

# SBE 16*plus* SEACAT

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*Conductivity and Temperature Recorder (pressure optional)  
with **RS-485** Interface*



## **User's Manual**

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**Manual Version #007, 12/14/07**  
**Digital Firmware Version 1.1a & later**  
**Communication Firmware Version 1.1 & later**

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# Section 1: Introduction

This section includes contact information, Quick Start procedure, and photos of a standard SEACAT shipment.

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## About this Manual

This manual is to be used with the SBE 16*plus* SEACAT Conductivity and Temperature (pressure optional) Recorder with RS-485 Interface.

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 e-mail any comments or suggestions to seabird@seabird.com.

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## How to Contact Sea-Bird

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Monday-Friday, 0800 to 1700 Pacific Standard Time  
(1600 to 0100 Universal Time)  
Except from April to October, when we are on *summer time*  
(1500 to 0000 Universal Time)

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## Quick Start

Follow these steps to get a Quick Start using the SEACAT.  
The manual provides step-by-step details for performing each task:

1. Install batteries and test power and communications (see *Section 3: Power and Communications Test*).
2. Deploy the SEACAT (see *Section 4: Deploying and Operating SEACAT*):
  - A. Install new batteries if necessary.
  - B. Ensure all data has been uploaded, and then send **#iInitLogging** to make entire memory available for recording if desired.
  - C. Set date and then time and establish setup and logging parameters.
  - D. Set SEACAT to start logging now or in the future.
  - E. Install dummy plugs and/or cable connectors, and locking sleeves.
  - F. Remove protective plugs from anti-foulant device cups, and verify AF24173 Anti-Foulant Devices are installed. Leave protective plugs off for deployment.
  - G. Deploy SEACAT, using customer-supplied hardware.

## Unpacking SEACAT

Shown below is a typical SEACAT shipment.



SBE 16*plus* SEACAT  
(shown in both plastic and titanium housing)



I/O Cable



25-pin to 9-pin adapter  
(for use with computer  
with DB-25 connector)



Spare o-ring and  
hardware kit



Conductivity cell filling  
and storage kit



Conductivity cell cleaning  
solution (Triton-X)



SEACAT manual



Software, and Electronic Copies of  
Software Manuals and User Manual

# Section 2: Description of SEACAT

This section describes the functions and features of the SBE 16*plus* SEACAT, including:

- system description
- specifications
- dimensions and end cap connectors
- communication settings
- data storage
- batteries and battery endurance
- external power and cable length limitations
- configuration options and plumbing

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## System Description

The SBE 16*plus* SEACAT is designed to measure conductivity, temperature, and (optional) pressure in marine or fresh-water environments in moored applications at depths up to 10,500 meters (34,400 feet). **This manual covers only the operation of the optional RS-485 version** (in place of the standard RS-232 version) of the SEACAT. The SEACAT operates as follows:

- **Autonomous sampling** - The SEACAT can acquire and record in memory time series measurements at sample rates of once every 10 seconds to once every 4 hours, adjustable in one-second increments. Between samples, the SEACAT powers down, drawing only 60 microamps of current.
- **Polled sampling** – A surface controller can request the last sample that was taken or ask the SEACAT to take a new sample. Data is transmitted over the RS-485 interface.
- **Serial line sync** – The SEACAT wakes up, samples, stores data in memory, and powers off in response to a pulse on the serial line. This provides an easy method for synchronizing SEACAT sampling with other instruments such as Acoustic Doppler Current Profilers (ADCPs) or current meters, without drawing on their battery or memory resources.

The SEACAT can be deployed in two ways:

- **Cable installed** – The SEACAT can be remotely controlled, allowing for polled sampling or serial line sync, or for periodic requests of data from the SEACAT memory. If desired, data can be periodically uploaded while the SEACAT remains deployed.
- **Dummy plug installed** – The SEACAT cannot be remotely controlled. Autonomous sampling is programmed before deployment, and data is uploaded after recovery.

Self-powered and self-contained, the SEACAT features the proven Sea-Bird conductivity and temperature sensors. Nine D-size alkaline batteries provide power for approximately 330,000 samples (with no internally mounted pressure sensor, pump, or auxiliary sensors). The 8 Mbyte FLASH RAM memory records 1.5 years of conductivity, temperature, and date/time data while sampling every 60 seconds (other configurations/setup vary). User-selectable output format is raw data or engineering units, in either hexadecimal or decimal form. Setup, diagnostics, and data extraction are performed without opening the housing. The SEACAT can power external sensors and acquire their outputs.

A standard SEACAT is supplied with:

- RS-232 interface (**not applicable to this manual**, see the *SBE 16plus SEACAT (RS-232) Manual*)
- Plastic housing for depths to 600 meters (1950 feet)
- Bulkhead connectors (Impulse glass-reinforced epoxy):
  - one 4-pin I/O connector,
  - one 2-pin pump connector, and
  - two 6-pin connectors, for two differential auxiliary A/D inputs each
- 8 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.

SEACAT options include:

- **RS-485 interface (applicable to this manual)** in place of RS-232
- 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
- Additional bulkhead connector: 4-pin RS-232 connector (for SBE 38 secondary temperature sensor, SBE 50 pressure sensor, or up to two Pro-Oceanus Gas Tension Devices) **or** 3-pin PAR connector
- Pump -
  - SBE 5M (available in 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, turbidity, and gas tension
- Wet-pluggable (MCBH) connectors in place of standard connectors
- **Inductive Modem (IM)** interface in place of RS-232 or RS-485 - The inductive modem uses a mooring cable as the communication link, permitting the SBE 16plus-IM to be easily positioned at any depth without the use of cable connectors. Each inductive modem instrument has a programmable address, allowing up to 100 SBE 16plus-IM SEACATs (or other sensors compatible with the Sea-Bird inductive modem) to be attached to a single mooring cable. See the *SBE 16plus-IM SEACAT Manual*.
- Battery pack kit for lithium batteries for longer deployments (lithium batteries **not** supplied by Sea-Bird).

**Notes:**

- Help files provide detailed information on the use of SEATERM and SBE Data Processing.
- A separate software manual contains detailed information on the setup and use of SBE Data Processing.

The SEACAT is supplied with a powerful Win 2000/XP software package, SEASOFT-Win32, which includes:

- **SEATERM** – terminal program for easy communication and data retrieval.
- **SBE Data Processing** – program for calculation and plotting of conductivity, temperature, pressure, auxiliary sensor data, and derived variables such as salinity and sound velocity.



## Specifications

	Temperature (°C)	Conductivity (S/m)	Internally Mounted Pressure (optional)
<b>Measurement Range</b>	-5 to +35	0 to 9	0 to full scale range: <ul style="list-style-type: none"> <li>• <i>Strain gauge sensor:</i> 20 / 100 / 350 / 600 / 1000 / 2000 / 3500 / 7000 meters</li> <li>• <i>Quartz sensor:</i> 20 / 60 / 130 / 200 / 270 / 680 / 1400 / 2000 / 4200 / 7000 / 10500 meters</li> </ul>
<b>Initial Accuracy</b>	0.005	0.0005	<ul style="list-style-type: none"> <li>• <i>Strain gauge sensor:</i> 0.1% of full scale range</li> <li>• <i>Quartz sensor:</i> 0.02% of full scale range</li> </ul>
<b>Typical Stability (per month)</b>	0.0002	0.0003	<ul style="list-style-type: none"> <li>• <i>Strain gauge sensor:</i> 0.004% of full scale range</li> <li>• <i>Quartz sensor:</i> 0.002% of full scale range</li> </ul>
<b>Resolution</b>	0.0001	<ul style="list-style-type: none"> <li>• 0.00005 (most oceanic water; resolves 0.4 ppm in salinity).</li> <li>• 0.00007 (high salinity water; resolves 0.4 ppm in salinity).</li> <li>• 0.00001 (fresh water; resolves 0.1 ppm in salinity).</li> </ul>	<ul style="list-style-type: none"> <li>• <i>Strain gauge sensor:</i> 0.002% of full scale range</li> <li>• <i>Quartz sensor:</i> Depends on sample integration time (see notes below)</li> </ul>
<b>Sensor Calibration</b> (measurement outside these ranges may be at slightly reduced accuracy due to extrapolation errors)	+1 to +32	0 to 9; physical calibration over 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:

Resolution = Sensitivity \* Counter Resolution

- Counter Resolution = frequency at depth of interest / (**#iiParosIntegration** \* 1,228,800)  
where **#iiParosIntegration** = user-input integration time (seconds)
- Sensitivity =  $\Delta$  pressure at depth of interest /  $\Delta$  frequency at depth of interest  
where  $\Delta$  pressure is change in pressure in desired units (psia, db, meters, etc.)  
 $\Delta$  frequency is change in frequency in Hz
- To convert pressure units: db = psia / 1.45

#### Example:

For a 7000 meter (10,000 psia) Quartz pressure sensor, what resolution can be obtained at depth?

Test data for a sample 10,000 psia sensor shows:

At 6896 db, output frequency = 36,500 Hz

At 7131.9 db, output frequency = 36,600 Hz

$\Delta$  pressure at depth of interest = 7131.9 db – 6896 db = 235.9 db

$\Delta$  frequency at depth of interest = 36,600 Hz – 36,500 Hz = 100 Hz

Sensitivity =  $\Delta$  pressure at depth of interest /  $\Delta$  frequency at depth of interest = 235.9 db / 100 Hz = 2.359 db / Hz

Counter Resolution = frequency at depth of interest / (**#iiParosIntegration** \* 1,228,800) =  
36,500 Hz / (**#iiParosIntegration** \* 1,228,800)

Resolution = Sensitivity \* Counter Resolution = 2.359 db/Hz \* 36,500 Hz / (**#iiParosIntegration** \* 1,228,800)

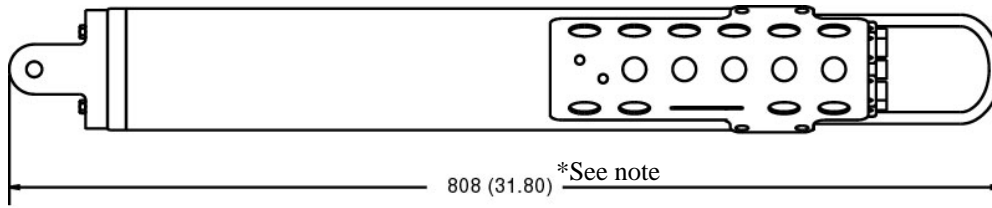
Looking at the resolution at depth that can be obtained with a range of values for the integration time:

Integration time ( <b>#iiParosIntegration</b> =)	Resolution
1 second	0.07 db (70 mm)
1.4 seconds	0.05 db (50 mm)
7 seconds	0.01 db (10 mm)
70 seconds	0.001 db (1 mm)

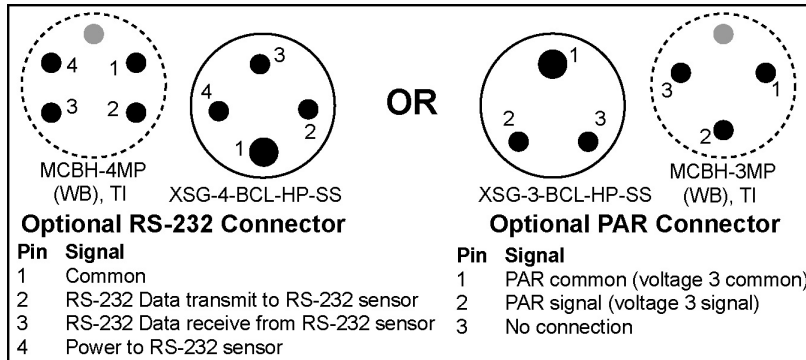
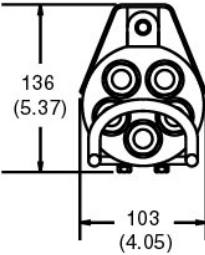
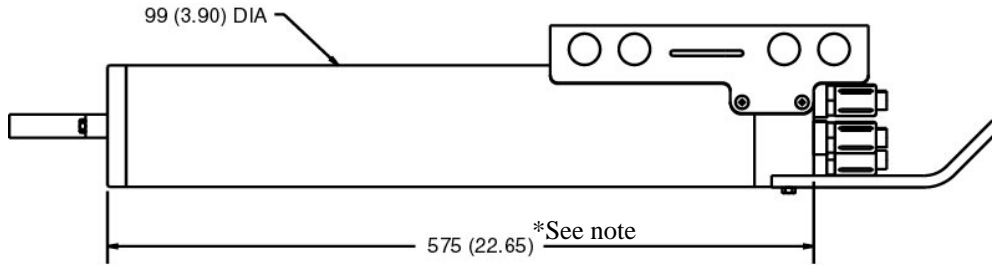
<b>Memory</b>	8 Mbyte non-volatile FLASH memory	
<b>Data Storage</b>	<b>Recorded Parameter</b>	<b>Bytes/sample</b>
	temperature + conductivity	6 (3 each)
	internally mounted strain gauge pressure	5
	internally mounted Quartz pressure with temperature compensation	6
	each external voltage	2
	SBE 38 secondary temperature	3
	SBE 50 pressure	3
	each Pro-Oceanus GTD	4 (pressure) + 3 (temperature)
	date and time	4
<b>Real-Time Clock</b>	32,768 Hz TCXO accurate to $\pm 1$ minute/year.	
<b>Internal Batteries</b>	Nine alkaline D-cells (Duracell MN 1300, LR20; nominal capacity 14 amp-hours).	
<b>External Power Supply</b>	<p>9 - 28 VDC; current requirement varies, depending on voltage and pump:</p> <ul style="list-style-type: none"> <li>• 3 Amps at 9V input - no pump or SBE 5M pump (cannot use SBE 5P or 5T with 9V input)</li> <li>• 0.5 Amps at 12V input – no pump or SBE 5M pump</li> <li>• 3 Amps at 12V input – SBE 5P or 5T pump</li> <li>• 0.25 Amps at 19V input – no pump</li> <li>• 0.5 Amps at 19V input – SBE 5M pump</li> <li>• 1.5 Amps at 19V input – SBE 5P or 5T pump</li> </ul>	
<b>Power Requirements</b>	<p><i>Sampling:</i> no pressure sensor 55 mA with internally mounted pressure 70 mA</p> <p><i>Optional Pump:</i> SBE 5M 100 mA SBE 5P or 5T 150 mA</p> <p><i>Communications:</i> 1.7 mA</p> <p><i>Quiescent:</i> 60 <math>\mu</math>A</p> <p>Sampling time:</p> <ul style="list-style-type: none"> <li>• Minimum 2.2 seconds/sample (no pump, no internally mounted pressure sensor, 1 measurement/sample, and no delays).</li> <li>• Add 0.3 seconds with internally mounted strain gauge pressure sensor.</li> <li>• Add integration time with internally mounted Quartz pressure sensor (<b>#iiParosIntegration=</b>; minimum 1 second).</li> <li>• Add 0.25 seconds for each additional measurement/sample (<b>#iiNCycles <math>\geq</math> 2</b>).</li> <li>• Add pump on-time (0.5 second) if pump running before taking sample (<b>#iiPumpMode=1</b>).</li> <li>• Add time for user-programmed delay before sampling (<b>#iiDelayBeforeSampling=</b>).</li> </ul> <p>Approximate Battery Endurance <sup>1</sup>:</p> <p>CT: 330,000 samples CTD: 225,000 samples CTD &amp; 5M pump: 130,000 samples</p> <p><sup>1</sup> With Duracell MN 1300 (LR20) cells. Dependent on sampling scheme; see <i>Battery Endurance</i> for example calculations.</p>	
<b>Auxiliary Voltage Sensors</b>	<p><i>Auxiliary power out:</i> up to 500 mA at 10.5 - 11 VDC</p> <p><i>A/D resolution:</i> 14 bits</p> <p><i>Input range:</i> 0 - 5 VDC</p>	
<b>Housing Depth Range and Materials</b>	<p>600 meter (1950 ft): acetal copolymer (plastic)</p> <p>7000 meter (22,900 ft): 3AL-2.5V titanium</p> <p>10,500 meter (34,400 ft): 6AL-4V titanium</p>	
<b>Weight (without pump)</b>	<p>With plastic housing: <i>in air</i> 7.3 kg (16 lbs)</p> <p>With 3AL-2.5V titanium housing: <i>in air</i> 13.7 kg (30 lbs)</p>	<p><i>in water</i> 2.3 kg (5 lbs)</p> <p><i>in water</i> 8.6 kg (19 lbs)</p>

## Dimensions and End Cap Connectors

Dimensions in millimeters (inches)

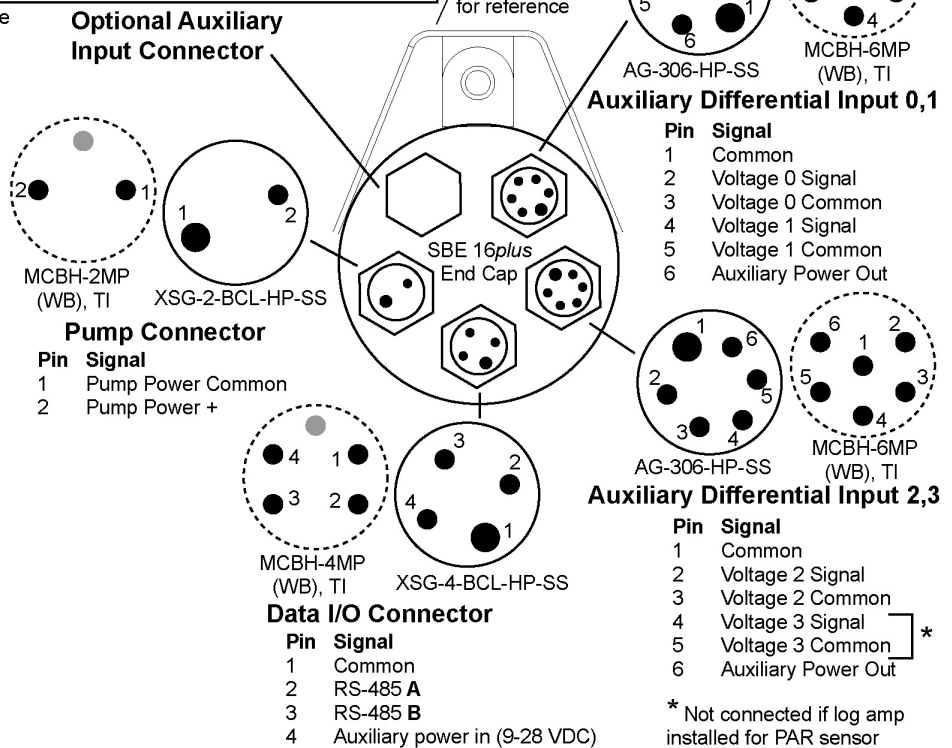


Note:  
SEACAT with optional Quartz pressure sensor is 190 mm (7.5 inches) longer than shown in drawing.



Note: RS-232 sensor must be set to same baud rate as 16plus.

○ = standard connector  
○ (dashed) = optional MCBH connector (all with 3/8" length base, 1/2-20 thread)



## Data I/O

The SEACAT receives setup instructions and outputs diagnostic information or previously recorded data via an RS-485 link, and is factory-configured for 9600 baud, 8 data bits, 1 stop bit, and no parity. The baud rate can be changed using **!iiBaud=** (see *Section 4: Deploying and Operating SEACAT*).

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## Data Storage

**Note:**  
See *Battery Endurance* for power limitations.

The SEACAT has an 8 Mbyte 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  
Internally mounted strain gauge P = 5 bytes/sample  
Date/Time = 4 bytes/sample  
Storage space  $\approx 8,000,000 / (6 + 5 + 4) \approx 533,000$  samples

*Example 2:* internally mounted Quartz pressure, 4 external voltages, and SBE 38 secondary temperature sensor  
T & C = 6 bytes/sample  
Internally mounted Quartz P = 6 bytes/sample  
External voltages = 2 bytes/sample \* 4 voltages = 8 bytes/sample  
SBE 38 = 3 bytes/sample  
Date/Time = 4 bytes/sample  
Storage space  $\approx 8,000,000 / (6 + 6 + 8 + 3 + 4) \approx 296,000$  samples

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## Batteries

For the main battery, the SEACAT uses nine D-cell alkaline batteries (Duracell MN 1300, LR20). If necessary, lithium, carbon-zinc, or mercury cells can also be used.

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, exhaustion, or removal. The main batteries may be replaced without affecting either the real-time clock or memory.

## Battery Endurance

### Notes:

- If the SEACAT is logging data and the battery voltage is less than 7.5 volts, the SEACAT 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 SEACAT with no pump or auxiliary sensors
- 10.5 amp-hours for a SEACAT drawing more current because of optional pump and/or auxiliary sensors

Current consumption and sampling times vary greatly, depending on 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, quartz pressure sensor integration time). Examples are shown below for several sampling schemes.

- Assuming the fasted practical interrogation scheme (wake all SEACATs on mooring, send **GData** or **AData**, send **Dataii** to each SEACAT, and power off all SEACATs), the communications current is drawn for approximately 0.5 seconds **per SEACAT on the mooring**. Each SEACAT on the mooring draws this current while any SEACAT is being queried to transmit data. Other interrogation schemes require more time.

10 SEACATs with standard alkaline batteries are set up to sample autonomously every 10 minutes (6 samples/hour), and the average of the samples will be requested by the computer every hour. How long can they be deployed?

*Example 1* – no pump, internally mounted 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 \* 0.12 amp-sec/sample = 0.72 amp-sec/hour

Quiescent current = 60 microamps = 0.06 mA

In 1 hour, quiescent current ≈ 0.06 mA \* 3600 sec/hour = 0.216 amp-sec/hour

Communication current / query = 1.7 mA \* 0.5 sec/SEACAT to be queried \* 10 instruments = 0.009 amp-seconds/hour

Current consumption / hour = 0.72 + 0.216 + 0.009 = 0.945 amp-sec/hour

Capacity = (12.2 amp-hours \* 3600 sec/hr) / (0.945 amp-sec/hour) = 46476 hours = 1936 days = 5.3 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 internally mounted pressure sensor or auxiliary sensors, 1 measurement/sample (**#iiNCycles=1**):

Sampling current = 55 mA \* (2.2 sec + 0.5 sec) = 0.149 amp-sec/sample

In 1 hour, sampling current = 6 \* 0.149 amp-sec/sample = 0.89 amp-sec/hour

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

In 1 hour, pump current = 6 \* 0.05 amp-sec/sample = 0.30 amp-sec/hour

Quiescent current = 60 microamps = 0.06 mA

In 1 hour, quiescent current ≈ 0.06 mA \* 3600 sec/hour = 0.216 amp-sec/hour

Communication current / query = 1.7 mA \* 0.5 sec/SEACAT to be queried \* 10 instruments = 0.009 amp-seconds/hour

Current consumption / hour = 0.89 + 0.30 + 0.216 + 0.009 = 1.415 amp-sec/hour

Capacity = (10.5 amp-hours \* 3600 seconds/hr) / (1.415 amp-seconds/hour) = 26713 hours = 1113 days = 3.0 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**), 15 sec delay before sampling (**#iiDelayBeforeSampling=15**), internally mounted Quartz pressure sensor integrating for 3 sec/sample (**#iiParosIntegration=3**), 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 = 60 microamps = 0.06 mA

In 1 hour, quiescent current ≈ 0.06 mA \* 3600 sec/hour = 0.216 amp-sec/hour

Communication current / query = 1.7 mA \* 0.5 sec/SEACAT to be queried \* 10 instruments = 0.009 amp-seconds/hour

Current consumption / hour = 8.8 + 18.9 + 12.6 + 0.216 + 0.009 = 40.5 amp-sec/hour

Capacity = (10.5 amp-hours \* 3600 sec/hr) / (40.5 amp-sec/hour) = 933 hours = 39 days = 0.11 years

## External Power

The SEACAT can be powered from an external source (9 - 28 volts DC) through the I/O bulkhead connector on the sensor end cap. The internal battery pack is diode-OR'd with the external source, so power will be drawn from whichever voltage source is higher. The SEACAT can also be operated from the external supply without having the internal battery pack installed. Electrical isolation of conductivity is retained in units powered externally, preventing ground loop noise contamination in the conductivity measurement.

### Cable Length and External Power

**Note:**

See *Real-Time Setup in Section 4: Deploying and Operating SEACAT* for additional limitations on cable length if transmitting real-time data.

While powering the SEACAT externally, a consideration in determining maximum cable length is supplying enough power at the power source so that sufficient voltage is available, after IR loss in the cable (*from the turn-on transient, two-way resistance*) to power the SEACAT. The table summarizes the maximum 2-way resistance for various input supplies and pump configurations:

**Note:**

Common wire resistances:

Gauge	Resistance (ohms/foot)
12	0.0016
14	0.0025
16	0.0040
18	0.0064
19	0.0081
20	0.0107
22	0.0162
24	0.0257
26	0.0410
28	0.0653

Power Supply Input and Pump Configuration	R <sub>limit</sub> = Maximum 2-way Resistance (ohms)
3 Amps at 9V input, no pump or SBE 5M pump (cannot use SBE 5P or 5T with 9V input)	1
0.5 Amps at 12V input, no pump	50
0.5 Amps at 12V input, SBE 5M pump	10
3.0 Amps at 12V input, SBE 5P or 5T pump	2
0.25 Amps at 19V input, no pump	150
0.5 Amps at 19V input, SBE 5M pump	30
1.5 Amps at 19V input, SBE 5P or 5T pump	7

Calculate maximum cable length as:

$$\text{Maximum cable length} = R_{\text{limit}} / 2 * \text{wire resistance per foot}$$

*Example 1* – For 20 gauge wire, what is maximum distance to transmit power to SEACAT if using 12 volt power source with SBE 5T pump?

Maximum cable length =  $R_{\text{limit}} / 2 * \text{wire resistance per foot} = 2 \text{ ohms} / 2 * 0.0107 \text{ ohms/foot} = 93 \text{ ft} = 28 \text{ meters}$

Using a higher voltage power supply or a different wire gauge would increase allowable cable length.

*Example 2* – Same as above, but there are 4 instruments powered from same power supply.

Maximum cable length =  $R_{\text{limit}} / 2 * \text{wire resistance per foot} * 4 \text{ instruments}$

$$= 2 \text{ ohms} / 2 * 0.0107 \text{ ohms/foot} * 4 = 23 \text{ ft} = 7 \text{ meters (to SEACAT furthest from power source)}$$

## Configuration Options and Plumbing

The SEACAT is available with an optional, externally mounted, submersible pump. The pump is required for a SEACAT 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:

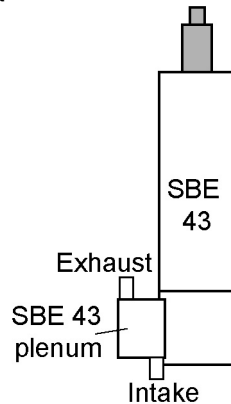
- SBE 5M miniature pump (available in plastic or titanium) - for pumped conductivity.
- SBE 5P (plastic) or 5T (titanium) pump - a more powerful pump for use if the SEACAT is configured with a dissolved oxygen sensor and/or pumped fluorometer.

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

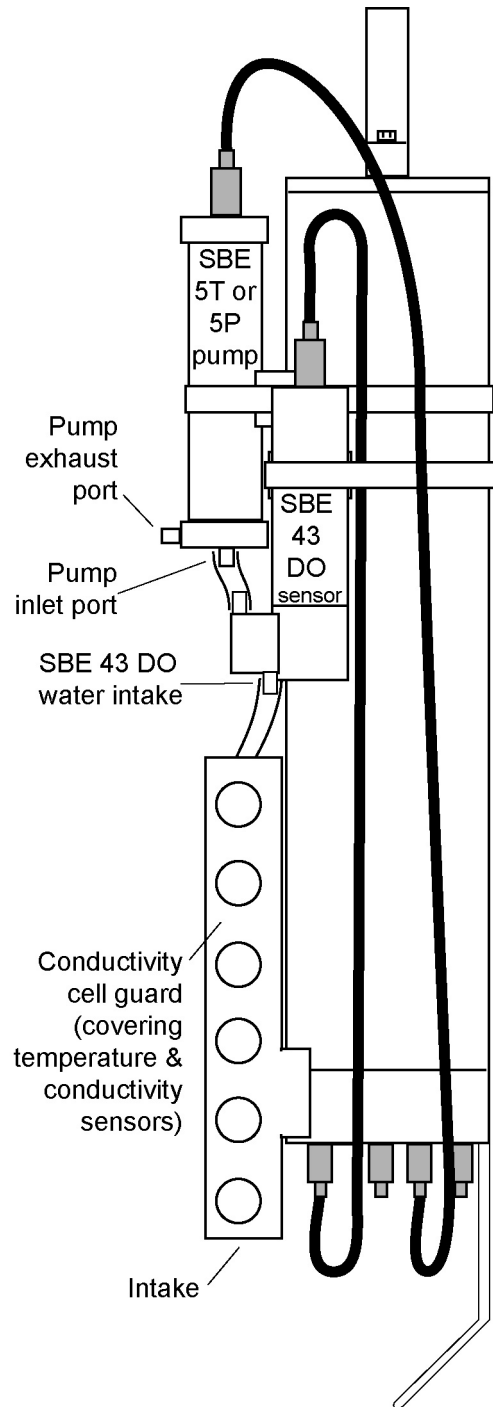
The SEACAT can be configured with a wide range of auxiliary sensors. Two standard 6-pin bulkhead connectors on the sensor end cap serve as the input ports for the auxiliary sensor signal voltages and provide power to the sensors. Additionally, an optional connector can be provided for interfacing with an RS-232 sensor, such as an SBE 38 secondary temperature sensor, an SBE 50 strain-gauge pressure sensor, or Pro-Oceanus Gas Tension Devices (up to two GTDs can be integrated with the SEACAT), or an optional connector can be provided for interfacing with a PAR sensor.

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

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



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





# Section 3: Power and Communications Test

This section describes the pre-check procedure for preparing the SEACAT for deployment. Installing software, testing power and communications, and setting the SEACAT ID are discussed. The power and communications test will verify that the system works, prior to deployment.

## Software Installation

Sea-Bird recommends the following minimum system requirements for SEASOFT-Win32: Windows 2000 or later, 500 MHz processor, 256 MB RAM, and 90 MB free disk space for installation.

**Note:**

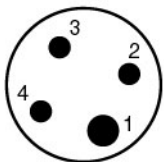
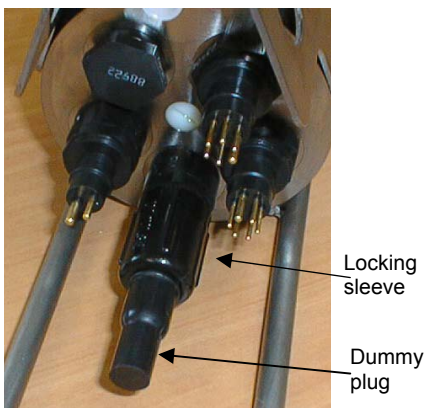
It is possible to use the SEACAT without SEATERM by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.

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

1. Insert the CD in your CD drive.
2. Double click on **Seasoft-Win32.exe**.
3. Follow the dialog box directions to install the software.

The default location for the software is c:/Program Files/Sea-Bird. Within that folder is a sub-directory for each program. The installation program allows you to install the desired components. Install all the components, or just install SEATERM (terminal program) and SBE Data Processing.

## Test Setup



**Data I/O Connector** (standard)

Pin	Signal
1	Common
2	RS-485 A
3	RS-485 B
4	Auxiliary power in

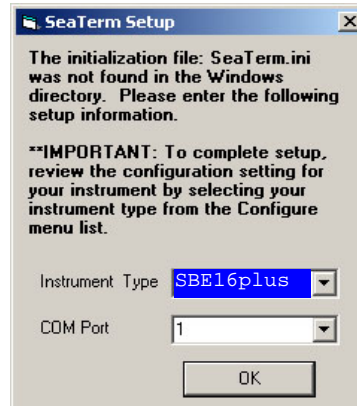
1. Remove the dummy plug and install the I/O cable:
  - A. By hand, unscrew the locking sleeve from the SEACAT I/O (4-pin) connector. If you must use a wrench or pliers, be careful not to loosen the I/O connector instead of the locking sleeve.
  - B. Remove the dummy plug from the SEACAT I/O connector by pulling the plug firmly away from the connector.
  - C. **Standard Connector** - Install the I/O cable connector, aligning the raised bump on the side of the connector with the large pin (pin 1 - ground) on the SEACAT. **OR** **MCBH Connector** - Install the I/O cable connector, aligning the pins.

2. Connect the I/O cable connector to your computer's RS-485 serial port.

## Power and Communications Test and Setting ID

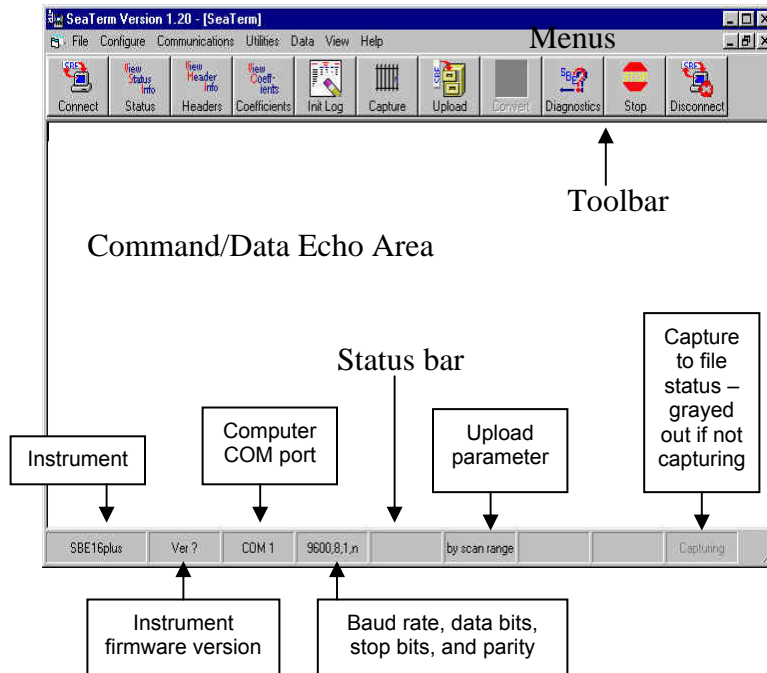
**Note:**  
See SEATERM's Help files.

1. Double click on SeaTerm.exe. If this is the first time the program is used, the setup dialog box may appear:



Select the instrument type (*SBE 16plus*) and the computer COM port for communication with the SEACAT. Click OK.

2. The main screen looks like this:



**Note:**  
There is at least one way, and as many as three ways, to enter a command:

- Manually type a command in Command/Data Echo Area
- Use a menu to automatically generate a command
- Use a Toolbar button to automatically generate a command

**Note:**  
Once the system is configured and connected (Steps 3 through 5 below), to update the Status bar:

- on the Toolbar, click Status; or
- from the Utilities menu, select Instrument Status.

SEATERM sends the status command, which displays in the Command/Data Echo Area, and updates the Status bar.

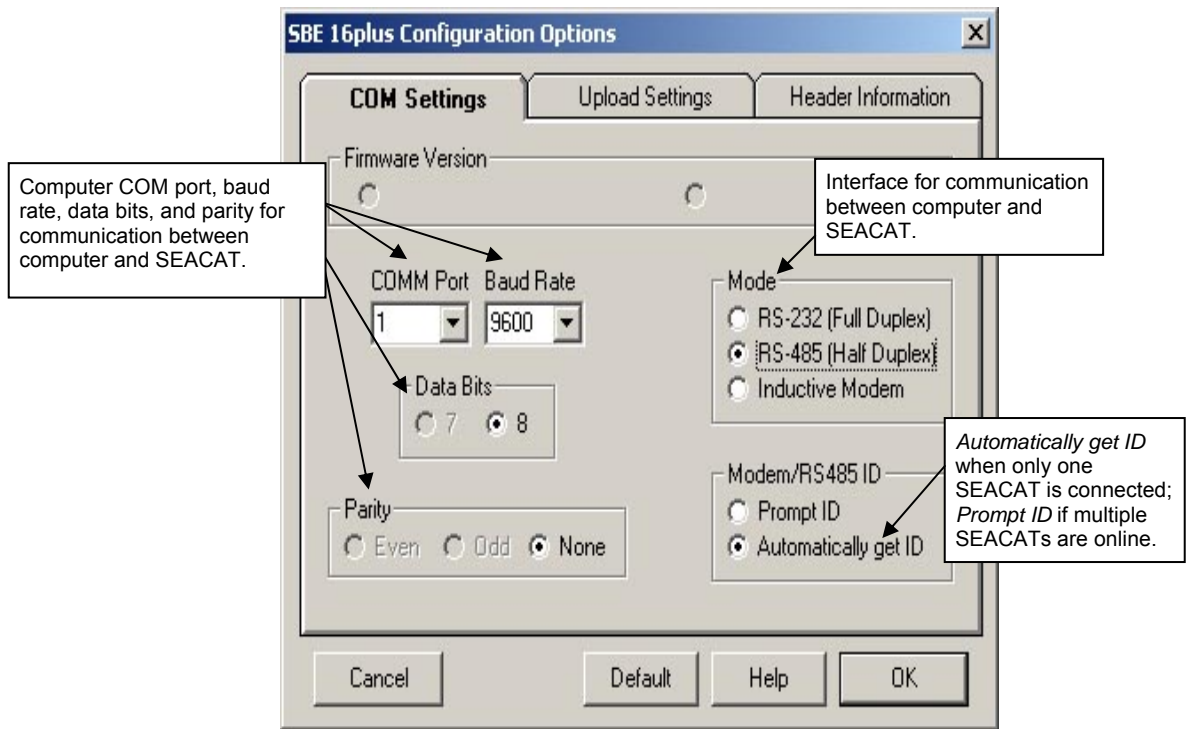
- **Menu** – Contains tasks and frequently executed instrument commands.
- **Toolbar** – Contains buttons for frequently executed tasks and instrument commands. All tasks and commands accessed through the Toolbar are also available in the Menu. To display or hide the Toolbar, select View Toolbar in the View menu. Grayed out Toolbar buttons are not applicable.
- **Command/Data Echo Area** – Echoes a command executed using a Menu or Toolbar button, as well as the instrument's response. Additionally, a command can be manually typed in this area, from the available commands for the instrument. Note that the instrument must be *awake* for it to respond to a command (use Connect on the Toolbar to wake up the instrument).
- **Status bar** – Provides status information. To display or hide the Status bar, select View Status bar in the View menu.

Following are the Toolbar buttons applicable to the SEACAT:

Toolbar Buttons	Description	Equivalent Command*
Connect	Re-establish communications with SEACAT. Computer responds with S> prompt. SEACAT <i>goes to sleep</i> after 2 minutes without communication from computer have elapsed.	—
Status	Display instrument setup and status (logging, samples in memory, etc.).	#iiDS
Headers	View data headers (header number, date and time, first and last sample, and sample interval). A new header is generated at the start of sampling and every subsequent 1000 scans.	#iiDH
Coefficients	Display calibration coefficients.	#iiDCal
Init Log	Reset data pointers and header numbers. This should be performed <b>after existing data has been uploaded from SEACAT</b> and prior to recording new data.	#iiInitLogging
Capture	Capture instrument responses on screen to file; may be useful for diagnostics. File has .cap extension. Press Capture again to turn off capture. Capture status displays in Status bar.	—
Upload	Upload data stored in memory, in format Sea-Bird's data processing software can use (raw hex). Uploaded data has .hex extension. Before using Upload: <ul style="list-style-type: none"> <li>• Configure upload and header parameters in Configure menu</li> <li>• <b>Stop logging</b> by sending #iiStop.</li> </ul>	#iiDDb,e (use Upload button if you will be processing data with SBE Data Processing)
Diagnostics	Perform one or more diagnostic tests on SEACAT. Diagnostic test(s) accessed in this manner are non-destructive – they do not write over any existing instrument settings.	#iiDS, #iiDCal, and #iiTS (with raw and converted decimal output)
Stop	—	<b>Not applicable to SEACAT RS-485</b>
Disconnect	Free computer COM port used to communicate with SEACAT. COM port can then be used by another program.	—

\*See *Command Descriptions* in Section 4: *Deploying and Operating SEACAT*.

3. In the Configure menu, select *SBE 16plus*. The dialog box looks like this:

**Notes:**

- SEATERM's baud rate must be the same as the SEACAT baud rate (set with `!iiBaud=`). Baud is factory-set to 9600, but can be changed by the user (see *Command Descriptions* in *Section 4: Deploying and Operating SEACAT*).
- When you click OK, SEATERM saves the Configuration Options settings to the `SeaTerm.ini` file in your Windows directory. `SeaTerm.ini` contains the last saved settings for **each** instrument. When you open SEATERM and select the desired instrument (*SBE 16plus*, 37, 39, etc.) in the Configure menu, the Configuration Options dialog box shows the last saved settings for that instrument.

Make the selections in the Configuration Options dialog box:

- **COMM Port:** COM 1 through COM 10, as applicable
- **Baud Rate:** 9600 (documented on Configuration Sheet in manual)
- **Data Bits:** 8
- **Parity:** None
- **Mode:** RS-485 (Half Duplex)
- **Modem/RS 485 ID:** Automatically get ID

Click OK to save the settings.

4. In the Communications menu, select *Options / Cycle baud when connecting*.
5. Click Connect on the Toolbar. SEATERM tries to connect to the SEACAT at the baud set in Step 3. If it cannot, it cycles through all other possible baud rates to try to connect. When it connects:
- If Configuration Options dialog box was set to *Automatically get ID*: SEATERM automatically sends `ID?` to get the SEACAT's ID number.
  - If Configuration Options dialog box was set to *Prompt ID*: SEATERM asks the user to input the SEACAT's ID number.
- SEATERM then sends a status command (`#ii*DS`) that is used for internal purposes only.

When the SEACAT is ready, the display looks like this:

```
S>
```

This shows that correct communications between the computer and SEACAT has been established.

If the system does not respond with the `S>` prompt:

- Click Connect again.
- Verify the correct instrument was selected in the Configure menu and the settings were entered correctly in the Configuration Options dialog box. Note that the baud rate is documented on the instrument Configuration Sheet.
- Check cabling between the computer and SEACAT.

**Notes:**

- The SEACAT automatically enters quiescent (sleep) state after 2 minutes without receiving a command. This timeout algorithm is designed to conserve battery energy if the user does not send **PwrOff** to put the SEACAT to sleep. If the system does not appear to respond, click Connect on the Toolbar to reestablish communications.
- Sending the status command causes the optional pump to turn on for a moment, so that the SEACAT 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.
- For reliable operation, all commands **may** need to be preceded with two @ characters to clear the communication microcontroller receive buffers.  
*Example* (take sample command for SEACAT with ID=01):  
S>@@#01TS

**Note:**

**If more than one SEACAT is on-line when you set the ID, all SEACATs will be set to the same ID.**

6. Confirm the SEACAT has responded to the wake-up signal by typing **ID?** and pressing the Enter key. The display looks like this:

```
id = 01
```

where 01 is the number set at the factory or by the previous user. See the manual Configuration page for the factory-set identification (ID) number. Note that the ID is stored in the SEACAT EEPROM and can be changed so that multiple SEACATs on a single RS-485 line each have a unique ID.

7. Display SEACAT status information by clicking Status on the Toolbar. The display looks like this:

```
S>#iids          (ii=SEACAT ID)
SBE 16plus V RS-485 1.0c SERIAL NO. 4597 30 Apr 2005 14:11:48
vbatt = 14.0, vlith = 8.5, ioper = 62.5 ma, ipump = 21.6 ma,
status = not logging
sample interval = 15 seconds, number of measurements per sample = 2
samples = 0, free = 524288
run pump during sample, delay before sampling = 2.0 seconds
battery cutoff = 7.5 volts
pressure sensor = strain gauge, range = 1000.0
SBE 38 = no, SBE 50 = no, Gas Tension Device = no
Ext Volt 0 = no, Ext Volt 1 = no, Ext Volt 2 = no, Ext Volt 3 = no
output format = converted decimal
output salinity = no, output sound velocity = no
S>
```

8. Command the SEACAT to take a sample by typing **#iITS** (**ii** = SEACAT ID) and pressing the Enter key. The display looks like this (if SEACAT includes optional internally mounted pressure sensor, and is set up for converted decimal output format, no output salinity or sound velocity, and no auxiliary sensors):

```
23.7658,0.00019, 0.062, 30 Apr 2005, 14:12:48
```

where

```
23.7658 = temperature in degrees Celsius
0.00019 = conductivity in S/m
0.062 = pressure in db
30 Apr 2005 = date
14:12:48 = time
```

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).

9. Each SEACAT on an RS-485 line must have a unique ID for communicating with the computer:
- A. Set the SEACAT 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. Press the Enter key to get the S> prompt.
  - E. Click Connect on the Toolbar. This allows the system to use the *Automatically get I.D.* feature when using the Toolbar keys or menus.
10. Command the SEACAT to go to sleep (quiescent state) by typing **PwrOff** and pressing the Enter key.

The SEACAT is ready for programming and deployment.

# Section 4:

## Deploying and Operating SEACAT

This section includes discussions of:

- Operation description
- Sampling modes, including example sets of commands
- Pump operation
- Real-time setup
- Timeout description
- Command descriptions
- Data output formats
- Deployment
- Recovery - physical handling and uploading data
- Processing data with SBE Data Processing
- Editing a raw data file

**Note:**

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

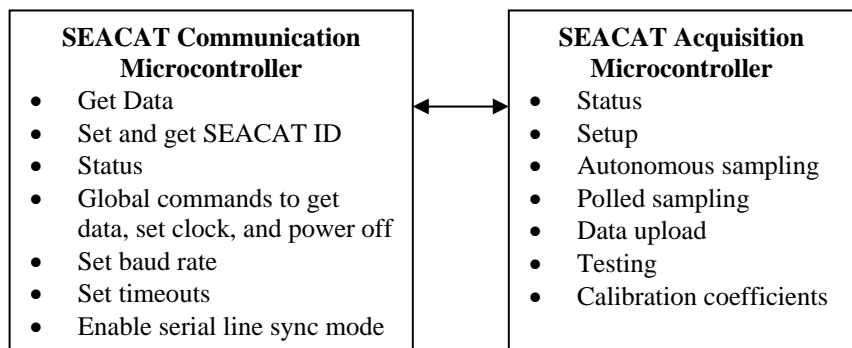
### Operation Description

The SEACAT's 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 SEACAT and computer. These two microcontrollers allows for independent control of power usage by the communications and acquisition circuits. Acquisition consumes more power, but for shorter duration. Communications protocols take proportionately more time, but can be controlled separately and are operated at lower power, thus maximizing battery life. This also prevents communications protocols from interfering with measurement acquisition timing.

Commands can be directed to the SEACAT communication microcontroller or its acquisition microcontroller. A command prefix (**!ii** or **#ii**) is used to direct commands to a SEACAT with the same ID (ii = ID):

- **!ii** directs command to Communication Microcontroller
- **#ii** directs command to Acquisition Microcontroller

Global commands do not require a prefix and are recognized by all SEACATs attached to the RS-485 interface.



## Sampling Modes

The SEACAT has three basic sampling modes for obtaining data:

- Polled Sampling
- Autonomous Sampling
- Serial Line Synchronization

**Note:**

The SEACAT automatically enters quiescent state after 2 minutes without receiving a command.

Commands can be used in various combinations to provide a high degree of operating flexibility.

Descriptions and examples of the sampling modes follow for a system with three SEACAT (IDs 01, 02, and 03) online. Note that the SEACATs' response to each command is not shown in the examples. Review the operation of the basic sampling modes and the commands described in *Command Descriptions* before setting up your system.

### Polled Sampling

On command, the SEACAT takes one sample of data and sends the data to the computer. Storing of data in the SEACAT FLASH memory is dependent on the particular command used.

*Example: Polled Sampling* (user input in bold)

Wake up all SEACATs. Globally set date and time to September 1, 2004 9 am. For each SEACAT: set up with internally mounted strain gauge pressure sensor and 1 voltage sensor, no pump; take and average 4 measurements per sample, and output data in converted decimal format. After all parameters are entered, verify setup. Then command each SEACAT to take a sample, and send data to computer (do not store data in SEACAT memory). Send power-off command to all SEACATs.

(Click Connect on Toolbar to wake up all SEACATs.)

S>**MMDDYY=090104**

S>**HHMMSS=090000**

S>**#01PTYPE=1**

S>**#01VOLT0=Y**

S>**#01PUMPMODE=0**

S>**#01NCYCLES=4**

S>**#01OUTPUTFORMAT=3**

S>**#01DS** (to verify setup)

(Repeat **#iiPTYPE=1** through **#iiDS** for SEACATs 02 and 03.)

S>**#01TS**

S>**#02TS**

S>**#03TS**

S>**PWROFF**

## Autonomous Sampling (logging)

At pre-programmed intervals, the SEACAT wakes up, samples data, stores the data in its FLASH memory, and enters quiescent (sleep) state. The SEACAT goes to sleep for a minimum of 3 seconds between each sample. Logging is started with **#iiStartNow** or **#iiStartLater**, and is stopped with **#iiStop**. **#iiSL** can be used to obtain the last data sample without interrupting data acquisition.

To synchronize data samples for each SEACAT (see *Specifications in Section 2: Description of SEACAT* for the real-time clock specifications):

- Send a global command to set the date and time for all SEACATs.
- Set the sampling interval for each SEACAT to the same value.
- Set the start sampling date and time for each SEACAT to the same value.

### Note:

Use **#iiStop** to:

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

Once **#iiStop** is sent, the SEACAT will accept all commands again.

The SEACAT has a *lockout* feature to prevent unintended interference with sampling. If the SEACAT is logging or is waiting to start logging (**#iiStartLater** has been sent, but logging has not started yet), the SEACAT will only accept:

- The following Communication Microcontroller commands:  
**AData, GData, StartSample, GSample, PwrOff, Dataii, ID?, !iiDS**
- The following Acquisition Microcontroller commands:  
**#iiDS, #iiDCal, #iiTS, #iiSL, #iiSLT, and #iiStop**

*Example: Autonomous Sampling* (user input in bold)

Wake up all SEACATs. Globally set date and time to September 1, 2004 9 am. For each SEACAT: Initialize logging to overwrite previous data in memory. Set up with internally mounted strain gauge pressure sensor and 1 voltage sensor, take a sample every 120 seconds, take and average 4 measurements per sample, and output data in raw hex format. Set pump to run for 0.5 seconds before each sample. Set up to start logging on September 15, 2004 at 11 am. Send command to start logging at designated date and time. After all parameters are entered, verify setup. Send power-off command to all SEACATs.

(Click Connect on Toolbar to wake up all SEACATs.)

```
S>MMDDYY=090104
S>HHMMSS=090000
S>#01INITLOGGING
S>#01PTYPE=1
S>#01VOLT0=Y
S>#01SAMPLEINTERVAL=120
S>#01NCYCLES=4
S>#01OUTPUTFORMAT=0
S>#01PUMPMODE=1
S>#01STARTMMDDYY=091504
S>#01STARTHHMMSS=110000
S>#01STARTLATER
S>#01DS (to verify setup)
```

(Repeat **#01INITLOGGING** through **#iiDS** for SEACATs 02 and 03.)

```
S>PWROFF
```

Deploy SEACAT. Logging starts automatically at designated date and time. As desired, send global command to calculate average data and start a new average for each SEACAT. Then send command to each SEACAT to transmit averaged data, and power down:

(Click Connect on Toolbar to wake up all SEACATs.)

```
S>ADATA
S>DATA01
S>DATA02
S>DATA03
S>PWROFF
```

Upon recovering instrument, stop logging. Upload data in memory, in format Sea-Bird's post-processing software can use. Send power-off command.

(Click Connect on Toolbar to wake up all SEACATs.)

```
S>#01STOP
```

(Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it.)

(Repeat **#iiSTOP** and Upload for SEACATs 02 and 03.)

```
S>PWROFF
```



## Serial Line Synchronization (Serial Line Sync)

Serial Line Sync allows a simple pulse on the RS-485 line to initiate a sample. This mode provides easy integration with ADCPs or current meters, which can synchronize SEACAT sampling with their own without drawing on their battery or memory resources.

### Note:

Use **!iiDS** to view Serial Line Sync enable/disable status.

If this mode is enabled (**!iiSyncMode=Y**) and the SEACAT is powered down, setting the RS-485 **B** line high (3 –10 VDC) and the RS-485 **A** line low (less than 0.5 VDC) for 1 to 1500 milliseconds wakes up the SEACAT and executes a Take Sample command (take sample and store in FLASH memory).

After executing the Take Sample command, the SEACAT checks the state of the RS-485 line. There are two states:

- **Mark State** (RS-485 **A** is greater than RS-485 **B**)
- **Space State** (RS-485 **A** is less than RS-485 **B**)

The state of the line for the period from 1.5 to 3 seconds after the initial pulse determines whether to leave serial line sync mode enabled or to disable it:

- **Line returns to Mark State or is not driven at any time during period** - SEACAT immediately powers down and enters quiescent (sleep) state. Serial line sync mode remains enabled (**!iiSyncMode=Y**).
- **Line remains in Space State for entire period** - SEACAT disables serial line sync mode (**!iiSyncMode=N**) after 3 seconds. Once serial line sync is disabled, you can communicate with the SEACAT using the full range of commands (polled sampling, autonomous sampling, upload, etc.).

In summary, to disable serial line sync mode after sending the wakeup pulse, put the RS-485 line in space state (RS-485 **A** is less than RS-485 **B**) for the period from 1.5 to 3 seconds after the initial pulse.

### Example: *Serial Line Sync* (user input in bold)

Wake up all SEACATs. Globally set date and time to September 1, 2004 9 am. For each SEACAT: Initialize logging to overwrite previous data in memory. Set up with internally mounted strain gauge pressure sensor and 1 voltage sensor, take and average 4 measurements per sample, output data in converted decimal format. Enable serial line sync mode. After all parameters are entered, verify setup. Send power off command.

(Click Connect on Toolbar to wake up all SEACATs.)

```
S>MDDYY=090104
S>HHMSS=090000
S>#01INITLOGGING
S>#01PTYPE=1
S>#01VOLT0=Y
S>#01NCYCLES=4
S>#01OUTPUTFORMAT=3
S>!01SYNCSMODE=Y
S>#01DS (to verify setup)
(Repeat #iiINITLOGGING through #iiDS for SEACATs 02 and 03.)
S>PWROFF
```

Take samples using serial line sync mode:

(Set RS-485 **B** high and RS-485 **A** low for 1-1500 msec. All SEACATs wake up, take sample, and store data in memory.)  
 (Immediately place RS-485 line in Mark State [**A>B**] for 3 seconds. SEACATs go to sleep after 3 seconds.)  
 (Repeat this process at periodic intervals as desired.)

When ready to upload all data to computer, wake up all SEACATs, disable serial line sync, and then upload data and power down:

(Set RS-485 **B** high and RS-485 **A** low for 1-1500 msec. All SEACATs wake up, take sample, and store data in memory.)  
 (Within 3 seconds, select *Send 5 second break* in Communications menu to disable serial line sync.)  
 (Press Enter key to get S> prompt.)  
 S>**#01DS** (to verify SEACAT is communicating)  
 (Click Upload on Toolbar – program leads you through screens to define data to be uploaded and where to store it.)  
 (Repeat **#iiDS** and upload for SEACATs 02 and 03.)  
 S>**PWROFF**

## Pump Operation

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

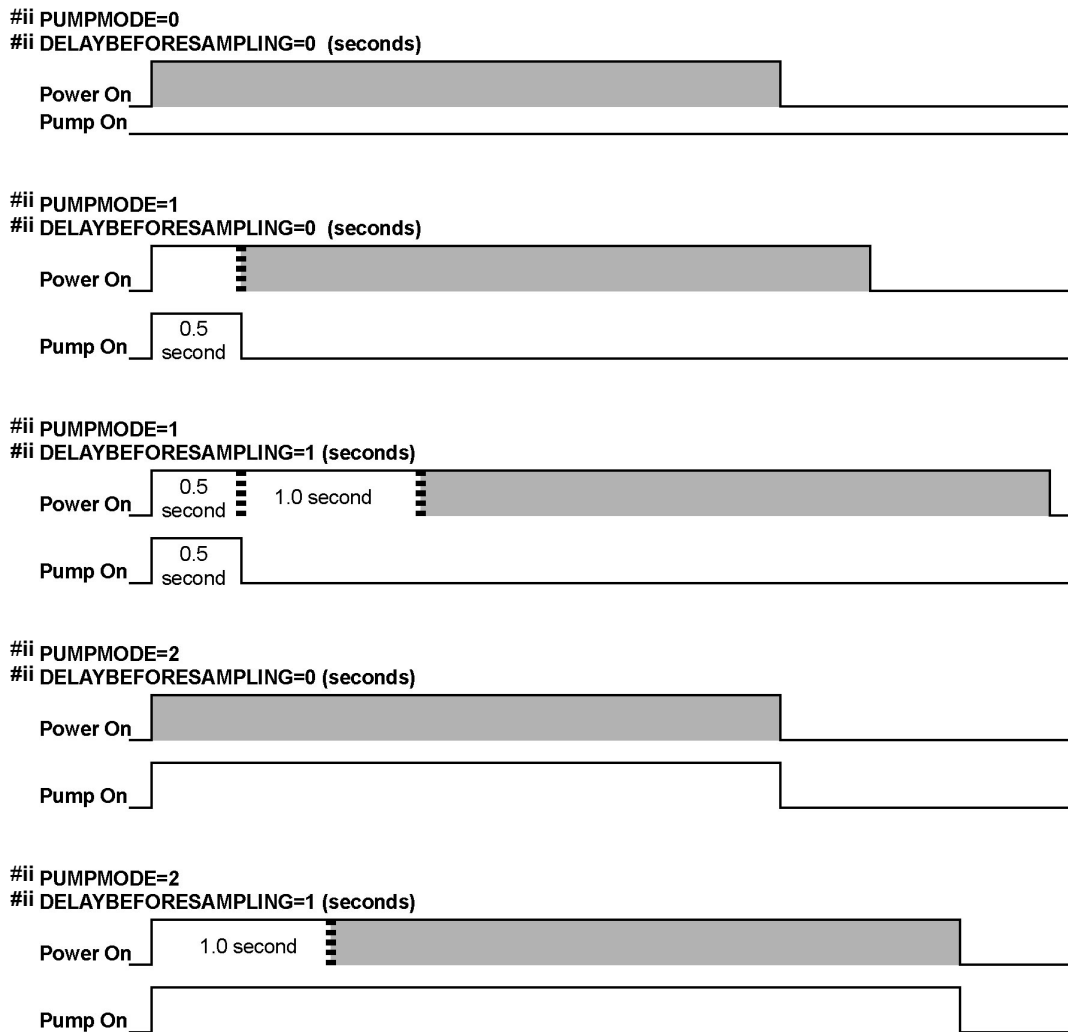
Pump operation is governed by two user-programmable parameters:

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

**Note:**

Set **#iiRxMax=** greater than **#iiDelayBeforeSampling=** to prevent the SEACAT from timing out during polled sampling.

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



■ = sampling time (≥ 2.2 seconds)

**Note:**

Sampling time includes time for instrument to warm up as well as time to actually measure parameters. The 2.2 second sampling time is for SEACAT with no internally mounted pressure sensor, and 1 measurement / sample (**#iiNCycles=1**). See *Specifications* in *Section 2: Description of SEACAT* for sampling times for other setups.

## Pump Setting Recommendations

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

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

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

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

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

Set **#iiPumpMode=2**.

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

**Note:**

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

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

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

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

## Real-Time Setup

**Notes:**

- Set baud rate with `!iiBaud=`.
- If using external power, see *External Power* in *Section 2: Description of SEACAT* for power limitations on cable length.

The SEACAT can transmit data over up to 1200 meters of twisted pair wire cable, 26 AWG or smaller gauge (larger diameter).

If you will be using SEATERM to view occasional data samples and/or averages while logging, click Capture on SEATERM's Toolbar before you begin sampling. The data displayed in SEATERM will be saved to the designated file. Process the data as desired. Note that this real-time data file **cannot be processed by SBE Data Processing, as it does not have the required headers and format**. To process data with SBE Data Processing, upload the data from the SEACAT's memory.

### Cable Termination

The MAX3471 transceivers used in the SEACAT are designed for bi-directional data communications on multi-point bus transmission lines. To minimize reflections, terminate the line at both ends in its characteristic impedance. Also, keep stub lengths off the main line as short as possible (although the slew-rate-limited MAX3471 is more tolerant of imperfect termination than standard RS-485 ICs).

---

## Timeout Description

The SEACAT has a timeout algorithm. If the SEACAT does not receive a command or sample data for 2 minutes, it powers down its main digital circuits. This places the SEACAT in quiescent state, drawing minimal current. **To re-establish control (wake up), click Connect on the Toolbar.** The system responds with the `S>` prompt.

## Command Descriptions

This section describes commands and provides sample outputs.  
See *Appendix III: Command Summary* for a summarized command list.

When entering commands:

**Note:**

**For reliable operation, all commands *may* need to be preceded with two @ characters to clear the communication microcontroller receive buffers.**

*Example* (status command for SEACAT 01):  
S>@@#01DS

- Input commands to the SEACAT in upper or lower case letters and register commands by pressing the Enter key.
- The SEACAT sends ? CMD if an invalid command is entered.
- If a new command is not received within 2 minutes after the completion of a command, the SEACAT returns to the quiescent (sleep) state.
- If in quiescent state, re-establish communications by clicking Connect on the Toolbar to get an S> prompt.
- The system may not return an S> prompt after executing a command, but may still be communicating properly. Always verify any setup changes by sending the Status (#iDS) command.
- **Do not send #iiInitLogging before uploading all data from memory.** 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.**
- **Do not send commands that change the scan length (#iiPType=, #iiVolt0=, #iiVolt1=, #iiVolt2=, #iiVolt3=, #iiSBE38=, #iiSBE50=, #iiGTD=, and #iiDualGTD before uploading all data from memory.** The SEACAT 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 SEACAT 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.**
- The SEACAT responds only to **AData, GData, StartSample, GSample, #iiDS, #iiDCal, #iiTS, #iiSL, #iiSLT, #iiGA, #iiSA, #iiSAG, and #iiStop** while sampling autonomously or while waiting to start autonomous sampling (if you sent #iiStartLater but sampling has not started yet).
  - If sampling autonomously: If you wake the SEACAT while it is sampling (for example, to send #iiDS to check on progress), it will temporarily stop sampling. Autonomous sampling resumes when it goes back to sleep again (either by sending PwrOff, or after the 2-minute timeout).
  - If waiting to start autonomous sampling: To send any other commands, send #iiStop, send the desired commands to modify the setup, and then send #iiStartLater again.

Entries made with the commands are permanently stored in the SEACAT 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 the date and time (MMDDYY= and HHMMSS= to reset globally, or #iiMMDDYY= and #iiHHMMSS= to reset for an individual SEACAT) and initialize logging (#iiInitLogging).

---

## SEACAT Communication Microcontroller Commands

---

### Global Commands

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**Note:**

Data from **AData**, **GData**, **StartSample**, and **GSample** is not stored in FLASH memory.

**AData**

Command **all** SEACATs to get **average** data from acquisition microcontrollers and start next averaging cycle. Communication microcontrollers send **#iiSAG** (send averaged data, start new average), and then **PwrOff** to turn power off. Averaged data is held in communication microcontroller buffers until receiving **Dataii**.

**GData**

Command **all** SEACATs to get 1 sample. Communication microcontrollers send **#iiTS** to acquisition microcontrollers to take sample, and then send **PwrOff** to turn power off. Data is held in communication microcontroller buffers until receiving **Dataii**.

**StartSample**

Command **all** SEACATs to get 1 sample. Communication microcontrollers send **#iiTS** to acquisition microcontrollers to take sample, and leave power on. Data is held in communication microcontroller buffers until receiving **DataAii**. Send this command once before using **GSample**.

**GSample**

Command **all** SEACATs to get last sample and then take new sample. Communication microcontrollers send **#iiSL** and **#iiTS** to acquisition microcontrollers, and leave power on. Data from last sample is held in communication microcontroller buffers until receiving **Dataii**; data from new sample is held in acquisition microcontroller buffers.

**Notes:**

- **DDMMYY=** and **MMDDYY=** are equivalent. Either can be used to set the date.
- If the SEACAT battery pack has been removed, the date and then time must be reset.
- **Always set date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **MMDDYY=**, **DDMMYY=**, **#iiMMDDYY=**, or **#iiDDMMYY=**.

**MMDDYY=mmddyy**

Set real-time clock month, day, and year for **all** SEACATs. Must be followed by **HHMMSS=** to set time.

**DDMMYY=ddmmyy**

Set real-time clock day, month, and year for **all** SEACATs. Must be followed by **HHMMSS=** to set time.

**HHMMSS=hhmmss**

Set real-time clock hour, minute, and second for **all** SEACATs.

**PwrOff**

Quit session and place **all** SEACATs in quiescent (sleep) state. Main power is turned off. Data logging and memory retention are not affected.

**Note:**

In SEATERM, to save data to a file, click Capture on the Toolbar before getting data.

---

### Get Data Command

---

**Dataii**

Get data obtained with **GData**, **AData**, **StartSample**, or **GSample** from SEACAT with ID = ii.

**SEACAT ID Commands**

**Only one SEACAT can be online when sending these commands.**

<b>ID?</b>	Get SEACAT ID (ID = ii, where ii= 0-99).
<b>*ID=ii</b>	Set SEACAT ID to ii, where ii= 0-99. <b>*ID=ii</b> must be sent twice, because computer requests verification. <b>Note that if more than one SEACAT is online when sending command, all SEACATs online will be set to same ID.</b>

**Miscellaneous Commands**

All these commands are preceded by **!ii**, where **ii**=SEACAT ID (0-99).

<b>!iiDS</b>	Display communication firmware version, timeouts, and serial line sync status.
--------------	--

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

```
S>!01DS
SBE 16plus RS-485 V1.0
rxdelay = 25 msec [!iiRxDelay=]
txdelay = 25 msec [!iiTxDelay=]
reply wait time = 30 sec [!iiRxMax=]
serial sync mode disabled [!iiSyncMode=]
```

<b>!iiRxDelay=x</b>	x= delay after SEACAT receives a command until transmitter is enabled (1 – 500 msec). Default 25 msec.
---------------------	--

<b>!iiTxDelay=x</b>	x= delay after SEACAT transmits a reply until transmitter is disabled (1 – 500 msec). Default 25 msec.
---------------------	--

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

<b>!iiRxMax=x</b>	x= time communication microcontroller waits for reply from acquisition microcontroller before it times out (1 - 180 sec). Default 30 sec.
-------------------	---

**Note:**  
See *Sampling Modes* for complete details on the operation of serial line synchronization.

<b>!iiSyncMode=x</b>	<b>x=Y:</b> Enable serial line sync mode. When RS-485 <b>B</b> is high and RS-485 <b>A</b> is low for 1-1500 msec, SEACAT takes sample, stores data in FLASH memory, and powers down. <b>x=N:</b> Disable serial line sync mode.
----------------------	---

**Notes:**

- The SEACAT baud rate (set with **!iiBaud=**) must be the same as SEATERM's baud rate (set in the Configure menu).
- An RS-232 sensor (SBE 38, SBE 50, or GTD) integrated with the SEACAT must use the same baud rate as used by the SEACAT. See the RS-232 sensor's manual for details on how to set its baud rate.

<b>!iiBaud=x</b>	x= baud rate (1200, 2400, 4800, or 9600).
------------------	---

<b>!ii*EETest</b>	Test EEPROM. <b>This test erases all calibration coefficients and user-programmed parameters.</b>
-------------------	---

## SEACAT Acquisition Microcontroller Commands

All Acquisition Microcontroller Commands are preceded by **#ii**, where **ii**= SEACAT ID (0-99).

### Notes:

- If configured with a pump, sending **#iiDS** causes the pump to turn on for a moment, so that the SEACAT 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, no voltage channels or RS-232 sensors are enabled, so external voltage currents (*iext01*= and *iext23*=) and RS-232 current (*iserial*=) are not shown.
- If the SEACAT 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.
- If the SEACAT is set up for dual GTDs, the status command shows: Dual Gas Tension Device = Yes

### Status Command

#### #iiDS

Display operating status and setup parameters.  
Equivalent to Status on Toolbar.

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

- Digital firmware version, serial number, date and time [MMDDYY= and HHMMSS=, or #iiMMDDYY= and #iiHHMMSS=]
- Voltages and currents (main and back-up lithium battery voltages, operating and pump current, external voltage currents, RS-232 instrument current)
- Logging status (not logging, logging, waiting to start at . . ., or unknown status)
- Sample interval [#iiSampleInterval=] and number of measurements to take and average per sample [#iiNCycles=]
- Integration time [#iiParosIntegration=] (only if pressure sensor = Digiquartz)
- Number of samples and available sample space in memory
- Pump turn-on parameter [#iiPumpMode=] and turn-on delay [#iiDelayBeforeSampling=]
- Battery cut-off voltage
- Internally mounted pressure sensor type [#iiPType=] and range [#iiPRange=]
- Sample SBE 38 secondary temperature sensor [#iiSBE38=]? Sample SBE 50 pressure sensor [#iiSBE50=]? Sample Gas Tension Device or Dual Gas Tension Devices [#iiGTD= or #iiDualGTD=]?
- Sample external voltages 0, 1, 2, and 3? [#iiVolt0= through #iiVolt3=]
- Output format [#iiOutputFormat=]
- Output salinity [#iiOutputSal=] and sound velocity [#iiOutputSV=] with each sample? (only if output format = converted decimal)

### Example: 16plus with ID=01 (user input in bold)

```
S>#01DS
SBE 16plus V RS-485 1.0c SERIAL NO. 4596 30 Apr 2005 09:47:48 [MMDDYY=, HHMMSS=]
vbatt = 14.0, vlith = 8.5, ioper = 62.5 ma, ipump = 21.6 ma,
status = not logging
sample interval = 15 seconds, number of measurements per sample = 2 [#iiSampleInterval=, #iiNCycles=]
samples = 0, free = 524288
run pump during sample pump, delay before sampling = 2.0 seconds [#iiPumpMode=, #iiDelayBeforeSampling]
battery cutoff = 7.5 volts
pressure sensor = strain gauge, range = 1000.0 [#iiPType=, #iiPRange=]
SBE 38 = no, SBE 50 =no, Gas Tension Device = no [#iiSBE38=, #iiSBE50=, #iiGTD=, #iiDualGTD=]
Ext Volt 0 = yes, Ext Volt 1 = yes, Ext Volt 2 = yes, Ext Volt 3 = yes [#iiVolt0= to #iiVolt3=]
output format = converted decimal [#iiOutputFormat=]
output salinity = no, output sound velocity = no [#iiOutputSal=, #iiOutputSV=]
```



---

**General Setup Commands**


---

**Notes:**

- **#iiDDMMYY=** and **#iiMMDDYY=** are equivalent. Either can be used to set the date.
- **Always set date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **#iiMMDDYY=** or **#iiDDMMYY=**.

<b>#iiMMDDYY=mmddy</b>	Set real-time clock month, day, and year. Must be followed by <b>#iiHHMMSS=</b> to set time.
<b>#iiDDMMYY=ddmmy</b>	Set real-time clock day, month, and year. Must be followed by <b>#iiHHMMSS=</b> to set time.
<b>#iiHHMMSS=hhmmss</b>	Set real-time clock hour, minute, and second.

*Example:* Set current date and time to 05 October 2004 12:00:00 for SEACAT 01 (user input in bold).

```
S>#01MMDDYY=100504
```

```
S>#01HHMMSS=120000
```

or

```
S>#01DDMMYY=051004
```

```
S>#01HHMMSS=120000
```

**Note:**

Pump operation is affected by both **#iiPumpMode=** and **#iiDelayBeforeSampling=**. See *Pump Operation*.

**#iiPumpMode=x**

**x=0:** No pump.

**x=1:** Run pump for 0.5 seconds before each sample (typical for pumping through conductivity cell only, with no auxiliary sensors connected to plumbing).

**x=2:** Run pump during each sample (typical for pumping through conductivity cell and in-line auxiliary sensor).

**Note:**

**#iiNCycles=**, **#iiParosIntegration=**, and **#iiDelayBeforeSampling=** affect the time required to sample. If these are too high, the SEACAT is unable to take the required number of measurements and do the calculations within **#iiSampleInterval=**. When it is beginning to log, the SEACAT checks all parameters, and if necessary it internally increases **#iiSampleInterval=**.

**#iiNCycles=x**

**x=** number of measurements to take and average for each sample (default = 1). SEACAT takes and averages **#iiNCycles=** measurements (each 0.25 seconds apart) for each sample; averaged data is stored in FLASH memory. Maximum **#iiNCycles=** is *smaller* of 255 or  $[4 * (\text{\#iiSampleInterval} - 3)]$ .

**General Setup** Commands (*continued*)**Notes:**

- **#iiInitLogging** and **#iiSampleNumber=0** have identical effects. Use either command to initialize logging.
- Initializing logging sets sample and header number to 0 *internally*. However, for data output, the first sample number and header number is 1.
- **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.

**Note:**

Only 550 lines (roughly corresponding to 550 blocks) can be transmitted at one time. When it reaches that point, SEATERM shows `Maximum number of lines from acquisition CPU exceeded,` and it appears that the mapping process has stopped. Click Status on the Toolbar, and the remainder of the mapping process will display on the screen.

**#iiInitLogging**

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

**#iiHeaderNumber=x**

**x**= header number for when sampling begins. Typically only used to recover data if you accidentally initialize logging (using **#iiInitLogging** or **#iiSampleNumber=0**) before uploading all existing data. SEACAT writes a new header each time autonomous sampling is started and / or after every 1000 samples are stored in memory.

**#iiFlashInit**

Map bad blocks and erase FLASH memory, **destroying all data**. SEACAT requires you to enter this command twice, to provide verification before it proceeds. All data bits are set to 1. Sample number, header number, and data pointers are set to 0. Allow 15 minutes for process.

Send **#iiFlashInit** (after uploading all data) if there are FLASH Read errors in Status (**#iDS**) response. If not encountering errors, **#iiFlashInit** is optional, as SEACAT writes over previously recorded information when **#iiInitLogging** is used before beginning sampling. However, knowledge of initial memory contents (i.e., all 1's) can be useful cross-check when data is retrieved.

---

**Output Format Commands**


---

**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 SEATERM.
- After stopping sampling, use SEATERM's Upload button to upload data from memory. This automatically resets the format to raw hex (**#iiOutputFormat=0**), so the data is compatible with SBE Data Processing.

**#iiOutputFormat=x**

**x=0:** Output raw frequencies and voltages in hexadecimal; required for data that will be processed with Sea-Bird software. When using SEATERM's Upload button, SEATERM sends **#iiOutputFormat=0**, causing SEACAT to upload data 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; required to output salinity or sound velocity.

**#iiOutputSal=x**

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

**x=N:** Do not calculate and output salinity.

**#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**.

**x=N:** Do not calculate and output sound velocity.

---

**Pressure Sensor Setup Commands**


---

**Notes:**

- **Do not send #iiPType= if there is data in memory that you have not yet uploaded.** Sending #iiPType= changes the scan length, requiring the SEACAT to initialize logging, setting the sample number and header number to 0.
- The SEACAT configuration (.con) file must match the #iiPType= selection of internally mounted pressure sensor when processing uploaded data. View and edit the .con file in SBE Data Processing. Note that #iiPType= is factory-set to match the ordered instrument configuration.

**#iiPType=x**

Internally mounted pressure sensor type.

**x=0:** No internally mounted pressure sensor.**x=1:** Strain gauge.**x=3:** Quartz with temperature compensation.**#iiRefPress=x**

**x=** reference pressure (gauge) in decibars to use if SEACAT does not include an internally mounted pressure sensor. SEACAT uses reference pressure in conductivity and salinity calculation. Value entered for #iiRefPress= is displayed in calibration coefficient (**#iiDCal**) command response if SEACAT does not include internally mounted pressure sensor. Entry ignored if SEACAT includes internally mounted pressure sensor. Note that if SEACAT interfaces with an SBE 50 pressure sensor, it does not use SBE 50 data in conductivity and salinity calculation.

**Notes:**

- The SEACAT does the integration for the Quartz pressure sensor *after* #iiNCycles= measurements have been taken.
- #iiNCycles=, #iiParosIntegration=, and #iiDelayBeforeSampling= affect the time required to sample. If these are too high, the SEACAT is unable to take the required number of measurements and do the calculations within #iiSampleInterval=. When it is beginning to log, the SEACAT checks all parameters, and if necessary it internally increases #iiSampleInterval=.

**#iiParosIntegration=x**

**x=** integration time for optional internally mounted Quartz pressure sensor (not applicable for strain gauge pressure sensor). Range 1 – 600 seconds; default 1 second. Increasing integration time increases resolution.

See *Specifications* in *Section 2: Description of SEACAT* for determining resolution for Quartz pressure sensor.

## Voltage Sensor Setup Commands

## Notes:

- Do not send **#iiVolt0=**, **#iiVolt1=**, **#iiVolt2=**, or **#iiVolt3=** if there is data in memory that you have not yet uploaded. These commands change the scan length, requiring the SEACAT to initialize logging, setting the sample number and header number to 0.
- The SEACAT configuration (.con) file must match this selection of number of external voltages when viewing real-time data or processing uploaded data. View and edit the .con file in SBE Data Processing. Note that these parameters are factory-set to match the ordered instrument configuration.
- External voltage numbers 0, 1, 2, and 3 correspond to wiring of sensors to a voltage channel on the SEACAT end cap (see *Dimensions and End Cap Connectors* in Section 2: Description of SEACAT). However, in the .con file, voltage 0 is the first external voltage in the data stream, voltage 1 is the second, etc.

#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. **#iiVolt3=Y** is required if PAR sensor connected to optional PAR connector on SEACAT.  
x=N: Do not enable external voltage 3.

*Example:* Enable voltage sensors wired to channels 0 and 3 on end cap for SEACAT 01 (user input in bold).

```
S>#01VOLT0=Y
S>#01VOLT1=N
S>#01VOLT2=N
S>#01VOLT3=Y
```

There will be 2 external sensor voltages in data stream. In .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.

## Notes:

- Set **liiRxMax=** (time communication microcontroller waits for reply from acquisition microcontroller before it times out) longer than **#iiDelayBeforeSampling=**.
- **#iiNCycles=**, **#iiParosIntegration=**, and **#iiDelayBeforeSampling=** affect the time required to sample. If these are too high, the SEACAT is unable to take the required number of measurements and do the calculations within **#iiSampleInterval=**. When it is beginning to log, the SEACAT checks all parameters, and if necessary it internally increases **#iiSampleInterval=**.
- Pump operation is affected by both **#iiPumpMode=** and **#iiDelayBeforeSampling=**. See *Pump Operation*.

#iiDelayBeforeSampling=x

x= time (seconds) to wait after switching on external voltage before sampling (0-32,000 seconds). Default 0 seconds. Typical values if using:

- SBE 43 oxygen sensor – dependent on membrane thickness and on water temperature. Use with **#iiPumpMode=2**. See *Pump Operation*.

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

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

## Note:

If an ECO-FL with Bio-Wiper is installed and **#iiBiowiper=N**, sending **#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, the ECO-FL may become fouled because the Bio-Wiper will remain open until the first sample is completed.

#iiBiowiper=x

x=Y: Configuration includes WET Labs ECO-FL fluorometer with Bio-Wiper. With this setup, 16plus is powered longer for **#iiDS** command, 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* for details).

x=N (default): Configuration does not include ECO-FL with Bio-Wiper.

**Notes:**

- Do not send #iiSBE38=, #iiSBE50=, #iiGTD=, or #iiDualGTD= if there is data in memory that you have not yet uploaded. These commands change the scan length, requiring the SEACAT to initialize logging, setting the sample number and header number to 0.
- The SEACAT configuration (.con) file must match this selection of RS-232 sensor when viewing real-time data or processing uploaded data. View and edit the .con file in SBE Data Processing. Note that these parameters are factory-set to match the ordered instrument configuration.
- See the SBE 38, SBE 50, or Pro-Oceanus GTD manual for command details for these instruments.

**RS-232 Sensor Setup Commands**

The SEACAT can interface with an SBE 38 secondary temperature sensor, an SBE 50 pressure sensor, or up to 2 Pro-Oceanus Gas Tension Devices (GTDs).

**Setup for SBE 38:**

Set up SBE 38 to interface with SEACAT, **before** you connect it to SEACAT. Connect SBE 38 directly to computer, power with an external power supply, and (using SEATERM) set:

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

Connect SBE 38 to SEACAT RS-232 bulkhead connector, using provided cable. In the SEACAT, set #iiSBE38=Y to enable interface.

#iiSBE38=x

x=Y: Enable RS-232 SBE 38 secondary temperature sensor.

x=N: Do not enable SBE 38.

**Setup for SBE 50:**

Set up SBE 50 to interface with SEACAT, **before** you connect it to SEACAT. Connect SBE 50 directly to computer, power with an external power supply, and (using SEATERM) set:

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

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

Connect SBE 50 to SEACAT RS-232 bulkhead connector, using provided cable. In the SEACAT, set #iiSBE50=Y to enable interface.

#iiSBE50=x

x=Y: Enable RS-232 SBE 50 pressure sensor.

x=N: Do not enable SBE 50.

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

The SEACAT 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 SEACAT to take sample ( $\approx 2.5$  sec).
- Time required for integration of optional Quartz pressure sensor (**#iiParosIntegration=**).
- Time required for SEACAT to take and average **#iiNCycles=** samples; samples are taken 0.25 sec apart.
- Delay after providing power to external voltage sensors before sampling (**#iiDelayBeforeSampling=**).
- Time required to run pump before sampling (0.5 sec if **#iiPumpMode=1**).

**Setup for GTD:**

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

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

Connect GTD to SEACAT RS-232 bulkhead connector, using provided cable (end labeled *Pro-Oceanus* to GTD and end labeled *Sea-Bird* to SEACAT). In the SEACAT, set:

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

Each time a sample is to be taken, SEACAT sends following commands to GTD (ID= *GTD* ID = 01, 02, etc.):

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

**Notes:**

- A SEACAT 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 RS-232 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 SEACAT 01 with dual GTDs (user input in bold):

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

**#iiSendGTD=command**Command SEACAT 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 to GTD #1 connected to SEACAT 01:

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

Send serial number command to GTD #2 connected to SEACAT 01:

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

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

- In SEATERM, to save data to a file (if transmitting occasional samples while logging), click Capture on the Toolbar before beginning logging.
- If the SEACAT is sampling and the voltage is less than the cut-off (7.5 volts) for five consecutive scans, the SEACAT halts logging and displays WARNING: LOW BATTERY VOLTAGE.

These commands direct the SEACAT to sample data at pre-programmed intervals. When commanded to start sampling with **#iiStartNow** or **#iiStartLater**, the SEACAT takes samples, stores the data in its FLASH memory, and enters quiescent (sleep) state between samples.

To start sampling, use **#iiStartNow** or **#iiStartLater**. Sampling starts **#iiSampleInterval=** seconds after receipt of **#iiStartNow**. The first time sampling starts after receipt of initialize logging (**#iInitLogging**), 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 previously recorded data. A new header is written each time sampling starts and every 1000 samples thereafter.

The SEACAT responds only to **AData**, **GData**, **StartSample**, **GSample**, **#iiDS**, **#iiDCal**, **#iiTS**, **#iiSL**, **#iiSLT**, **#iiGA**, **#iiSA**, **#iiSAG**, and **#iiStop** while sampling. If you wake the SEACAT (for example, to send **#iiDS** to check progress), it temporarily stops sampling. Sampling resumes when it goes back to sleep again (either by sending **PwrOff** or after 2-minute timeout).

**Note:**

**#iiNCycles=**, **#iiParosIntegration=**, and **#iiDelayBeforeSampling=** affect the time required to sample. If these are too high, the SEACAT is unable to take the required number of measurements and do the calculations within **#iiSampleInterval=**. When it is beginning to log, the SEACAT checks all parameters, and if necessary it internally increases **#iiSampleInterval=**.

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

*Example:* If **#iiSampleInterval=10** and **#iiNCycles=4**, every 10 seconds SEACAT takes 4 measurements (each 0.25 seconds apart), averages data from measurements, and stores averaged data in FLASH memory.

**Notes:**

- **#iiStartDDMMYY=** or **#iiStartMMDDYY=** must be followed by **#iiStartHHMMSS=** to set delayed start time.
- **#iiStartDDMMYY=** and **#iiStartMMDDYY=** are equivalent. Either can be used to set delayed start time.
- After receiving **#iiStartLater**, the SEACAT displays waiting to start at... in reply to **#iiDS**. Once sampling starts, the **#iiDS** reply displays logging.
- If the delayed start time has already passed when **#iiStartLater** is received, the SEACAT executes **#iiStartNow**.

**#iiStartNow**                                      Start autonomous sampling now.

**#iiStartMMDDYY=mmddy**                      Set delayed start month, day, and year.

**#iiStartDDMMYY=ddmmy**                      Set delayed start day, month, and year.

**#iiStartHHMMSS=hmmss**                      Set delayed start hour, minute, and second.

**#iiStartLater**                                      Start autonomous sampling at delayed start date and time.

*Example:* Program SEACAT 01 to start logging on 20 May 2004 12:00:00 (user input in bold).

```
S>#01STARTMMDDYY=052004
S>#01STARTHHMMSS=120000
S>#01STARTLATER
```

or

```
S>#01STARTDDMMYY=200504
S>#01STARTHHMMSS=120000
S>#01STARTLATER
```

**Notes:**

- You may need to send **#iiStop** several times to get the SEACAT to respond.
- You must stop sampling before uploading data.

**#iiStop**    Stop autonomous sampling or stop waiting to start autonomous sampling (if **#iiStartLater** was sent but sampling has not begun yet). Click Connect in SEATERM to get S> prompt before entering **#iiStop**.



**Notes:**

- Averaged data is not stored in FLASH memory.
- Logging commands related to averaging are typically used only for customized acquisition. **AData** more easily starts averaging and gets averaged data. See *Communication Microcontroller Commands*.

**Autonomous Sampling (logging) Commands** (*continued*)

<b>#iiGA</b>	Start averaging data. First sample will be taken after delay of ( <b>#iiSampleInterval</b> / 2).
<b>#iiSA</b>	Output averaged data. Continue averaging.
<b>#iiSAG</b>	Output averaged data. Start new average.

**Polled Sampling Commands**

These commands request a single sample. The SEACAT always stores data for the most recent sample in its buffer. Some Sampling commands also store data in FLASH memory - the SEACAT will not execute the *store data in FLASH memory* portion of those commands while sampling autonomously.

<b>#iiSL</b>	Output last sample from buffer (sample obtained with polled sampling command, or latest sample from autonomous sampling). Turn power off.
<b>#iiSLT</b>	Output last sample from buffer, then take new sample and store data in buffer. Turn power off. <b>Data is not stored in FLASH memory.</b>
<b>#iiTS</b>	Take new sample, store data in buffer, and output data. Turn power off. <b>Data is not stored in FLASH memory.</b>
<b>#iiTSS</b>	Take new sample, <b>store data in buffer and FLASH memory</b> , and output data. Turn power off.

**Notes:**

- The SEACAT has a buffer that stores the most recent data samples. Unlike data in the FLASH memory, data in the buffer is erased upon removal or failure of power.
- *Turn power off* in the command descriptions refers to power for the SEACAT as well as for a pump any auxiliary sensors.

---

**Data Upload Commands**


---

Stop sampling autonomously before uploading data.

**Notes:**

- **Use Upload on the Toolbar or Upload Data in the Data menu to upload data that will be processed by SBE Data Processing.** Manually entering **#iiDDb,e** 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.
- To save data to a file, click Capture on the Toolbar before entering **#iiDDb,e** or **#iiDHb,e**.
- See *Data Output Formats*.

**#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.

*Example:* Upload samples 1 - 199 from SEACAT 01 (user input in bold):  
(Click Capture on Toolbar and enter desired filename in dialog box.)  
S>**#01DD1,199**

**#iiDHb,e**

Upload header **b** to header **e**. If **b** and **e** are omitted, all headers are uploaded.  
First header is number 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** command or Home or Ctrl Z character;  
timeout = error condition;  
unknown = error condition;  
?????? = error condition)

*Example:* Upload second header for SEACAT 01 (user input in bold):  
(Click Capture on Toolbar and enter desired filename in dialog box.)  
S>**#01DH2**

SEACAT responds:

```
hdr 2 30 Nov 2004 12:30:33 samples 35 to 87, int=60, stop=stop cmd
```

---

**Testing Commands**


---

The SEACAT takes and outputs **50 samples** for each test; data is **not** stored in FLASH memory.

**Note:****If your SEACAT includes an optional pump:**

Except as noted for **#iiTVRP** and **#iiTFRP**, the optional pump does not run for testing commands. Therefore, for instruments plumbed with the pump, testing commands report data from essentially the same sample of water for all 50 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, use polled sampling commands instead of testing commands.

<b>#iiTT</b>	Measure temperature, output converted data.												
<b>#iiTC</b>	Measure conductivity, output converted data.												
<b>#iiTP</b>	Measure internally mounted pressure (strain gauge or Quartz), output converted data.												
<b>#iiTV</b>	Measure four external voltage channels, output converted data.												
<b>#iiTF</b>	Measure frequency (internally mounted Quartz pressure sensor), output converted data.												
<b>#iiT38</b>	Measure SBE 38 (secondary temperature), output converted data.												
<b>#iiT50</b>	Measure SBE 50 pressure, output converted data.												
<b>#iiTTR</b>	Measure temperature, output raw data.												
<b>#iiTCR</b>	Measure conductivity, output raw data.												
<b>#iiTPR</b>	Measure internally mounted pressure (strain gauge or Quartz), output raw data.												
<b>#iiTVR</b>	Measure voltages read by A/D converter, output raw data:												
	<table border="1"> <thead> <tr> <th>Column</th> <th>Output</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Main battery voltage / 11</td> </tr> <tr> <td>2</td> <td>Back-up lithium battery voltage / 3.741</td> </tr> <tr> <td>3</td> <td>External current / 333.33</td> </tr> <tr> <td>4</td> <td>Pressure temperature voltage</td> </tr> <tr> <td>5-8</td> <td>External voltages</td> </tr> </tbody> </table>	Column	Output	1	Main battery voltage / 11	2	Back-up lithium battery voltage / 3.741	3	External current / 333.33	4	Pressure temperature voltage	5-8	External voltages
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1	Main battery voltage / 11												
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4	Pressure temperature voltage												
5-8	External voltages												
<b>#iiTVRP</b>	<i>With the pump running</i> , measure voltages read by A/D converter, output raw data (output in same format as <b>#iiTVR</b> above).												
<b>#iiTFR</b>	Measure frequency (internally mounted Quartz pressure sensor), output raw data.												
<b>#iiTFRP</b>	<i>With the pump running</i> , measure frequency (internally mounted Quartz pressure sensor), output raw data.												

---

**Calibration Coefficients Commands**


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**Notes:**

- Dates shown are when calibrations were performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificate shipped with SEACAT.
- See individual Coefficient Commands below for definitions of the data in the example.

**#iDCal**

Display calibration coefficients.  
Equivalent to Coefficients on Toolbar.

*Example:* Display coefficients for SEACAT 01 with an internally mounted Quartz pressure sensor (user input in bold).

```
S>#01dcal
SBE 16plus V RS-485 1.0c SERIAL NO. 4597 30 Apr 2005 14:46:05
temperature: 26-apr-04
  TA0 = -3.178124e-06
  TA1 = 2.751603e-04
  TA2 = -2.215606e-06
  TA3 = 1.549719e-07
  TOFFSET = 0.000000e+00
conductivity: 26-apr-04
  G = -9.855242e-01
  H = 1.458421e-01
  I = -3.290801e-04
  J = 4.784952e-05
  CF0 = 2.584100e+03          (not used in calculations; ignore)
  CPCOR = -9.570000e-08
  CTCOR = 3.250000e-06
  CSLOPE = 1.000000e+00
pressure S/N , range = 2000 psia: 14-apr-04
  PC1 = 0.000000e+00
  PC2 = 0.000000e+00
  PC3 = 0.000000e+00
  PD1 = 0.000000e+00
  PD2 = 0.000000e+00
  PT1 = 0.000000e+00
  PT2 = 0.000000e+00
  PT3 = 0.000000e+00
  PT4 = 0.000000e+00
  PSLOPE = 1.000000e+00
  POFFSET = 0.000000e+00
volt 0: offset = 0.000000e+00, slope = 1.000000e+00
volt 1: offset = 0.000000e+00, slope = 1.000000e+00
volt 2: offset = 0.000000e+00, slope = 1.000000e+00
volt 3: offset = 0.000000e+00, slope = 1.000000e+00
EXTFREQS F = 1.000000e+00
```

**Calibration Coefficients Commands** (*continued*)**Notes:**

- F = floating point number  
S = string with no spaces
- If using an SBE 38 secondary temperature sensor or SBE 50 pressure sensor, its calibration coefficients are not stored in the SEACAT EEPROM. View and/or modify the instrument's calibration coefficients by connecting the instrument to the computer directly and using SEATERM.
- If using auxiliary A/D sensors (**#iiVolt0=** through **#iiVolt3=**), their calibration coefficients are not stored in the SEACAT EEPROM, but are stored in the SEACAT configuration (.con) file. View and/or modify the calibration coefficients using SBE Data Processing's Configure menu.

The individual commands listed below are used to modify a particular coefficient or date:

**Temperature**

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

**Conductivity**

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

**Internally Mounted Pressure - General**

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

**Internally Mounted Strain Gauge Pressure**

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

**Internally Mounted Quartz Pressure**

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

**External Frequency**

<b>#iiExtFreqSF=F</b>	F=external frequency scale factor (applies to internally mounted Quartz pressure sensor)
-----------------------	--

## Data Output Formats

**Note:**

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

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

For example, if the SEACAT 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 SEACAT 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, or 3)** 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.

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

- When using SEATERM's Upload button, SEATERM sends **#iiOutputFormat=0**. This causes the SEACAT to upload data in memory in raw hex, regardless of the user-programmed format, providing the data in a format that Sea-Bird's data processing software 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 internally mounted 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 SEACAT outputs pressure relative to the ocean surface (i.e., at the surface the output pressure is 0 decibars). The SEACAT uses the following to convert psia to decibars:  
pressure (db) =  
[pressure (psia) - 14.7] \* 0.689476
- Although **#iiOutputFormat=0** outputs *raw* data for temperature, conductivity, etc., it outputs engineering units for SBE 38, SBE 50, and GTD data. SBE 50 units are dependent on **OutputFormat=** programmed into the SBE 50; if you will be using SEASAVE or SBE Data Processing, you must set the SBE 50 format to psia (**OutputFormat=1**).

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 #iiDDb,e, Upload on Toolbar, or Upload Data in Data menu) or Polled Data (from #iiSL, #iiSLT, #iiTS, or #iiTSS):**

1. Temperature  
A/D counts = tttttt
2. Conductivity  
conductivity frequency (Hz) = cccccc / 256
3. Internally mounted strain gauge pressure sensor pressure (if #iiPType=1)  
A/D counts = pppppp
4. Internally mounted strain gauge pressure sensor pressure temperature compensation (if #iiPType=1)  
pressure temperature compensation voltage = vvvv / 13,107
5. Internally mounted Quartz pressure sensor pressure (if #iiPType=3)  
pressure frequency (Hz) = pppppp / 256
6. Internally mounted Quartz pressure sensor temperature compensation (if #iiPType=3)  
temperature compensation voltage = vvvv / 13,107
7. External voltage 0 (if #iiVolt0=Y)  
external voltage 0 = vvvv / 13,107
8. External voltage 1 (if #iiVolt1=Y)  
external voltage 1 = vvvv / 13,107
9. External voltage 2 (if #iiVolt2=Y)  
external voltage 2 = vvvv / 13,107
10. External voltage 3 (if #iiVolt3=Y)  
external voltage 3 = vvvv / 13,107
11. SBE 38 secondary temperature (if #iiSBE38=Y)  
SBE 38 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
12. SBE 50 strain gauge pressure (if #iiSBE50=Y)  
SBE 50 pressure (decibars, psia, meters, or feet) = (pppppp / 10,000) - 100
13. GTD #1 pressure (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 pressure (millibars) = pppppppp / 100,000
14. GTD #1 temperature (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
15. GTD #2 pressure (if #iiDualGTD=Y)  
GTD #2 pressure (millibars) = pppppppp / 100,000
16. GTD #2 temperature (if #iiDualGTD=Y)  
GTD #2 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
17. Time  
seconds since January 1, 1980 = ssssssss

*Example:* SEACAT with internally mounted strain gauge pressure sensor and 2 external voltages sampled, example scan = tttttccccppppppvvvvvvvvvvvssssss = 0A53711BC7220C14C17D820305059425980600

- Temperature = ttttt = 0A5371 (676721 decimal);  
temperature A/D counts = 676721
- Conductivity = 1BC722 (1820450 decimal);  
conductivity frequency = 1820450 / 256 = 7111.133 Hz
- Internally mounted strain gauge pressure = pppppp = 0C14C1 (791745 decimal);  
Strain gauge pressure A/D counts = 791745
- Internally mounted strain gauge temperature compensation =  
vvvv = 7D82 (32,130 decimal);  
Strain gauge temperature = 32,130 / 13,107 = 2.4514 volts
- First external voltage = vvvv = 0305 (773 decimal);  
voltage = 773 / 13,107 = 0.0590 volts
- Second external voltage = vvvv = 0594 (1428 decimal);  
voltage = 1428 / 13,107 = 0.1089 volts
- Time = ssssssss = 25980600 (630,720,000 decimal)  
seconds since January 1, 1980 = 630,720,000

**Polled Data from Dattai:**

- Data obtained with **GData**: Data is preceded by the SEACAT's two-character ID and a comma. The rest of the data stream is as described above for uploaded data.
- Data obtained with **AData**: Data is preceded by the SEACAT's two-character ID and a comma and is followed by the number of samples in the average. The rest of the data stream is as described above for uploaded data.

*Example:* SEACAT01 with internally mounted strain gauge pressure sensor and 2 external voltages sampled.

**S>GDATA**

**S>DATA01**

01, 0A53711BC7220C14C17D820305059425980600

(Same as example above for uploaded data, but hex data stream is preceded by ID.)

**S>ADATA**

**S>DATA01**

01, 0A53711BC7220C14C17D820305059425980600, 11

(Same as example above for uploaded data, but hex data stream is preceded by ID and followed by number of samples in average.)



**#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 #iiDDb,e) or Polled Data (from #iiSL, #iiSLT, #iiTS, or #iiTSS):**

1. Temperature  
temperature (°C, ITS-90) = (ttttt / 100,000) - 10
2. Conductivity  
Conductivity (S/m) = (ccccc / 1,000,000) - 1
3. Internally mounted pressure (Quartz or strain gauge - #iiPType=1 or 3)  
pressure (decibars) = (pppppp / 1,000) - 100
4. External voltage 0 (if #iiVolt0=Y)  
external voltage 0 = vvvv / 13,107
5. External voltage 1 (if #iiVolt1=Y)  
external voltage 1 = vvvv / 13,107
6. External voltage 2 (if #iiVolt2=Y)  
external voltage 2 = vvvv / 13,107
7. External voltage 3 (if #iiVolt3=Y)  
external voltage 3 = vvvv / 13,107
8. SBE 38 secondary temperature (if #iiSBE38=Y)  
SBE 38 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
9. SBE 50 strain gauge pressure (if #iiSBE50=Y)  
SBE 50 pressure (decibars, psia, meters, or feet) = (pppppp / 10,000) - 100
10. GTD #1 pressure (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 pressure (millibars) = pppppppp / 100,000
11. GTD #1 temperature (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
12. GTD #2 pressure (if #iiDualGTD=Y)  
GTD #2 pressure (millibars) = pppppppp / 100,000
13. GTD #2 temperature (if #iiDualGTD=Y)  
GTD #2 temperature (°C, ITS-90) = (ttttt / 100,000) - 10
14. Time  
seconds since January 1, 1980 = ssssssss

**Note:**

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

*Example:* SEACAT with internally mounted strain gauge pressure sensor and 2 external voltages sampled, example scan = tttttccccppppppvvvvvvvsssssss = 3385C40F42FE0186DE0305059425980600

- Temperature = ttttt = 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 = 25980600 (630,720,000 decimal)  
seconds since January 1, 1980 = 630,720,000

**Polled Data from Dataii:**

- Data obtained with **GData**: Data is preceded by the SEACAT's two-character ID and a comma. The rest of the data stream is as described above for uploaded data.
- Data obtained with **AData**: Data is preceded by the SEACAT's two-character ID and a comma and is followed by the number of samples in the average. The rest of the data stream is as described above for uploaded data.

*Example:* SEACAT01 with internally mounted strain gauge pressure sensor and 2 external voltages sampled.

**S>GDATA**

**S>DATA01**

01, 3385C40F42FE0186DE0305059425980600

(Same as example above for uploaded data, but hex data stream is preceded by ID.)

**S>ADATA**

**S>DATA01**

01, 3385C40F42FE0186DE0305059425980600, 11

(Same as example above for uploaded data, but hex data stream is preceded by ID and followed by number of samples in average.)

**#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 #iiDDb,e) or Polled Data (from #iiSL, #iiSLT, #iiTS, or #iiTSS):**

1. Temperature  
A/D counts = ttttt
2. Conductivity  
conductivity frequency (Hz) = cccc.ccc
3. Internally mounted strain gauge pressure sensor pressure (if #iiPType=1)  
A/D counts = pppppp
4. Internally mounted strain gauge pressure sensor pressure temperature compensation (if #iiPType=1)  
pressure temperature compensation voltage = v.vvvv
5. Internally mounted Quartz pressure sensor pressure (if #iiPType=3)  
Quartz pressure frequency (Hz) = ppppp.ppp
6. Internally mounted Quartz pressure sensor temperature compensation (if #iiPType=3)  
Quartz temperature compensation voltage = v.vvvv
7. External voltage 0 (if #iiVolt0=Y)  
external voltage 0 = v.vvvv
8. External voltage 1 (if #iiVolt1=Y)  
external voltage 1 = v.vvvv
9. External voltage 2 (if #iiVolt2=Y)  
external voltage 2 = v.vvvv
10. External voltage 3 (if #iiVolt3=Y)  
external voltage 3 = v.vvvv
11. SBE 38 secondary temperature (if #iiSBE38=Y)  
SBE 38 temperature (°C, ITS-90) = ttt.ttt
12. SBE 50 strain gauge pressure (if #iiSBE50=Y)  
SBE 50 pressure (decibars, psia, meters, or feet) = pppp.ppp
13. GTD #1 pressure (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 pressure (millibars) = pppppppp / 100,000
14. GTD #1 temperature (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 temperature (°C, ITS-90) = tt.ttt
15. GTD #2 pressure (if #iiDualGTD=Y)  
GTD #2 pressure (millibars) = pppppppp / 100,000
16. GTD #2 temperature (if #iiDualGTD=Y)  
GTD #2 temperature (°C, ITS-90) = tt.ttt
17. Time  
date, time = dd mmm yyyy, hh:mm:ss (day month year hour:minute:second)

**Notes:**

- Although #iiOutputFormat=2 outputs raw data for temperature, conductivity, etc., it outputs engineering units for SBE 38, SBE 50, and GTD data.
- SBE 50 units are dependent on OutputFormat= programmed into the SBE 50.

*Example:* SEACAT with internally mounted strain gauge pressure sensor and 2 external voltages sampled, example scan = ttttt, cccc.ccc, pppppp, v.vvvv, v.vvvv, v.vvvv, dd mmm yyyy, hh:mm:ss  
= 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089, 12 nov 2000, 12:23:05

- Temperature = ttttt = 676721;  
temperature A/D counts = 676721
- Conductivity = cccc.ccc = 7111.133;  
conductivity frequency = 7111.133 Hz
- Internally mounted strain gauge pressure = pppppp = 791745;  
Strain gauge pressure A/D counts = 791745
- Internally mounted strain gauge temperature compensation = v.vvvv = 2.4514;  
Strain gauge temperature = 2.4514 volts
- First external voltage = v.vvvv = 0.0590;  
voltage = 0.0590 volts
- Second external voltage = v.vvvv = 0.1089;  
voltage = 0.1089 volts
- Date, time = dd mmm yyyy, hh:mm:ss = 12 nov 2000, 12:23:05  
Date, time = 12 November 2000, 12:23:05

**Polled Data from Dattai:**

- Data obtained with **GData**: Data is preceded by the SEACAT's two-character ID and a comma. The rest of the data stream is as described above for uploaded data.
- Data obtained with **AData**: Data is preceded by the SEACAT's two-character ID and a comma and is followed by the number of samples in the average. The rest of the data stream is as described above for uploaded data.

*Example:* SEACAT 01 with internally mounted strain gauge pressure sensor and 2 external voltages sampled.

**S>GDATA**

**S>DATA01**

01, 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089, 12 nov 2000, 12:23:05

(Same as example above for uploaded data, but data stream is preceded by ID.)

**S>ADATA**

**S>DATA01**

01, 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089, 12 nov 2000, 12:23:05, 11

(Same as example above for uploaded data, but data stream is preceded by ID and followed by number of samples in average.)

**#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 #iiDDb,e) or Polled Data (from #iiSL, #iiSLT, #iiTS, or #iiTSS):**

1. Temperature  
temperature (°C, ITS-90) = ttt.tttt
2. Conductivity  
Conductivity (S/m) = cc.ccccc
3. Internally mounted pressure (Quartz or strain gauge - #iiPType=1 or 3)  
pressure (decibars) = pppp.ppp
4. External voltage 0 (if #iiVolt0=Y)  
external voltage 0 = v.vvvv
5. External voltage 1 (if #iiVolt1=Y)  
external voltage 1 = v.vvvv
6. External voltage 2 (if #iiVolt2=Y)  
external voltage 2 = v.vvvv
7. External voltage 3 (if #iiVolt3=Y)  
external voltage 3 = v.vvvv
8. SBE 38 secondary temperature (if #iiSBE38=Y)  
SBE 38 temperature (°C, ITS-90) = ttt.tttt
9. SBE 50 strain gauge pressure (if #iiSBE50=Y)  
SBE 50 pressure (decibars, psia, meters, or feet) = pppp.ppp
10. GTD #1 pressure (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 pressure (millibars) = ppppppppp / 100,000
11. GTD #1 temperature (if #iiGTD=Y or #iiDualGTD=Y)  
GTD #1 temperature (°C, ITS-90) = tt.ttt
12. GTD #2 pressure (if #iiDualGTD=Y)  
GTD #2 pressure (millibars) = ppppppppp / 100,000
13. GTD #2 temperature (if #iiDualGTD=Y)  
GTD #2 temperature (°C, ITS-90) = tt.ttt
14. Salinity (if #iiOutputSal=Y)  
salinity (psu) = sss.ssss
15. Sound velocity (if #iiOutputSV=Y)  
sound velocity (meters/second) = vvvv.vvv
16. 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:* SEACAT with internally mounted 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, 12 nov 2000, 12:23:05

- 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 = 12 nov 2000, 12:23:05  
Date, time = 12 November 2000, 12:23:05

**Polled Data from Dattai:**

- Data obtained with **GData**: Data is preceded by the SEACAT's two-character ID and a comma. The rest of the data stream is as described above for uploaded data.
- Data obtained with **AData**: Data is preceded by the SEACAT's two-character ID and a comma and is followed by the number of samples in the average. The rest of the data stream is as described above for uploaded data.

*Example:* SEACAT 01 with internally mounted strain gauge pressure sensor and 2 external voltages sampled.

**S>GDATA**

**S>DATA01**

01, 23.7658, 0.00019, 0.062, 0.0590, 0.1089, 12 nov 2000, 12:23:05

(Same as example above for uploaded data, but data stream is preceded by ID.)

**S>ADATA**

**S>DATA01**

01, 23.7658, 0.00019, 0.062, 0.0590, 0.1089, 12 nov 2000, 12:23:05, 11

(Same as example above for uploaded data, but data stream is preceded by ID and followed by number of samples in average.)

## Setup for Deployment

1. Install new batteries or ensure the existing batteries have enough capacity to cover the intended deployment (see *Replacing Alkaline Batteries* in *Section 5: Routine Maintenance and Calibration*).
2. Program the SEACAT for the intended deployment using SEATERM (see *Section 3: Power and Communications Test* for connection information; see this section for commands and sampling modes):
  - 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 then time. Note that the date and time can be set globally for all SEACATs online (**MMDDYY=** or **DDMMYY=** to set date; **HHMMSS=** to set time) or individually for each SEACAT (**#iiMMDDYY=** or **#iiDDMMYY=** to set date; **#iiHHMMSS=** to set time). To synchronize autonomous sampling for a system with multiple SEACATs online, set the date and time globally with all the SEACATs online (see *Autonomous Sampling* for synchronization details).
  - C. Establish setup and (if applicable) autonomous sampling parameters.
  - D. If the system will have multiple SEACATs online, verify the SEACAT is set to *Prompt ID* to allow use of SEATERM's Toolbar buttons and Menus:
    - (1) In the Configure menu, select *SBE 16plus*.
    - (2) Click on the COM Settings tab.
    - (3) For Modem/RS485 ID, click on *Prompt ID*.
    - (4) Click OK.
  - E. Send **#iiDS** to verify the setup.
  - F. Use **one** of the following sequences to initiate sampling:
    - **#iiStartNow** to start logging now, taking a sample every **#iiSampleInterval=** seconds.
    - **#iiStartMMDDYY=**, **#iiStartHHMMSS=**, and **#iiStartLater** to start logging at the specified date and time, taking a sample every **#iiSampleInterval=** seconds.
    - **!iiSyncMode=Y** to place the SEACAT in serial line sync mode, so that a simple pulse on the RS-485 line will initiate a sample.
3. If you will be using SEATERM to view occasional data samples and/or averages while logging, click Capture on the Toolbar 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**.

**Note:**

**It is always necessary to set date and then time.** If a new date is entered but not a new time, the new date will not be saved. If a new time is entered without first entering a new date, the date will reset to the last date it was set for with **MMDDYY=**, **DDMMYY=**, **#iiMMDDYY=**, or **#iiDDMMYY=**.

## 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 SEACAT 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 SEACAT. 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. Verify that the hardware and external fittings are secure.
4. 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 SEACAT with a pump, verify that the system plumbing is correctly installed (see *Configuration Options and Plumbing* in *Section 2: Description of SEACAT*).

The SEACAT is ready to go into the water.



## Recovery

**WARNING!**

**If the SEACAT 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 SEACAT is flooded, point the SEACAT 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.

## Physical Handling

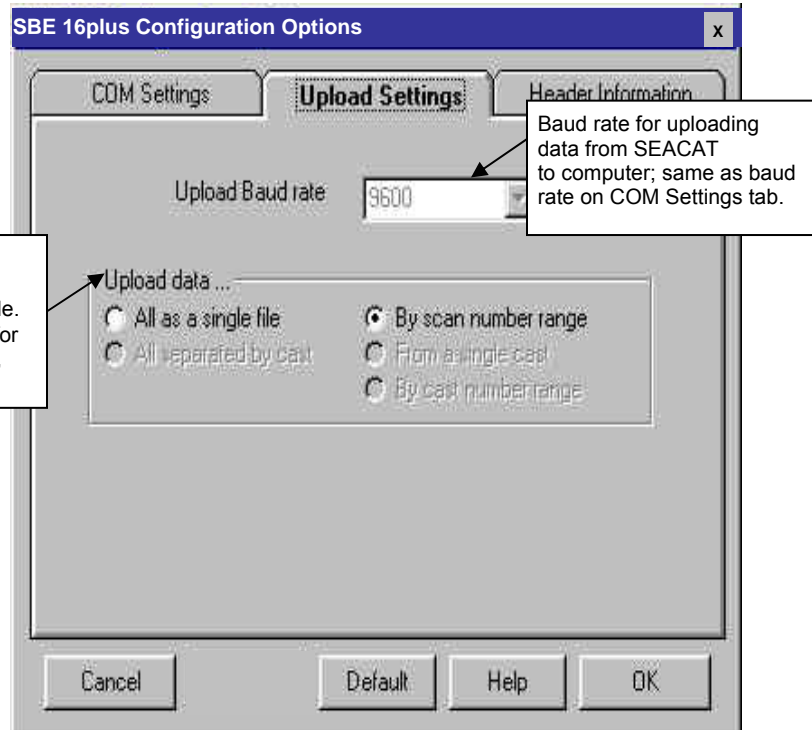
1. Rinse the instrument and conductivity cell with fresh water. (See *Section 5: Routine Maintenance and Calibration* for cell cleaning and storage.)
2. Reinsert the protective plugs in the anti-foulant device cups.
3. If the batteries are exhausted, new batteries must be installed before the data can 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 SEACAT with batteries in place and in a quiescent state (**PwrOff**). Because the quiescent current required is only 60 microamps, the batteries can be left in place without significant loss of capacity. If the SEACAT is to be stored for a long time, **replace the batteries yearly to prevent battery leakage** (which could damage the SEACAT).

## Uploading Data

### Note:

Data may be uploaded during deployment or after recovery. If uploading after recovery, connect the I/O cable as described in *Section 3: Power and Communications Test*.

1. Double click on SeaTerm.exe. The display shows the main screen.
2. In the Configure menu, select *SBE 16plus*. Click on the Upload Settings tab. The dialog box looks like this:



Defines data upload type when using Upload on Toolbar or Upload Data in Data menu:

- All as single file – All data uploaded into one file.
- By scan number range – SEATERM prompts for beginning and ending scan (sample) numbers, and uploads all data within range into one file.

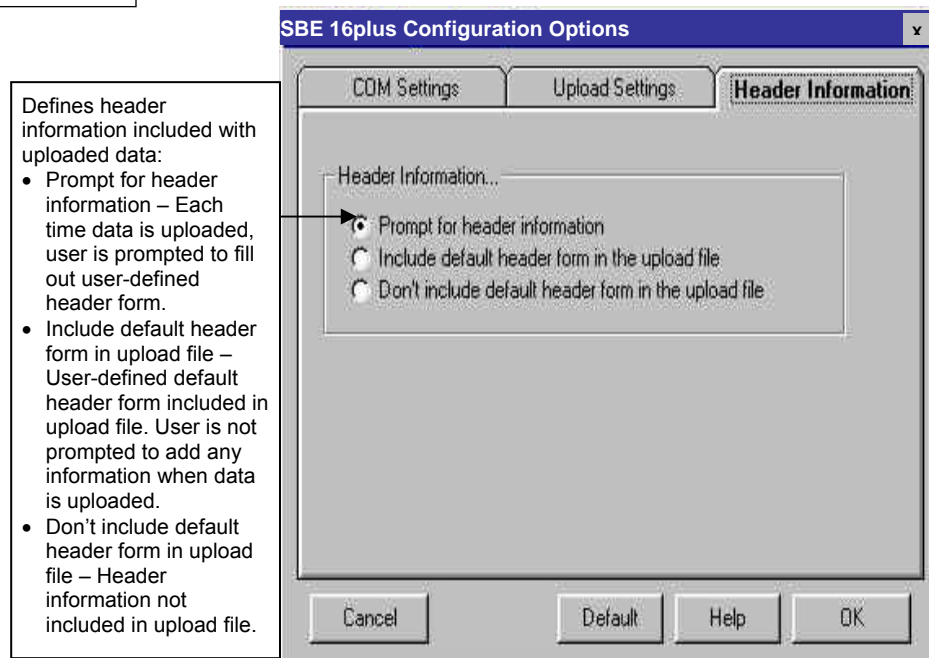
### Note:

Set up **Upload Settings**, **Header Information**, and/or **Header Form** (Steps 2 through 4):

- The first time you upload data, and
- If you want to change upload or header parameters.

Make the selection for Upload Settings.

3. Click on the Header Information tab. The dialog box looks like this:



Select the desired header information option. Click OK to save the settings.

4. In the Configure menu, select Header Form to customize the header. The dialog box looks like this (default prompts are shown):

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 in the Configuration Options dialog box (Step 3)
- the header included with the uploaded data, if *Include default header form in upload file* was selected in the Configuration Options dialog box (Step 3)

Enter the desired header/header prompts. Click OK.

5. Click Connect on the Toolbar to begin communications with the SEACAT. The display looks like this:

```
S>
```

This shows that correct communications between the computer and the SEACAT has been established.

If the system does not respond as shown above:

- Click Connect again.
- Check cabling between the computer and SEACAT.
- Verify the correct instrument was selected and the COM settings were entered correctly in the Configure menu.

**Note:**

You may need to send **#iiStop** several times to get the SEACAT to respond.

6. If sampling autonomously, command the SEACAT to stop logging by pressing the Enter key and sending **#iiStop** (ii=SEACAT ID).

7. Display SEACAT status information by clicking Status on the Toolbar. The display looks like this:

```
S>#iids (ii=SEACAT ID)
SBE 16plus V RS-485 1.0c SERIAL NO. 4597 30 Apr 2005 14:11:48
vbatt = 14.0, vlith = 8.5, ioper = 62.5 ma, ipump = 21.6 ma,
status = not logging
sample interval = 15 seconds, number of measurements per sample = 2
samples = 97, free = 524191
run pump during sample, delay before sampling = 2.0 seconds
battery cutoff = 7.5 volts
pressure sensor = strain gauge, range = 1000.0
SBE 38 = no, SBE 50 = yes, Gas Tension Device = no
Ext Volt 0 = no, Ext Volt 1 = no, Ext Volt 2 = no, Ext Volt 3 = no
output format = converted decimal
output salinity = no, output sound velocity = no
S>
```

8. Click Upload on the Toolbar to upload stored data in a form that Sea-Bird's data processing software can use. SEATERM responds as follows:
- SEATERM sends **#iiOutputFormat=0** to set the output format to raw hexadecimal.
  - SEATERM sends the status (**#iids**), header (**#iidH**), and calibration coefficients (**#iidCal**) commands, displays the responses, and writes the commands and responses to the upload file. This provides you with information regarding the number of samples in memory, sample interval, headers, calibration coefficients, etc.
  - If you selected *By scan number range in the Configuration Options dialog box (Configure menu)*** – a dialog box requests the range. Enter the desired values, and click OK.
  - If you selected *Prompt for header information in the Configuration Options dialog box (Configure menu)*** – a dialog box with the header form appears. Enter the desired header information, and click OK. SEATERM writes the header information to the upload file.
  - In the Open dialog box, enter the desired upload file name and click OK. The upload file has a .hex extension.
  - SEATERM sends the data upload command (**#iiddb,e**).
  - When the data has been uploaded, SEATERM shows the S> prompt.
9. Ensure all data has been uploaded from the SEACAT by reviewing and processing the data. Use **SBE Data Processing** to process and plot the data (see *Processing Data Using SBE Data Processing* and *SBE Data Processing manual / Help files*).

**Note:**

To prepare for re-deployment:

- After all data has been uploaded, send **#iilnitLogging**. If this command is not sent and sampling is started, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
- Send **PwrOff** to put the SEACAT in quiescent (sleep) state until ready to redeploy. The quiescent current is only 60 microamps, so the batteries can be left in place without significant loss of capacity.

## Processing Data Using SBE Data Processing

### Notes:

- See the SBE Data Processing manual and/or Help files.
- When we ship a new instrument, we include a .con file that reflects the current instrument configuration as *we know it*. The .con file is named with the instrument serial number, followed with the .con extension. For example, for a SEACAT with serial number 2375, we name the .con file *2375.con*. You may rename the .con file if desired; this will not affect the results.
- In the SEACAT's setup commands, external voltage numbers 0, 1, 2, and 3 correspond to wiring of sensors to a voltage channel on the end cap (see *Dimensions and End Cap Connectors* in *Section 2: Description of SEACAT*). However, in the .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 SEACAT 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 (.con) File

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

To view or modify the .con file:

1. Double click on SBEDataProc.exe.
2. In the Configure menu, select *16 Seacat plus CTD*. The configuration dialog box appears. In the configuration dialog box, click Open.
3. In the Open dialog box, select the appropriate .con file and click Open. Verify that the sensors match those on your SEACAT, and that auxiliary sensors are assigned to the correct voltage channels. Verify that calibration coefficients for all sensors are up-to-date.

Channel/Sensor table reflects this choice. Must agree with SEACAT setup for #iiVoltN= (N=0, 1, 2, and 3); see reply from #iiDS. Voltage channel 0 in .con file corresponds to first external voltage in data stream, voltage channel 1 to second external voltage in data stream, etc.

Interval between scans. Must agree with SEACAT setup (#iiSampleInterval=); see reply from #iiDS.

Not applicable to RS-485 SEACAT.

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

None, SBE 38 (secondary temperature), SBE 50 (pressure), or up to 2 GTDs (dissolved oxygen or nitrogen). Must agree with SEACAT setup; see reply from #iiDS. Channel/Sensor table lists RS-232C sensors below voltage channels.

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

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

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

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

**Configuration for the SBE**

Configuration file opened: [ ]

Pressure sensor type: Strain Gauge [Data...]

External voltage channels: 2

Serial RS-232C sensor: Temperature, SBE 38

Sample interval seconds: 10

NMEA position data added

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

Report... Help... Exit Cancel

4. Click *Save* or *Save As* to save any changes to the .con file. Click *Exit* when done reviewing / modifying the .con file.

## Editing Raw Data File

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

### Note:

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

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

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

```
* Sea-Bird SBE 21 Data File:
* FileName = C:\Odis\SAT2-ODIS\oct14-19\oct15_99.hex
* Software Version Seasave Win32 vl.10
* Temperature SN = 2366
* Conductivity SN = 2366
* System UpLoad Time = Oct 15 1999 10:57:19
* Testing adding header lines
* Must start with an asterisk
* Place anywhere between System Upload Time & END of header
* NMEA Latitude = 30 59.70 N
* NMEA Longitude = 081 37.93 W
* NMEA UTC (Time) = Oct 15 1999 10:57:19
* Store Lat/Lon Data = Append to Every Scan and Append to .NAV
File When <Ctrl F7> is Pressed
** Ship:          Sea-Bird
** Cruise:       Sea-Bird Header Test
** Station:
** Latitude:
** Longitude:
*END*
```

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

# Section 5: Routine Maintenance and Calibration

This section reviews:

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

The accuracy of the SEACAT is sustained by the care and calibration of the sensors and by establishing proper handling practices.

---

## Corrosion Precautions

Rinse the SEACAT with fresh water after use and prior to storage.

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

---

## Connector Mating and Maintenance

**Note:**

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

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

When remating:

**CAUTION:**

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

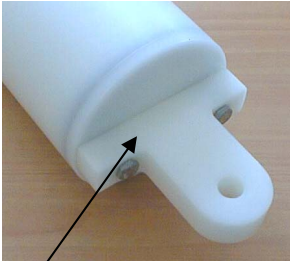
1. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).
2. **Standard Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the SEACAT. Remove any trapped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

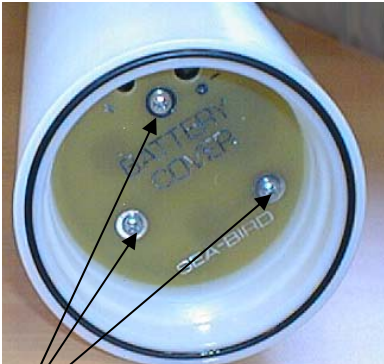
## Replacing Alkaline Batteries



Alkaline D-cell  
(MN1300, LR20)



Unthread cap by rotating counter-clockwise



Remove Phillips-head screws and washers

The SEACAT uses alkaline D-cells (Duracell MN1300, LR20), dropped into the battery compartment.

Leave the batteries in place when storing the SEACAT to prevent depletion of the back-up lithium batteries by the real-time clock. Even *exhausted* main batteries will power the clock (60 microamperes) almost indefinitely. If the SEACAT is to be stored for long periods, **replace the batteries yearly to prevent battery leakage** (which could damage the SEACAT).

1. Remove the battery 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. Unthread the end cap by rotating counter-clockwise (use a wrench on the white plastic bar if necessary).
  - C. Remove any water from the O-ring mating surfaces inside the housing with a lint-free cloth or tissue.
  - D. Put the end cap aside, being careful to protect the O-ring 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 SEACAT 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 battery 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. Carefully fit the end cap into the housing and rethread the end cap into place. Use a wrench on the white plastic bar to ensure the end cap is tightly secured.

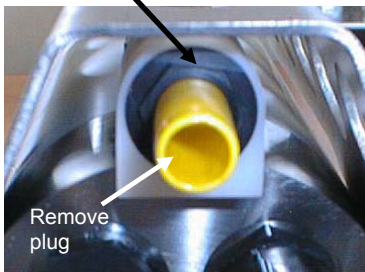


## Conductivity Cell Maintenance

### 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 SEACAT 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.

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



The SEACAT'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 SEACAT, which is intended for use as a moored instrument.

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

Cleaning and storage instructions require use of the syringe and tubing assembly at the intake end of the cell (requiring one barbed cap), and looping Tygon tubing from end to end of the cell (requiring two barbed caps). Remove the installed anti-foulant device cap(s) and replace them with the anti-foulant device cap(s) with hose barbs **for cleaning and storage only**. Remember to reinstall the original anti-foulant device cap(s) before deployment. **Deploying a SEACAT with barbed anti-foulant device cap(s) in place of the installed caps is likely to produce undesirable results in your data.**

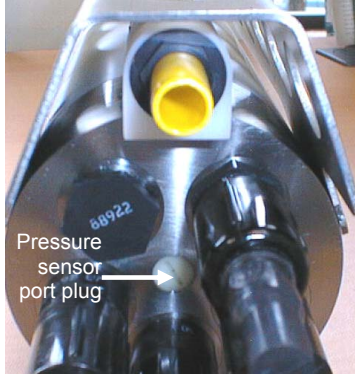
See *Replacing Anti-Foulant Devices* for safety precautions when handling the AF24173 Anti-Foulant Devices.

## 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 SEACAT.



### Strain Gauge Pressure Sensor

The pressure port plug has a small vent hole to allow hydrostatic pressure to be transmitted to the pressure sensor inside the instrument, while providing protection for the pressure sensor, keeping most particles and debris out of the pressure port.

Periodically (approximately once a year) inspect the pressure port to remove any particles, debris, etc:

1. Unscrew the pressure port plug from the pressure port.
2. Rinse the pressure port with warm, de-ionized water to remove any particles, debris, etc.
3. Replace the pressure port plug.

### Quartz Pressure Sensor



Nylon pressure capillary fitting for SEACAT 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):

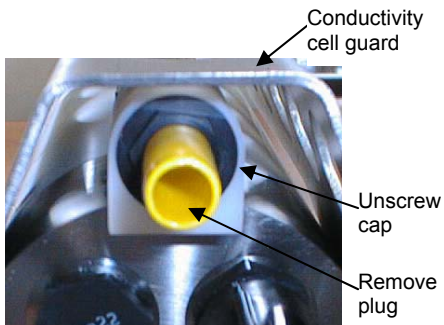
1. Remove the protective plug;
2. Unscrew the cap with a 5/8-inch socket wrench;
3. Remove the old Anti-Foulant Device. If the old Anti-Foulant Device is difficult to remove:
  - Use needle-nose pliers and carefully break up material;
  - If necessary, remove the conductivity cell guard to provide easier 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 SEACAT EEPROM, and ships the instrument back to the user with Calibration Certificates showing the new coefficients. The user must enter the coefficients in the instrument configuration (.con) file in SBE Data Processing's Configure menu.

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) internally mounted pressure sensor on the SEACAT are supplied fully calibrated, with coefficients stored in EEPROM in the SEACAT and printed on their respective Calibration Certificates.

We recommend that the SEACAT 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.

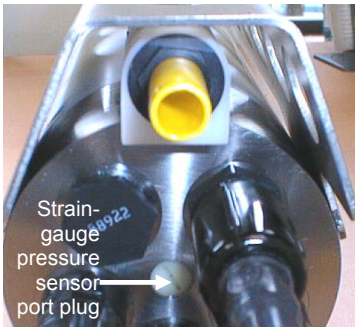
The primary mechanism for calibration drift in conductivity sensors is the fouling of the cell by chemical or biological deposits. Fouling changes the cell geometry, resulting in a shift in cell constant.

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

Allow the SEACAT 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 SEACAT to equilibrate before starting will provide the most accurate calibration correction.

### Note:

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

1. Place the SEACAT in the orientation it will have when deployed.
2. In SEATERM:
  - A. Set the pressure offset to 0.0 (**#iiPOffset=0**).
  - B. Send **#iiTP** to measure the SEACAT pressure 50 times and transmit converted data in engineering units (decibars).
3. Compare the SEACAT output to the reading from a good barometer at the same elevation as the SEACAT pressure sensor.  
 Calculate *offset* = barometer reading – SEACAT reading
4. Enter the calculated offset (positive or negative) in two places:
  - In the SEACAT EEPROM, using **#iiPOffset=** in SEATERM, **and**
  - In the configuration (.con) file, using SBE Data Processing.

### *Offset Correction Example*

*Absolute* pressure measured by a barometer is 1010.50 mbar. Pressure displayed from SEACAT 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 SEACAT's internal calculations and our processing software output gage pressure, using an assumed value of 14.7 psi for atmospheric pressure. Convert SEACAT reading from gage to absolute by adding 14.7 psia to the SEACAT output:

$-2.5 \text{ dbars} + (14.7 \text{ psi} * 0.689476 \text{ dbar/psia}) = -2.5 + 10.13 = 7.635 \text{ dbars}$

Offset = 10.1050 – 7.635 = + 2.47 dbars

Enter offset in SEACAT and in .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 SEACAT, and provides the most common causes and solutions.

---

## Problem 1: Unable to Communicate with SEACAT

The `S>` prompt indicates that communications between the SEACAT and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by clicking Connect on SEATERM's toolbar.

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

**Cause/Solution 2:** The instrument type and/or its communication settings may not have been entered correctly in SEATERM. Select the *SBE 16plus* in the Configure menu and verify the settings in the Configuration Options dialog box. The settings should match those on the instrument Configuration Sheet.

**Cause/Solution 3:** The I/O cable may not be the correct one. See *Dimensions and End Cap Connectors* in *Section 2: Description of SEACAT* for cable pinouts.

---

## 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 `#iDS` (*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, `#iDS` will show *samples = 0*.

### Problem 3: Nonsense or Unreasonable Data

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

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

- Bad data may be caused by incorrect configuration in the SEACAT. Send **#iiDS** to verify the SEACAT setup matches the instrument Configuration Sheet (correct internally mounted pressure sensor, voltage sensors assigned to correct channels, etc).
- Bad data may be caused by incorrect configuration in the instrument .con file. Verify the settings in the instrument .con file match the instrument Configuration Sheet.

**Note:**

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

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

- If you uploaded data in engineering units (**#iiOutputFormat=1** or **3**) – Bad data may be caused by incorrect calibration coefficients in the SEACAT. Send **#iiDCal** to verify the calibration coefficients in the SEACAT match the instrument Calibration Certificates. Note that calibration coefficients do not affect the raw data stored in SEACAT 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 uploaded data in raw hexadecimal (**#iiOutputFormat=0**) and are processing the data in SBE Data Processing - Bad data may be caused by incorrect calibration coefficients in the instrument .con file. Verify the calibration coefficients in the .con file match the instrument Calibration Certificates.
- For RS-232 sensor interfacing to the SEACAT: Bad data may be caused by incorrect calibration coefficients programmed into the instrument. Connect the instrument directly to the computer to verify the calibration coefficients match the instrument Calibration Certificate.

### Problem 4: Program Corrupted

**Note:**

Using the reset switch does not affect the SEACAT memory - data in memory and user-programmable parameter values are unaffected.

**Cause/Solution 1:** In rare cases, the program that controls the SEACAT microprocessor can be corrupted by a severe static shock or other problem. This program can be initialized by using the reset switch. Proceed as follows to initialize:

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

# Glossary

**Battery pack** – Nine alkaline D-cells (Duracell MN1300, LR20) standard.

**Fouling** – Biological growth in the conductivity cell during deployment.

**PCB** – Printed Circuit Board.

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

**Scan** – One data sample containing temperature, conductivity, optional internally mounted 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). A *plus* version of the SBE 21 (thermosalinograph) is under development.

The 16*plus* is available in three versions:

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

**SEASAVE V7** – Sea-Bird's Win 2000/XP software used to acquire, convert, and display real-time or archived raw data. **SEASAVE cannot be used to acquire data from the RS-485 SEACAT, but can be used to display in engineering units the raw hexadecimal data uploaded from the 16*plus*.**

**SEASOFT-Win32**– Sea-Bird's complete Win 2000/XP software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT-Win32 includes *SEATERM*, *SBE Data Processing*, *SEASAVE V7*.

**SEATERM** – Sea-Bird's Win 95/98/NT/2000/XP terminal program used to communicate with the SEACAT.

**TCXO** – Temperature Compensated Crystal Oscillator.

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



# Appendix I: Functional Description and Circuitry

## Sensors

The SEACAT embodies the same sensor elements (three-electrode, two-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* SEACAT differs from the SBE 16 in that it uses three independent channels to digitize temperature, conductivity, and internally mounted pressure concurrently. Multiplexing is not used for these channels.

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

---

## Sensor Interface

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

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

Internally mounted 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 four 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  $\pm 1$  minute per year (0 °C to 40 °C).

## Battery Wiring

SEACAT 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 (and external power source, if used). The back-up lithium supply is capable of maintaining the buffer and the real-time clock if the main batteries and/or external power is removed. If the back-up lithium battery voltage (*V<sub>lith</sub>* in the #iDS response) falls below 7 volts, replace the back-up batteries.

# Appendix II: Electronics Disassembly/Reassembly

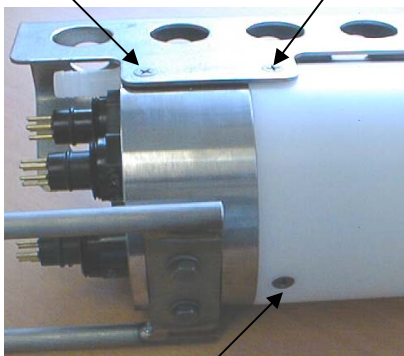
## CAUTION:

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

## Disassembly

Do not remove screw  
attaching guard to  
sensor end cap  
(2 places)

Remove screw  
(2 places)



Remove screw

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.

## 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 (**MMDDYY=** and **HHMMSS=** or **#iiMMDDYY=** and **#iiHHMMSS=**) and initialize logging (**#iiInitLogging**) before redeploying. No other parameters should have been affected by electronics disassembly (send **#iiDS** to verify).

# Appendix III: Command Summary

For all commands that include **ii**, **ii** is the SEACAT ID (**ii= 0-99**).

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
Communication Microcontroller Commands	Global Commands	<b>AData</b>	Command <b>all</b> SEACATs to get <b>average</b> data from acquisition units, start next averaging cycle, and turn power off. Communication microcontrollers hold averaged data in buffer until receiving <b>Dataii</b> . Data is not stored in FLASH memory.
		<b>GData</b>	Command <b>all</b> SEACATs to get 1 sample. Communication microcontrollers send command to acquisition microcontrollers to take sample and turn power off. Communication microcontrollers hold data in buffer until receiving <b>Dataii</b> . Data is not stored in FLASH memory.
		<b>StartSample</b>	Command <b>all</b> SEACATs to get 1 sample. Communication microcontrollers send command to acquisition microcontrollers to take sample and leave power on. Communication microcontrollers hold data in buffer until receiving <b>Dataii</b> . Data is not stored in FLASH memory. Send command once before using <b>GSample</b> .
		<b>GSample</b>	Command <b>all</b> SEACATs to get last sample and then take new sample. Communication microcontrollers send command to acquisition microcontrollers to send last sample and then take new sample, and leave power on. Communication microcontrollers hold last sample data in buffer until receiving <b>Dataii</b> . Data is not stored in FLASH memory.
		<b>MMDDYY=mmddyy</b>	Set clock month, day, and year. Follow with <b>HHMMSS=</b> or it will not set date.
		<b>DDMMYY=ddmmyy</b>	Set clock day, month, and year. Follow with <b>HHMMSS=</b> or it will not set date.
		<b>HHMMSS=hmmss</b>	Set clock hour, minute, and second.
		<b>PwrOff</b>	Enter quiescent (sleep) state. Main power turned off, but data logging and memory retention unaffected.
	Get Data Command	<b>Dataii</b>	Get data obtained with <b>GData</b> , <b>AData</b> , <b>StartSample</b> , or <b>GSample</b> from SEACAT <b>ii</b> .
	SEACAT ID Commands	<b>ID?</b>	Get SEACAT ID.
		<b>*ID=ii</b>	Set SEACAT ID. Must be sent twice, because computer responds by requesting verification.
	Miscellaneous Commands	<b>!iiDS</b>	Display communication microcontroller status.
		<b>!iiRxDelay=x</b>	<b>x</b> = delay after SEACAT receives a command until transmitter is enabled (1 – 500 msec). Default 25 msec.
		<b>!iiTxDelay=x</b>	<b>x</b> = delay after SEACAT transmits a reply until transmitter is disabled (1 – 500 msec). Default 25 msec.
		<b>!iiRxMax=x</b>	<b>x</b> = time communication microcontroller waits for reply from acquisition microcontroller before it times out (1 - 180 sec). Default 30 sec.
		<b>!iiSyncMode=x</b>	<b>x=Y</b> : Enable serial line sync mode. When RS-485 <b>B</b> is high and RS-485 <b>A</b> is low for 1-1500 milliseconds, SEACAT takes a sample, stores data in FLASH memory, and powers down. <b>x=N</b> : Disable serial line sync mode.
		<b>!iiBaud=x</b>	<b>x</b> = baud rate (1200, 2400, 4800, or 9600).
		<b>!ii*EETest</b>	Test EEPROM. Erases <b>all calibration coefficients and user-programmed parameters</b> .

FUNCTION	CATEGORY	COMMAND	DESCRIPTION	
Acquisition Microcontroller Commands	Status	#iDS	Display status and setup parameters.	
	General Setup	#iMMDDYY=mmddy	Set real-time clock month, day, year. Follow with #iHHMMSS= or it will not set date.	
		#iDDMMYY=ddmmy	Set real-time clock day, month, year. Follow with #iHHMMSS= or it will not set date.	
		#iHHMMSS=hmmss	Set real-time clock hour, minute, second.	
		#iiPumpMode=x	x=0: No pump. x=1: Run pump for 0.5 seconds before each sample. x=2: Run pump during each sample.	
		#iiNCycles=x	x= number of measurements to take and average for each sample. Default = 1.	
		#iiInitLogging	After all previous data uploaded, send this command before starting to sample to make entire memory available for recording. If not sent, data stored after last sample. Equivalent to #iiSampleNumber=0.	
		#iiSampleNumber=x	x= sample number for first sample when sampling begins. After all previous data uploaded, set to 0 before starting to sample to make entire memory available for recording. If not reset to 0, data stored after last sample. Equivalent to #iiInitLogging.	
		#iiHeaderNumber=x	x= header number for first header when sampling begins.	
	Output Format	#iiFlashInit	Map bad blocks and erase FLASH memory, <b>which destroys all data in SEACAT.</b>	
		#iiOutputFormat=x	x=0: output raw frequencies and voltages in Hex. x=1: output converted data in Hex. x=2: output raw frequencies and voltages in decimal. x=3: output converted data in decimal.	
		#iiOutputSal=x	x=Y: Calculate and output salinity (psu). Only applies if #iiOutputFormat=3. x=N: Do not.	
	Pressure Sensor Setup	#iiOutputSV=x	x=Y: Calculate and output sound velocity (m/sec). Only applies if #iiOutputFormat=3. x=N: Do not.	
		#iiPType=x	<b>Internally mounted pressure sensor type -</b> 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 SEACAT does not include internally mounted pressure sensor.	
			#iiParosIntegration=x	x= integration time (seconds) for optional internally mounted Quartz pressure sensor (1 - 600 seconds; default = 1).

FUNCTION	CATEGORY	COMMAND	DESCRIPTION
Continued . . .  Acquisition Microcontroller Commands	Voltage Sensor Setup	#iVolt0=x	x=Y: Enable external voltage 0. x=N: Do not.
		#iVolt1=x	x=Y: Enable external voltage 1. x=N: Do not.
		#iVolt2=x	x=Y: Enable external voltage 2. x=N: Do not.
		#iVolt3=x	x=Y: Enable external voltage 3. x=N: Do not.
		#iiDelayBeforeSampling =x	x= time (seconds) to wait after switching on external voltage before sampling (0-32,000 seconds). Default 0 seconds.
		#iiBiowiper=x	x=Y: Configuration includes ECO-FL fluorometer with Bio-Wiper. x=N (default): Does not.
	RS-232 Sensor Setup	#iiSBE38=x	x=Y: Enable SBE 38. x=N: Do not.
		#iiSBE50=x	x=Y: Enable SBE 50. x=N: Do not.
		#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 SEACAT to send <b>command</b> to GTD and receive response ( <b>command</b> can be any command recognized by GTD).	
	Autonomous Sampling (logging)	#iiSampleInterval=x	x= interval (seconds) between samples (10 - 14,400).
		#iiStartNow	Start autonomous sampling now.
		#iiStartMMDDYY =mmdyy	Delayed start: month, day, year. Must follow with #iiStartHHMMSS=.
		#iiStartDDMMYY =ddmmyy	Delayed start: day, month, year. Must follow with #iiStartHHMMSS=.
		#iiStartHHMMSS =hhmmss	Delayed start: hour, minute, second.
		#iiStartLater	Start autonomous sampling at delayed start date and time.
		#iiStop	Stop autonomous sampling or stop waiting to start autonomous sampling. Click Connect in SEATERM to get S> prompt before entering #iiStop. Must stop sampling before uploading data.
		#iiGA	Start averaging data. First sample taken after delay of (#iiSampleInterval / 2).
		#iiSA	Output averaged data. Continue averaging.
		#iiSAG	Output averaged data. Start new average.
	Polled Sampling	#iiSL	Output last sample from buffer. Turn power off.
		#iiSLT	Output last sample from buffer, then take new sample and store data in buffer. Turn power off.
		#iiTS	Take sample, store data in buffer, output data. Turn power off.
		#iiTSS	Take sample, <b>store in buffer and FLASH memory</b> , output data. Turn power off.
	Data Upload	#iiDDb,e	Upload data from scan <b>b</b> to scan <b>e</b> . Stop autonomous sampling before sending #iiDDB,e.
#iiDHb,e		Upload headers from header <b>b</b> to header <b>e</b> .	

**Note:**

Use Upload on the Toolbar or Upload Data in the Data 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
<b>Continued . . .</b>  <b>Acquisition Microcontroller Commands (ii = SEACAT ID)</b>	<b>Testing</b> Takes and outputs 50 samples for each test (except as noted).	<b>#iiTT</b>	Measure temperature, output converted data.
		<b>#iiTC</b>	Measure conductivity, output converted data.
		<b>#iiTP</b>	Measure internally mounted pressure, output converted data.
		<b>#iiTV</b>	Measure 4 external voltage channels, output converted data.
		<b>#iiTF</b>	Measure frequency (internally mounted Quartz pressure sensor), output converted data.
		<b>#iiT38</b>	Measure SBE 38, output converted data.
		<b>#iiT50</b>	Measure SBE 50 pressure, output converted data.
		<b>#iiTTR</b>	Measure temperature, output raw data
		<b>#iiTCR</b>	Measure conductivity, output raw data.
		<b>#iiTPR</b>	Measure internally mounted pressure, output raw data.
		<b>#iiTVR</b>	Measure main battery voltage, lithium battery voltage, external current, pressure temperature, and 4 external voltage channels, output raw data.
		<b>#iiTVRP</b>	With pump running, measure main battery voltage, lithium battery voltage, external current, pressure temperature, and 4 external voltage channels, output raw data.
		<b>#iiTFR</b>	Measure frequency (internally mounted Quartz pressure sensor), output raw data.
		<b>#iiTFRP</b>	With pump running, measure frequency (internally mounted Quartz pressure sensor), output raw data.
	<b>Coefficients</b> (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 SEACAT. Pressure sensor coefficients are for internally mounted pressure sensor.	<b>#iiDCal</b>	Display calibration coefficients; all coefficients and dates listed below are included in display (as applicable). Use individual commands below to modify a particular coefficient or date.
		<b>#iiTCalDate=S</b>	S=Temperature calibration date.
		<b>#iiTAO=F</b>	F=Temperature A0.
		<b>#iiTA1=F</b>	F=Temperature A1.
		<b>#iiTA2=F</b>	F=Temperature A2.
		<b>#iiTA3=F</b>	F=Temperature A3.
		<b>#iiTOffset=F</b>	F=Temperature offset correction.
		<b>#iiCCalDate=S</b>	S=Conductivity calibration date.
		<b>#iiCG=F</b>	F=Conductivity G.
		<b>#iiCH=F</b>	F=Conductivity H.
		<b>#iiCI=F</b>	F=Conductivity I.
		<b>#iiCJ=F</b>	F=Conductivity J.
		<b>#iiCPCor=F</b>	F=Conductivity pcor.
		<b>#iiCTCor=F</b>	F=Conductivity tcor.
		<b>#iiCSlope=F</b>	F=Conductivity slope correction.
		<b>#iiPCalDate=S</b>	S=Pressure calibration date.
		<b>#iiPRange=F</b>	F=Pressure sensor full scale range (psia).
		<b>#iiPOffset=F</b>	F=Pressure offset correction (db).
		<b>#iiPA0=F</b>	F=Strain gauge pressure A0.
		<b>#iiPA1=F</b>	F=Strain gauge pressure A1.
		<b>#iiPA2=F</b>	F=Strain gauge pressure A2.
		<b>#iiPTempA0=F</b>	F=Strain gauge pressure temperature A0.
		<b>#iiPTempA1=F</b>	F=Strain gauge pressure temperature A1.
		<b>#iiPTempA2=F</b>	F=Strain gauge pressure temperature A2.
		<b>#iiPTCA0=F</b>	F=Strain gauge pressure temperature compensation ptca0.
		<b>#iiPTCA1=F</b>	F=Strain gauge pressure temperature compensation ptca1.
		<b>#iiPTCA2=F</b>	F=Strain gauge pressure temperature compensation ptca2.
		<b>#iiPTCB0=F</b>	F=Strain gauge pressure temperature compensation ptcb0.
<b>#iiPTCB1=F</b>		F=Strain gauge pressure temperature compensation ptcb1.	
<b>#iiPTCB2=F</b>		F=Strain gauge pressure temperature compensation ptcb2.	
<b>#iiPC1=F</b>	F=Quartz pressure C1.		
<b>#iiPC2=F</b>	F=Quartz pressure C2.		
<b>#iiPC3=F</b>	F=Quartz pressure C3.		
<b>#iiPD1=F</b>	F=Quartz pressure D1.		
<b>#iiPD2=F</b>	F=Quartz pressure D2.		
<b>#iiPT1=F</b>	F=Quartz pressure T1.		
<b>#iiPT2=F</b>	F=Quartz pressure T2.		
<b>#iiPT3=F</b>	F=Quartz pressure T3.		
<b>#iiPT4=F</b>	F=Quartz pressure T4.		
<b>#iiPSlope=F</b>	F=Quartz pressure slope correction.		
<b>#iiExtFreqSF=F</b>	F=Externally frequency (internally mounted Quartz pressure sensor) scale factor.		

# Appendix IV: AF24173 Anti-Foulant Device

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

<b>AF24173 ANTI-FOULANT DEVICE</b>	
FOR USE ONLY IN SEA-BIRD ELECTRONICS' CONDUCTIVITY SENSORS TO CONTROL THE GROWTH OF AQUATIC ORGANISMS WITHIN ELECTRONIC CONDUCTIVITY SENSORS.	
ACTIVE INGREDIENT:	
Bis(tributyltin) oxide.....	53.0%
OTHER INGREDIENTS: .....	<u>47.0%</u>
Total.....	100.0%
<b>DANGER</b>	
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.	EPA Registration No. 74489-1
1808 - 136 <sup>th</sup> Place Northeast	EPA Establishment No. 74489-WA-1
Bellevue, WA 98005	



## AF24173 Anti-Foulant Device

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

**ACTIVE INGREDIENT:**

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

**DANGER**

See Precautionary Statements for additional information.

<b>FIRST AID</b>	
If on skin or clothing	<ul style="list-style-type: none"> <li>• Take off contaminated clothing.</li> <li>• Rinse skin immediately with plenty of water for 15-20 minutes.</li> <li>• Call a poison control center or doctor for treatment advice.</li> </ul>
If swallowed	<ul style="list-style-type: none"> <li>• Call poison control center or doctor immediately for treatment advice.</li> <li>• Have person drink several glasses of water.</li> <li>• Do not induce vomiting.</li> <li>• Do not give anything by mouth to an unconscious person.</li> </ul>
If in eyes	<ul style="list-style-type: none"> <li>• Hold eye open and rinse slowly and gently with water for 15-20 minutes.</li> <li>• Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye.</li> <li>• Call a poison control center or doctor for treatment advice.</li> </ul>
<b>HOT LINE NUMBER</b>	
<b>Note to Physician</b>	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.  
1808 - 136<sup>th</sup> Place Northeast  
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 DISPOSAL:** Dispose of in a sanitary landfill or by other approved State and Local procedures.

# Appendix V: Replacement Parts

Part Number	Part	Application Description	Quantity in SEACAT
22018	Batteries, alkaline D-cell, Duracell MN 1300 (LR20)	Power SEACAT	9
41124B	Battery cover plate	Retains batteries	1
801483	9D (10.8V / 42 amp-hour) lithium battery pack kit	For longer deployments; <b>batteries not included in kit, and not available from Sea-Bird</b>	-
801479	3DD (10.8V / 30 amp-hour) lithium battery pack kit	For longer deployments; <b>batteries not included in kit, and not available from Sea-Bird</b>	-
30411	Triton X-100	Octyl Phenol Ethoxylate – Reagent grade non-ionic cleaning solution for conductivity cell (supplied in 100% strength; dilute as directed)	1
801542	AF24173 Anti-Foulant Device	bis(tributyltin) oxide device inserted into anti-foulant device cup	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
801225 *	4-pin RMG-4FS to 9-pin DB -9S I/O cable, 2.4 m (8 ft) long	From SEACAT to computer	1
171888	25-pin DB-25S to 9-pin DB-9P cable adapter	For use with computer with DB-25 connector	-
17133 *	2-pin RMG-2FS to 2-pin RMG-2FS cable, 1.1 m (3.7 ft.) long	From SEACAT to optional pump	1
17044.1 *	2-pin RMG-2FS dummy plug and locking sleeve	For when pump not used	1
17045.1 *	3-pin RMG-3FS dummy plug and locking sleeve	For when optional PAR connector not used	-
17046.1 *	4-pin RMG-4FS dummy plug and locking sleeve	For when I/O cable and/or optional RS-232 connector not used	1
17047.1 *	6-pin AG-206 dummy plug and locking sleeve	For when auxiliary differential input sensors not used	2
801374	4-pin MCIL-4FS (wet-pluggable connector) to 9-pin DB-9S I/O cable, 2.4 m (8 ft) long	From SEACAT to computer	1
171503	2-pin MCIL-2FS to 2-pin MCIL-2FS (wet-pluggable connector) cable, 1.1 m (3.7 ft) long	From SEACAT to optional pump	1
171497.1	2-pin MCDC-2-F wet-pluggable dummy plug and locking sleeve	For when pump not used	1
171500.1	3-pin MCDC-3-F wet-pluggable dummy plug and locking sleeve	For when optional PAR connector not used	-
171398.1	4-pin MCDC-4-F wet-pluggable dummy plug and locking sleeve	For when I/O cable and/or optional RS-232 connector not used	1
171498.1	6-pin MCDC-6-F wet-pluggable dummy plug and locking sleeve	For when auxiliary differential input sensors not used	2
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	-
22009	Panasonic BR-2/3A lithium batteries	Back-up lithium cells on Power PCB	3

\* For standard bulkhead connectors

*continued on next page*

continued from previous page

Part Number	Part	Application Description	Quantity in SEACAT
60021	Spare battery end cap hardware and o-rings	O-rings and hardware, including: <ul style="list-style-type: none"> <li>• 30145 Screw, 6-32 x 1/2 Phillips-head, stainless steel (secures battery cover plate to battery posts)</li> <li>• 30242 Washer, #6 flat, stainless steel (for 30145)</li> <li>• 30816 Parker 2-234E603-70 (battery end cap to housing piston seal, sensor end cap to housing seals)</li> <li>• 30090 Parker 2-153N674-70 (battery end cap to housing face seal)</li> </ul>	-
50274	Spare o-ring kit	Assorted o-rings, including: <ul style="list-style-type: none"> <li>• 30816 Parker 2-234E603-70 (battery end cap to housing piston seal, sensor end cap to housing seals)</li> <li>• 30090 Parker 2-153N674-70 (battery end cap to housing face seal)</li> <li>• 30507 Parker 2-206N674-70 (each end of conductivity cell)</li> <li>• 30802 Parker 2-110DUR070, ethylene (titanium conductivity cell tray face seal, groove surface)</li> <li>• 30809 Morrison seal, .047" hole, NIT (temperature probe Morrison seal)</li> <li>• 30072 Parker 2-017N674-70 (bulkhead connector seal)</li> <li>• 30070 Parker 3-904N674-70 (pressure sensor mounting seal)</li> <li>• 30087 Parker 2-232N674-70 (buffer for top retainer of PCB sandwich assembly)</li> <li>• 30801 Parker 5-374E603-70 (base of battery bulkhead seal)</li> </ul>	-
50273	Spare hardware kit	Assorted hardware, including: <ul style="list-style-type: none"> <li>• 30145 Screw, 6-32 x 1/2 Phillips-head, stainless steel (secures battery cover plate to battery posts)</li> <li>• 30242 Washer, #6 flat, stainless steel (for 30145)</li> <li>• 30414 Washer, #12, internal tooth (secures battery bulkhead retainer)</li> <li>• 30954 Screw 4-40 x 3/16 Phillips-head, stainless steel (securing screw for PCB retainer rod)</li> <li>• 31119 Screw 6-32 x 5/8 Truss Head (secures battery bulkhead retainer to bulkhead bottom plate)</li> <li>• 30176 Screw, 10-24 x 3/4, Phillips-head, stainless steel (secures Celcon threaded ring inside titanium battery end cap)</li> <li>• 30249 Washer #10, Flat, stainless steel (for 30176)</li> <li>• 30447 Bolt, 1/4-20 x 1 1/4 Hex, titanium (secures lift eye to battery end cap)</li> <li>• 31089 Screw, 10-32 x 1/2 flat Phillips-head, titanium (secures sensor end cap to housing - side opposite conductivity cell guard)</li> <li>• 31090 Screw, 10-32 x 5/8 flat Phillips-head, titanium (secures conductivity cell guard to housing)</li> <li>• 31118 Screw, 10-32 x 3/8 Phillips-head, titanium (secures conductivity cell guard to sensor end cap)</li> <li>• 30875 Bolt 1/4-20 x 5/8 Hex, titanium (secures connector guard to sensor end cap)</li> <li>• 30633 Washer, 1/4" split ring lock, titanium (for 30875)</li> <li>• 30919 Screw, 6-32 x 3/8 flat slotted, titanium (secures anti-foulant device cup to conductivity cell guard)</li> <li>• 31066 Screw, 8-32 x 3/4 socket, titanium (secures conductivity cell and TC duct to sensor end cap)</li> </ul>	-
50276	Seaspares kit, standard connectors	Includes o-rings, hardware, bulkhead connectors, dummy plugs, etc.: <ul style="list-style-type: none"> <li>• 50087 Conductivity cell filling and storage kit</li> <li>• 50273 Spare hardware kit (see above)</li> <li>• 50274 Spare o-ring kit (see above)</li> <li>• 41124B Battery cover plate</li> <li>• 801225 Data I/O cable, 4-pin RMG-4FS to 9-pin DB -9S I/O cable, 2.4 m (8 ft) long</li> <li>• 17044.1 2-pin RMG-2FS dummy plug with locking sleeve</li> <li>• 17046.1 4-pin RMG-4FS dummy plug with locking sleeve</li> <li>• 17047.1 6-pin AG-206 dummy plug with locking sleeve</li> <li>• 17652 2-pin XSG-2-BCL-HP-SS bulkhead connector</li> <li>• 17654 4-pin XSG-4-BCL-HP-SS bulkhead connector</li> <li>• 17628 6-pin AG-306-HP-SS bulkhead connector</li> <li>• 30388 Vinyl tube, 3/4" x 1/2" (main sensor plumbing tubing)</li> <li>• 30409 Teflon tape (for insides of hose clamps)</li> <li>• 30411 Triton X100 (for cell cleaning)</li> <li>• 30457 Parker O-Lube (o-ring lubricant)</li> </ul>	-

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Part Number	Part	Application Description	Quantity in SEACAT
50301	Seaspares kit, wet-pluggable connectors	Includes o-rings, hardware, bulkhead connectors, dummy plugs, etc.: <ul style="list-style-type: none"> <li>• 50087 Conductivity cell filling and storage kit</li> <li>• 50273 Spare hardware kit (see above)</li> <li>• 50274 Spare o-ring kit (see above)</li> <li>• 50275 Spare magnetic switch</li> <li>• 41124B Battery cover plate</li> <li>• 801374 Data I/O cable, 4-pin MCIL-4FS (wet-pluggable connector) to 9-pin DB-9S I/O cable, 2.4 m (8 ft) long</li> <li>• 171192 Locking sleeve</li> <li>• 171497 2-pin MCDC-2-F wet-pluggable dummy plug</li> <li>• 171398 4-pin MCDC-4-F wet-pluggable dummy plug</li> <li>• 171498 6-pin MCDC-6-F wet-pluggable dummy plug</li> <li>• 172019 2-pin MCBH-2MP(WB), TI 1/2-20 bulkhead connector</li> <li>• 172021 4-pin MCBH-4MP(WB), TI 1/2-20 bulkhead connector</li> <li>• 172022 6-pin MCBH-6MP(WB), TI 1/2-20 bulkhead connector</li> <li>• 171888 Cable adapter, DB-25F to DB-9M</li> <li>• 30388 Vinyl tube, 3/4" x 1/2" (main sensor plumbing tubing)</li> <li>• 30409 Teflon tape (for insides of hose clamps)</li> <li>• 30411 Triton X100 (for cell cleaning)</li> <li>• 30457 Parker O-Lube (o-ring lubricant)</li> </ul>	

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