**#iiNCycles ≥ 2**). • Add pump on-time (0.5 sec) if pump running before taking sample (**#iiPumpMode=1**). • Add time for user-programmed delay before and after sampling (**#iiDelayBeforeSampling=** and **#iiDelayAfterSampling=**). Approximate Battery Endurance [1]: CT only: 290,000 samples CTD only: 200,000 samples CTD & 5M pump: 110,000 samples [1] With Duracell MN 1300 (LR20) cells. Dependent on sampling and telemetry scheme; see *Battery Endurance* for example calculations.
Auxiliary Voltage and RS-232 Sensors	*Auxiliary power out*: up to 500 mA at 10.5 - 11 VDC *Voltage sensor A/D resolution*: 14 bits *Voltage sensor Input range*: 0 - 5 VDC
Housing Depth Range and Materials	600 meter (1950 ft): acetal copolymer (plastic) 7000 meter (22,900 ft): 3AL-2.5V titanium 10,500 meter (34,400 ft): 6AL-4V titanium Note: Although 16*plus*-IM V2 is available with a 10,500 m pressure sensor and housing, maximum transmission distance between SIM or IMM and 16*plus*-IM V2 is rated only to 8000 m.
Weight (without pump)	With plastic housing: *in air* - 9 kg (20 lbs) *in water* - 4 kg (9 lbs) With 3AL-2.5V titanium housing: *in air* - 17 kg (38 lbs) *in water* - 12 kg (27 lbs)

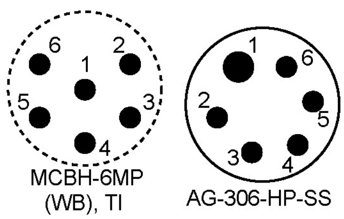
Dimensions and End Cap Connectors

Dimensions in millimeters (inches)



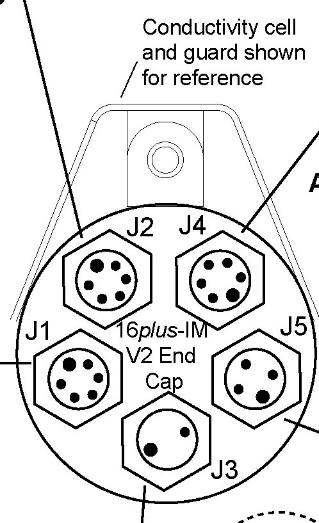
Note:
16*plus*-IM V2 with optional *Quartz* pressure sensor is 127 mm (5 inches) longer than shown in drawing.

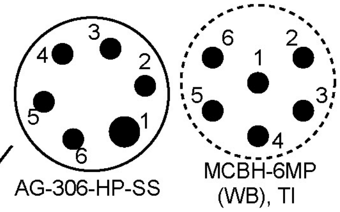




Auxiliary Differential Input 2,3

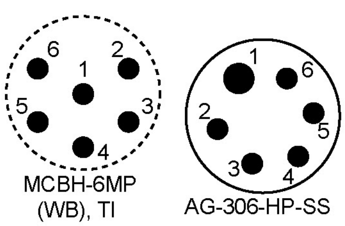
Pin	Signal
1	Common
2	Voltage 2 Signal
3	Voltage 2 Common
4	Voltage 3 Signal
5	Voltage 3 Common
6	Auxiliary Power Out





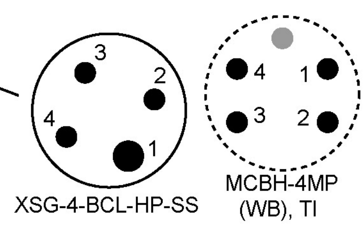
Auxiliary Differential Input 4,5

Pin	Signal
1	Common
2	Voltage 4 Signal
3	Voltage 4 Common
4	Voltage 5 Signal
5	Voltage 5 Common
6	Auxiliary Power Out



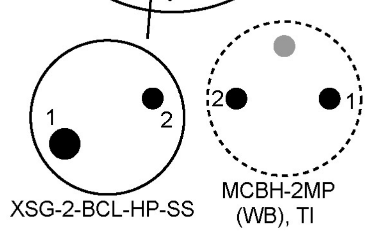
Auxiliary Differential Input 0,1

Pin	Signal
1	Common
2	Voltage 0 Signal
3	Voltage 0 Common
4	Voltage 1 Signal
5	Voltage 1 Common
6	Auxiliary Power Out



Auxiliary RS-232 Input

Pin	Signal
1	Common
2	RS-232 Data transmit to RS-232 sensor
3	RS-232 Data receive from RS-232 sensor
4	Power to RS-232 sensor

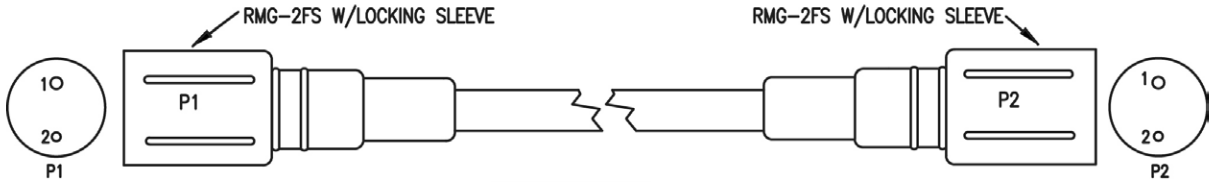


Pump Connector

Pin	Signal
1	Pump Power Common
2	Pump Power +

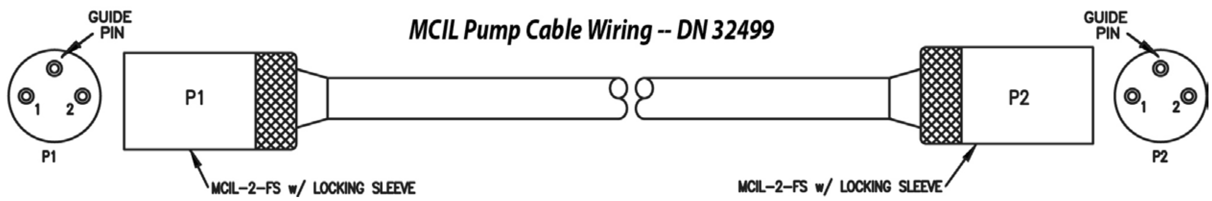
Cables

RMG Pump Cable Wiring -- DN 30565

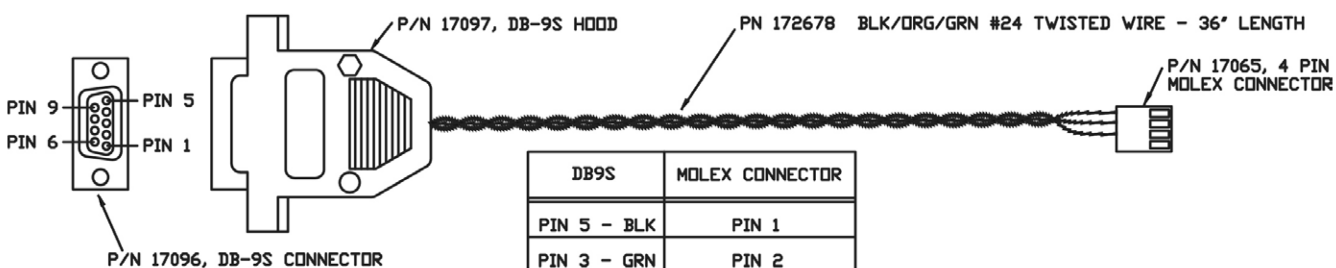


P1	P2
PIN 1	PIN 1
PIN 2	PIN 2

MCIL Pump Cable Wiring -- DN 32499



(Optional) Data I/O Cable Wiring -- DN 33447



DB9S	MOLEX CONNECTOR
PIN 5 - BLK	PIN 1
PIN 3 - GRN	PIN 2
PIN 2 - ORN	PIN 3
	PIN 4

Data Storage

Note:
See *Battery Endurance* for power limitations.

The SBE 16*plus*-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 ≈ 64,000,000 / (6 + 5 + 4) ≈ 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 ≈ 64,000,000 /(6 + 5 + 12 + 3 + 4) ≈ 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 16*plus*-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=**), user-programmable sampling parameters for number of samples per measurement (**#iiNCycles=**), delay before sampling to allow time for auxiliary sensors to stabilize or for WET Labs auxiliary sensor bio-wipers to open (**#iiDelayBeforeSampling=**), and delay after sampling to allow time for WET Labs auxiliary sensor bio-wipers to close (**#iiDelayAfterSampling=**).

For autonomous sampling (logging), the 16*plus*-IM V2 requires a minimum of 5 sec 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 sec remaining until the programmed start of the next sample, the 16*plus*-IM V2 provides a message:

```
Error - - > alarm time not far enough in the future,
resetting alarm to 5 sec from now
```

The 16*plus*-IM V2 takes the next sample in 5 sec. The 16*plus*-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** #ii**SampleInterval=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 16*plus*-IM V2 that is integrated with an SBE 5T or 5P pump.

For the main battery, the SBE 16*plus*-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 16*plus*-IM V2 is logging data and the battery voltage is less than 7.5 volts, the 16*plus*-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 16*plus*-IM V2 with no pump or auxiliary sensors
- 10.5 amp-hours for a 16*plus*-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 16*plus*-IM V2s on mooring, send **GData**, send **Dataii** or **!iiData** to each 16*plus*-IM V2, and power off all 16*plus*-IM V2s), the communications current is drawn for approximately 0.5 sec **per 16*plus*-IM V2 on the mooring**. Each 16*plus*-IM V2 on the mooring draws this current while any 16*plus*-IM V2 is being queried to transmit data. Other interrogation schemes require more time.

Ten 16*plus*-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 / 16*plus*-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-sec/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 / 16*plus*-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 sec/hr) / (1.71 amp-sec/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 / 16*plus*-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.

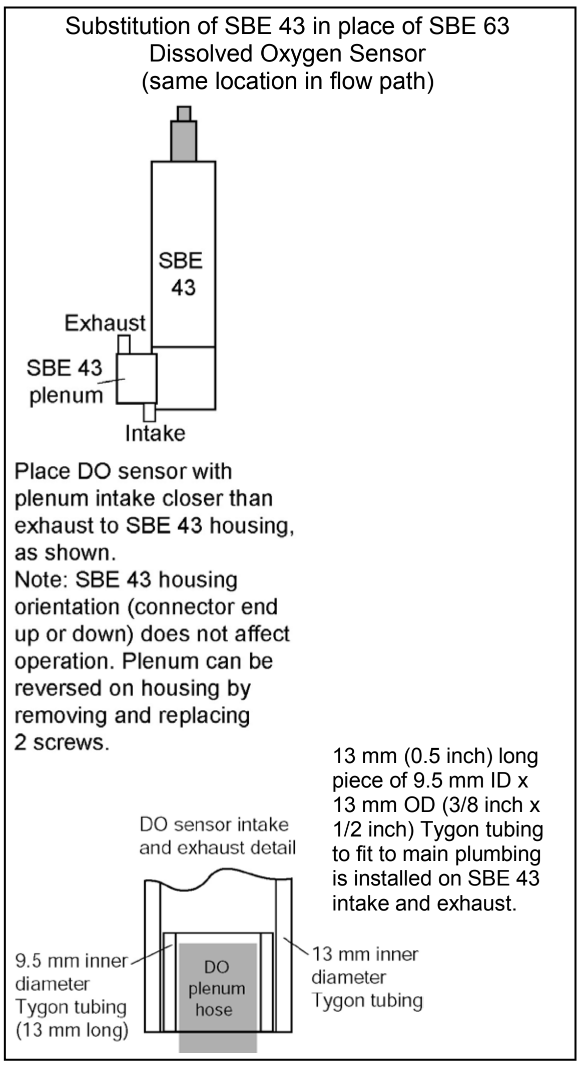
Additionally, a standard 4-pin bulkhead connector on the sensor end cap is provided for interfacing with one of the following RS-232 sensors:

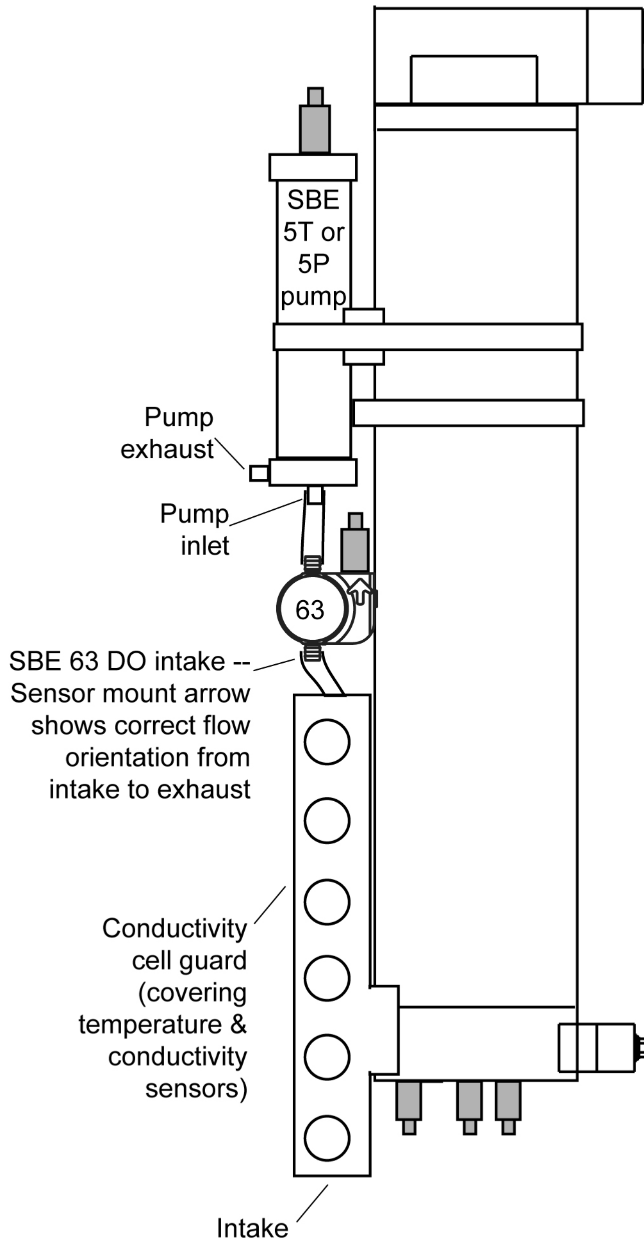
- SBE 63 optical dissolved oxygen sensor
- SBE 38 secondary temperature sensor
- SBE 50 secondary strain-gauge pressure sensor
- WET Labs sensor - single, dual, or triple channel ECO sensor; WETStar; or C-Star
- Pro-Oceanus Gas Tension Devices (up to two GTDs can be integrated)
- Aanderaa Optode 4330 or 4835

Shown below is the plumbing arrangement of an SBE 16*plus*-IM V2 equipped with the optional SBE 5T or 5P pump and SBE 63 Optical Dissolved Oxygen sensor. Note that the SBE 63 is plumbed into the system between the conductivity cell outlet and the pump (same configuration can be used with SBE 43 DO sensor in place of SBE 63; see diagram below for mounting detail). See *Section 4: Deploying and Operating SBE 16plus-IM V2* for pump setup and operation details.

Configuration Notes:

- Cables not shown; pump and DO sensor are cabled to 16*plus*-IM V2 end cap.
- 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 main plumbing is installed on conductivity cell exhaust.





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

An Inductive Modem Module or Surface Inductive Modem is required for communication with the SBE 16*plus*-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 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*.

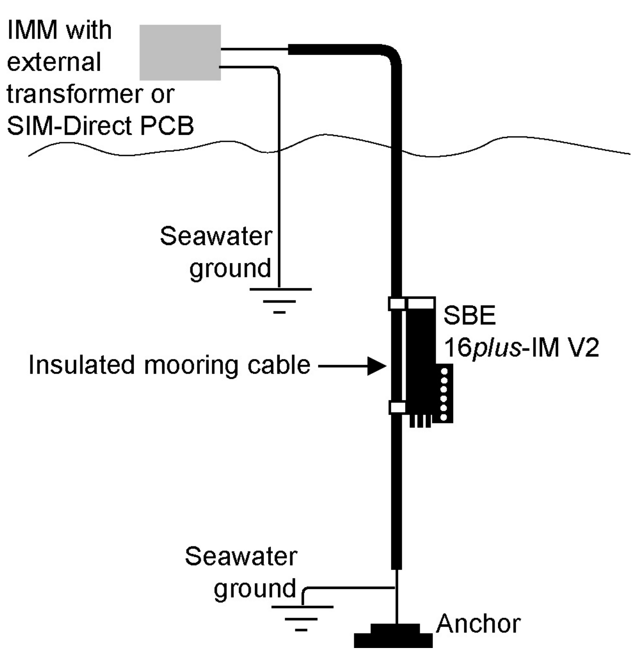
The SBE 16*plus*-IM V2 can mechanically accommodate mooring cables up to 16 mm (0.63 inches) in diameter. Clamps for specific cable diameters are available, or can be supplied on a custom basis. Suitable mooring cables use steel wire rope with a polypropylene or polyethylene-insulating jacket. The SIM 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.

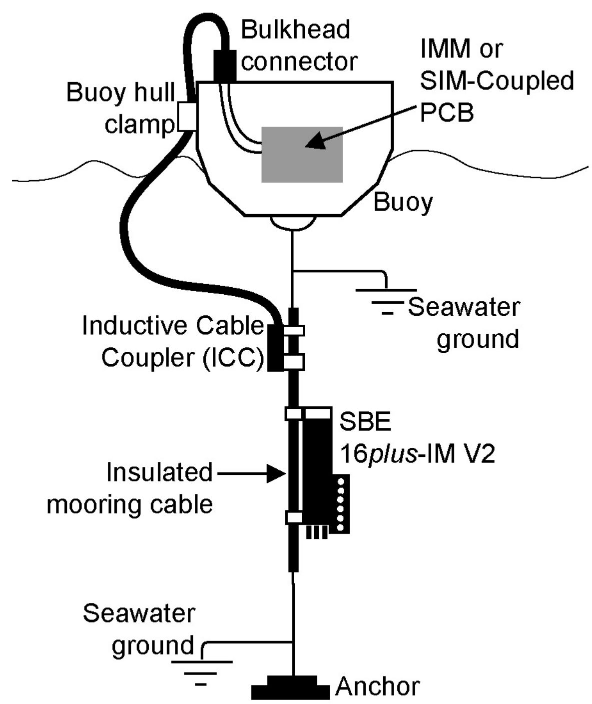
The mooring cable must also provide for connection to the IMM or SIM.

- 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.



Direct Connection



Connection with Inductive Cable Coupler (ICC)

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 16*plus*-IM V2 ID - each 16*plus*-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 16*plus*-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.

Seasoft V2 was designed to work with a PC running Windows XP service pack 2 or later, Windows Vista, or Windows 7.

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.exe**. 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 16*plus*-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

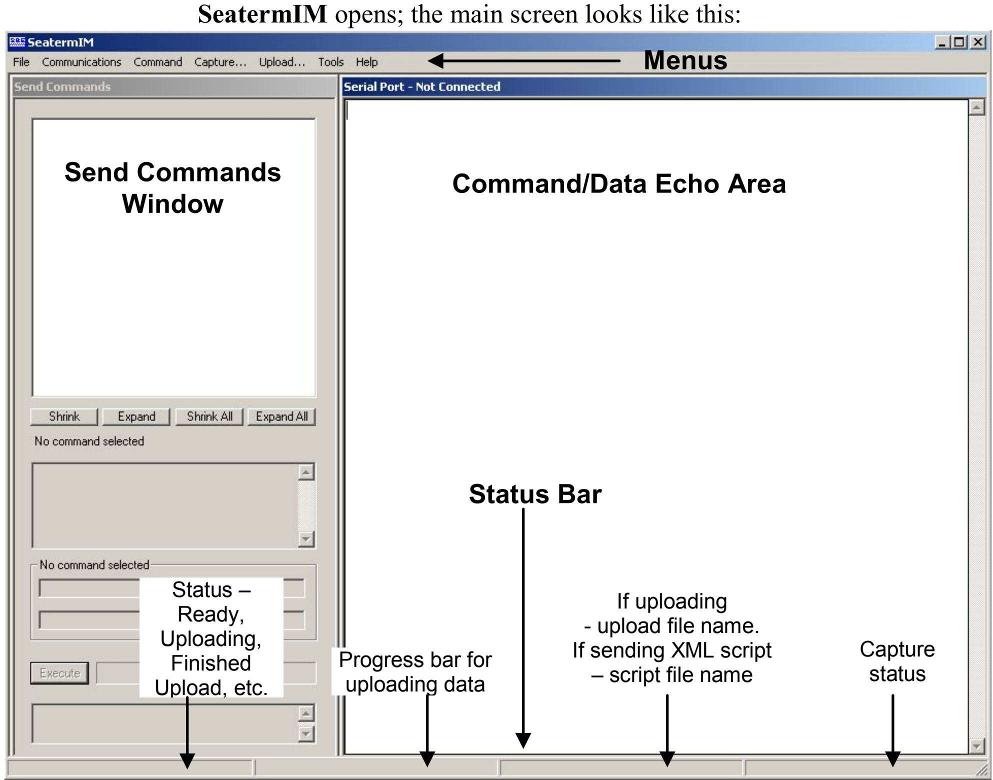
> **Note:**
> See SeatermV2's Help files.

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

SeatermV2 is a *launcher*, and launches the appropriate terminal program for the selected instrument.

> **Notes:**
> - See SeatermIM's Help files.
> - If using the 16*plus*-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:



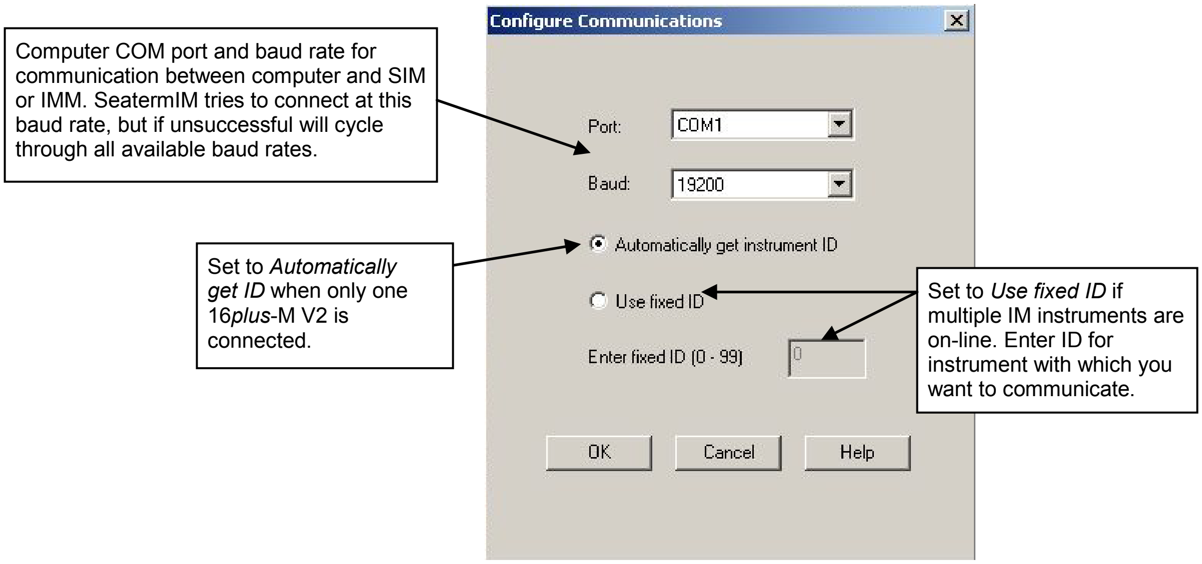
- Menus – For tasks and frequently executed instrument commands.
- Send Commands window – Contains commands applicable to your 16*plus*-IM V2. The list appears after you connect to the 16*plus*-IM V2.
- Command/Data Echo Area – Title bar of this window shows SeatermIM's current comm port and baud rate. Commands and the 16*plus*-IM V2 responses are echoed here. Additionally, a command can be manually typed or pasted (ctrl + V) here. Note that the 16*plus*-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	• 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	• 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 *go to sleep* 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.	• **PwrOn**
Command	• Abort – interrupt and stop 16*plus*-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.	• (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	• 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 16*plus*-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 16*plus*-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:
   - 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 16*plus*-IM V2. Once the ID response is received, SeatermIM sends **!iiDS** and #**iiGetHD**, using the ID provided by the 16*plus*-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 16*plus*-IM V2 's communication microcontroller and acquisition microcontroller.

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

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 16*plus*-IM V2 with which you want to communicate. Click OK.

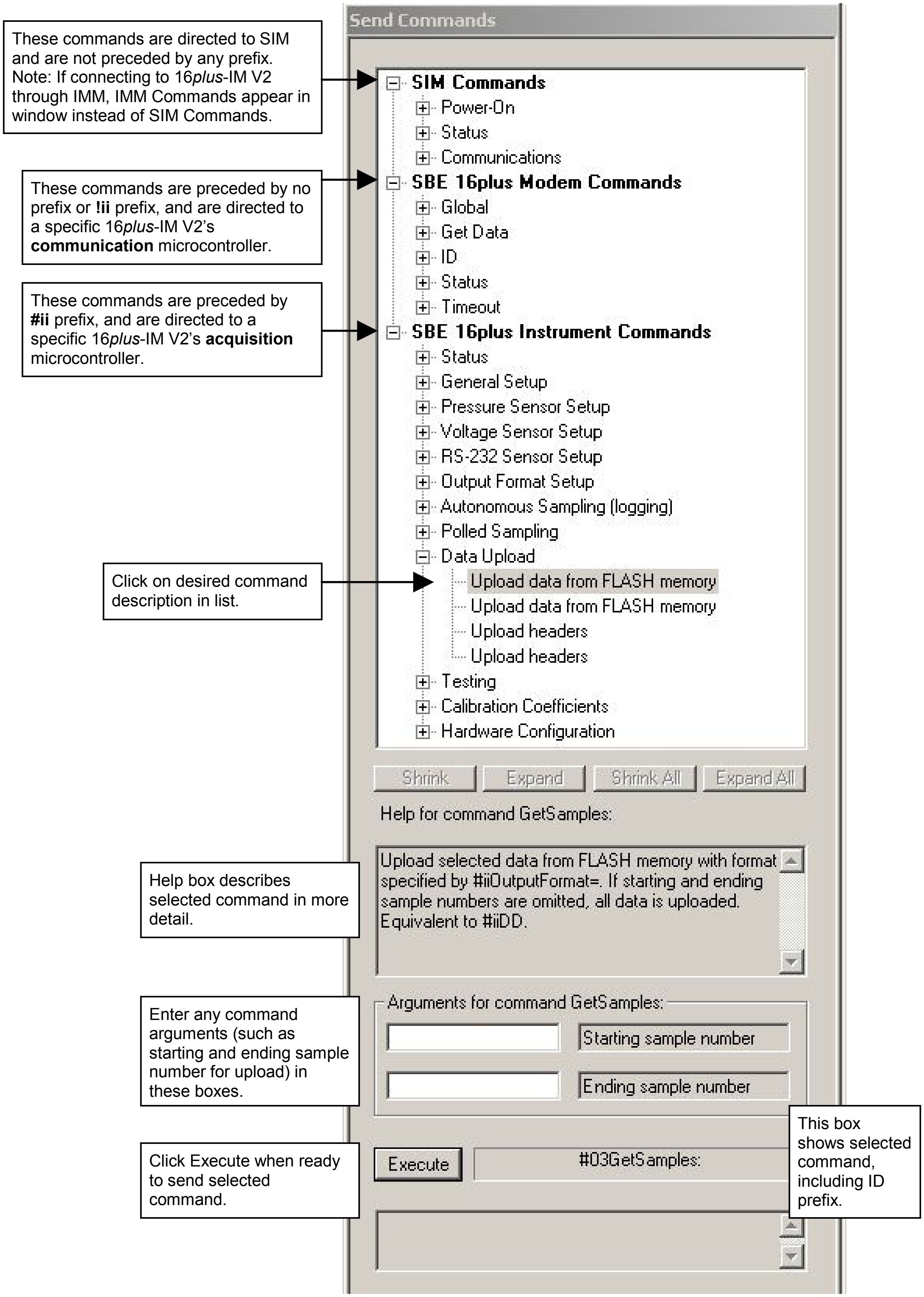
B. In the Communications menu, select *Connect* (if *Connect* is grayed out, select *Disconnect and reconnect*). SeatermIM will attempt to connect at the baud specified in Step A, but if unsuccessful will then cycle through all other available baud rates.

C. If there is still no communication, check cabling between the computer, SIM or IMM, and 16*plus*-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.

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 16*plus*-IM V2 if there are multiple 16*plus*-IM V2s on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16*plus*-IM V2 on the IM line. Note that the ID is stored in the 16*plus*-IM V2's EEPROM and can be changed so that multiple 16*plus*-IM V2s on a single IM line each have a unique ID. See the Configuration Sheet for the factory-set ID.

Taking a look at the Send Commands window:



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 16*plus*-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

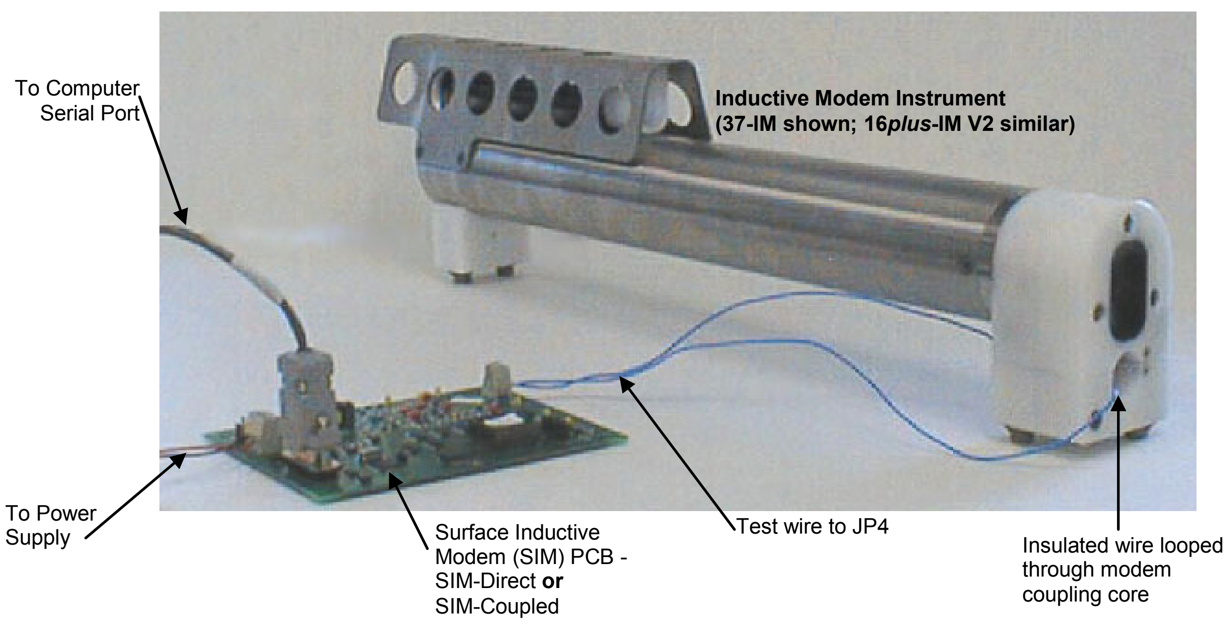
1. Loop insulated wire through the 16*plus*-IM V2 modem coupling core to simulate a mooring cable. Connect the test wire ends to the SIM's mooring cable terminals (JP4). (See *Appendix IV: SIM Hookup and Configuration* for detailed information.)

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 16*plus*-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.

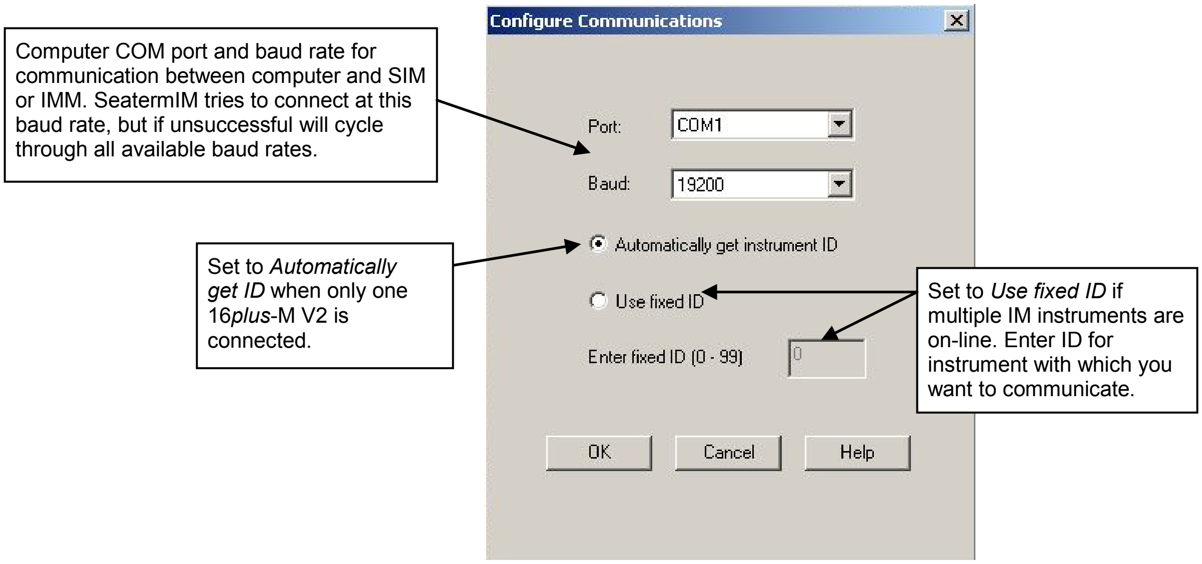


Test and Set SBE 16*plus*-IM V2 ID Using SIM

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 16*plus*-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 16*plus*-IM V2. Once the ID response is received, SeatermIM sends **!iiDS** and #**iiGetHD**, using the ID provided by the 16*plus*-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 16*plus*-IM V2's communication microcontroller and acquisition microcontroller.

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

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 16*plus*-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 16*plus*-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.

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 16*plus*-IM V2 if there are multiple IM instruments on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16*plus*-IM V2 on the IM line. Note that the ID is stored in the 16*plus*-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.

Note:
Sending the status command causes the optional pump to turn on for a moment, so that the 16*plus*-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 16*plus*-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 16*plus*-IM V2 status information by typing **#iiDS** (ii = 16*plus*-IM V2 ID) and pressing the Enter key. The display looks like this:

```
SBE 16plus-IM V 2.5.2  SERIAL NO. 0001    01 Dec 2013  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, delay after
sampling = 0.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38=no, SBE 50 = no, WETLABS = no, OPTODE = no, SBE 63 = 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 16*plus*-IM V2 to take a sample by typing **#iiTS** (ii = 16*plus*-IM V2 ID) and pressing the Enter key. The display looks like this (if 16*plus*-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 Dec 2013, 14:10:10, 5
```

where 0001 = 16*plus*-IM V2 serial number 4000 (16pxxxxx-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 Dec 2013 = 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 16*plus*-IM V2 is on-line before you set the ID:
   A. Set the 16*plus*-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 16*plus*-IM V2 to go to sleep (quiescent state) by typing **PwrOff** and pressing the Enter key.

The SBE 16*plus*-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 16*plus*-IM V2 IDs – Using Inductive Modem Module (IMM)

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

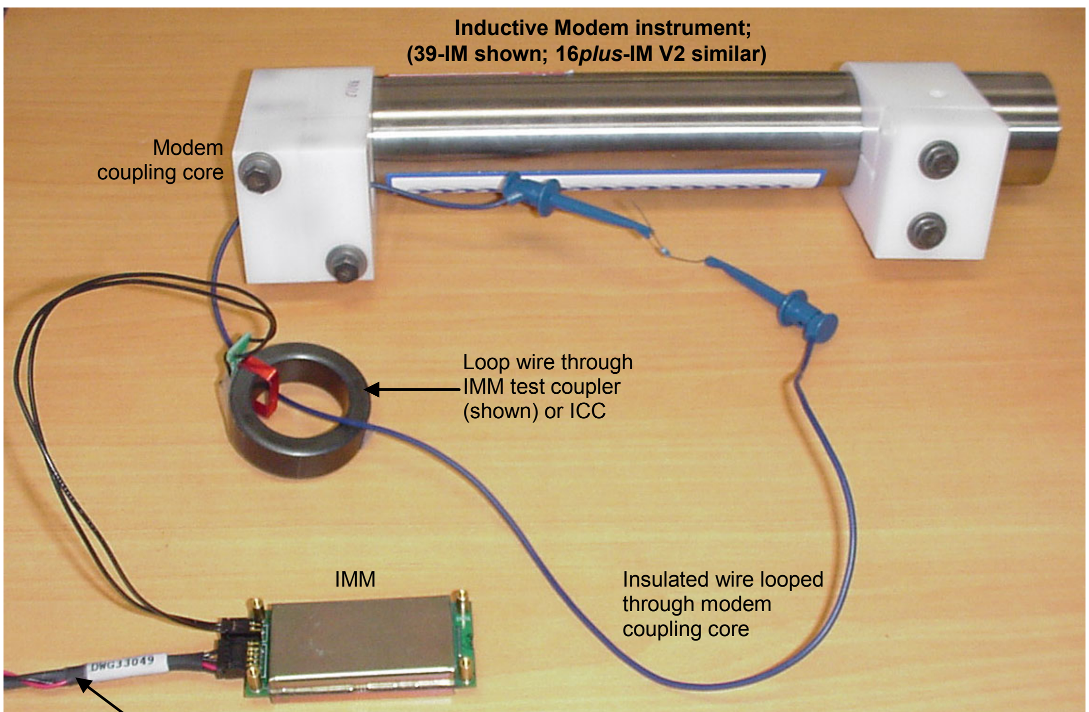
Test Setup with IMM

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 16*plus*-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 16*plus*-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 16*plus*-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

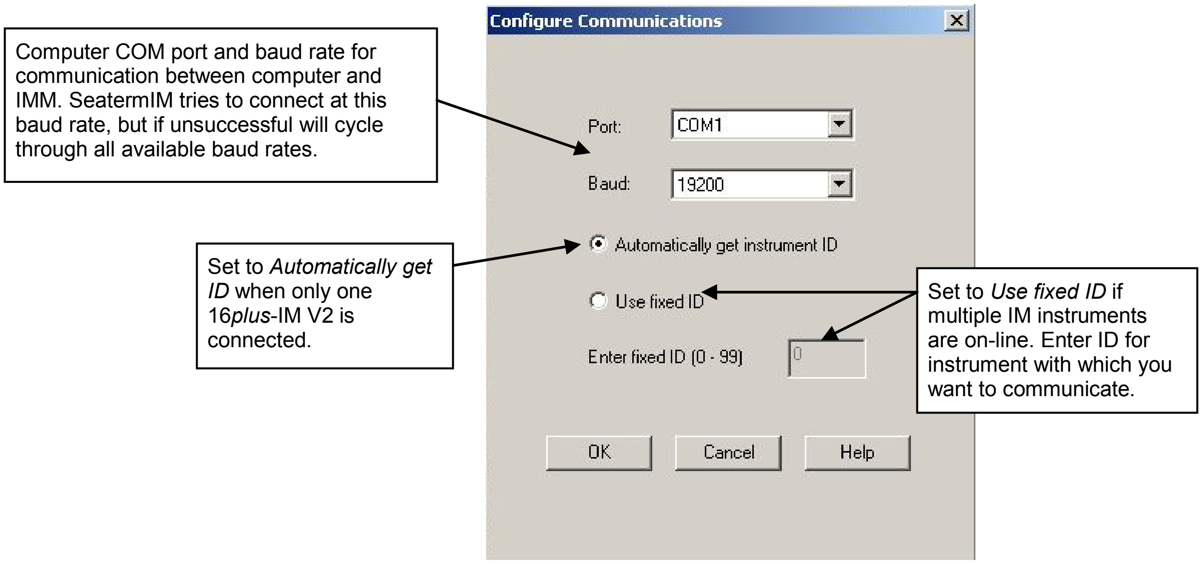
Verify that the IMM is set up as described by sending the **GetCD** command before proceeding with the 16*plus*-IM V2 setup.

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 16*plus*-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:



Make the desired selections, and click OK.

3. SeatermIM tries to automatically connect to the 16*plus*-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 16*plus*-IM V2. It then sends **!iiDS** and #**iiGetHD**, using the ID provided by the 16*plus*-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 16*plus*-IM V2.

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

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 16*plus*-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 16*plus*-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.

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 16*plus*-IM V2 if there are multiple IM instruments on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16*plus*-IM V2 on the IM line. Note that the ID is stored in the 16*plus*-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.

Note:
The IMM and 16*plus*-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 sec, send **ForceCaptureLine**, and send **SendWakeupTone**.

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

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

```
SBE 16plus-IM V 2.5.2  SERIAL NO. 0001    01 Dec 2013  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, delay after
sampling = 0.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38=no, SBE 50 = no, WETLABS = no, OPTODE = no, SBE 63 = 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
```

Note:
Sending the status command causes the optional pump to turn on for a moment, so that the 16*plus*-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 16*plus*-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.

6. Command the 16*plus*-IM V2 to take a sample by typing **#iiTS** (ii = 16*plus*-IM V2 ID) and pressing the Enter key. The display looks like this (if 16*plus*-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 Dec 2013, 14:10:10, 5
```

where 0001 = 16*plus*-IM V2 serial number 4000 (16pxxxxx-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 Dec 2013 = 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 16*plus*-IM V2 is on-line before you set the ID:
   A. Set the 16*plus*-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 16*plus*-IM V2 to go to sleep (quiescent state) by typing **PwrOff** and pressing the Enter key.

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

Section 4: Deploying and Operating SBE 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-IM V2 communication microcontroller (with a ! prefix), or the 16*plus*-IM V2 acquisition microcontroller (with a # prefix).

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

Surface Inductive Modem (SIM)
- Power on/Power off
- SIM status
- Set baud (SIM to computer)
- Set timeouts
- Set echo parameter

OR

Inductive Modem Module (IMM)
See IMM manual for details.

↔

16*plus*-IM V2 Communication Microcontroller
- Get data
- Get and set 16*plus*-IM V2 ID
- Display status
- Set timeout
- Global commands to get data and set clock

↔

16*plus*-IM V2 Acquisition Microcontroller
- Display status
- Setup
- Autonomous sampling (logging)
- Data upload
- Polled sampling
- Testing
- Calibration coefficients
- Hardware configuration

Timeout Descriptions

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

SIM timeouts restore control to the computer if no reply is received from the 16*plus*-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 millisec.
- **RelayMax** – timeout for all other commands. Default 20 sec.

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 **16*plus*-IM V2 timeout** powers down the 16*plus*-IM V2 communication circuits if the 16*plus*-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 sec, send **ForceCaptureLine**, and then send **SendWakupTone**.

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

The SBE 16*plus*-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 16*plus*-IM V2s (IDs 01, 02, and 03) on a mooring cable. Note that the 16*plus*-IM V2 response to each command is not shown in the examples.

Polled Sampling

On command, the SBE 16*plus*-IM V2 takes one sample of data and sends the data to the SIM or IMM. Storing of data in the 16*plus*-IM V2 FLASH memory is dependent on the particular command used. Note that it is not possible to synchronize the data samples from each 16*plus*-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, 2013 at 9:05 am.
Set up each 16*plus*-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 16*plus*-IM V2s.

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16*plus*-IM V2s.)
DATETIME=09012013090500
#01VOLT0=Y
#01PUMPMODE=0
#01NCYCLES=4
#01OUTPUTFORMAT=3
#01GETCD (to verify setup)
(Repeat **#iiVOLT0=** through **#iiGETCD** for 16*plus*-IM V2s 02 and 03.)
PWROFF

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

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16*plus*-IM V2s.)
#01TS (16*plus*-IM V2 with ID=01 takes and transmits a sample.)
#02TS (16*plus*-IM V2 with ID=02 takes and transmits a sample.)
#03TS (16*plus*-IM V2 with ID=03 takes and transmits a sample.)
PWROFF

Autonomous Sampling (logging)

At pre-programmed intervals, the SBE 16*plus*-IM V2 wakes up, samples data, stores the data in its FLASH memory, and enters quiescent (sleep) state. The 16*plus*-IM V2 goes to sleep for a minimum of 5 sec between each sample. The 16*plus*-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 16*plus*-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 16*plus*-IM V2s.
- Set the sampling interval for each 16*plus*-IM V2 to the same value.
- Set the start sampling date and time for each 16*plus*-IM V2 to the same value, and then send **#iiStartLater**.

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

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

The 16*plus*-IM V2 has a *lockout* feature to prevent unintended interference with sampling. If the 16*plus*-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 16*plus*-IM V2 Communication Microcontroller commands: **GData** (send **SendGData** if using IMM), **Dataii**, **!iiData**, **ID?**, and **!iiDS**
- These 16*plus*-IM V2 Acquisition Microcontroller commands: **#iiGetCD**, **#iiGetSD**, **#iiGetCC**, **#iiGetEC**, **#iiResetEC**, **#iiGetHD**, **#iiDS**, **#iiDCal**, **#iiTS**, **#iiSL**, **#iiSLT**, and **#iiStop**.

Example: ***Autonomous Sampling*** (user input in bold)
Send wakeup tone to all 16*plus*-IM V2*s*. Globally set date and time to September 1, 2013 at 9:05 am. For each 16*plus*-IM V2: initialize logging to overwrite previous data in memory, set up with 1 voltage sensor, take a sample every 120 sec, take and average 4 measurements for each sample, and output data in raw hex format. Set up pump to run for 0.5 sec before each sample. Set up to start logging on 15 September 2013 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 16*plus*-IM V2s.

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

```
DATETIME=09012013090500
#01INITLOGGING
#01VOLT0=Y
#01SAMPLEINTERVAL=120
#01NCYCLES=4
#01OUTPUTFORMAT=0
#01PUMPMODE=1
#01STARTDATETIME=09152013120000
#01STARTLATER
#01GETCD          (to verify setup)
```

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

```
PWROFF
```

Deploy 16*plus*-IM V2. Logging starts automatically at designated date and time.
When ready to upload all data to computer, wake up all 16*plus*-IM V2s, stop sampling, and upload data:

(Select *Connect* in SeatermIM's Communications menu to connect and wake up all 16*plus*-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 16*plus*-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 16*plus*-IM V2, to look at data without stopping the sampling. As in Autonomous Sampling, the 16*plus*-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 16*plus*-IM V2. There are two ways to get the last stored sample:

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

Example: ***Combo Sampling*** (user input in bold)
Set up all 16*plus*-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 16*plus*-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 16*plus*-IM V2s.)
GDATA
!01DATA
!02DATA
!03DATA
PWROFF

Upload all data as shown above for Autonomous Sampling.

Pump Operation

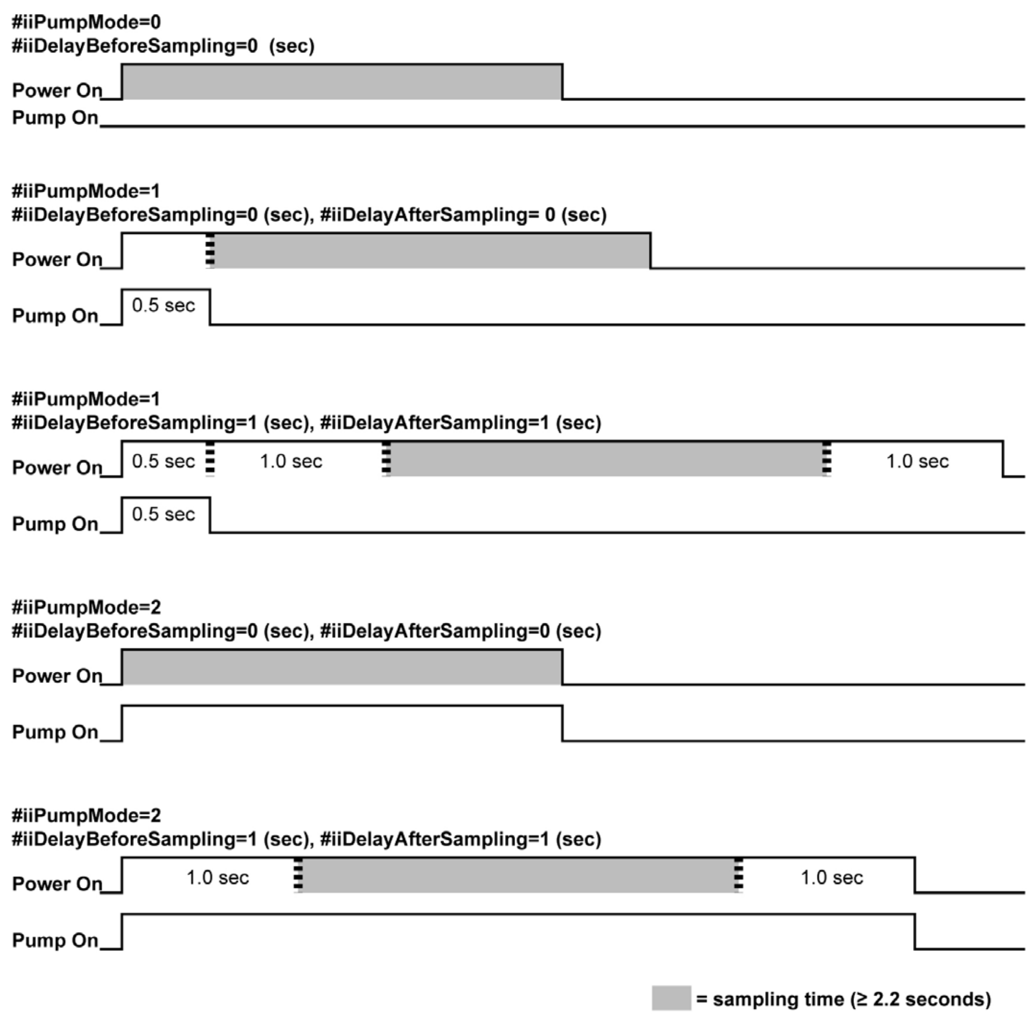
Do not run the pump dry. The pump is water lubricated; running it without water will damage it. If briefly testing your system in dry conditions, fill the inside of the pump head with water via the pump exhaust port. This will provide enough lubrication to prevent pump damage during brief testing.

Pump operation is governed by three user-programmable parameters:

- **#iiPumpMode=0**, **1**, or **2**
  16*plus*-IM V2 can be set up to operate with no pump (0), pump running for 0.5 sec before each sample (1), or pump running during each sample (2).
- **#iiDelayBeforeSampling=**
  16*plus*-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. WET Labs sensors with bio-wipers require time to open the bio-wiper before sampling.
- **#iiDelayAfterSampling=**
  16*plus*-IM V2 can be set up to delay turning off power to the pump and external voltage and RS-232 sensors. WET Labs sensors with bio-wipers require time to shut the bio-wiper after sampling is completed.

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

These parameters interact in the operation of the pump, as shown below. Recommendations for settings are provided on the next page.



Note: Sampling time includes time for instrument to warm up as well as time to measure parameters. The 2.2 sec sampling time is for 16*plus*-IM V2 with no internally mounted 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

Note:
#iiDelayAfterSampling= is typically set to a non-zero value only if using a WET Labs sensor with a bio-wiper.

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 sec before the conductivity measurement is made, providing enough time to ventilate the cell and bring in a new sample of water.

If the 16*plus*-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**.

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

As the pump brings new water into the SBE 43 plenum, 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. Sea-Bird now offers two membrane thicknesses:

- **0.5 mil thick** membrane (faster response, typically for profiling applications) – Recommended **#iiDelayBeforeSampling=** varies in a non-linear fashion, from 15 sec at 15 °C to 30 sec at 0 °C.
- **1.0 mil thick** membrane (slower response but more durable, typically for moored applications) – Recommended **#iiDelayBeforeSampling=** varies in a non-linear fashion, from 25 sec at 15 °C to 40 sec at 0 °C.

Pump through Conductivity Cell and SBE 63 Optical Dissolved Oxygen Sensor (requires SBE 5P or 5T pump)

Set **#iiPumpMode=2**.

Note:
See the *SBE 63 manual*.

As the pump brings new water into the SBE 63 plenum, time is required for the sensor to equilibrate to the new oxygen level. The time required is dependent on the water temperature. Recommended **#iiDelayBeforeSampling=** varies in a linear fashion, from 25 sec at 15 °C to 40 sec 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 sec, allowing time for the oxygen sensor to polarize before taking the measurement.

Command Descriptions

Notes:
- If using the 16*plus*-IM V2 with an **Inductive Modem Module (IMM)**, see the IMM manual for details on IMM commands.
- If using the 16*plus*-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 16*plus*-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 16*plus*-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 sec, sending **ForceCaptureLine**, and sending **Send WakeupTone**.
- The 16*plus*-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 16*plus*-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=**, **#iiSBE63=**, **#iiSBE38=**, **#iiSBE50=**, **#iiWetLabs= #iiGTD=**, **#iiDualGTD=**, **#iiOptode=**.
- When sampling autonomously, the 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-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.

> **Note:**
> **AutoPwrOn=N** is not typically used with the 16*plus*-IM V2.

AutoPwrOn=x — **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.

x=N: Do not send **PwrOn** when power applied to SIM.

> **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 pwron 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 millisec.

DataNNMax=x — **x**= timeout (0 – 32767 millisec; SIM rounds down to nearest 50 millisec) 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 millisec.

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

RelayMax=x — **x**= timeout (0-3276 sec) 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 sec.***

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

EchoOff — Do not echo characters.

16*plus*-IM V2 Communication Microcontroller Commands

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

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**.

Global Commands

Note:
If the 16*plus*-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** 16*plus*-IM V2s.

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

Note:
The 16*plus*-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 16*plus*-IM V2 with ID = ii (ii = 0-99).

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

16*plus*-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 16*plus*-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 (sec) for communication microcontroller to wait for response from acquisition microcontroller.
Range 2 – 600 sec.

16*plus*-IM V2 Acquisition Microcontroller Commands

Notes:
- All 16*plus*-IM V2s are factory assigned to Group 0 and Group 9.
- If using the 16*plus*-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 16*plus*-IM V2 Acquisition Microcontroller commands are preceded by **#ii** (ii= 16*plus*-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 16*plus*-IM V2's internal RS-232 serial connector), omit the **#ii** prefix shown in the command listings.

Status Commands

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.

#iiGetCD

Get and display configuration data, which includes all parameters related to setup of 16*plus*-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:

- 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=**]
- Pump turn-off delay [**#iiDelayAfterSampling=**]
- 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 [**#iiWetLabs=**]?
- Sample Optode [**#iiOptode=**]?
- Sample SBE 63 optical dissolved oxygen sensor [**#iiSBE63=**]?
- 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: 16*plus*-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=]
      <DelayAfterSampling>0.0</DelayAfterSampling>                           [#iiDelayAfterSampling=]
   </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=]
      <SBE63>no</SBE63>                                                      [#iiSBE63=]
      <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_I>no</OutputSigmaT_V_I>                                   [#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 16*plus* –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 16*plus*-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: 16*plus*-IM V2 with ID=01 (user input in bold, command used to modify parameter in parentheses)

```
#01getsd
<StatusData DeviceType = 'SBE16plus-IM' SerialNumber = '01606001'>
   <DateTime>2013-12-01T10:53:03</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 16*plus*-IM V2.

Example: 16*plus*-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-Nov-13</CalDate>                         [#iiTCalDate=]
      <TA0>1.155787e-03</TA0>                              [#iiTA0=]
      <TA1>2.725208e-04</TA1>                              [#iiTA1=]
      <TA2>-7.526811e-07</TA2>                             [#iiTA2=]
      <TA3>1.716270e-07</TA3>                              [#iiTA3=]
      <TOFFSET>0.000000e+00</TOFFSET>                      [#iiTOffset=]
   </Calibration>
   <Calibration format = 'WBCOND0' id = 'Main Conductivity'>
      <SerialNum>01600001</SerialNum>
      <CalDate>19-Nov-13</CalDate>                         [#iiCCalDate=]
      <G>-1.006192e+00</G>                                 [#iiCG=]
      <H>1.310565e-01</H>                                  [#iiCH=]
      <I>-2.437852e-04</I>                                 [#iiCI=]
      <J>3.490353e-05</J>                                  [#iiCJ=]
      <CPCOR>-9.570000e-08</CPCOR>                         [#iiCPCor=]
      <CTCOR>3.250000e-06</CTCOR>                          [#iiCTCor=]
      <CSLOPE>1.000000e+00</CSLOPE>                        [#iiCSlope=]
   </Calibration>
   <Calibration format = 'STRAIN0' id = 'Main Pressure'>
      <SerialNum>01600001</SerialNum>
      <CalDate>07-Nov-13</CalDate>                         [#iiPCalDate=]
      <PA0>-5.137085e-02</PA0>                             [#iiPA0=]
      <PA1>1.550601e-03</PA1>                              [#iiPA1=]
      <PA2>7.210415e-12</PA2>                              [#iiPA2=]
      <PTCA0>5.154159e+05</PTCA0>                          [#iiPTCA0=]
      <PTCA1>2.560262e-01</PTCA1>                          [#iiPTCA1=]
      <PTCA2>-8.533080e-02</PTCA2>                         [#iiPTCA2=]
      <PTCB0>2.426612e+01</PTCB0>                          [#iiPTCB0=]
      <PTCB1>-7.750000e-04</PTCB1>                         [#iiPTCB1=]
      <PTCB2>0.000000e+00</PTCB2>                          [#iiPTCB2=]
      <PTEMPA0>-7.667877e+01</PTEMPA0>                     [#iiPTempA0=]
      <PTEMPA1>4.880376e+01</PTEMPA1>                      [#iiPTempA1=]
      <PTEMPA2>-4.555938e-01</PTEMPA2>                     [#iiPTempA2=]
      <POFFSET>0.000000e+00</POFFSET>                      [#iiPOffset= (decibars)]
      <PRANGE>1.000000e+03</PRANGE>                        [#iiPRange= (psia);factory set]
   </Calibration>
   <Calibration format = 'VOLT0' id = 'Volt 0'>
      <OFFSET>0.000000e+00</OFFSET>                        [factory set]
      <SLOPE>1.260977e+00</SLOPE>                          [factory set]
   </Calibration>
   <Calibration format = 'VOLT0' id = 'Volt 1'>
      <OFFSET>-4.728750e-02</OFFSET>                       [factory set]
      <SLOPE>1.259474e+00</SLOPE>                          [factory set]
   </Calibration>
   <Calibration format = 'VOLT0' id = 'Volt 2'>
      <OFFSET>-4.715313e-02</OFFSET>                       [factory set]
      <SLOPE>1.259946e+00</SLOPE>                          [factory set]
   </Calibration>
   <Calibration format = 'VOLT0' id = 'Volt 3'>
      <OFFSET>-4.772396e-02</OFFSET>                       [factory set]
      <SLOPE>1.260486e+00</SLOPE>                          [factory set]
   </Calibration>
   <Calibration format = 'VOLT0' id = 'Volt 4'>
      <OFFSET>-4.765417e-02</OFFSET>                       [factory set]
      <SLOPE>1.260014e+00</SLOPE>                          [factory set]
   </Calibration>
   <Calibration format = 'VOLT0' id = 'Volt 5'>
      <OFFSET>-4.744167e-02</OFFSET>                       [factory set]
      <SLOPE>1.260255e+00</SLOPE>                          [factory set]
   </Calibration>
   <Calibration format = 'FREQ0' id = 'external frequency channel'>
      <EXTFREQSF>1.000000e+00</EXTFREQSF>                  [factory set]
   </Calibration>
</CalibrationCoefficients>
```

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 16*plus*-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 16*plus*-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'/>                    [can clear with #iiResetEC]
   <Event type='alarm short' count='1'/>
</EventCounters>
```

#iiResetEC

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

Status Commands (*continued*)

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

#iiGetHD

Get and display hardware data, which is fixed data describing 16*plus*-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 63, SBE 38, WET Labs, etc.) and serial numbers

Example: 16*plus*-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>2.5.2</FirmwareVersion>
   <FirmwareDate>13 Nov 2013 12:00</FirmwareDate>
   <CommandSetVersion>2.3</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 nov 2013</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>                              [#iiSetVoltType0=]
         <SerialNumber>not assigned</SerialNumber>              [#iiSetVoltSN0=]
      </Sensor>
      <Sensor id = 'volt 1'>
         <type>not assigned</type>                              [#iiSetVoltType1=]
         <SerialNumber>not assigned</SerialNumber>              [#iiSetVoltSN1=]
      </Sensor>
      <Sensor id = 'volt 2'>
         <type>not assigned</type>                              [#iiSetVoltType2=]
         <SerialNumber>not assigned</SerialNumber>              [#iiSetVoltSN2=]
      </Sensor>
      <Sensor id = 'volt 3'>
         <type>not assigned</type>                              [#iiSetVoltType3=]
         <SerialNumber>not assigned</SerialNumber>              [#iiSetVoltSN3=]
      </Sensor>
      <Sensor id = 'volt 4'>
         <type>not assigned</type>                              [#iiSetVoltType4=]
         <SerialNumber>not assigned</SerialNumber>              [#iiSetVoltSN4=]
      </Sensor>
      <Sensor id = 'volt 5'>
         <type>not assigned</type>                              [#iiSetVoltType5=]
         <SerialNumber>not assigned</SerialNumber>              [#iiSetVoltSN5=]
      <Sensor id = 'serial'>
         <type>not assigned</type>                              [#iiSetSerialType=]
         <SerialNumber> not assigned </SerialNumber>            [#iiSetSerialSN=]
      </Sensor>
   </ExternalSensors>
</HardwareData>
```

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 16*plus*-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 16*plus*-IM V2 is set up for dual GTDs, the **#iiDS** shows: `Dual Gas Tension Device = Yes`
- If the 16*plus*-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=**], turn-on delay [**#iiDelayBeforeSampling=**], turn-off delay [**#iiDelayAfterSampling=**].
- Battery cut-off voltage
- Internally mounted pressure sensor type [**#iiPType=**] and range [**#iiPRange=**]; factory set
- Sample RS-232 sensor - SBE 38 secondary temperature sensor [**#iiSBE38=**], SBE 50 pressure sensor [**#iiSBE50=**], WET Labs [**#iiWetLabs=**], Optode [**#iiOptode=**], SBE 63 optical dissolved oxygen sensor [**#iiSBE63=**], 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: 16*plus*-IM V2 with ID=01 (user input in bold, command used to modify parameter in parentheses)

```
#01DS
SBE 16plus-IM V 2.5.2 SERIAL NO. 0001    01 Dec 2013  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, delay after sampling = 0.0 seconds
                          [#iiPumpMode=, #iiDelayBeforeSampling=, #iiDelayAfterSampling=]
pressure sensor = strain gauge, range = 1000.0         [#iiPType=, #iiPRange=; both factory set]
SBE 38=no, SBE 50=no, WETLABS = no, OPTODE = no, SBE63 = no, Gas Tension Device = no
   [#iiSBE38=, #iiSBE50=, #iiWetLabs=, #iiOptode=, #iiSBE63=, #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 16*plus*-IM V2.

Example: 16*plus*-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 2.5.2  SERIAL NO. 0001  01 Dec 2013  14:46:05        [#iiDateTime=]
temperature:  20-nov-13                                              [#iiTCalDate=]
    TA0 = -3.178124e-06                                              [#iiTA0=]
    TA1 = 2.751603e-04                                               [#iiTA1=]
    TA2 = -2.215606e-06                                              [#iiTA2=]
    TA3 = 1.549719e-07                                               [#iiTA3=]
    TOFFSET = 0.000000e+00                                           [#iiTOffset=]
conductivity:  20-nov-13                                             [#iiCCalDate=]
    G = -9.855242e-01                                                [#iiCG=]
    H = 1.458421e-01                                                 [#iiCH=]
    I = -3.290801e-04                                                [#iiCI=]
    J = 4.784952e-05                                                 [#iiCJ=]
    CPCOR = -9.570000e-08                                            [#iiCPCor=]
    CTCOR = 3.250000e-06                                             [#iiCTCor=]
    CSLOPE = 1.000000e+00                                            [#iiCSlope=]
pressure S/N 2580011, range = 2000 psia:  14-nov-13    [#iiPRange= (psia), #iiPCalDate=]
    PA0 = 0.000000e+00                                               [#iiPA0=]
    PA1 = 0.000000e+00                                               [#iiPA1=]
    PA2 = 0.000000e+00                                               [#iiPA2=]
    PTEMPA0 = 0.000000e+00                                           [#iiPTempA0=]
    PTEMPA1 = 0.000000e+00                                           [#iiPTempA1=]
    PTEMPA2 = 0.000000e+00                                           [#iiPTempA2=]
    PTCA0 = 0.000000e+00                                             [#iiPTCA0=]
    PTCA1 = 0.000000e+00                                             [#iiPTCA1=]
    PTCA2 = 0.000000e+00                                             [#iiPTCA2=]
    PTCB0 = 0.000000e+00                                             [#iiPTCB0=]
    PTCB1 = 0.000000e+00                                             [#iiPTCB1=]
    PTCB2 = 0.000000e+00                                             [#iiPTCB2=]
POFFSET = 0.000000e+00                                   [#iiPOffset= (decibars)]
volt 0: offset = 0.000000e+00, slope = 1.000000e+00                  [factory set]
volt 1: offset = 0.000000e+00, slope = 1.000000e+00                  [factory set]
volt 2: offset = 0.000000e+00, slope = 1.000000e+00                  [factory set]
volt 3: offset = 0.000000e+00, slope = 1.000000e+00                  [factory set]
volt 4: offset = 0.000000e+00, slope = 1.000000e+00                  [factory set]
volt 5: offset = 0.000000e+00, slope = 1.000000e+00                  [factory set]
    EXTFREQSF = 1.000000e+00                                         [factory set]
```

General Setup Commands

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

Example: Set current date and time for 16*plus*-IM V2 with ID=01 to 05 October 2013 12:05:00 (user input in bold).

```
#01DATETIME=10052013120500
```

#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 16*plus*-IM V2 response to command requires additional time.

x=N: Do not.

Example: Set 16*plus*-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=**, **#iiDelayBeforeSampling=**, and **#iiDelayAfterSampling=**. See *Pump Operation*.
- **#iiPumpMode=**, **#iiNCycles=**, **#iiParosIntegration=**, and **#iiDelayBeforeSampling=** affect the time required to sample. If the time required to sample is too high, the 16*plus*-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 sec 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***. 16*plus*-IM V2 takes and averages **#iiNCycles=** measurements (each 0.25 sec apart). For autonomous sampling; averaged data is stored in FLASH memory.

General Setup Commands (*continued*)

Notes:
- When **#iiInitLogging** or **#iiSampleNumber=** are sent, the 16*plus*-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**) before uploading all existing data.
16*plus*-IM V2 can have a maximum of 1000 stored headers. Note that 16*plus*-IM V2 writes a new header each time autonomous sampling is started and after every 2000 samples are stored in memory.

Note:
If a WET Labs sensor 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 sensor with Bio-Wiper (voltage *or* RS-232 auxiliary sensor). With this setup, 16*plus*-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 WET Labs sensor with Bio-Wiper.

Pressure Sensor Setup Commands

Note:
The 16*plus*-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; do not modify**):

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 16*plus*-IM V2 does not include internally mounted pressure sensor; 16*plus*-IM V2 uses reference pressure in conductivity, salinity, and sound velocity calculation. Value entered for **#iiRefPress=** is displayed in **#iiGetCD** and **#iiDS** responses if 16*plus*-IM V2 does not include internally mounted pressure sensor.
Entry ignored if 16*plus*-IM V2 includes internally mounted pressure sensor.
If 16*plus*-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 16*plus*-IM V2 does the integration for the Quartz pressure sensor *after* **#iiNCycles=** measurements have been taken.
- **#iiPumpMode=**, **#iiNCycles=**, **#iiParosIntegration=**, **#iiDelayBeforeSampling=**, and **#iiDelayAfterSampling=** affect the time required to sample. If the time required to sample is too high, the 16*plus*-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 sec; ***default 1 sec***.
Increasing integration time increases resolution.
See *Specifications* in *Section 2: Description of SBE 16plus-IM V2* to determine resolution for Quartz pressure sensor.

Notes:
- **Do not send #iiVolt0 = through #iiVolt5= unless all previous data has been uploaded from memory.** When one of these commands is sent, the 16*plus*-IM V2 responds that it is initializing logging.
- The 16*plus*-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 16*plus*-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 16*plus*-IM V2 before it times out) longer than **#iiDelayBeforeSampling=**.
- Set **!iiWait=** longer than (10 sec + **#iiDelayBeforeSampling=**).
- **#iiPumpMode=**, **#iiNCycles=**, **#iiParosIntegration=**, **#iiDelayBeforeSampling=**, and **#iiDelayAfterSampling=** affect the time required to sample. If the time required to sample is too high, the 16*plus*-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 **#iiDelayBeforeSampling=**, **#iiDelayAfterSampling=**, 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 16*plus*-IM V2 turns on power to the Optode when the 16*plus*-IM V2 is ready to acquire Optode data.

Voltage Sensor Setup Commands

#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 (sec) to wait after switching on external voltages and RS-232 sensors before sampling (0-600 sec). ***Default 0 sec.***
Typical value if using:
- WET Labs sensor with bio-wiper – approximately 4 sec, to provide time for bio-wiper to open (sensor dependent; see WET Labs documentation).
- SBE 43 or 63 oxygen sensor – time is dependent on membrane thickness and water temperature (see *Pump Operation*). Use with **#iiPumpMode=2**.
- Beckman- or YSI-type oxygen sensor – 120-180 sec to provide time for sensor to polarize. Use with **#iiPumpMode=2**.
- Sea Tech fluorometer - 15 sec to provide time for sensor to stabilize.

#iiDelayAfterSampling=x
x= time (sec) to wait after sampling is completed, before turning off power to external voltages and RS-232 sensors (0 – 100 sec). ***Default 0 sec***.
Typical value if using WET Labs sensor with bio-wiper is 4 sec, to allow time for sensor to shut bio-wiper after sampling is completed (sensor dependent; see WET Labs documentation).

Notes:
- **Do not send #iiSBE63=**, **#iiSBE38=, #iiSBE50=, #iiWetLabs=, #iiGTD=, #iiDualGTD=, or #iiOptode= unless all previous data has been uploaded from memory.** When one of these commands is sent, the 16*plus*-IM V2 responds that it is initializing logging.
- The 16*plus*-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.

Note:
You can use Seaterm232 to communicate directly with the SBE 63 when it is connected directly to the computer.

Note:
The 16*plus*-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 16*plus*-IM V2 to take a CTD sample and to request and receive a sample from SBE 63 (≈ 10 sec).
- Time required for integration of optional Quartz pressure sensor (**#iiParosIntegration=**).
- Time required for 16*plus*-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=**); when used with the SBE 63, minimum **#iiDelayBeforeSampling=** is 25 sec at 15 °C to 40 sec at 0 °C (linear interpolation between those values). This provides enough time for the SBE 63 to equilibrate after pumping begins, before the measurement is made.
- Delay after sampling before turning off power to external sensors (**#iiDelayAfterSampling=**).

RS-232 Sensor Setup Commands

The 16*plus*-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 16*plus*-IM V2 end cap):
- SBE 63 optical dissolved oxygen sensor
- 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 63:
Set up SBE 63 to interface with SBE 16*plus*-IM V2, **before** you connect it to 16*plus*-IM V2. Connect SBE 63 directly to computer, power with an external power supply, and (using Seaterm232) set:
- Set baud rate to 9600 (**SetBaud=**)
- Turn echoing on (**SetEcho=1**)
- Set samples averaged to 1 to 16; default value of 2 recommended (**SetAvg=2**)
- Set output format for compatibility with 16*plus*-IM V2 (**SetFormat=1**)
- Disable automatic sampling when power applied (**SetAutoRun=0**)

Connect SBE 63 to SBE 16*plus*-IM V2 *Auxiliary RS-232 Input* connector, using provided cable. In the 16*plus*-IM V2, set **#iiSBE63=Y** to enable interface.

#iiSBE63=x

x=Y: Enable SBE 63 optical dissolved oxygen sensor.

x=N: Do not enable SBE 63.

#iiSend63=command

Command 16*plus*-IM V2 to send **command** to SBE 63 and receive response; **command** can be any command recognized by SBE 63 (see SBE 63 manual).

RS-232 Sensor Setup Commands (*continued*)

Setup for SBE 38:
Set up SBE 38 to interface with SBE 16*plus*-IM V2, **before** you connect it to 16*plus*-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 16*plus*-IM V2 *Auxiliary RS-232 Input* connector, using provided cable. In the 16*plus*-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 16*plus*-IM V2, **before** you connect it to 16*plus*-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 16*plus*-IM V2 *Auxiliary RS-232 Input* connector, using provided cable. In the 16*plus*-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 16*plus*-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 16*plus*-IM V2 to take a sample (≈ 2.5 sec).
- Time required for integration of optional Quartz pressure sensor (**#iiParosIntegration=**).
- Time required for 16*plus* 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.*
- Delay after sampling before turning off power to external sensors (**#iiDelayAfterSampling=**).
- 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):

- **16*plus*-IM V2 #iiDelayBeforeSampling=** must be ≥ 2 sec if using a WET Labs RS-232 sensor. If **#iiWetLabs=Y** and #ii**DelayBeforeSampling** < 2 sec, 16*plus*-IM V2 automatically sets **#iiDelayBeforeSampling=2**.
- If using a WET Labs sensor with a bio-wiper – set **16*plus*-IM V2 #iiDelayBeforeSampling=** and **#iiDelayAfterSampling=** to enough time to allow bio-wiper to open before sampling and to close after sampling. Sea-Bird typically sets this parameter to 4.0 sec for use with a sensor with a bio-wiper (sensor dependent).

Note that the SBE 16*plus*-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 16*plus*-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 16*plus*-IM V2 to take a sample (≈ 2.5 sec).
- Time required for integration of optional Quartz pressure sensor (**#iiParosIntegration=**).
- Time required for 16*plus*-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=**).
- Delay after sampling before turning off power to external sensors (**#iiDelayAfterSampling=**)
- Time required to run pump before sampling (0.5 sec if **#iiPumpMode=1**).

Setup for GTD:

Set up GTD to interface with SBE 16*plus*-IM V2, **before** you connect it to 16*plus*-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 sec or less (required so that 16*plus*-IM V2 does not *time out* while waiting for reply).

Connect GTD to SBE 16*plus*-IM V2 *Auxiliary RS-232 Input* connector, using provided cable (end labeled *Pro-Oceanus* to GTD and end labeled *Sea-Bird* to 16*plus*-IM V2). In the 16*plus*-IM V2, set:
- **#iiGTD=Y** or **#iiDualGTD=Y** to enable interface.
- **#iiSendGTD=** to change IDs if necessary.

The 16*plus*-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 16*plus*-IM V2 sends following commands to GTD (ID= 01, 02, etc.):
- ***ID00VR** <CR><LF> - get GTD firmware version; wait up to 3 sec for reply.
- ***ID00SN** <CR><LF> - get GTD serial number; wait up to 5 sec 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 sec 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 sec for reply.

Notes:
- A 16*plus*-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.

#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).

Example: Output GTD data for 16*plus*-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 10^5)
GTD#2 pressure reply = *00021010.01580, p = 101001580   (millibars x 10^5)
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 16*plus*-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 16*plus*-IM V2 (ID=01) to GTD #1:

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

Send serial number command from 16*plus*-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 16*plus*-IM V2 turns on power to the Optode when the 16*plus*-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 16*plus*-IM V2, **before** you connect it to 16*plus*-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 16*plus*-IM V2 *Auxiliary RS-232 Input* connector. In 16*plus*-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 16*plus*-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

Autonomous sampling commands direct the 16*plus*-IM V2 to sample at a pre-programmed interval. When commanded to start sampling with **#iiStartNow** or **#iiStartLater**, the 16*plus*-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 16*plus*-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 16*plus*-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).

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 16*plus*-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 16*plus*-IM V2 continues to sample and store sample data in FLASH memory without writing additional headers.
- If the 16*plus*-IM V2 is sampling and the voltage is less than the cut-off voltage (7.5 volts), the 16*plus*-IM V2 halts logging and displays `WARNING: LOW BATTERY VOLTAGE`.

Note:
#iiPumpMode=, **#iiNCycles=**, **#iiParosIntegration=**, **#iiDelayBeforeSampling=**, and **#iiDelayAfterSampling=** affect the time required to sample. If the time required to sample is too high, the 16*plus*-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*.

#iiSampleInterval=x — **x**= interval (sec) between samples (10 – 14,400 sec).

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

#iiStartNow — Start autonomous sampling now.

Notes:
- After receiving **#iiStartLater**, the 16*plus*-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 16*plus*-IM V2 executes **#iiStartNow**.
- If the delayed start date and time is more than 1 month in the future when **#iiStartLater** is received, the 16*plus*-IM V2 assumes that the user made an error in setting the delayed start date and time, and it executes **#iiStartNow**.

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

#iiStartLater — Start autonomous sampling at time set with **#iiStartDateTime=**. If you need to change 16*plus*-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 16*plus*-IM V2 with ID=01 to start logging on 20 January 2014 12:00:00 (user input in bold).
>
> **#01STARTDATETIME=01202014120000**
> **#01STARTLATER**

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

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

Polled Sampling Commands

Note:
The 16*plus*-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 16*plus*-IM V2 always stores data for the most recent sample in its buffer. Some Sampling commands also store data in FLASH memory - the 16*plus*-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, 16*plus*-IM V2 outputs all samples in memory. If **x** is omitted, 16*plus*-IM V2 outputs just the last sample. **You do not need to stop logging (#iiStop) before sending #iiGetLastSamples:x.**

Data Upload Commands

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*.

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

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 16*plus*-IM V2 housing to access the internal RS-232 serial connector. When using RS-232 telemetry, select *SBE 16lus 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 16*plus*-IM V2.
- **Inductive modem** – Data can be uploaded while the 16*plus*-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 16*plus*-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: 16*plus*-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: 16*plus*-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
16*plus*-IM V2 responds:
```
hdr 2 30 Nov 2013 12:30:33 samples 35 to 87, int=60, stop=stop cmd
```

Testing Commands

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.

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

#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.

#iiT63 Measure SBE 63 optical dissolved oxygen, output aa.aaaa, b.bbbb, o.oooo, tt.tttt *where*
aa.aaaa = phase (µsec)
b.bbbb = temperature voltage
o.oooo = dissolved oxygen (ml/l)
tt.tttt = temperature in (°C)

#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

Notes:
- F = floating point number
  S = string with no spaces
- Auxiliary sensor calibration coefficients are not stored in the 16*plus* V2 EEPROM.
  - Calibration coefficients for sensors that output raw data are stored in the 16*plus*-IM V2 configuration (.xmlcon or .con) file. View and/or modify the calibration coefficients using the Configure menu in SBE Data Processing.
  - Some RS-232 auxiliary sensors store their calibration coefficients internally, and output data in engineering units. For the SBE 63, view and/or modify the instrument's calibration coefficients by sending **#iiSend63=** to the SBE 63 *through the 16plus-IM V2.* For other Sea-Bird auxiliary sensors such as the SBE 38 or SBE 50, view and/or modify the instrument's calibration coefficients by connecting the instrument to the computer directly and using Seaterm, our older terminal program software (not SeatermIM).

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

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

Hardware Configuration Commands

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

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 sec) 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 63 data is always output as phase delay and temperature voltage.
- 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):

1. Temperature A/D counts = tttttt
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) = (tttttt / 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 = wwwwxxxxyyyy
    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) = (tttttt / 100,000) – 10
18. (if **#iiDualGTD=Y**)
    GTD #2 pressure (millibars) = pppppppp / 100,000
19. (if **#iiDualGTD=Y**)
    GTD #2 temperature (°C, ITS-90) = (tttttt / 100,000) – 10
20. (if **#iiOptode=Y**)
    Optode oxygen (micromoles/liter) = (oooooo / 10,000) – 10
21. (if **#iiSBE63=Y**) SBE 63 oxygen phase (µsec) = (oooooo / 100,000) – 10
22. (if **#iiSBE63=Y**) SBE 63 oxygen temperature voltage = (tttttt / 1,000,000) – 1
23. Time
    seconds since January 1, 2000 = ssssssss

Notes:

- When using SeatermIM's Upload menu, SeatermIM sends **#iiOutputFormat=0**. This causes the 16*plus*-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 16*plus*-IM V2 outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). The 16*plus*-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**).

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

- Temperature = tttttt = 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 = 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, 0A53711BC7220C14C17D82030505940EC4270B

Same as example above, but hex data stream is preceded by 16*plus*-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) = (tttttt / 100,000) - 10
2. Conductivity (S/m) = (cccccc / 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) = (tttttt / 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 = wwwwxxxxyyyy
    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) = (tttttt / 100,000) – 10
15. (if **#iiDualGTD=Y**)
    GTD #2 pressure (millibars) = pppppppp / 100,000
16. (if **#iiDualGTD=Y**)
    GTD #2 temperature (°C, ITS-90) = (tttttt / 100,000) – 10
17. (if **#iiOptode=Y**)
    Optode oxygen (micromoles/liter) = (oooooo / 10,000) – 10
18. (if **#iiSBE63=Y**) SBE 63 oxygen phase (μsec) = (oooooo / 100,000) – 10
19. (if **#iiSBE63=Y**) SBE 63 oxygen temperature voltage = (tttttt / 1,000,000) – 1
20. Time
    seconds since January 1, 2000 = ssssssss

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

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

- Temperature = tttttt = 3385C4 (3376580 decimal); temperature (°C, ITS-90) = (3376580 / 100,000) - 10 = 23.7658
- Conductivity = cccccc = 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 = tttttt
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.tttt
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) = ppppppppp / 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) = ppppppppp / 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. (if **#iiSBE63=Y**) SBE 63 oxygen phase (µsec) = oo.ooo
22. (if **#iiSBE63=Y**) SBE 63 oxygen temperature voltage = t.tttttt
23. 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: 16*plus*-IM V2 with strain gauge pressure sensor and 2 external voltages sampled,
example scan = tttttt, cccc.ccc, pppppp, v.vvvv, v.vvvv, v.vvvv, dd mmm yyyy, hh:mm:ss
= 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089, 7 Dec 2013, 07:34:35

- Temperature = tttttt = 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 Dec 2013, 07:34:35; Date, time = 7 December 2013, 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 Dec 2013, 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 = 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
13. (if **#iiGTD=Y** or #ii**DualGTD=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 **#iiSBE63=Y**) SBE 63 oxygen phase (µsec) = oo.ooo
19. (if **#iiSBE63=Y**) SBE 63 oxygen temperature voltage = t.tttttt
20. (if **#iiOutputSal=Y**) Salinity (psu) = sss.ssss
21. (if **#iiOutputSV=Y**) Sound velocity (m/sec) = vvvv.vvv
22. 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: 16*plus*-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 Dec 2013, 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 Dec 2013, 07:34:35
  Date, time = 7 December 2013, 07:34:35

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

- If **#iiOutputUCSD=Y** and the 16*plus*-IM V2 is logging (autonomous sampling is in progress), data is followed by density sigma-t in kg/m^3(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: 16*plus*-IM V2 does not respond to **#iiTSS** while logging.

- If **#iiOutputSampleNumber=N**, data is preceded by the 16*plus*-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 16*plus*-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 16*plus*-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 Dec 2013, 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/m^3 (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 16*plus*-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 16*plus*-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 16*plus*-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 Dec 2013, 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, Optode, or sbe63*</type>	(type of RS-232 sensor)
<t38>ttt.tttt</t38>	(if **#iiSBE38=Y**)
<p2>pppp.ppp</p2>	(if **#iiSBE50=Y**)
<wl0>wwww</wl0>	(if **WetLabs=Y**)
<wl1>xxxx</wl1>	(if **WetLabs=Y**)
<wl2>yyyy</wl2>	(if **WetLabs=Y**)
<p1>ppppppppp</p1>	(if **#iiGTD=Y** or **#iiDualGTD=Y**)
<t1>tt.ttt</t1>	(if **#iiGTD=Y** or **#iiDualGTD=Y**)
<p2>ppppppppp</p2>	(if **#iiDualGTD=Y**)
<t2>tt.ttt</t2>	(if **#iiDualGTD=Y**)
<oox>oooo.ooo</oox>	(if **#iiOptode=Y**)
<oxph>oo.ooo</oxph>	(if **#iiSBE63=Y**)
<oxtv> t.tttttt</oxtv>	(if **#iiSBE63=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.tttt
- 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.tttt
- SBE 50 pressure (decibars, psia, meters, or feet) = pppp.ppp
- WET Labs
  - sensor 0 (raw signal counts) = wwww
  - 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) = oooo.ooo
- SBE 63 oxygen phase (µsec) = oo.ooo
- SBE 63 oxygen temperature voltage = t.tttttt
- Salinity (psu) = sss.ssss
- Sound velocity (m/sec) = 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: 16*plus*-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>2013-12-07T07:34:35</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 = December 7, 2013, 07:34:35

Polled Data from #iiSL, #iiSLT, #iiTS, or #iiTSS:
If **#iiOutputUCSD=Y** and the 16*plus*-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/m^3) = 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 16*plus*-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 16*plus*-IM V2s online (**DateTime=**) or individually for each 16*plus*-IM V2 (**#iiDateTime=**) To synchronize autonomous sampling for a system with multiple 16*plus*-IM V2s on a mooring cable, set the date and time globally, with all the 16*plus*-IM V2s online (see *Autonomous Sampling* for synchronization details).

   C. Establish setup and logging parameters.

   D. If the system will have multiple 16*plus*-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 16*plus*-IM V2's ID.
      3) Click OK.

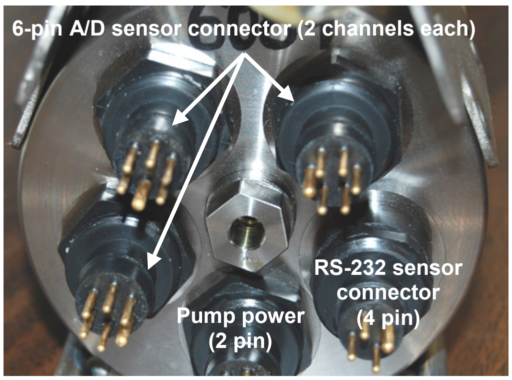
   E. Send **#iiGetCD** or **#iiDS** to verify the setup.

   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.

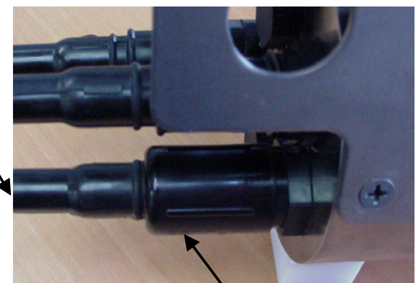
3. If you will be using SeatermIM to view occasional data samples while logging, click the Capture menu to save the data to a file. Note that this file **cannot be processed by SBE Data Processing, as it does not have the required headers and format for Sea-Bird's processing software**.

Deployment

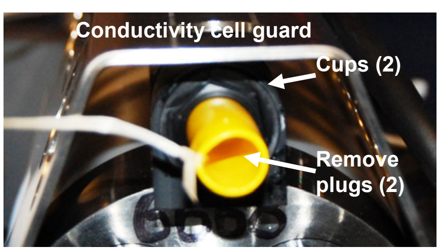
> **CAUTION:**
> **Do not use WD-40** or other petroleum-based lubricants, as they will damage the connectors.



1. Install a cable or dummy plug for each connector on the 16*plus*-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 16*plus*-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 16*plus*-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*).

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.

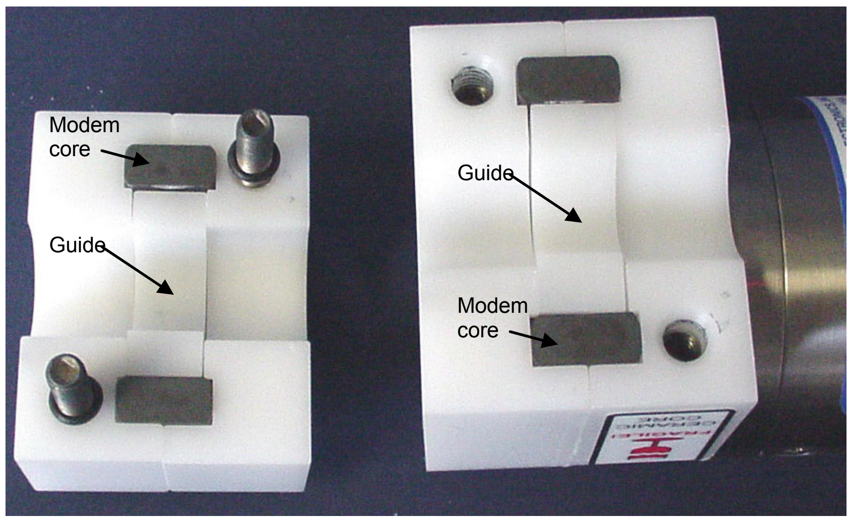
5. Verify that the hardware and external fittings are secure.

Mounting 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).

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



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

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

System Installation and Wiring

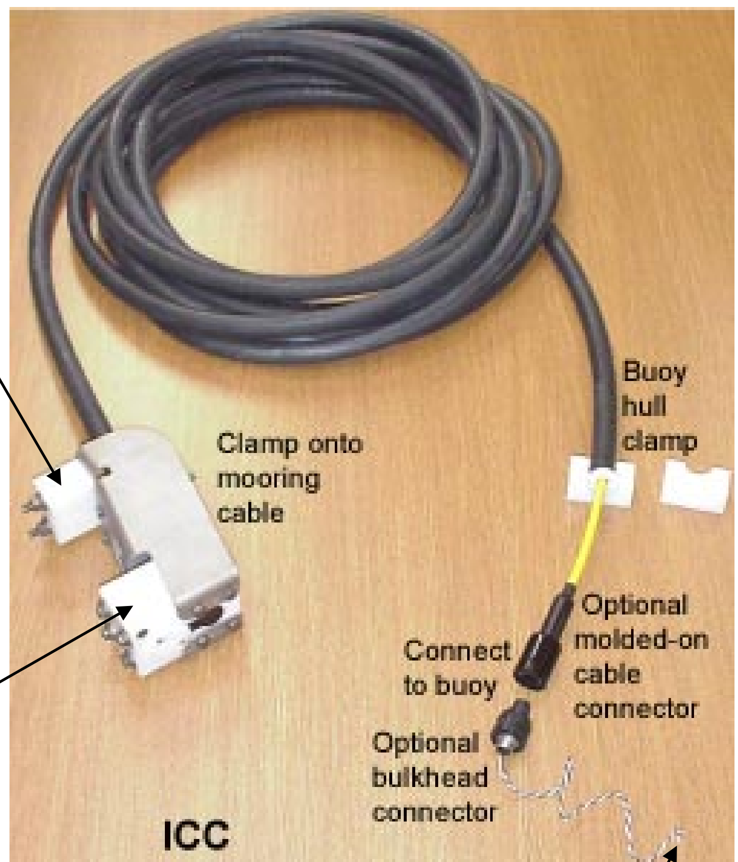
For system installation and wiring details, refer to:

- *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)

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

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.



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 16*plus*-IM V2 guide and core.**

Wiring to SIM PCB

Recovery

> ***WARNING!***
> **If the 16*plus*-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 16*plus*-IM V2 is flooded, point the 16*plus*-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 16*plus*-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 16*plus*-IM V2 is to be stored for a long time, **replace the batteries yearly to prevent battery leakage** (which could damage the 16*plus*-IM V2).

Uploading Data

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 16*plus*-IM V2**.

Upload data using one of these telemetry methods:

- **Inductive modem** – Data can be uploaded while the SBE 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-IM V2. Once the ID response is received, SeatermIM sends **!iiDS** and #**iiGetHD**, using the ID provided by the 16*plus*-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 16*plus*-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 16*plus*-IM V2 if there are multiple 16*plus*-IM V2s on the IM line. If desired, use *Automatically get instrument ID* if there is only one 16*plus*-IM V2 on the IM line. Note that the ID is stored in the 16*plus*-IM V2's EEPROM and can be changed so that multiple 16*plus*-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 16*plus*-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 16*plus*-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:**
> You may need to send **#iiStop** several times to get the 16plus-IM V2 to respond.

4. If you have not already done so, command the 16*plus*-IM V2 to stop autonomous sampling by typing **#iiStop** (ii= 16plus-IM V2 ID) and pressing the Enter key.

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

```
SBE 16plus-IM V 2.5.2 SERIAL NO. 0001 01 Dec 2013 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, delay after
sampling = 0.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38=no, SBE 50 = no, WETLABS = no, OPTODE = no, SBE 63 = no, Gas Tension
Device = no
Ext Volt 0 = yes, Ext Volt 1 = yes,
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`**.

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

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.

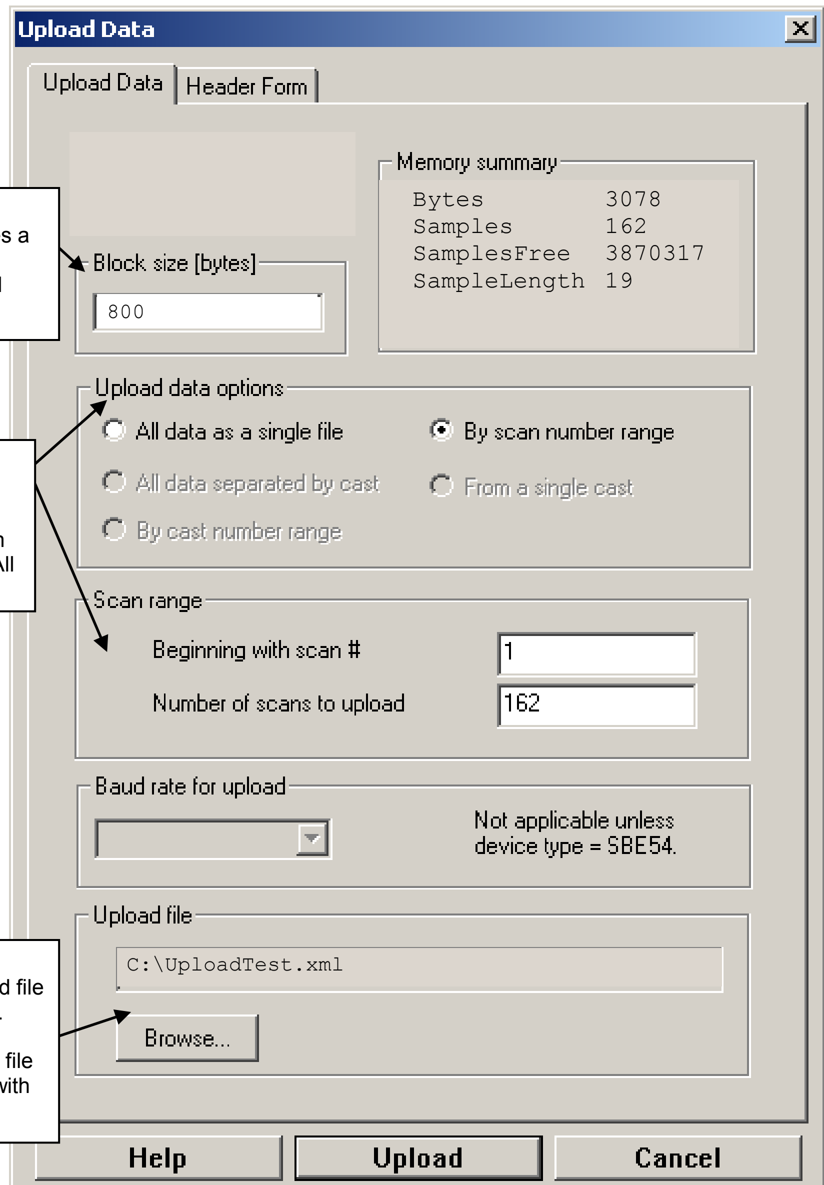
   E. An Upload data dialog box appears.

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.

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.

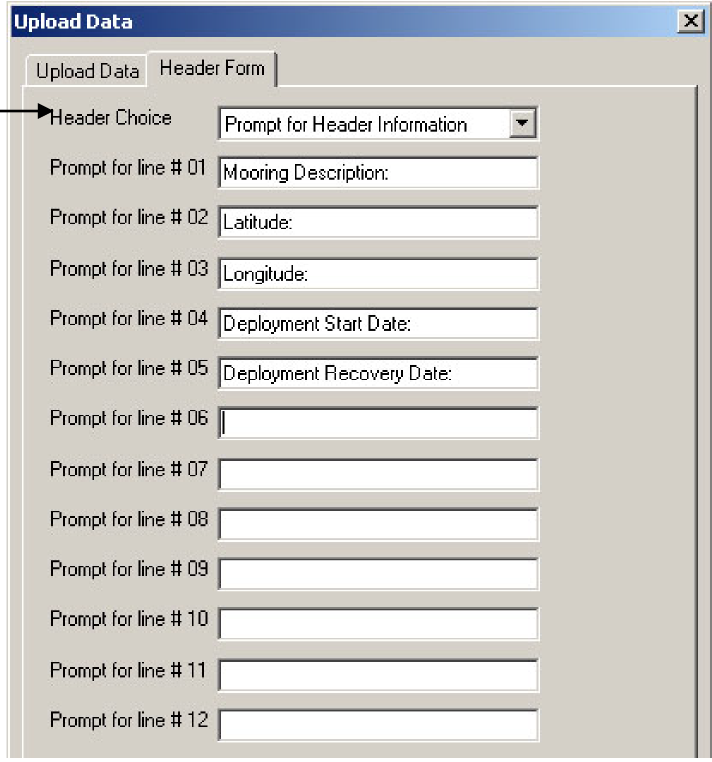
To change upload file name selected in Step D above, click Browse to navigate to desired upload file path and name. Upload file has a .xml extension. After SeatermIM uploads data into .xml file, it automatically converts .xml file to .hex file (same file name, different extension), which is compatible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



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 Upload; the Status bar at the bottom of the window displays the upload progress.

   A. 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.

   B. **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.

   C. 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 16*plus*-IM V2 for re-deployment:
1. After all data has been uploaded, send **#iiInitLogging**. 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 16*plus*-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).

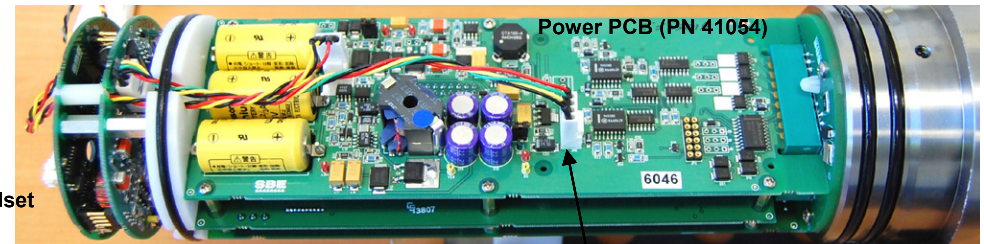
   B. Use **SBE Data Processing** to process and plot the data (see *Processing Data Using SBE Data Processing* and SBE Data Processing manual / Help files).

CAUTION:
Do not disconnect the 2-pin power cable from the battery pack when removing the electronics from the housing. If you remove power from the battery pack, the 16*plus*-IM V2 will draw power from the back-up lithium batteries during upload; if they are low, you may have unpredictable results and/or lose data.

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 16*plus*-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 16*plus*-IM V2.

8. Command the 16*plus*-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 16*plus*-IM V2 should respond:
```
Switching to <38400 or 115200> for 5 minutes.
```

Notes:
- The 16*plus*-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. **Check the capability of your computer and terminal program before setting the baud rate to 115200**; high baud rates require a short cable and good PC serial port with accurate clock.
- You may need to send **Stop** several times to get the 16*plus*-IM V2 to respond.
- Check your computer's capabilities before resetting the baud. The 16*plus*-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 16*plus*-IM V2 automatically switches back to 1200 baud.**

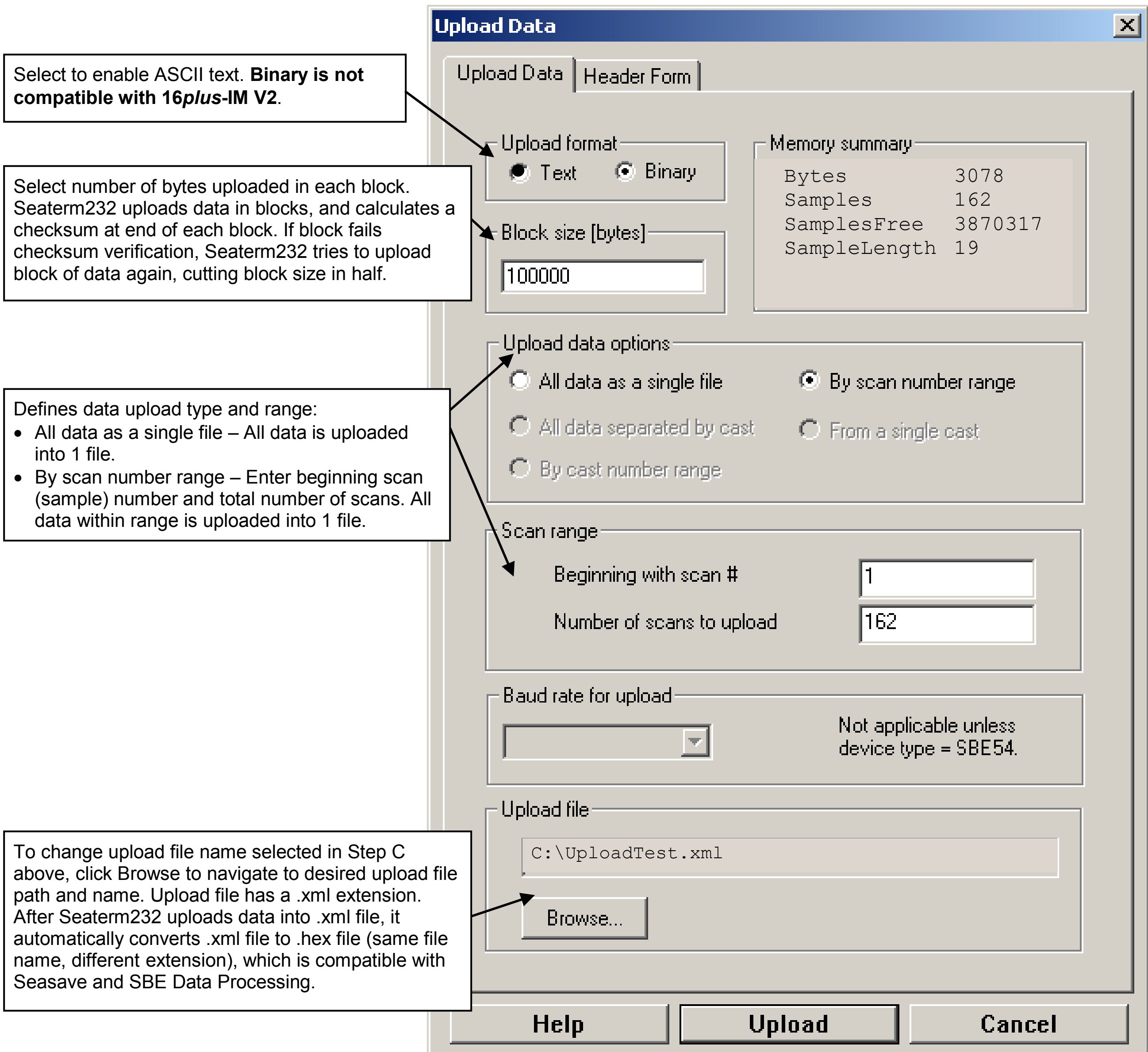
10. In the Communications menu, select *Configure*. The Serial Port Configuration dialog box appears.
    A. Select the Comm port, and select 38400 or 115200 as the baud rate (match the baud rate entered in Step 9).
    B. Click OK.

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 2.5.2 SERIAL NO. 0001 01 Dec 2013 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 = 1
run pump during sample, delay before sampling = 2.0 seconds, delay
after sampling = 0.0 seconds
pressure sensor = strain gauge, range = 1000.0
SBE 38=no, SBE 50 = no, WETLABS = no, OPTODE = no, SBE 63 = no, Gas
Tension Device = no
Ext Volt 0 = yes, Ext Volt 1 = yes,
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:

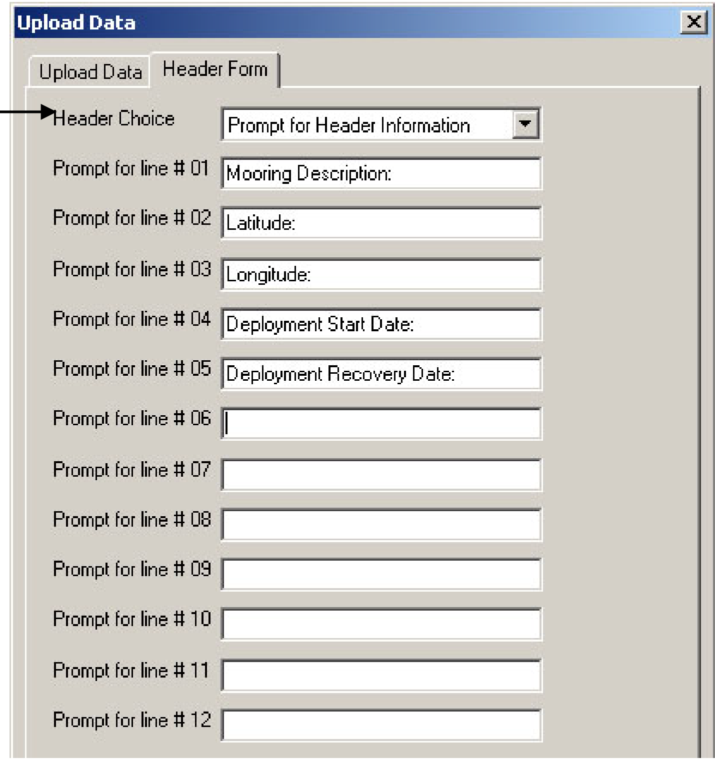


Make the desired selections.

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 Upload; the Status bar at the bottom of the window displays the upload progress:
    A. 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.
    B. **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.
    C. 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.
    D. 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 **#iiInitLogging**. 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 16*plus*-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 16*plus*-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 16*plus*-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

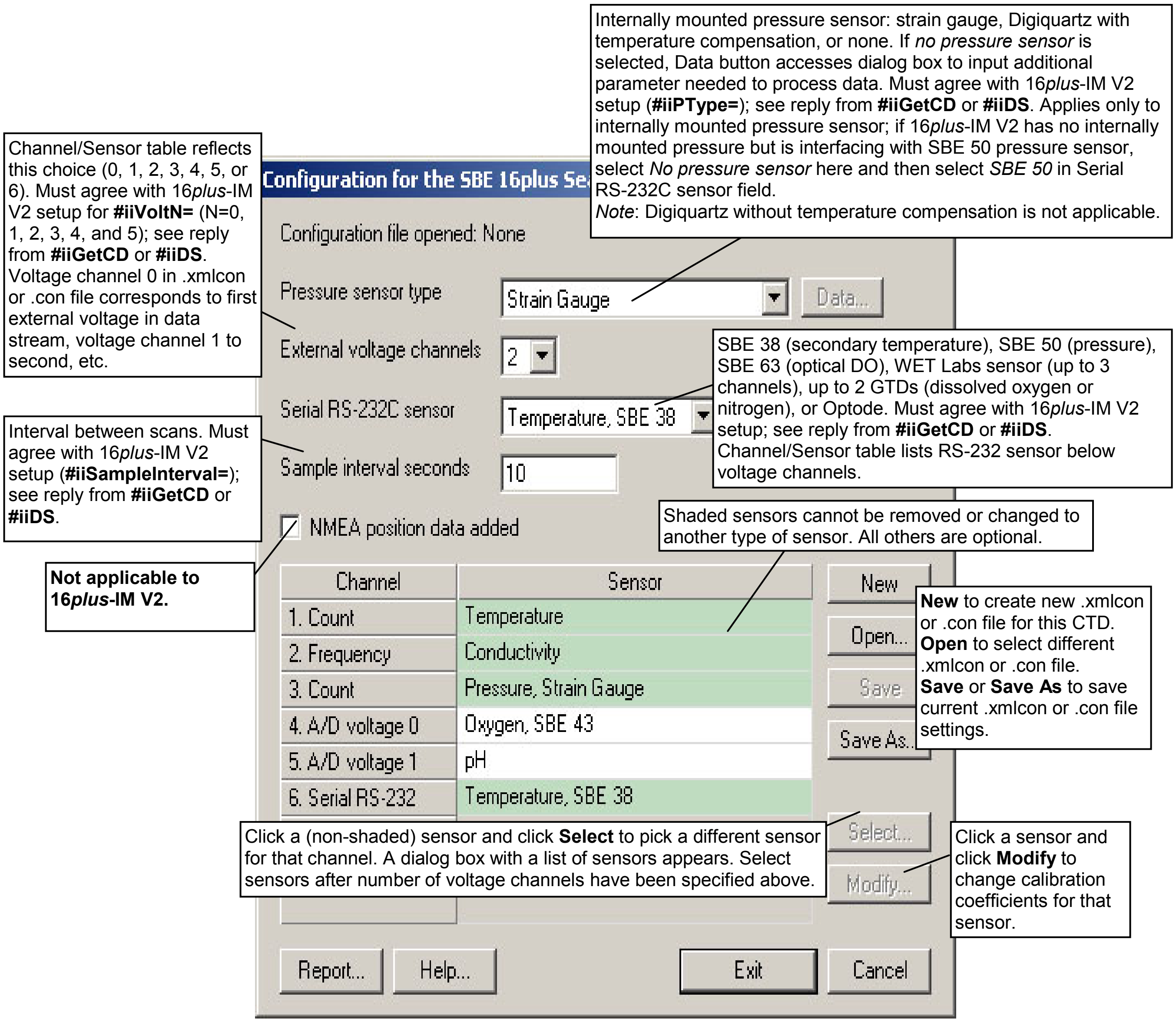
To convert the .hex (raw data) file, you need a .xmlcon or .con configuration file, which defines the instrument – integrated sensors, and channels, serial numbers, and calibration dates and coefficients for all sensors (conductivity, temperature, and pressure as well as auxiliary sensors). SBE Data 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.

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



4. 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

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.**

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. **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.

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 v1.10
* 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
- O-ring maintenance
- conductivity cell storage and cleaning
- pressure sensor maintenance
- pump maintenance
- AF24173 Anti-Foulant Device replacement
- sensor calibration

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

Corrosion Precautions

Rinse the SBE 16*plus*-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*.

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

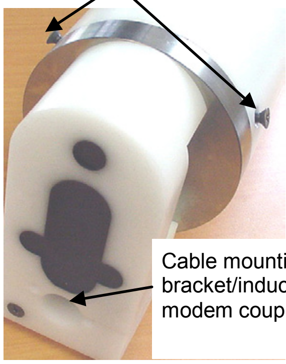
Clean and inspect connectors, cables, and dummy plugs before every deployment and as part of your yearly equipment maintenance. Inspect connectors that are unmated for signs of corrosion product around the pins, and for cuts, nicks or other flaws that may compromise the seal.

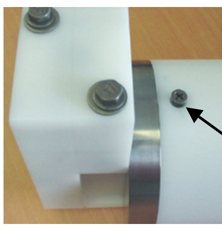
1. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).
2. **Standard Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the 16*plus*-IM V2. Remove 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.**

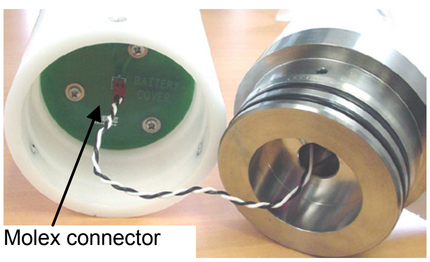
Verify that a cable or dummy plug is installed for each connector on the system before deployment.

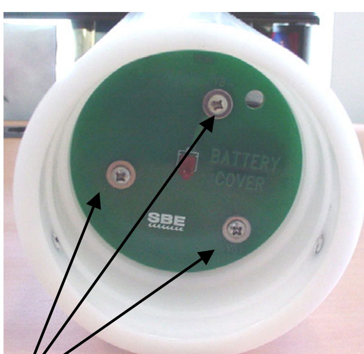
Replacing Alkaline Batteries

Alkaline D-cell (MN1300, LR20)









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

Leave the batteries in place when storing the SBE 16*plus*-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 16*plus*-IM V2 is to be stored for long periods, **replace the batteries yearly to prevent battery leakage** (which could damage the 16*plus*-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 16*plus*-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.

O-Ring Maintenance

Note:
For details on recommended practices for cleaning, handling, lubricating, and installing O-rings, see the *Basic Maintenance of Sea-Bird Equipment* module in the Sea-Bird training materials: www.seabird.com/training/TrainingHandouts.htm.

Recommended inspection and replacement schedule:

- For modem end cap O-rings – inspect each time you open the housing to replace the batteries; replace approximately once a year.
- For O-rings that are not normally disturbed (for example, on the connector end cap) - approximately every 3 to 5 years.
  Note: If you open the electronics compartment to upload data via the internal RS-232 connector, inspect each time you open the housing; replace approximately once a year.

Remove any water from the O-rings and mating surfaces in the housing with a lint-free cloth or tissue. Inspect 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.

Conductivity Cell Maintenance

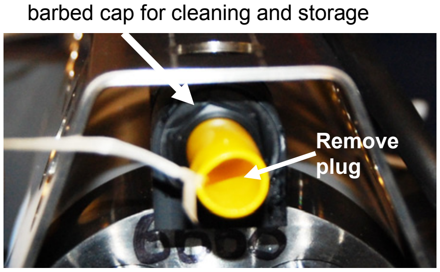
CAUTIONS:

- **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 16*plus*-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 16*plus*-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 16*plus*-IM V2, which is intended for use as a moored instrument.

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



The 16*plus*-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 16*plus*-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 16*plus*-IM V2 includes a pump - the installed anti-foulant device cap at the pump end of the cell is barbed (for connection to the Tygon tubing); the installed anti-foulant device cap at the intake end of the cell is not barbed.

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 (non-barbed caps at both ends if the 16*plus*-IM V2 does not include a pump; non-barbed cap at the intake end if the 16*plus*-IM V2 does include a pump). **Deploying a 16*plus*-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.

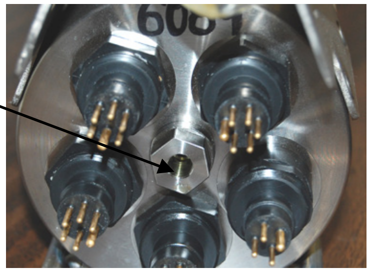
Internally Mounted Pressure Sensor (optional) Maintenance

> **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 16*plus*-IM V2.

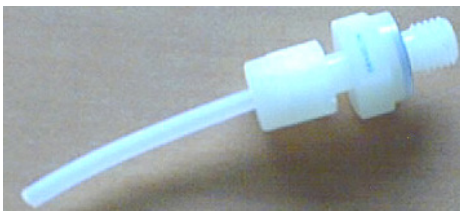
Strain Gauge Pressure Sensor

Strain-gauge pressure sensor port



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 16*plus*-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 16*plus*, SBE 19*plus*)

AF24173
Anti-Foulant
Device

The SBE 16*plus* and 19*plus* (moored option) have an anti-foulant device cup and cap on each end of the conductivity cell. A new SBE 16*plus* (or moored option 19*plus*) 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):

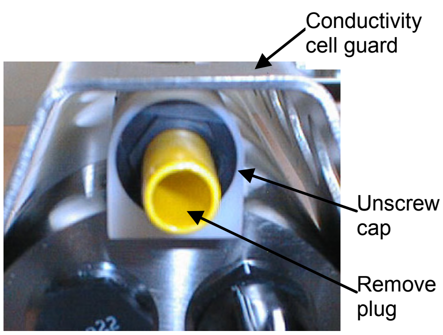
1. Remove the protective plug;
2. Unscrew the cap with a 5/8-inch socket wrench;
3. Remove the old Anti-Foulant Device. If the old Anti-Foulant Device is difficult to remove:
   - Use needle-nose pliers and carefully break up material;
   - If necessary, remove the conductivity cell guard to provide 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.

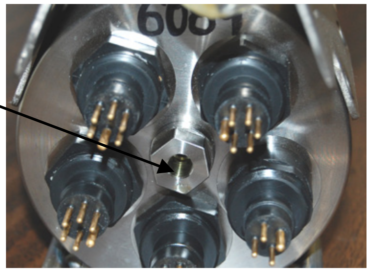
The primary mechanism for calibration drift in conductivity sensors is the fouling of the cell by chemical or biological deposits. Fouling changes the cell geometry, resulting in a shift in cell constant.

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 16*plus*-IM V2 is available with an internally mounted strain-gauge or Quartz pressure sensor. These sensors are capable of meeting the 16*plus*-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 16*plus*-IM V2 pressure output to readings from a barometer.

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 16*plus*-IM V2 outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars).
The 16*plus*-IM V2 uses the following equation to convert psia to decibars:
pressure (db) =
[pressure (psia) - 14.7] * 0.689476

Allow the 16*plus*-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 16*plus*-IM V2 to equilibrate before starting will provide the most accurate calibration correction.

1. Place the 16*plus*-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 16*plus*-IM V2 pressure 30 times and transmit converted data in engineering units (decibars).

3. Compare the 16*plus*-IM V2 output to the reading from a good barometer at the same elevation as the 16*plus*-IM V2 pressure sensor.
   Calculate *offset* = barometer reading – 16*plus*-IM V2 reading

4. Enter the calculated offset (positive or negative) in two places:
   - In the 16*plus*-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 16*plus*-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 16*plus*-IM V2's internal calculations and our processing software output gage pressure, using an assumed value of 14.7 psi for atmospheric pressure. Convert 16*plus*-IM V2 reading from gage to absolute by adding 14.7 psia to the 16*plus*-IM V2 output:
-2.5 dbars + (14.7 psi * 0.689476 dbar/psia) = -2.5 + 10.13 = 7.635 dbars
Offset = 10.1050 – 7.635 = + 2.47 dbars
Enter offset in 16*plus*-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 16*plus*-IM V2, and provides the most common causes and solutions.

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

The `S>` prompt indicates that communications between the 16*plus*-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 16*plus*-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 16*plus*-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: Scan Length Error in SBE Data Processing

Note:
To view the Diagnostics file, select *Diagnostics* in Data Conversion's Options menu. In the Diagnostics dialog box, click on *Display Log File*.

Cause/Solution 1: If the scan length in the data file does not match the selected .xmlcon or .con configuration file (for example, the configuration file indicates that there are four external voltage sensors integrated with the CTD, but you only enabled three external voltage sensors in the instrument setup [**#iiVolt0=**, **#iiVolt1=**, etc.]), SBE Data Processing's Data Conversion module will not process the data. If you look in the Diagnostics file, you will see a *scan length error*. Check the configuration file against the header in the data file, and correct the configuration file as required.

Problem 4: 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).

Note:
Each 16*plus*-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 1: An uploaded data file with nonsense values may be caused by incorrect instrument configuration:

- Bad data may be caused by incorrect setup in the 16*plus*-IM V2. Send **#iiGetCD** or **#iiDS** to verify the setup of the 16*plus*-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.

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 16*plus*-IM V2. Send **#iiGetCC** or **#iiDCal** to verify the calibration coefficients in the 16*plus*-IM V2 match the instrument Calibration Certificates. Note that calibration coefficients do not affect the raw data stored in 16*plus*-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 16*plus*-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 5: Program Corrupted

Note:
Using the reset switch does not affect the 16*plus*-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 16*plus*-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 sec.
3. Reinstall or replace the batteries, and close the battery end cap.
4. Establish communications with the 16*plus*-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

> **Note:**
> All Sea-Bird software listed was designed to work with a computer running Windows XP service pack 2 or later, Windows Vista, or Windows 7.

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

Deployment Endurance Calculator – Sea-Bird's Windows 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 16*plus*-IM V2s or other compatible IM instruments. Either an IMM or SIM is required to interface with the 16*plus*-IM V2.

PCB – Printed Circuit Board.

SBE Data Processing – Sea-Bird's Windows 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 16*plus* (moored applications), and SBE 19*plus* (moored or profiling applications).
The 16*plus* is available in two versions:

- 16*plus* with **RS-232** interface (standard)
- 16*plus*-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).

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

Seasoft V2 – Sea-Bird's complete Windows 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 – Windows terminal program *launcher*.
Depending on the instrument selected, it launches SeatermIM (inductive modem instruments), Seaterm232 (RS-232 instruments), or Seaterm485 (RS-485 instruments).

Seaterm232 – Windows terminal program used with Sea-Bird instruments that communicate via an RS-232 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. **Use Seaterm232 (by selecting *SBE 16plus V2 RS232* in SeatermV2) when communicating with the SBE 16*plus*-IM V2 via its internal RS-232 connector.**

SeatermIM – Windows 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.

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 Avantor Performance Materials (www.avantormaterials.com/commerce/product.aspx?id=2147509608).

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 ºC 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 ºC to 40 ºC).

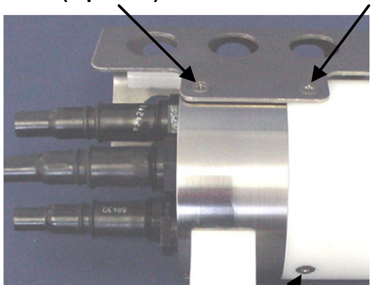
Battery Wiring

SBE 16*plus*-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 **#iiGetSD** or **#iiDS** response) falls below 7 volts, replace the back-up batteries.

Appendix II: Electronics Disassembly/Reassembly

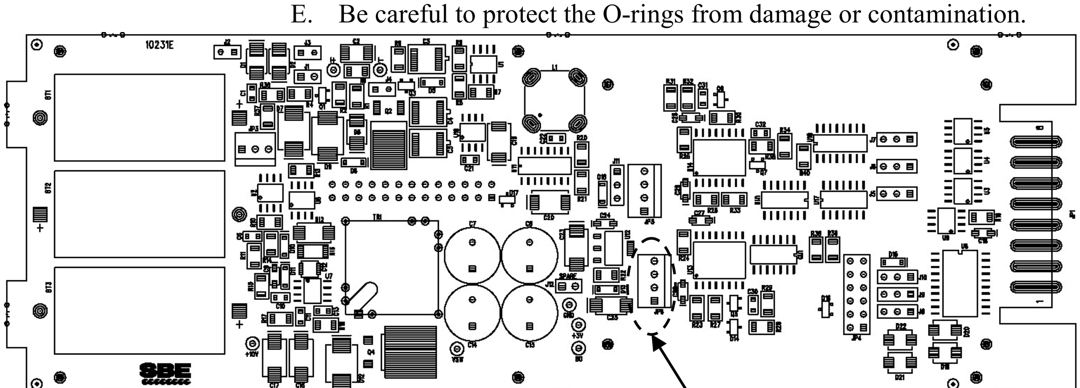
CAUTION:
Use caution during disassembly and reassembly to avoid breaking the conductivity cell.



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.

Power PCB (PN 41054)



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:

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.

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).

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** 16*plus*-IM V2s.
		PwrOff	Send power off command to **all** 16*plus*-IM V2s. SBE 16*plus*-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 16*plus*-IM V2s when power applied to SIM. This wakes up all 16*plus*-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	**Baud=x**	**x**= baud rate between SIM and computer/controller (1200, 2400, 4800, or 9600). ***Default 9600***.
		DataNNMax=x	**x**= timeout (millisec) 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 millisec***.
		RelayMax=x	**x**= timeout (sec) 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 sec***.
		EchoOn	Echo characters received from computer (***default***).
		EchoOff	Do not echo characters.
16*plus*-IM V2 Communication Microcontroller Commands	**Global**	**DateTime= mmddyyyyhhmmss**	Set real-time clock month, day, year, hour, minute, second for **all** 16*plus*-IM V2s.
		GData	Command **all** *16plus*-IM V2 communication microcontrollers to get last data sample from acquisition units. 16*plus*-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 16*plus*-IM V2 with ID=ii.
	16*plus*-IM V2 ID Only 1 16*plus*-IM V2 can be on line when sending these commands.	**ID?**	Display 16*plus*-IM V2 ID (ID=ii, where ii=0 to 99)
		***ID=ii** (If more than 1 16*plus*-IM V2 on line when setting ID, all will have same ID)	Set 16*plus*-IM V2 ID to ii (ii=0 to 99). Command must be sent twice, because verification requested.
	16*plus*-IM V2 communication microcontroller status	**!iiDS**	Display firmware version and timeout parameter.
	16*plus*-IM V2 communication microcontroller timeout	**!iiWait=x**	**x**= maximum time (sec) for communication microcontroller to wait for response from acquisition microcontroller. Range 2 – 600 sec.

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
16*plus*-IM V2 Acquisition Microcontroller Commands (ii = 16*plus*-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 sec 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.
		#iiSampleNumber=x	**x=** sample number for last sample in memory.
		#iiHeaderNumber=x	**x=** header number for last header in memory.
		#iiBiowiper=x	**x=Y**: Configuration includes WET Labs sensor with Bio-Wiper (voltage or RS-232 auxiliary sensor). **x=N** (***default***): Does not.
	Pressure Sensor Setup	**#iiPType=x**	Internally mounted pressure sensor type **(set at factory; do not modify) -** **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 16*plus*-IM V2 does not include internally mounted pressure sensor.
		#iiParosIntegration=x	**x=** integration time (sec) for optional internally mounted Quartz pressure sensor (1 - 600 sec; ***default 1 sec***).
	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 (sec) to wait after switching on external voltages and RS-232 sensors before sampling (0-600 sec). ***Default 0 sec***.
		#iiDelayAfterSampling =x	**x=** time (sec) to wait after sampling is completed, before turning off power to external voltages and RS-232 sensors (0–100 sec). Default 0.

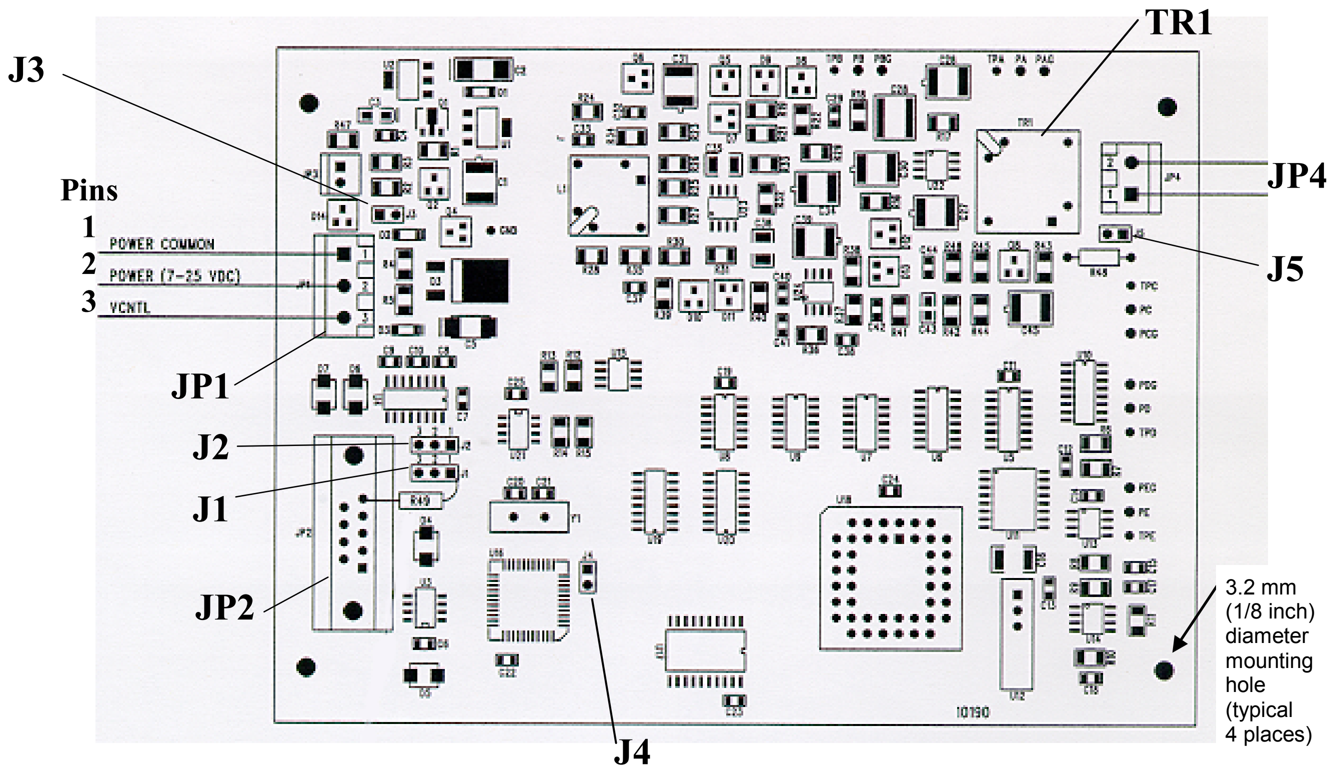
FUNCTION	CATEGORY	COMMAND	DESCRIPTION
16*plus*-IM V2 Acquisition Microcontroller Commands (**ii** = **16*plus***-IM V2 ID) (*continued*)	**RS-232 Sensor Setup**	**#iiSBE63=x**	**x=Y**: Enable SBE 63. **x=N**: Do not.
		#iiSend63=command	Command 16*plus*-IM V2 to send **command** to SBE 63 and receive response (**command** can be any command recognized by SBE 63).
		#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 16*plus*-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 (sec) between samples (10 – 14,400).
		#iiStartNow	Start autonomous sampling now.
		#iiStartDateTime =mmddyyyyhhmmss	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
16*plus*-IM V2 Acquisition Microcontroller Commands (ii = 16*plus*-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.
		#iiT63	Measure SBE 63, output 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
16*plus*-IM V2 Acquisition Microcontroller Commands (ii = 16*plus*-IM V2 ID) (continued)	**Coefficients** (F=floating point number; S=string with no spaces) Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificates shipped with 16*plus*-IM V2. View all coefficients with **#iiGetCC** or **#iiDCal**.	**#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.
	Hardware Configuration	*Auxiliary Sensor Settings – can be modified in the field to accommodate changes in auxiliary sensors cabled to 16plus-IM V2* **#iiSetVoltType0=, #iiSetVoltSN0=** **#iiSetVoltType1=, #iiSetVoltSN1=** **#iiSetVoltType2=, #iiSetVoltSN2=** **#iiSetVoltType3=, #iiSetVoltSN3=** **#iiSetVoltType4=, #iiSetVoltSN4=** **#iiSetVoltType5=, #iiSetVoltSN5=** **#iiSetSerialType=, #iiSetSerialSN=**	

Appendix IV: SIM Hookup and Configuration



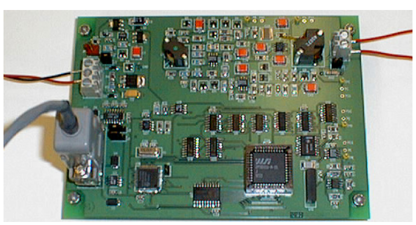


Photo shows SIM-Direct for use without Inductive Cable Coupler. SIM-Coupled for use with Inductive Cable Coupler is similar, but does not include TR1.

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

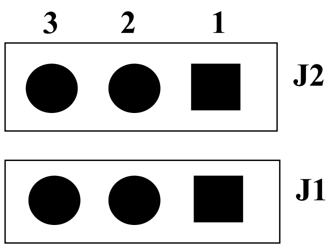
The SIM can be configured to power up in either of the following two modes:

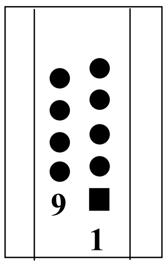
- **Normal Power Switching (factory setting)** – The SIM runs when power is applied. Set up the SIM as follows:
  1. Connect Power Common to JP1 pin 1.
  2. Connect 7-25 VDC to JP1 pin 2.
  3. Verify there is no connection to JP1 pin 3.
  4. Verify jumper is across J3.

- **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) and I/O Connector Wiring (JP2)





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**.

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'

Notes on RS-485 Interface

- This implementation of RS-485 allows for extended cable lengths, but does not include the ability to address multiple SIMs online. The RS-485 interface is described as *Simple*, because it does not allow you to communicate with more than one SIM on a single line.
- The RS-485 interface is half-duplex. Do not type or send a command while the SIM is transmitting data or responding to a command, or you will disrupt both sent and received data.
- This SIM can transmit data at 38400 baud over up to 1200 meters of twisted pair wire cable, 26 AWG or smaller gauge (larger diameter); data transmission at long distances is highly application specific, and requires high-quality cable and appropriate termination .

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 16*plus*-IM V2 installed with Inductive Cable Coupler (ICC)** - Connect wires from the ICC to JP4 on SIM-Coupled.
- **SBE 16*plus*-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 16*plus*-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: ………………………………....	47.0%
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	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for15-20 minutes. • Call a poison control center or doctor for treatment advice.
If swallowed	• 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	• 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.

Sea-Bird Electronics/label revised 01-28-10

Appendix VI: Replacement Parts

Part Number	Part	Application Description	Quantity in 16*plus*-IM V2
22018	Batteries, alkaline D-cell, Duracell MN 1300 (LR20)	Power 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-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 16*plus*-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, ½ inch ID x ¾ inch OD	Main plumbing tubing for pumped configuration	-
30579	Tygon tube, 3/8 inch ID x ½ 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 16*plus*-IM V2
22009	Panasonic BR-2/3A lithium batteries	Back-up lithium cells on Power PCB	3
50062	Pump O-ring kit	Includes: • 30010 Pump thrust washer (insulates each end of impeller against pump shaft) • 30095 Parker 2-002N674-70 (pump impeller retainer) • 30571 Parker 2-124N674-70 (pump head to impeller housing) • 30082 Parker 2-213N1000-70 (pump end cap to housing, 5T pump with retaining ring) • 31011Parker 2-026 N674-70 (pump end cap to housing, all 5M/5P pumps, and 5T pump without retaining ring)	-
50391	Pump impeller replacement kit	Includes: • 30009 Pump impeller • 30010 Pump thrust washer (insulates each end of impeller against pump shaft) • 30095 Parker 2-002N674-70 (pump impeller retainer) • 30571 Parker 2-124N674-70 (pump head to impeller housing) • 30082 Parker 2-213N1000-70 (pump end cap to housing, 5T pump with retaining ring) • 31011Parker 2-026 N674-70 (pump end cap to housing, all 5M/5P pumps, and 5T pump without retaining ring)	-
60021	Spare battery end cap hardware and O-rings	O-rings and hardware, including: • 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: • 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: • 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, ¼-20 x 1 ¼ 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 ¼-20 x 5/8 Hex, titanium (secures connector guard to sensor end cap) • 30633 Washer, ¼” 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 ¾ socket, titanium (secures conductivity cell and TC duct to sensor end cap)	-

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Part Number	Part	Application Description	Quantity in 16*plus*-IM V2
50323	Seaspares kit, standard connectors	Includes o-rings, hardware, bulkhead connectors, dummy plugs, etc.: • 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, 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)	-
50324	Seaspares kit, wet-pluggable connectors	Includes o-rings, hardware, bulkhead connectors, dummy plugs, etc.: • 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	• Release of firmware version 2 (16*plus*-IM V2).
002	01/09	• 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 3.0**a** (not 3.0**9**).
003	07/09	• Firmware 2.2: - 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	• 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	• Firmware 2.3: 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 Digiquartz 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.

006	10/12	• Add **#iiDelayBeforeSampling=** information when integrated with WET Labs sensor with bio-wiper. • Update **#iiBioWiper=** description to make it more generic (applies to all WET Labs sensors with bio-wipers, not just to ECO-FL). • Add more information on RS-485 version of SIM. • Add note on not disconnecting power cable from battery pack when uploading using RS-232, and on high baud rates limitations when using RS-232. • Clarify that barbed cap used on intake end for conductivity cell maintenance should never be used for deployment. • Add more troubleshooting information. • Remove commands that should only be used at the factory: **#iiVOffset0** through **5**, **#iiVSlope0** through **5**, **#iiSetMfgDate**, **#iiSetPcbSerialNum1** through **4**, **#iiSetPCBAssembly1** through **4**. • Correct information about **#iiSampleNumber=0** resetting header number. • Add information about software compatibility with Windows 7. • Update Triton website information. • Add pump replacement parts to replacement parts list. • Remove references to RS-485 version of 16*plus* V2. • Remove references to RS-485 version of IMM. • Remove references to *plus* version of SBE 21. • Correct typos.
007	12/13	• Firmware version 2.5.2: Add **#iiDelayAfterSampling=** command; add compatibility with SBE 63 (add **#iiSBE63=**, **#iiSend63=**, and **#iiT63** commands), update **GetCD** response for XML compliance. • Update plumbing drawings to include mounting for SBE 63. • Update SeatermV2 screen capture and Upload dialog box. • Add cable wiring diagrams. • Clarify that accuracy specifications are ±. • Update software compatibility information. • Update Declaration of Conformity. • Add O-ring maintenance. • Add information on maximum transmission distance between SIM/IMM and 16plus-IM V2. • Fix typos.

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