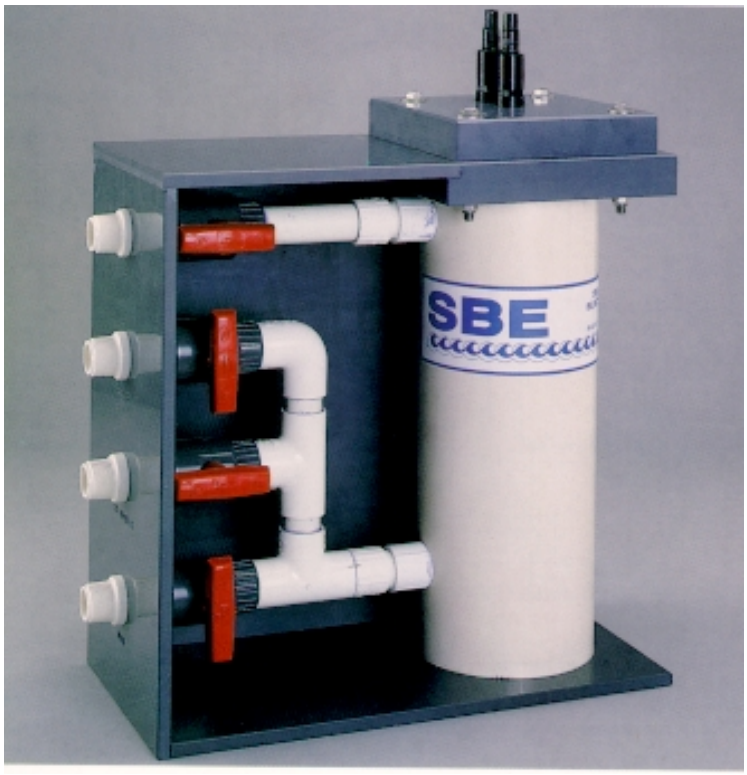
SBE 21 SEACAT Thermosalinograph

Conductivity and Temperature Recorder with RS-232 Interface



User's Manual

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Firmware Version 4.2 and later

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Table of Contents

Section 1: Introduction

This section includes contact information and photos of a standard SBE 21 shipment.

About this Manual

This manual is to be used with the SBE 21 SEACAT Thermosalinograph Conductivity and Temperature Recorder.

It is organized to guide the user from installation through operation and data collection. We've 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.

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)

Unpacking the SBE 21

Shown below is a typical SBE 21 shipment.

SBE 21

NMEA Interface Box

I/O Cable
(SBE 21 to NMEA Interface Box)

AC power cable

NMEA Interface Box to computer cable

9-pin adapter

NMEA Interface test cable
(NMEA Interface Box to NMEA navigation device simulation computer)

Cell cleaning solution
(Triton X-100)

User Manual

Software and Software Manuals

Section 2: Description of the SBE 21

This section describes the functions and features of the SBE 21, including specifications and dimensions.

System Description

The SBE 21 SEACAT Thermosalinograph is an externally powered, high-accuracy, conductivity and temperature recorder, designed for shipboard determination of sea surface (pumped-water) conductivity and temperature. Data is simultaneously transmitted to a computer's serial port and stored in 8 Mb FLASH RAM memory, allowing both real-time data acquisition and independent data logging. The SBE 21 is connected by cable to an AC-powered NMEA Interface Box. The NMEA Interface Box provides isolated DC power and an optically-isolated RS-232 data interface, and contains a NMEA 0183 port for appending GPS navigation information to the data stream. An internal lithium back-up battery in the SBE 21 supports the real-time clock when the main power supply is off.

The platinum-electrode glass conductivity cell's unique internal-field geometry eliminates proximity effects. This feature is critically important in thermosalinograph applications, where the cell must operate in a water jacket's confined volume. The internal-field cell also allows the use of expendable anti-fouling attachments (supplied) to inhibit biological fouling. The anti-foulant is typically effective for at least six months of deployment.

For corrosion resistance, only plastic, titanium, and the glass/platinum conductivity cell are exposed to seawater. Valves are provided for controlling seawater circulation and fresh water flushing. The sensor assembly is easily removed for cleaning and calibration.

The PVC base or back plate may be drilled for mounting to the ship. Seawater connections (for normal use) and fresh water connections (for cleaning) are PVC pipes with 1-inch (25.4 mm) U.S. standard NPT threads. Mating female fittings are provided, and can easily be adapted to locally available pipe sizes.

Communication with the SBE 21 is over an internal, 3-wire, RS-232C link, providing real-time data transmission. Commands can be sent to the SBE 21 to provide status display, data acquisition setup, data retrieval, and diagnostic tests. The SBE 21 samples continuously at 4 Hz. At pre-programmed 3- to 600-second intervals, the SBE 21 averages the sample data, stores the average in memory, and sends the average to the computer (through the NMEA Interface Box). Output format is raw, hexadecimal data.

The SBE 21 comes standard with the ability to record the output of an optional remote temperature sensor (SBE 38), allowing for the measurement of sea surface temperature with minimum thermal contamination from the ship’s hull. A stainless steel and plastic in-line pipe mount is available for safe below-waterline installation of the remote temperature sensor. See *Section 3: Installing the System* for details.

A standard SBE 21 is supplied with:

- Bulkhead connectors:
  - one 4-pin I/O connector
  - one 6-pin connector for A/D inputs (4 single-ended or 2 differential channels)
  - one 4-pin connector for remote temperature sensor
  - one 1-pin connector for ground to ship's hull
- 8 Mbyte FLASH RAM memory
- Expendable anti-foul assemblies. These are attached to each end of the conductivity cell, so that any water that enters the cell is treated. The anti-foulant is effective for approximately 6 months.
- 100-250 VAC NMEA Interface Box, providing optically isolated RS-232 interface and a NMEA 0183 input port for navigation data

SBE 21 options include:

- Remote temperature sensor (SBE 38) and mounting kit
- Sensors for dissolved oxygen, pH, fluorescence, light (PAR), light transmission, and turbidity (mounts not supplied)

Notes:

- Help files provide detailed information on the use of SEATERM, SEASAVE, and SBE Data Processing.
- Separate software manuals contains detailed information on the setup and use of SEASAVE and SBE Data Processing.
- Sea-Bird also supplies a DOS software package, SEASOFT-DOS. However, this manual details only the use of the Windows software with the SBE 21.

The SBE 21 is supplied with a powerful Win 95/98/NT software package, SEASOFT-Win32, that includes:

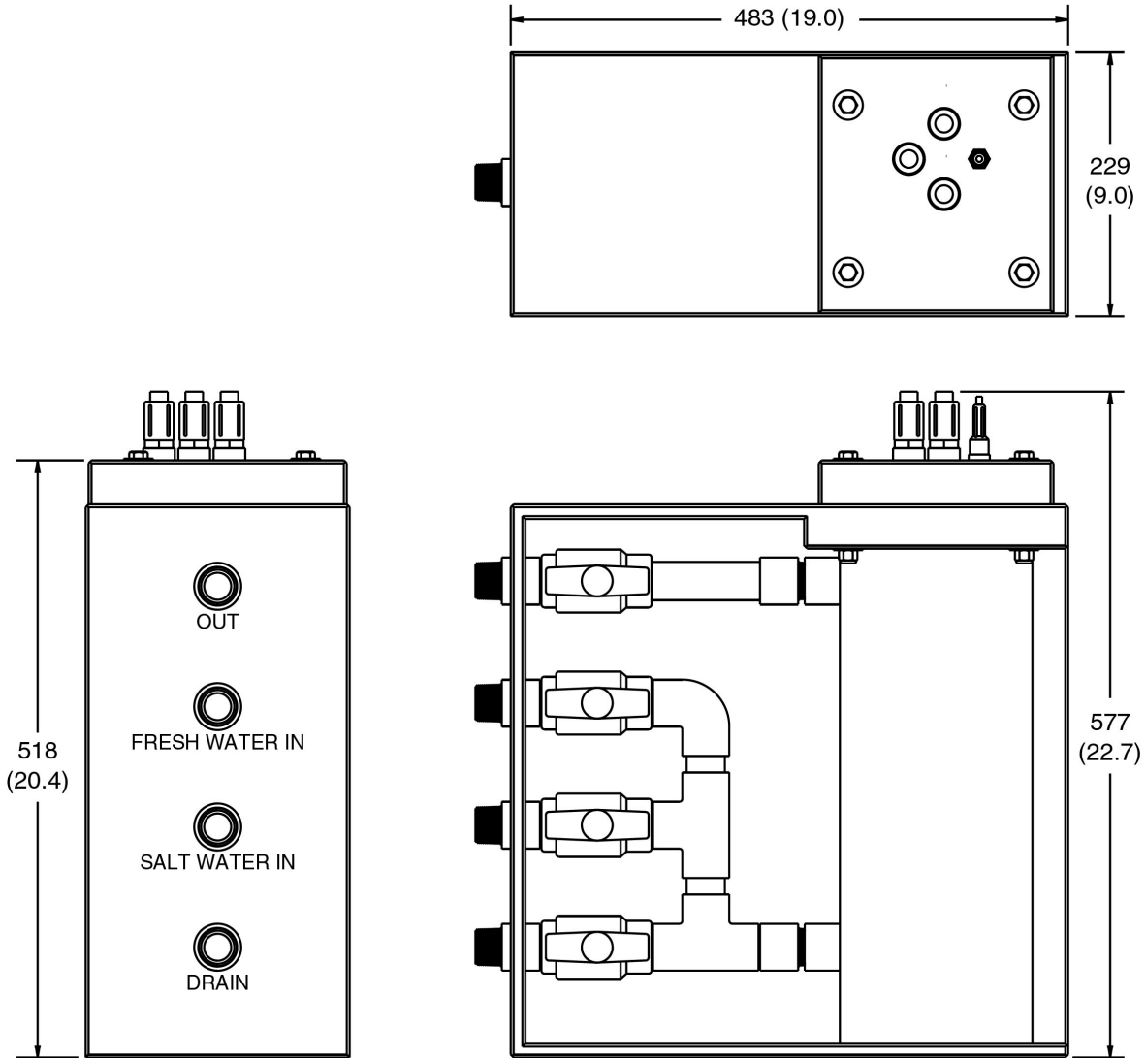
- **SEATERM** –terminal program for easy communication and data retrieval.
- **SEASAVE** –program for acquiring, converting, and displaying real-time or archived raw data.
- **SBE Data Processing** - program for calculation of conductivity, temperature, data from auxiliary sensors, and derived variables such as salinity and sound velocity. SBE Data Processing includes the functions in most of the post-processing modules in SEASOFT.

SBE 21 Specifications

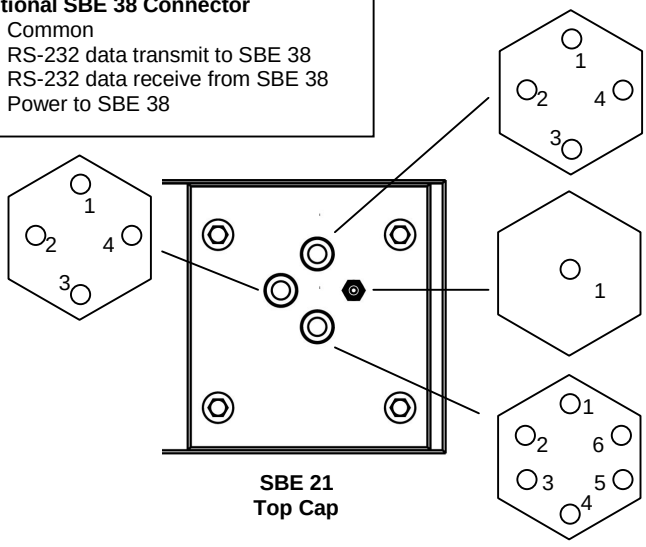
	Conductivity (S/m)	Primary Temperature (°C)	Secondary Temperature (°C)
Measurement Range	0 to 7	-5 to +35	-5 to +35
Initial Accuracy	0.001	0.01	0.01
Resolution	0.0001	0.001	0.0003
Calibration (measurement outside these ranges may be at slightly reduced accuracy due to extrapolation errors)	0 to 7; physical calibration over the range 1.4 to 6 S/m, plus zero conductivity (air)	+1 to +32	-1 to +32
Memory	8 Mbyte non-volatile FLASH memory		
Data Storage	**Recorded Parameter** — **Bytes/sample** temperature and conductivity — 4 (2 each) each external voltage — 2 SBE 38 or SBE 3 secondary temperature — 3		
Real-Time Clock	32,768 Hz TCXO accurate to ±1 minute/year		
Sample Rate	*Remote temperature **not enabled***: 1 sample / 3 seconds to 1 sample / 600 seconds *Remote temperature **enabled***: 1 sample / 4 seconds to 1 sample / 600 seconds Sample rate is incremented in 1-second steps		
Materials	PVC housing, water jacket, piping, and valves; titanium end cap		
Recommended Flow Rate	1 liter/second (15.8 gallons/minute)		
Auxiliary Voltage Sensors	Auxiliary power out: up to 500 mA at 10.5 - 11 VDC A/D resolution: 12 bits Input range: 0 - 5 VDC		
Maximum Safe Operating Pressure	34.5 decibars (50 psi)		
Weight	41 kg (90 lbs)		

SBE 21 Dimensions and Bulkhead Connectors

Dimensions in millimeters (inches)



Optional SBE 38 Connector
1 Common
2 RS-232 data transmit to SBE 38
3 RS-232 data receive from SBE 38
4 Power to SBE 38



SBE 21
Top Cap

I/O Connector - RS-232C Communications
1 Common
2 RX
3 TX
4 Power in
Note: I/O connector is **counter-clockwise** from ground connector. Do not connect I/O cable to 4-pin SBE 38 connector.

Ground
1 Ground to ship's hull

A/D Inputs - Single-ended
1 Common
2 External Volt 0
3 External Volt 3
4 External Volt 1
5 External Volt 2
6 Power out

A/D Inputs - Differential
1 Common
2 Signal external Volt 0
3 Com external Volt 0
4 Signal external Volt 1
5 Com external Volt 1
6 Power out

Data I/O

The SBE 21 receives set-up instructions and outputs diagnostic information or previously recorded data via a three-wire RS-232C link, and is factory-configured for 9600 baud, 7 data bits, 1 stop bit, and even parity. SBE 21 RS-232 levels are directly compatible with standard serial interface cards (IBM Asynchronous Communications Adapter or equal). The communications baud rate can be changed using the **BAUD=** command (see *Command Descriptions* in *Section 4: Setting Up the SBE 21* for details).

Data Storage

Note:
If the FLASH memory is filled to capacity, data sampling and transmission of real-time data continue, but excess data is not saved in memory. **The SBE 21 will not overwrite the data stored in memory**.

The SBE 21 has an 8 Mbyte FLASH memory. Shown below are examples of available data storage for several configurations. (See *SBE 21 Specifications* in this section for storage space required for each parameter.)

Example 1: no auxiliary sensors
T & C = 4 bytes/sample
Storage space ≈ 8,000,000 / 4 ≈ 2,000,000 samples

Example 2: 4 external voltages, SBE 38 secondary temperature sensor
T & C = 4 bytes/sample
External voltages = 2 bytes/sample x 4 voltages = 8 bytes/sample
SBE 38 = 3 bytes/sample
Storage space ≈ 8,000,000 /(4 + 8 + 3) ≈ 533,333 samples

Remote Temperature Sensor (optional)

The SBE 21 has the ability to record the output of an external SBE 38 temperature sensor. Often, the SBE 21 is mounted in the interior of the vessel. In this configuration the recorded conductivity is correct, but the water temperature has changed as it has passed through the plumbing system. The remote temperature sensor can be placed in a location that provides more accurate measurement of the sea surface water temperature. **The ideal location for the remote sensor is at the seawater intake (before the pump) near the bow of the ship.** This minimizes contamination of the surface temperature measurement by the ship's own thermal mass.

Always use the data from the temperature sensor on the SBE 21, not from the remote temperature sensor, to compute salinity. Conductivity has a strong thermal coefficient; therefore, it is critical to know the temperature of the water when the conductivity sensor samples it in order to compute salinity correctly. On a typical installation, there may be 20 to 30 meters of plumbing between the remote temperature sensor and the SBE 21. As the water flows through the pipes it changes temperature dramatically, making the data from the remote temperature sensor an inaccurate representation of the temperature when the water reaches the conductivity sensor. Use the remote temperature sensor only to report surface temperature.

Note that the remote temperature sensor can be added to the system at any time, and does not need to be part of the original order for the SBE 21. No modifications to the SBE 21 are required to integrate the remote sensor, other than programming the SBE 21 to accept the sensor signal and updating the configuration (.con) file.

Section 3: Installing the System

This section provides instructions for:
- Installing software
- System installation guidelines
- Mounting and wiring the SBE 21 and NMEA Interface Box

Installing Software

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

SEASOFT-Win32

1. With the CD in your CD drive, double click on **Seasoft-Win32.exe**.

2. Follow the dialog box directions to install the software.

The installation program allows you to install the desired components. Install all the components, or (for the SBE 21) just install SEATERM (terminal program), SEASAVE (real-time data acquisition program), and SBE Data Processing (data processing program). The default location for the software is c:/Program Files/Sea-Bird. Within that folder is a sub-directory for each component.

Note:
SEASOFT-DOS contains NMEA navigation simulation programs that may be useful for troubleshooting purposes. See the NMEA Interface Box manual for details.

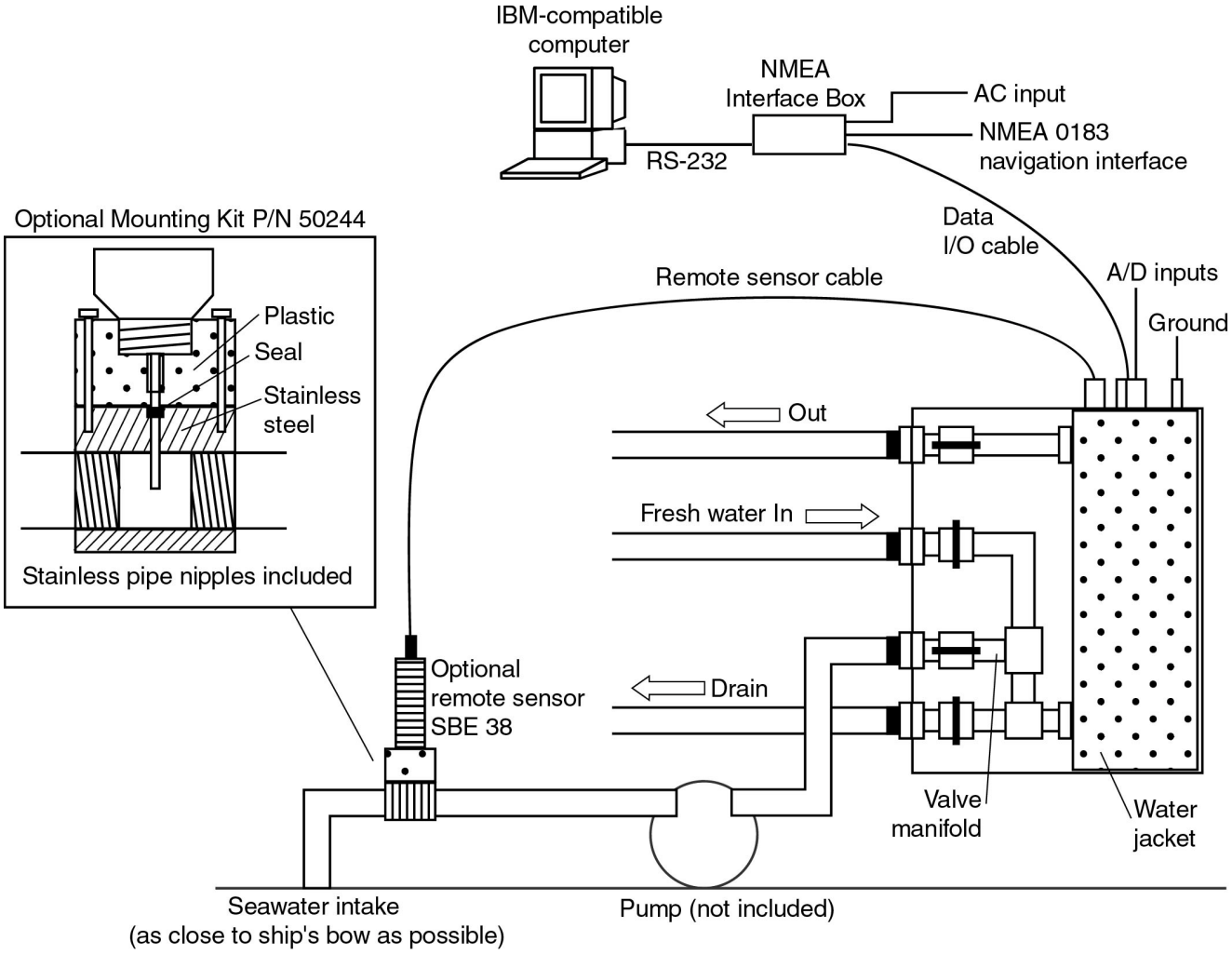
SEASOFT-DOS

1. With the CD in your CD drive, copy the **Seasoft.dos** folder, which contains three files.

2. Paste the Seasoft.dos folder in the desired location on your hard drive.

3. In the Seasoft.dos folder on your hard drive, double click on **sinstall.bat** to install the software.

System Schematic and Installation Guidelines



Valves are show in normal operating position. Valves are open when handle is horizontal, closed when handle is vertical.

Sea-Bird does not provide detailed installation instructions for the SBE 21 and remote temperature sensor, given the unique nature of every ship and type of installation. The installation of the SBE 21 should be done by qualified shipfitters, with the oversight of a competent ship designer or naval architect.

Consider the following:

- The SBE 21 can be mounted anywhere it will *fit* that is accessible for maintenance and cleaning.
  - If the remote temperature sensor is not used, mount the SBE 21 as close to the seawater intake as possible to avoid thermal contamination of long plumbing runs.
  - If the remote temperature sensor is used, the SBE 21 can be mounted in the ship's lab or other convenient location.
  - The maximum recommended cable length from the SBE 21 to the NMEA Interface Box is 100 meters.

- Sea-Bird does not recommend or supply a pump. The pump should be able to provide 1 liter/second flow.

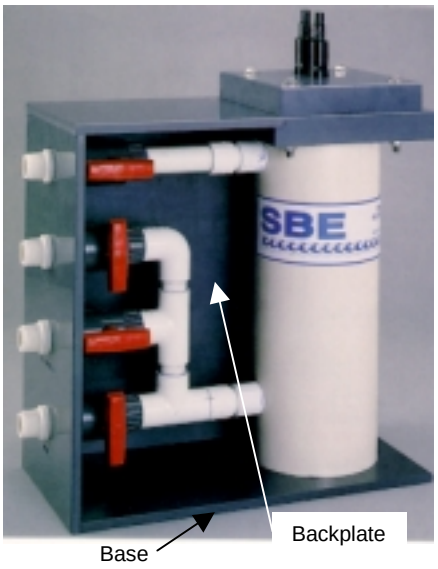
- Bubbles in the plumbing of a flow-through system are a common problem and will cause noisy salinity data. Depending on the chosen design of a permanent seawater supply (including pump, intake fitting, pipes, etc.), you may find that a de-bubbling device is needed to separate bubbles from the water before it enters the SBE 21. Not all ships require de-bubblers, but many do for best quality salinity data. Note that large single point salinity spikes can be removed with the WILD EDIT module in SBE Data Processing.

- Cabling should be routed as cleanly as possible, avoiding sources of noise. Electric motors are a particular problem. Avoid routing the cable next to generators and air conditioners.

- If practical, the optional SBE 38 remote temperature sensor should be mounted outside the hull. However, the remote temperature sensor is usually mounted in the remote sensor mount kit, which has 1-inch pipe threads on each end. The mount kit must be plumbed into your seawater system. It should be installed as close to the seawater intake as possible (before the pump), near the bow of the ship. Since the installation will be below the water line, consult with your ship's engineer / naval architect / shipyard regarding the actual installation. Sea-Bird cannot offer advice in this matter as each ship is different and plumbing regulations vary.

- The SBE 21 can record a maximum of four auxiliary voltages from auxiliary sensors. However, Sea-Bird has not developed methods for the mechanical integration of these auxiliary sensors with the SBE 21. When integrating auxiliary sensors with the SBE 21, consider the following issues:
  - Installation of the sensors in a flow-through chamber that receives the outflow from the SBE 21.
  - Design of the flow-through chamber so sensors can be removed and replaced for service and calibration.
  - Protection of some auxiliary sensors (fluorometer, dissolved oxygen sensor, etc.) from bio-fouling.

Mechanical Installation



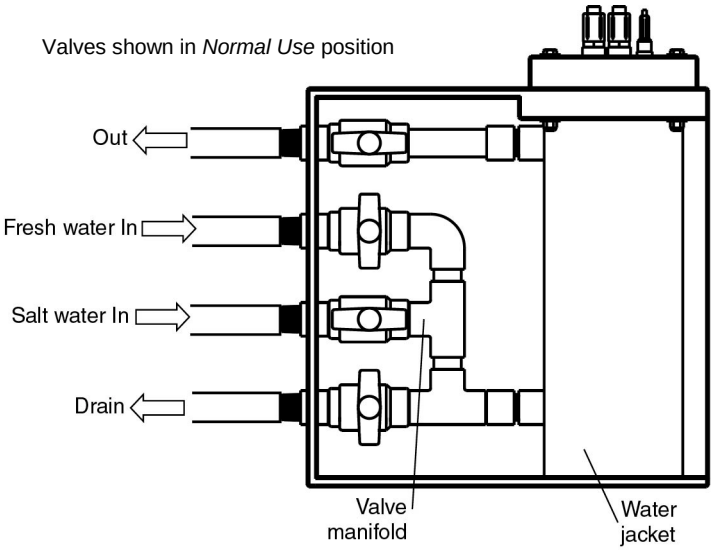
1. A new SBE 21 is shipped with anti-foul cylinders pre-installed. Verify that the cylinders are installed (see *Section 7: Routine Maintenance and Calibration* for access to and replacement of the anti-foul cylinders).

2. Mount the SBE 21 at the desired location:
   - Orient the SBE 21 with the bulkhead connectors at the top.
   - Provide minimum top clearance of 559 mm (22 inches) for removal of the sensor/electronics module from the water jacket.
   - Drill the PVC base or backplate, and mount to the ship using machine bolts.

3. Install the piping connections to the SBE 21. The connectors are 1-inch (25.4 mm) National (USA) threads. Female mating fittings suitable for connecting to PVC plastic pipe with glue are provided; they may be modified for use with existing piping.
   A. Connect the Out fitting to the shipboard drain or to the low pressure side of salt water supply.
   B. Connect the Fresh Water In fitting to the shipboard fresh water supply.
   C. Connect the Salt Water In fitting to the shipboard sea surface water intake line.
   D. Connect the Drain fitting to shipboard drain.

4. Set the valves, as described in the following table. The valve is open when the handle is horizontal and closed when the handle is vertical.

Valve	Normal Use	Fresh Water Flushing	Storage, Cleaning, or Removal of Sensor/Electronics Module
Out	Open	Open	Closed
Fresh Water In	Closed	Open	Closed
Salt Water In	Open	Closed	Closed
Drain	Closed	Closed	Closed



Electrical Installation

Connecting the SBE 21 to the NMEA Interface Box

1. Locate the NMEA Interface Box near the computer.
   - If the distance between the SBE 21 and NMEA Interface Box is longer then the provided 10 meter I/O cable, cut the cable and splice it into the ship's cable. The ship's cable should have 3 conductors, preferably with at least 2 of the conductors shielded (RS-232 TX and RX) if engine ignition noise or other EM interference might be encountered. See drawing number 31063 for cable wiring details.

2. Connect the I/O cable to the SBE 21:
   A. By hand, unscrew the locking sleeve from the SBE 21's 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 SBE 21's I/O connector by pulling the plug firmly away from the connector.
   C. Lightly lubricate the inside of the 4-pin cable connector with silicone grease (DC-4 or equivalent).
   D. Install the 4-pin cable connector on the SBE 21, aligning the raised bump on the side of the connector with the large pin on the SBE 21's bulkhead connector. Remove any trapped air by *burping* or gently squeezing the connector near the top and moving your fingers toward the end cap.
   E. Place the locking sleeve over the cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve, and do not use a wrench or pliers.**

Note:
Follow the procedure in Steps 2A through 2E for proper installation of all cables with similar connectors.

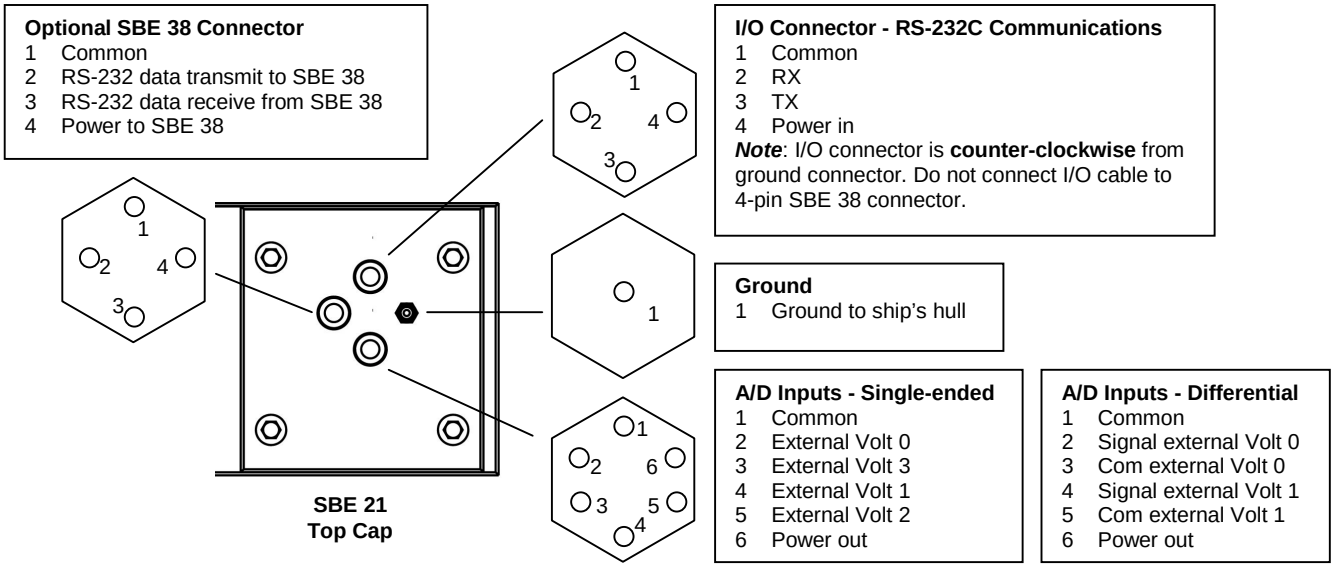
3. Connect the MS-style metal shell connector on the I/O cable to *SEACAT Data I/O* on the NMEA Interface Box.

Connecting the SBE 21 to Ground and to Auxiliary Sensors

1. Connect the SBE 21's 1-pin ground connector to ship's ground.

2. (optional) Install the cable between the SBE 21 and optional SBE 38 Remote Temperature Sensor.

3. (optional) Install the cable(s) for optional auxiliary voltage sensors.



Connecting the NMEA Interface Box

1. Connect *RS-232C* on the NMEA Interface Box to the computer using the DB-25S/DB-25P cable. A 25-to-9 pin adapter is supplied for use if your computer has a 9-pin serial port.

2. Connect the NMEA Interface Box *AC Input* to a standard, 3-prong, grounded, AC outlet, using the supplied UL/IEC-approved power cord (AC voltage between 85-270 VAC).

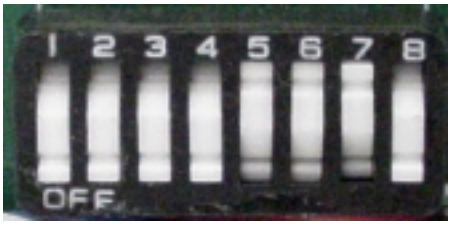
3. (optional) Connect a NMEA navigation device to *NMEA Input* on the NMEA Interface Box with the supplied 5-pin MS connector (MS3106A14S-5P). The connector pin designations are:

NMEA Interface Box	Function
Pin A	Optional power return
Pin B	NMEA *A* (signal)
Pin C	NMEA *B* (signal return)
Pin D	No connection
Pin E	Optional +12 DC power out, up to 2 amps

Section 4: Setting Up the SBE 21

This section describes:
- Setting communications parameters with the NMEA Interface Box dip switch
- Testing power and communications and setting up the SBE 21 in SEATERM
- Setting up the configuration (.con) file in SEASAVE
- Command descriptions
- Data output format

Setting NMEA Interface Box Dip Switch



WARNING!
Remove power from the NMEA Interface Box before opening the box to change the dip switch settings.

Note that a switch is ON when pushed IN at the position number.
In the photo at left:
- positions 1, 2, 3, 4, and 8 are ON
- positions 5, 6, and 7 are OFF

An 8-position dip switch in the NMEA Interface Box sets communication parameters. **The correct settings for the SBE 21 are shown in bold**:

- Data bits and parity for communication (SBE 21 to NMEA Interface Box and NMEA Interface Box to computer)

Data Bits and Parity	Dip Switch Setting - **Position 4**
7 data bits, even parity	**ON**
8 data bits, no parity	OFF

- Baud rate between the SBE 21 and NMEA Interface Box

Baud Rate Between SBE 21 and NMEA Interface Box	Dip Switch Setting	
	Position 5	**Position 6**
9600 (factory default)	**ON**	**ON**
4800	OFF	ON
1200	ON	OFF
600	OFF	OFF

- Baud rate between the NMEA Interface Box and computer

Baud Rate Between NMEA Interface Box and Computer	Dip Switch Setting	
	Position 7	**Position 8**
19200	ON	ON
9600 (factory default)	**OFF**	**ON**
4800	ON	OFF
1200	OFF	OFF

Note:
See *Section 5: Setting Up the NMEA Interface* for details.

- NMEA message to decode

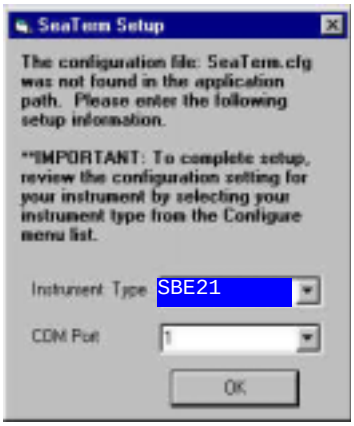
NMEA Message to Decode	Dip Switch Setting		
	Position 1	**Position 2**	**Position 3**
GGA	ON	ON	ON
GLL	OFF	ON	ON
RMA	ON	OFF	ON
RMC (factory default)	OFF	OFF	ON
TRF	ON	ON	OFF

Power and Communications Test and SBE 21 Setup in SEATERM

Notes:
- See SEATERM's help files for detailed information on the use of the program.
- It is possible to use the SBE 21 without SEATERM by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.

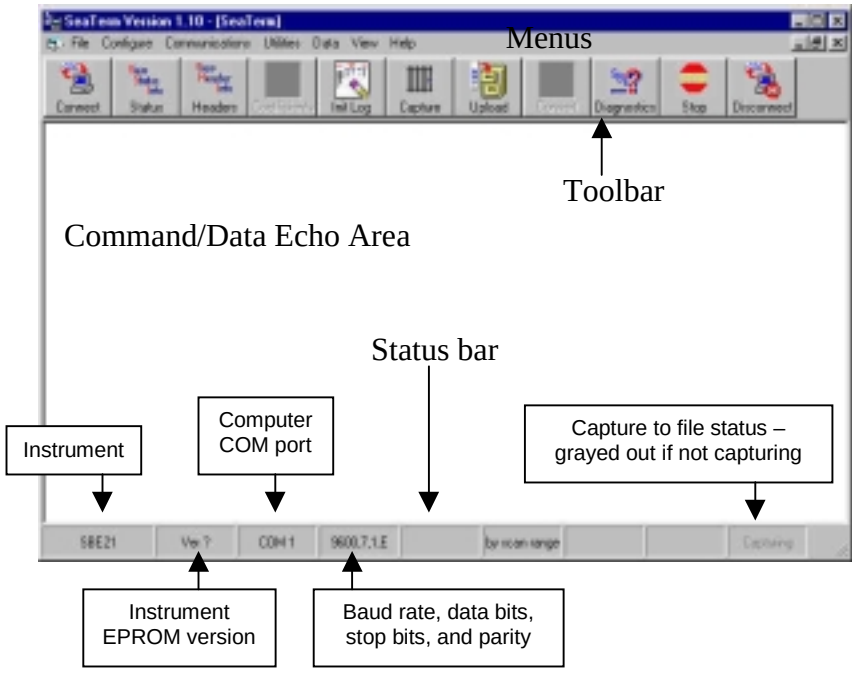
1. Wire the SBE 21 to the NMEA Interface Box, wire the NMEA Interface Box to the computer, and provide power to the NMEA Interface Box, as described in *Electrical Installation* in *Section 3: Installing the System*.

2. Double click on SeaTerm.exe. If this is the first time the program is used, the setup dialog box appears:



Select the instrument type (SBE 21) and the computer COM port for communication with the SBE 21. Click OK.

3. 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

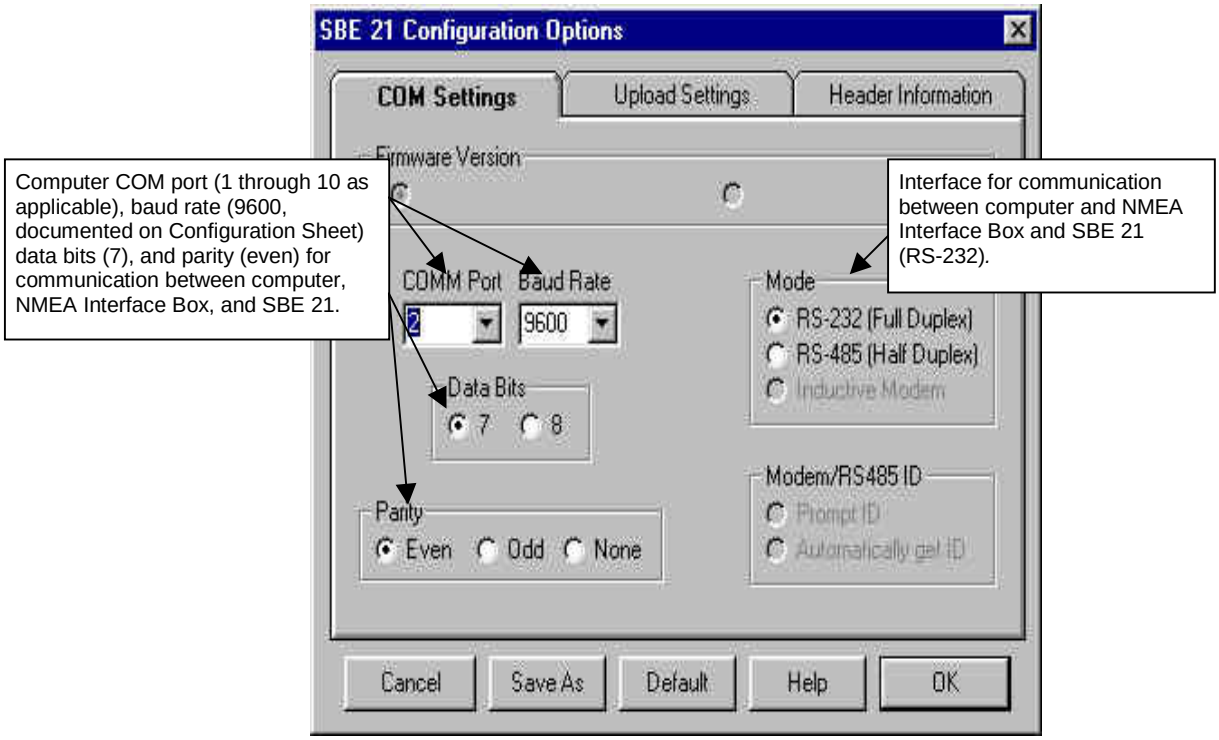
- Menus – Contains tasks and frequently executed instrument commands.
- Toolbar – Contains buttons for frequently executed tasks and instrument commands. All tasks and commands accessed through the Toolbar are also available in the Menus. To display or hide the Toolbar, select View Toolbar in the View 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 the Connect button 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 SBE 21:

Toolbar	Description	Equivalent Command*
Connect	Re-establish communications with SBE 21. Computer responds with **S>** prompt.	(press Enter key)
Status	Display instrument setup and status (logging, samples in memory, etc.).	**DS**
Headers	View data headers (header number, date and time, first and last sample, and sample interval). New header is generated at start of logging and every subsequent 1000 scans.	**DH**
Init Log	Reset data pointers and cast numbers. This should be performed **after existing data has been uploaded from SBE 21** and prior to recording new data.	**IL**
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 post-processing software can use. Uploaded data has .hex extension. Before using Upload: • Configure upload and header parameters in Configure menu. • **Stop logging** by sending **QL** command.	**DD** (use Upload key if will be data processing with SBE Data Processing)
Diagnostics	Perform one or more diagnostic tests on SBE 21. Test(s) accessed in this manner are non-destructive –they do not write over any existing instrument settings.	**DS, FR**, and **VR**
Stop	Interrupt and end current activity, such as uploading or diagnostic test.	(press Esc key or Ctrl C)
Disconnect	Free computer COM port used to communicate with SBE 21. COM port can then be used by another program.	—

*See *Command Descriptions* in this section.

4. In the Configure menu, select SBE 21. The dialog box looks like this:



Make the selections in the Configuration Options dialog box. Click OK to overwrite an existing COM/Upload/Header Settings file, or click Save As to save the settings as a new filename.

5. Turn on power to the NMEA Interface Box. The red PWR LED should light. The display in SEATERM looks like this:

```
NMEA interface box V 2.3 setup:
PC baud rate = 9600
SEACAT baud rate = 9600
7 data bits, even parity
NMEA message to decode = RMA
Mode = add Lat/Lon to real-time Hex data
Menu time out enabled

Press @ to change the NMEA interface box setup
```

This shows that correct communications **between the computer and NMEA Interface Box** has been established. If the system does not respond as shown:

- Verify the SBE 21 was selected in the Configure menu and the settings were entered correctly in the dialog box.
- Check cabling between the computer and NMEA Interface Box.

Note:
See *Section 5: Setting Up the NMEA Interface* for details on the NMEA Interface menu.

6. Type @ to access the NMEA interface setup menu. The display looks like this:

```
NMEA interface set up menu:
1. Echo characters to and from the instrument
2. Add Lat/Lon to the real-time HEX data from the instrument
3. Transmit Lat/Lon only

the current mode = 2. Add Lat/Lon to the real-time HEX data

Enter 1, 2, or 3 to change the NMEA interface box mode, or
press @ to exit the set up menu.

Selection =
```

7. Type *1* and press the Enter key. The display then shows the current mode as *1. Echo characters to and from the instrument*, which is the mode required for communicating with the SBE 21 to set it up.

8. Type @ to exit the setup menu.

9. Click the Connect button on the Toolbar. The display looks like this:

```
S>*ds
SC21, 3164, 4.0b, 206, 1, 6, N
S>
```

   The first two lines are a factory-diagnostic status command and reply (reply indicates instrument serial number, firmware version, etc.). **The S> shows that correct communications between the computer and SBE 21 (through the NMEA Interface Box) have been established**. If the system does not respond as shown:
   - Click the Connect button again.
   - Verify the correct instrument was selected in the Configure menu and the settings were entered correctly in the Configuration Options dialog box. The baud rate is documented on the instrument Configuration Sheet.
   - Check cabling between the computer, NMEA Interface Box, and SBE 21.

10. Display SBE 21 status information by clicking the Status button on the Toolbar. The display looks like this:

```
SEACAT THERMOSALINOGRAPH V4.0b SERIAL NO. 3166 01/15/2002 14:23:14
ioper = 50.7 ma,     vmain = 11.4,    vlith = 8.8
samples = 0, free = 1396736
sample interval = 5 seconds
sample external SBE 38 temperature sensor
no. of volts sampled = 0
output format = SBE21
start sampling when power on = no
logging data = no
voltage cutoff = 7.5 volts
```

11. Command the SBE 21 to take a sample by typing **TS** and pressing the Enter key. The display looks like this (if output format=SBE 21, number of volts sampled=0, and no external temperature sensor):

```
78610428
```

    where 7861 = raw Hex temperature data
    0428 = raw Hex conductivity data

    See *Data Output Formats* in this section to interpret the data and determine if they are reasonable (i.e., room temperature and zero conductivity if running in air, or expected temperature and conductivity for water).

12. Set up the SBE 21 as desired. See *Command Descriptions* in this section for details.

13. Command the SBE 21 to go to sleep (quiescent state) by typing **QS** and pressing the Enter key.

14. Turn off power to the NMEA Interface Box.

Command Descriptions

This section describes commands in detail and provides examples of their use. See *Appendix III: Command Summary* for a summarized command list.

Commands are entered in SEATERM. When entering commands:

- Input commands in upper or lower case letters and register commands by pressing the Enter key.
- The SBE 21 sends ***? CMD*** if an invalid command is entered.
- If the system does not return an **S>** prompt after executing a command, press the Enter key to get the **S>** prompt.
- If in quiescent state, re-establish communications by pressing Connect on the Toolbar or the Enter key to get an **S>** prompt.
- If the SBE 21 is transmitting data and you want to stop it, press the Esc key or Stop on the Toolbar (or type ^C). Then press the Enter key to get the **S>** prompt. Note that this does not stop logging that is in progress, but allows you to enter a limited number of commands (**DS**, **SS**, **TS**, **QL**, and **QS** can be entered while logging).
- The SBE 21 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 SBE 21 must initialize logging. Initializing logging sets the sample number and header number to 0, so the entire memory is available for recording data with the new scan length. **Initializing logging should only be performed after all previous data has been uploaded**. Therefore, commands that change the scan length (**SVx**, **SBE38=**, and **SBE3=**) prompt the user for verification before executing, to prevent accidental overwriting of existing data.

Entries made with the commands are permanently stored in the SBE 21 and remain in effect until you change them.

- The only exception occurs if J1 is removed from the Power PCB (top board in PCB assembly) to replace the back-up lithium battery or to do a reset of the instrument. Upon reassembly, set the date and time (**ST**) and initialize logging (**IL**).
  (See *Appendix II: Electronics Disassembly/Reassembly* for details on accessing the PCBs. See *Section 8: Troubleshooting* for details on performing a reset of the instrument.)

Note:
If the external power is below the cut-off voltage (7.5 volts), the following displays in response to the status command: **WARNING: LOW BATTERY VOLTAGE!!**

Status Command

DS

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

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

- firmware version, serial number, and date and time [**ST**]
- operating current (milliamps), external power voltage, and lithium battery voltage
- number of samples and available sample space in memory
- sample interval [**SI**]
- sample SBE 3 remote temperature sensor [**SBE3=x**]? only appears in status display if SBE 3 is enabled (custom application)
- sample SBE 38 remote temperature sensor [**SBE38=x**]? only appears in status display if SBE 38 is enabled
- number of external voltages [**SVx**]
- output format [**Fx**]
- start sampling automatically when power on? [**AUTORUN=x**]
- logging status
- power cutoff voltage

Example: Display status for SBE 21 that has SBE 38 remote temperature sensor enabled.

```
S>DS
SEACAT THERMOSALINOGRAPH V4.0b  SERIAL NO. 3166  01/15/2002  14:23:14
ioper = 50.7 ma,       vmain = 11.4,      vlith = 8.8
samples = 0, free = 1396736
sample interval = 5 seconds
sample external SBE 38 temperature sensor
no. of volts sampled = 0
output format = SBE21
start sampling when power on = no
logging data = no
voltage cutoff = 7.5 volts
```

Setup Commands

ST — Set real-time clock date and time as prompted.

Example: Set current date and time to October 5, 2002 12:00:00. (user input shown in bold)

S>**ST**

The SBE 21 prompts:

Date (MMDDYY) =**100502**

Note:
The SBE 21 baud rate (set with **BAUD=**) must be the same as SEATERM's baud rate (set in the Configure menu).

BAUD=x — **x=** baud rate (600, 1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.

Notes:
- The SBE 21 configuration (.con) file must match this selection of secondary temperature sensor and external voltages when viewing real-time data in SEASAVE or processing uploaded data. View and edit the .con file in SEASAVE or SBE Data Processing. Note that these parameters are factory-set to match the ordered instrument configuration.
- The SBE 21 requires verification when **SBE38=**, **SBE3=**, or **SVx** are sent. Instrument responds: *this command will change the scan length and initialize logging. Proceed Y/N?* Press the Y and the Enter key to proceed. The SBE 21 responds: *Scan length has changed, Initializing logging*

SBE38=x — **x**= Y: Sample SBE 38 secondary temperature sensor.
Note: When using the SBE 38, set up the .con file as if using the SBE 3 (set *External frequency channels* to 1), and enter these calibration coefficients: G= 4.0e-3, H = 2.0e-4, I = 0, J = 0, f0 = 1000. SEASAVE (and SBE Data Processing) will apply the coefficients to the *pseudo frequency* and output the remote temperature in °C (ITS-90).

x= N: Do not sample SBE 38.

SBE3=x — **x**= Y: Sample SBE 3 secondary temperature sensor. (available for integration with SBE 21 for custom applications only.)

x= N: Do not sample SBE 3.

SVx — **x**= number of external voltages to be acquired (0, 1, 2, 3, or 4). Maximum number of voltages is 4 if single-ended A/D channels are installed, or 2 if differential A/D channels are installed.

Fx — **x=**1: Set data output format to SBE 21, which outputs raw data (in Hex):
- primary temperature
- conductivity
- remote temperature
- voltages

Note:
- Output format does not affect how data is stored in memory.
- **If you will be using Sea-Bird software (SEASAVE and/or SBE Data Processing), set the format to SBE 21 (F1).**
- See *Data Output Formats* in this section for a complete description of the data output.

x=2: Set data output format to SBE 16 (for custom applications which are not using Sea-Bird software), which outputs raw data (in Hex):
- # (attention character)
- primary temperature
- conductivity
- remote temperature
- voltages
- linear count (starting at 0)

FLASHINIT

Map bad blocks and erase FLASH memory, **which destroys all data in SBE 21**. SBE 21 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 to initialize entire memory.

Send this command (after uploading all data) if you are encountering FLASH Read errors in the Status command (**DS**) response. If not encountering these errors, use of this command is optional, as SBE 21 writes over previously recorded information when **IL** command is used before beginning logging. However, knowledge of initial memory contents (i.e., all ones) can be a useful cross-check when data is uploaded from memory.

QS

Quit session and place SBE 21 in quiescent (sleep) state. Quiescent current is only 30 microamps. Memory retention is not affected.

Logging Commands

Logging commands configure the SBE 21's response upon waking up, and direct the SBE 21 to sample data at pre-programmed intervals. When commanded to start sampling with the **GL** or **RL** command, or upon powering up (if **AUTORUN=Y**), the SBE 21:

1. Takes samples continuously at 4 Hz (every 0.25 seconds),
2. Averages the samples taken within each sample interval [**SI**],
3. Stores the averaged data in its FLASH memory and transmits the real-time averaged data, and
4. Writes a header to memory, listing the logging start date and time, sample interval, and sample number range. A new header is also written after every 1000 samples.

The SBE 21 does not enter quiescent (sleep) state between samples.

Note:
- In SEATERM, to save real-time data to a file, click the Capture button on the Toolbar before beginning logging.
- If the FLASH memory is filled to capacity, data sampling and transmission of real-time data continue, but excess data is not saved in memory. **The SBE 21 will not overwrite the data stored in memory**.
- If the SBE 21 is logging data and the external voltage is less than 7.5 volts for ten consecutive scans, the SBE 21 halts logging and displays **WARNING: LOW BATTERY VOLTAGE** in response to the status (**DS**) command.

SI

Set interval (seconds) between sample averages. Minimum interval 3 seconds (4 seconds for custom application with SBE 3 remote temperature sensor), maximum interval 600 seconds. SBE 21 takes as many samples as possible (each 0.25 seconds apart) during this interval, and then averages samples. Averaged data is stored in FLASH memory and transmitted real-time.

Example (user input shown in bold)*:* Set sample interval to 5 seconds.

S>**SI**
Sample interval (seconds) **=5**

When logging starts, every 5 seconds SBE 21 takes ~20 samples (1 sample every 0.25 seconds), averages data, stores averaged data in FLASH memory, and transmits averaged data real-time.

Notes:
- **IL** and **SAMPLENUMBER=0** have identical effects. Use either command to initialize logging.
- **Do not initialize logging until all data has been uploaded.** These commands do not delete data; they reset the data pointer. **If you accidentally initialize logging before uploading**, recover data as follows:
  1. Set **SAMPLENUMBER=a** and **HEADERNUMBER=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 in memory 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.

IL

Initialize logging - after all previous data has been uploaded from SBE 21, initialize logging before starting to log again to make entire memory available for recording. This command sets sample number (**SAMPLENUMBER=x**) and header number (**HEADERNUMBER=x**) to 0 internally. **Do not send IL until all existing data has been uploaded.** SBE 21 requires verification before it proceeds with command, as shown in example.

If **AUTORUN=Y**: If **IL** is not sent, when power is applied logging will resume storing data to memory without resetting sample number (does not overwrite previously recorded data).

If **AUTORUN=N**: Overwriting of data is controlled by which command is used to start logging - **GL** (start logging, storing data at beginning of memory) or **RL** (resume logging, storing data without resetting sample number).

Example (user input shown in bold)*:*

S>**IL**
Initialize logging Y/N ? **y**
Are you sure ^Y/N ? **^y** (Note: The ^ symbol indicates the Ctrl key. Hold down the Ctrl key while typing y or n.)

SAMPLENUMBER=x

x= sample number for first sample when logging begins. This command is typically only used to recover data if you accidentally initialize logging (using **IL**) before uploading all existing data.

HEADERNUMBER=x

x= header number for first sample when logging begins. This command is typically only used to recover data if you accidentally initialize logging (using **IL** or **SAMPLENUMBER=0**) before uploading all existing data.

GL

Start logging now. SBE 21 overwrites any previously recorded data and headers in memory. SBE 21 requires verification before it proceeds with **GL** command, as shown in example. SBE 21 takes first sample 3 seconds after **GL** command is verified.

Example (user input shown in bold)*:*

S>**GL**
Start logging Y/N ? **y**
Are you sure ^Y/N ? **^y** (Note: The ^ symbol indicates the Ctrl key. Hold down the Ctrl key while typing y or n.)

RL

Resume logging now. SBE 21 resumes writing data and headers to memory without resetting the sample or header number (it does not overwrite previously recorded data). SBE 21 requires verification before it proceeds with **RL** command, as shown in the example. SBE 21 takes the first sample 3 seconds after **RL** command is verified.

Example (user input shown in bold)*:*

S>**RL**
resume logging Y/N ? **y**
Are you sure ^Y/N ? **^y** (Note: The ^ symbol indicates the Ctrl key. Hold down the Ctrl key while typing y or n.)

AUTORUN=x

x=Y: Automatically start logging when power is applied. When power is applied, SBE 21 resumes writing data and headers to memory without resetting sample number or header number (does not overwrite previously recorded data).

x= N: Do not automatically start logging when power is applied.

Note:
After sending **AUTORUN=Y**, you must turn power to the SBE 21 off and then on again to start logging.

QL

Stop logging. Press Enter key to get **S>** prompt before entering this command. SBE 21 requires verification before it proceeds with **QL** command, as shown in example.

Example (user input shown in bold)*:*

S>**QL**
quit logging Y/N ? **y**
Are you sure ^Y/N ? **^y** (Note: The ^ symbol indicates the Ctrl key. Hold down the Ctrl key while typing y or n.)

Notes:
- You may need to type the **QL** command several times to get the SBE 21 to respond.
- If the SBE 21 does not appear to respond to the **QL** command, press Ctrl Z several times, then try the **QL** command again.
- If **AUTORUN=Y**, remove power to stop logging.
- You must stop logging before uploading data.

Notes:
- To save data to a file, click the Capture button on the Toolbar before entering the **DD** or **DH** command.
- See *Data Output Formats* after these *Command Descriptions*.
- **To upload data in a form that can be used by SBE Data Processing:**
  1. Set the output format to SBE 21 using the **F1** command before uploading.
  2. Use the Upload button on the Toolbar or Upload Data in the Data menu. Manually entering the data upload command does not produce data in the correct format for processing by SBE Data Processing.

Data Upload Commands

Stop logging before uploading data.

DDb,e — Upload data in raw Hex form from scan **b** to scan **e**. If **b** and **e** are omitted, all data is uploaded. First sample is number 0.

Example: Upload samples 0 through 199 to a file:
(Click Capture on Toolbar and enter desired filename in dialog box.)
S>**DD0,199**

DH — Upload all headers. First header is 0. New header was written when logging started or resumed and every 1000 samples thereafter. The header includes:
- Header number
- month, day, year, hour, minute, and second when header was written
- first and last sample for header
- interval between samples (**SI**)

Example: Upload headers to a file:
(Click Capture on Toolbar and enter desired filename in dialog box.)
S>**DH**

```
hdr 0 01/15/2002 12:30:33 samples 0 to 4, interval=60 sec
hdr 1 01/15/2002 13:02:12 samples 5 to 10, interval=60 sec
```

Note:
The SBE 21 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.

Sampling Commands

These commands request a single sample. The SBE 21 always stores data for the most recent sample in its buffer.

SS — Output last sample from buffer (sample obtained with **TS** command, or latest sample from logging).

TS — Sample for 1 second at 4 Hz (take 4 samples), average data, store averaged data in buffer, and output averaged data. **Data is not stored in FLASH memory**.

Diagnostic Commands

The SBE 21 outputs 100 samples for each diagnostic test. Data is not stored in FLASH memory. Press the Esc key or Stop button to stop the test.

FR Display frequencies:

Column	Output
1	Raw temperature A/D counts
2	Raw conductivity frequency
3	Temperature frequency converted to match older SBE 21 (firmware version < 4.0)
4	Conductivity frequency converted to match older SBE 21 (firmware version < 4.0)
5	External frequency (custom application with SBE 3 remote temperature sensor)

VR Display external voltages with offset and scale factors applied.

Column	Output
1	External voltage 0
2	External voltage 1
3	External voltage 2
4	External voltage 3
5 - 8	Diagnostics for factory use

T38 Display output from SBE 38 remote temperature sensor.

Coefficients Command

DCAL Display calibration coefficients.

- Voltage (0, 1, 2, and 3) channel offset and slope, as determined at the factory

  Output voltage =
  (slope * calculated V from sensor equation) + offset

- conductivity zero frequency - characteristic frequency of conductivity sensor for zero conductivity, as determined at the factory. This is obtained from a cell thoroughly rinsed in distilled or de-ionized water, with all the water shaken out. A zero frequency that has changed by a few tenths of a Hz indicates a dirty cell. A zero frequency that has changed by more than a few tenths of a Hz may indicate a cell that is damaged or considerably out of calibration.
- External frequency scale factor for SBE 3 remote temperature sensor (custom application)

Notes:
- Calibration coefficients for the conductivity and primary temperature sensor, and for any auxiliary sensors, are stored in the SBE 21's configuration (.con) file. View and/or modify the calibration coefficients using the Configure menu in SBE Data Processing or SEASAVE. See *Checking SBE 21 Configuration (.con) File in SEASAVE* in this section for details.

Example: Display coefficients for SBE 21.

```
S>DCAL
SEACAT THERMOSALINOGRAPH V4.0b SERIAL NO. 3166 01/15/2002 14:30:14
volt 0: offset = -4.662333e-02, slope = 1.249281e+00
volt 1: offset = -4.658000e-02, slope = 1.249034e+00
volt 2: offset = -4.699667e-02, slope = 1.248704e+00
volt 3: offset = -4.707333e-02, slope = 1.249847e+00
Cfo = 2596.697
```

Checking SBE 21 Configuration (.con) File in SEASAVE

Note:
When Sea-Bird ships 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 an instrument with serial number 2375, Sea-Bird names the .con file *2375.con*. You may rename the .con file if desired; this will not affect the results.

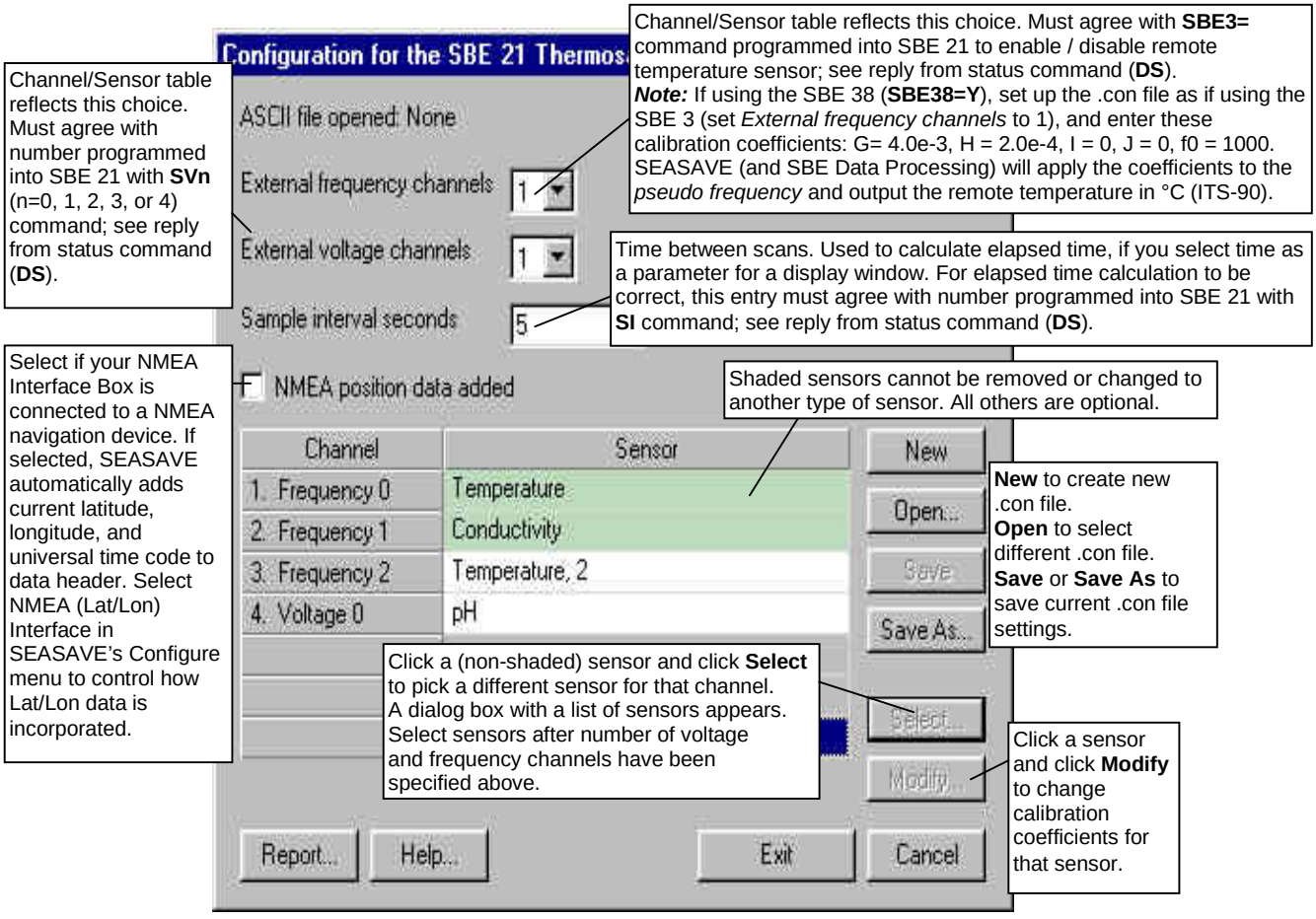
SEASAVE, Sea-Bird's real-time data acquisition and display program, requires a .con file, which defines the instrument - auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the integrated sensors (conductivity and temperature as well as auxiliary sensors). SEASAVE (as well as our data processing software) uses the information in the .con file to interpret and process the raw data. **If the .con file does not match the actual instrument configuration, the software will not be able to interpret and process the data correctly.**

To verify the contents of the .con file:

1. Double click on Seasave.exe.

2. In SEASAVE's Configure menu, select *New Style Instrument Configuration/Select Instrument Configuration*. In the dialog box, select the appropriate .con file and click Open.

3. In the Configure menu, select *Modify Selected Instrument Configuration*. The configuration dialog box appears. Verify that the sensors match those on your instrument, and that auxiliary sensors are assigned to the correct voltage channels. Verify that the calibration coefficients for all the sensors are up-to-date.



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

Data Output Formats

The SBE 21 outputs data in raw, hexadecimal form as described below.

The inclusion of some output parameters is dependent on the system configuration - if the specified sensor is not enabled (see *Command Descriptions* above), the corresponding data is not included in the output data stream, shortening the data string.

Note:
SBE 21 always outputs an even number of voltage characters. If you enable 1 or 3 voltages, it adds a *0* to the data stream before the last voltage, as shown below:
- 1 voltage enabled - ttttccccrrrrrr0uuu or #ttttccccrrrrrr0uuunnnn
- 3 voltages enabled - ttttccccrrrrrruuuvvv0www #ttttccccrrrrrruuuvvv0wwwnnnn

- SBE 21 Format (**F1**) - ttttccccrrrrrruuuvvvwwwxxx (use this format if you will be using SEASAVE to acquire real-time data and/or SBE Data Processing to process the data)
- SBE 16 Format (**F2**) - #ttttccccrrrrrruuuvvvwwwxxxnnnn

  where
  tttt = primary temperature
  cccc = conductivity
  rrrrrr = remote temperature (from SBE 38 or SBE 3 remote sensor)
  uuu, vvv, www, xxx = voltage outputs 0, 1, 2, and 3 respectively
  # = attention character
  nnnn = lineal sample count (0, 1, 2, etc.)

Data is output in the order listed, with no spaces or commas between parameters. Shown with each parameter is the number of digits.

Calculation of the parameter from the data is described below (use the decimal equivalent of the hex data in the equations).

1. Temperature
   temperature frequency (Hz) = (tttt / 19) + 2100
2. Conductivity
   conductivity frequency (Hz) = square root [(cccc * 2100) + 6250000]
3. SBE 3 secondary temperature (if **SBE3=Y**)
   SBE 3 temperature frequency (Hz) = rrrrrr / 256
4. SBE 38 secondary temperature (if **SBE38=Y**)
   SBE 38 temperature psuedo frequency (Hz) = rrrrrr / 256
5. External voltage 0 (if 1 or more external voltages defined with **SVx**)
   external voltage 0 (volts) = uuu / 819
6. External voltage 1 (if 2 or more external voltages defined with **SVx**)
   external voltage 1 (volts) = vvv / 819
7. External voltage 2 (if 3 or more external voltages defined with **SVx**)
   external voltage 2 (volts) = www / 819
8. External voltage 3 (if 4 external voltages defined with **SVx**)
   external voltage 3 (volts) = xxx / 819

Notes:
- Sea-Bird's data processing software (SBE Data Processing) uses the equations shown to perform these calculations; it then uses the calibration coefficients in the configuration (.con) file to convert the raw frequencies and voltages to engineering units. Alternatively, you can use the equations to develop your own processing software.
- If using the SBE 38, set up the SBE 21 .con file as if using the SBE 3 (set *External frequency channels* to 1), and enter the following values for the calibration coefficients: G= 4.0e-3, H = 2.0e-4, I = 0, J = 0, f0 = 1000. SEASAVE and SBE Data Processing will apply the coefficients to the *pseudo frequency* and output the remote temperature in °C (ITS-90).

Example: SBE 21 with SBE 38 and two external voltages sampled, example scan = ttttccccrrrrrruuuvvv = A80603DA1B58001F5A21

- Temperature = tttt = A806 (43014 decimal);
  temperature frequency = (43014 / 19) + 2100 = 4363.89 Hz
- Conductivity = cccc = 03DA (986 decimal);
  conductivity frequency =
  square root [986 *2100) + 6250000] = 2884.545 Hz
- SBE 38 = rrrrrr = 1B5800 (1,792,000 decimal)
  temperature (Hz) = (1,792,000 / 256) = 7000 Hz
- First external voltage = uuu = 1F5 (501 decimal);
  voltage = 501 / 819 = 0.612 volts
- Second external voltage = vvv = A21 (2593 decimal);
  voltage = 2593 / 819 = 3.166 volts

Section 5: Setting Up the NMEA Interface

The NMEA Interface Box includes a NMEA 0183 Interface that permits position data to be merged with the SBE 21 data. The NMEA Interface is designed to decode messages that are output from navigation devices supporting NMEA 0183 protocol. **A complete description of the NMEA Interface Box - specifications, setup, troubleshooting, data format, and NMEA simulation programs - is provided in a separate manual.** However, setup information is repeated in this section for ease-of-use.

Note:
If NMEA date and time are available in the NMEA message, SEASAVE substitutes the NMEA information for the computer clock time in the header.

The decoded Latitude and Longitude can be appended to the SBE 21 data stream in the NMEA Interface Box and passed to the computer for storage and/or display with the SBE 21 data. Position data is appended to the end of the SBE 21 data, with the position data always last. Position data format is detailed in the NMEA Interface Box manual. The Yellow *TX NMEA* LED on the Interface Box flashes each time a NMEA message is received (should be the same rate at which your navigation device is transmitting). The Interface Box appends the same NMEA message multiple times, until a new message is decoded.

Example: A navigation device outputs its NMEA message once every 5 seconds. The Yellow *TX NMEA* LED flashes every 5 seconds, and the same message is appended to each scan of SBE 21 data within that 5 seconds.

Setting NMEA Interface Box PCB Dip Switch

An 8-position dip switch on the NMEA Interface Box PCB sets the baud rates between the SBE 21 and the Interface Box and between the Interface Box and the computer, the data bits and parity, and the NMEA message to decode. The dip switch positions are shown in *Section 4: Setting Up the SBE 21*. For reference when setting up the NMEA interface, the NMEA message to decode settings are repeated below:

Message to Decode	Position 1	Position 2	Position 3
GGA - Global Positioning System Fix Data	ON	ON	ON
GLL - Geographic Position: Latitude/Longitude	OFF	ON	ON
RMA - Recommended Minimum Specific Loran-C Data	ON	OFF	ON
RMC (factory default) - Recommended Minimum Specific GPS/TRANSIT Data	OFF	OFF	ON
TRF - TRANSIT Fix Data	ON	ON	OFF

If you are not sure which NMEA message your navigation device is sending, see the NMEA Interface Box manual for information on viewing the raw NMEA message using the NMEA Interface's diagnostic mode.

NMEA Operating Modes

The NMEA Interface has three normal operating modes and two diagnostic modes. The mode is set in the NMEA Interface menu while communicating with the NMEA Interface Box with SEATERM (see *Setting Up and Testing NMEA* below).

Notes:
- In SEATERM, use the @ character to access and exit the NMEA Interface menu.
- To enter diagnostic modes (4 or 5), first put the NMEA Interface in Mode 3. Then, enter a 4 or 5 at the mode selection prompt.
- To exit diagnostic modes (4 or 5), turn off power to the NMEA Interface Box.
- In the NMEA Interface menu, Diagnostic level 1 = Mode 4 Diagnostic level 2 = Mode 5

The modes are:

Type	Mode	Description
Operating	1: Echo only	Characters to and from SBE 21 pass through NMEA Interface. No position data is sent. Useful for setting up SBE 21.
	2: Add Lat/Lon to hex data (default power-up mode)	Seven bytes of hex latitude/longitude data are added to each line of hex data from SBE 21. Used when position data is required with SBE 21 data.
	3: Transmit Lat/Lon only	Data from SBE 21 is not transmitted. Hex latitude/longitude data is converted to ASCII text whenever a new position is received from NMEA navigation device. Format is: *LAT 47 37.51 N* *LON 122 09.41 W* If NMEA message RMC is decoded, date and time display on next line. Format is: *DDMMYY HHMMSS*
Diagnostic	4 (diagnostic level 1): Transmit raw NMEA message only	All NMEA messages received are echoed to computer in raw form. Used to determine which NMEA messages are being received by NMEA Interface.
	5 (diagnostic level 2): Transmit raw and decoded NMEA message	All NMEA messages received are echoed to computer in raw form. If a correct NMEA message is received, decoded data displays below raw data. Decoded format same as for Mode 3.

Setting Up and Testing NMEA

Note:
The NMEA Interface Box must be connected to the SBE 21 to test the NMEA interface. If it is not connected, noise on the open *SEACAT Data I/O* connector may interfere with communication with the NMEA Interface Box.

After connecting the NMEA navigation device, NMEA Interface Box, computer, and SBE 21, run SEATERM.

1. Double click on seaterm.exe.

2. In the Configure menu, select the SBE 21.
   A. In the Configuration Options dialog box, click on the COM Settings tab.
   B. Set the COM Settings to:
      - Comm Port 1 through 10 as applicable
      - 9600 baud, 7 data bits, and even parity
      - RS-232

      Click *OK* or *Save As* to save the settings and exit the dialog box.

3. Turn on power to the NMEA Interface Box. The red PWR LED should light. The display in SEATERM looks like this:

```
NMEA interface box V 2.3 setup:
PC baud rate = 9600
SEACAT baud rate = 9600
7 data bits, even parity
NMEA message to decode = RMA
Mode = add Lat/Lon to real-time Hex data
Menu time out enabled

Press @ to change the NMEA interface box setup
```

Looking at selected lines:

Text	Description
PC baud rate	Communication between computer and NMEA Interface Box, set on NMEA Interface Box PCB switch positions 7 and 8 (factory set to 9600)
SEACAT baud rate	Communication between NMEA Interface Box and SBE 21, set on NMEA Interface Box PCB switch positions 5 and 6 (factory set to 9600)
7 data bits, even parity	Set on NMEA Interface Box PCB switch position 4 (factory set to 7 data bits, even parity)
NMEA message to decode	Set on NMEA Interface Box PCB switch positions 1 to 3 (must match output from NMEA navigation device)
Mode=add Lat/Lon to real-time Hex data	Default power-up mode, enabling system to acquire navigational data along with real-time thermosalinograph data
Menu time out enabled	If in the setup menu and no user input is received within 90 seconds, the Interface Box times out, exits the setup menu, and sets the mode to *Add Lat/Lon to real-time Hex Data*. Re-enter the setup menu by typing @. Note that the menu time out feature cannot be disabled.

Note:
In SEASAVE, Lat/Lon data transmission is determined by the setting in the SBE 21 configuration (.con) file. So even though the NMEA Interface Box default power-up mode is set to append Lat/Lon data, you must also set the .con file to append NMEA data.

4. Type @ to access the NMEA Interface menu. The display looks like this:

```
NMEA interface set up menu:
1. Echo characters to and from the instrument
2. Add Lat/Lon to the real-time HEX data from the
instrument
3. Transmit Lat/Lon only

the current mode = 2. Add Lat/Lon to the real-
time HEX data

enter 1, 2, or 3 to change the NMEA interface box
mode, or press @ to exit the set up menu

selection =
```

5. Type *3* and press the Enter key to switch to mode 3. The display looks like this:

```
NMEA interface set up menu:
1. Echo characters to and from the instrument
2. Add Lat/Lon to the real-time HEX data from the
instrument
3. Transmit Lat/Lon only

the current mode = 3. Transmit Lat/Lon only

enter 1, 2, or 3 to change the NMEA interface box
mode, or press @ to exit the set up menu

selection =
```

6. Type @ to exit the menu. You should begin seeing position data display in SEATERM. Each time position data is received, the yellow *TX NMEA* LED on the NMEA Interface Box should flash. If the data is correct and is updating properly, the NMEA Interface Box is working.
   - If position data does not appear, verify that the Interface Box is connected to the NMEA navigation device and that the proper cable is used.
   - See the NMEA Interface Box manual for troubleshooting instructions if needed.

7. Turn off power to the NMEA Interface Box.

Troubleshooting NMEA Interface

See the NMEA Interface Box manual for troubleshooting.

Setting Up SBE 21 Configuration (.con) File

Notes:
When Sea-Bird ships 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 an instrument with serial number 2375, Sea-Bird names the .con file *2375.con*. You may rename the .con file if desired; this will not affect the results.

The NMEA Interface Box integrates the position data from the NMEA navigation device into the SBE 21 data stream. SEASAVE, Sea-Bird's real-time data acquisition and display program, stores and optionally displays the NMEA data along with the thermosalinograph data. SEASAVE requires a .con file, which defines the SBE 21 - auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the integrated sensors (conductivity and temperature as well as auxiliary sensors). SEASAVE (as well as our data processing software) uses the information in the .con file to interpret and process the raw data. If the .con file does not match the actual instrument configuration, the software will not be able to interpret and process the data correctly.

The .con file must indicate if position data is being added to the SBE 21 data by the NMEA Interface Box. See *Section 4: Setting Up the SBE 21* for details on viewing and modifying the .con file in SEASAVE. Note that the .con file setup overrides the mode selection in the NMEA interface setup menu (default power-up mode is to add Lat/Lon to the real-time Hex data from the instrument). In other words, the real-time transmission of NMEA position data is dependent on the .con file setting in SEASAVE.

Section 6: Operating the System

This section covers:
- Acquiring real-time data with SEASAVE
- Uploading SBE 21 data from memory

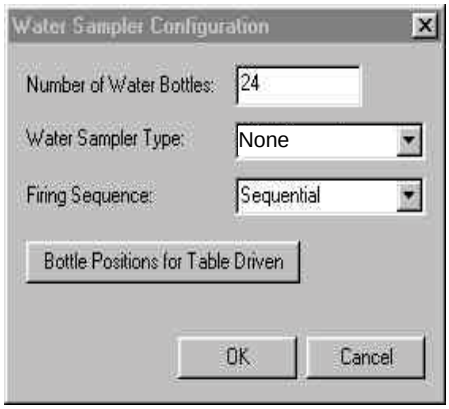
Acquiring Real-Time Data with SEASAVE

Proceed as follows:

1. Turn on power to the NMEA Interface Box.
   - If **AUTORUN=Y** (SBE 21 is set up to start logging automatically when power is turned on), SBE 21 will start logging and will store data in its internal memory. Note that the data will not appear in SEASAVE until you tell SEASAVE to start real-time data acquisition below.
   - If **AUTORUN=N** (SBE 21 is not set up to start logging automatically when power is turned on), run SEATERM and send the **GL** or **RL** command to start logging, then close SEATERM. See *Section 4: Setting Up the SBE 21* for details on running SEATERM.

2. Double click on Seasave.exe.

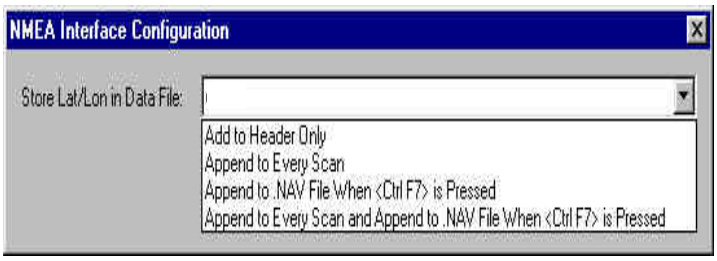
3. In the Configure menu, select *Water Sampler Configuration*. The dialog box looks like this:



   Set:
   - Water sampler - *None* is the only valid selection for a system using the SBE 21
   - Number of Water Bottles and Firing Sequence - not applicable (selection does not affect operation)

   Click OK.

4. (For NMEA Navigation Box connected to NMEA navigation device) In the Configure menu, select *NMEA [Lat/Lon] Interface*. The dialog box looks like this:



Select how to store the NMEA data:

- *Add to Header Only* - Latitude, longitude, and time are automatically written to the header when data acquisition is started.
- *Append to Every Scan* - Latitude, longitude, and time are automatically written to the header when data acquisition is started. Additionally, 7 bytes of Lat/Lon data are appended to every scan of SBE 21 data.
- *Append to .NAV File when <Ctrl F7> is Pressed* - Latitude, longitude, and time are automatically written to the header when data acquisition is started. Additionally, latitude, longitude, time, and scan number are written to *filename*.NAV every time Ctrl F7 is pressed (*filename* is the same as the name of the .hex output data file).
- *Append to Every Scan and Append to .NAV File when <Ctrl F7> is Pressed* - Latitude, longitude, and time are automatically written to the header when data acquisition is started. Additionally, 7 bytes of Lat/Lon data are appended to every scan of SBE 21 data. And, latitude, longitude, time, and scan number are written to *filename*.NAV every time Ctrl F7 is pressed (*filename* is the same as the name of the .hex output data file).

Click OK.

Note:
When running DATA CONVERSION in the data processing software, if *filename*.NAV is found in the same directory as the .hex output data file, the contents of *filename*.NAV are added to the converted data file header.

5. Perform any other desired setup in the Configure menu.

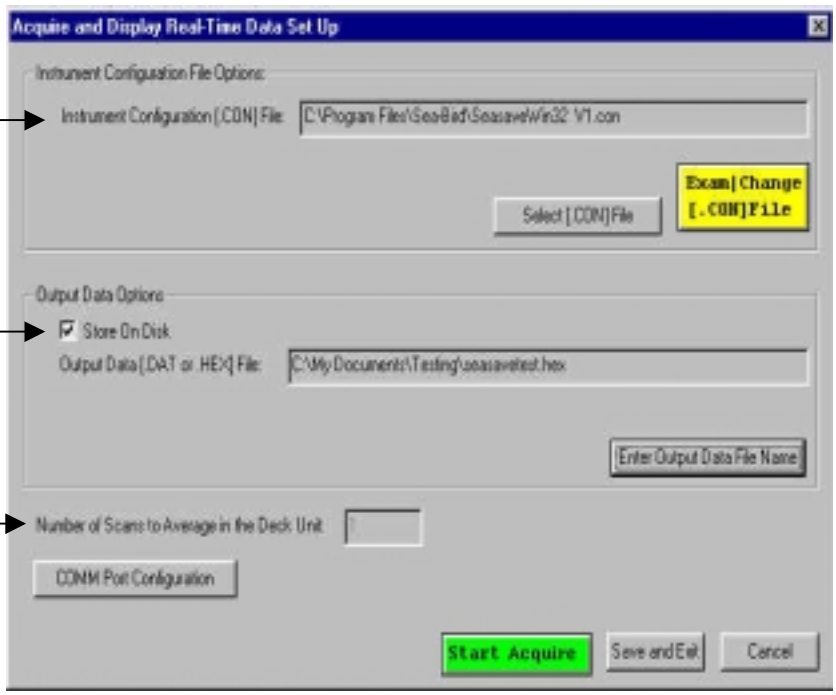
6. Perform any desired setup in the ScreenDisplay menu.

7. In the RealTime Data menu, select *Start Acquisition*. The dialog box looks like this:

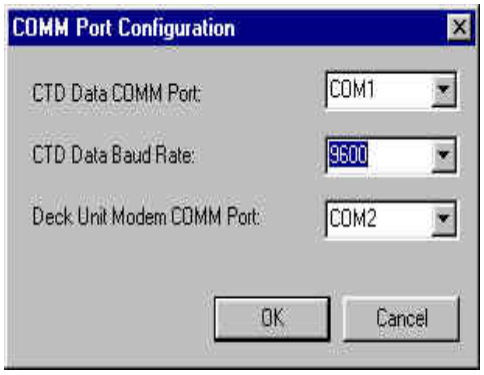
Configuration file defines the auxiliary sensors integrated with the instrument, and channels, serial numbers, and calibration dates and coefficients for all the integrated sensors (conductivity and temperature as well as auxiliary sensors). Verify that .con file matches your instrument setup. See *Checking SBE 21 Configuration (.con) File in SEASAVE* in *Section 4: Setting Up the SBE 21* for details.

Select to save real-time data to a file.

Not applicable.



8. Click *COMM Port Configuration*. The dialog box looks like this:



In the dialog box, enter:

- CTD Data COMM Port - computer port connected to NMEA Interface Box; sends commands to and receives replies from SBE 21 (through Interface Box)
- CTD Data Baud Rate - baud rate **between NMEA Interface Box and computer**; must agree with NMEA Interface Box dip switch setting position 7 and 8 (9600 baud)
- Deck Unit Modem COMM Port - not applicable (selection does not affect operation)

Click OK.

9. In the Acquire and Display Real Time Data Set Up dialog box, click *Start Acquire*.
   A. If SEASAVE was set up to prompt for header information (Configure menu / Header Form), the Header Information dialog box appears. Fill in the desired information to be added to the header portion of the real-time data acquisition .hex file, and click OK.
   B. SEASAVE automatically sends a command to put the NMEA Interface in Mode 1 (do not transmit NMEA data) or Mode 2 (append position data to SBE 21 data), depending on whether the SBE 21 .con file was set to add NMEA data. If the .con file was set to add NMEA data, the screen then displays: *Getting Latitude, Longitude and Time from the NMEA Interface.*
   C. Real-time data then starts appearing in the screen display(s).

10. When done acquiring data, in the RealTime Data menu, select *Stop Acquisition*.

11. Close SEASAVE.

12. Double click on seaterm.exe.
   A. Establish communications with the SBE 21 by pressing the Enter key several times. The SBE 21 should respond with an S> prompt.
   B. Send the **QL** command to stop logging.
   C. If you want to upload data from the SBE 21's memory now, see *Uploading Data from Memory* below.
   D. Send the **QS** command to place the SBE 21 in quiescent (sleep) state.

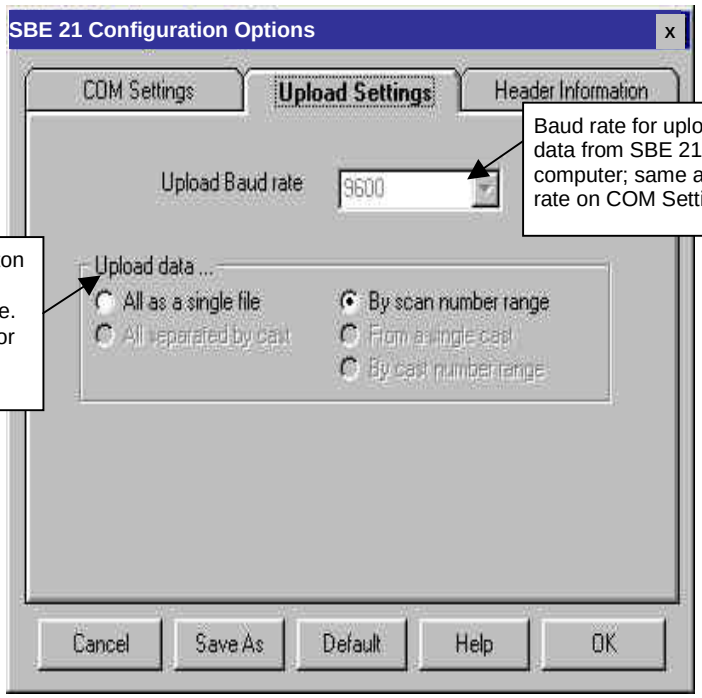
13. Turn off power to the NMEA Interface Box.

Note:
See the SBE Data Processing manual and/or help files for details on processing the data.

Uploading SBE 21 Data from Memory

1. Double click on SeaTerm.exe. The display shows the main screen.

2. In the Configure menu, select *SBE 21*. Click on the Upload Settings tab. The dialog box looks like this:



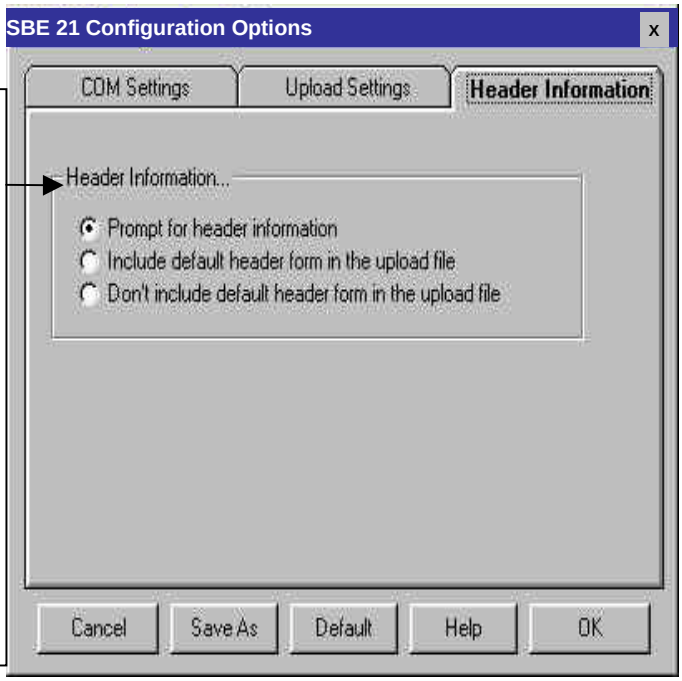
Baud rate for uploading data from SBE 21 to computer; same as baud rate on COM Settings tab.

Defines data upload type when using Upload button 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.

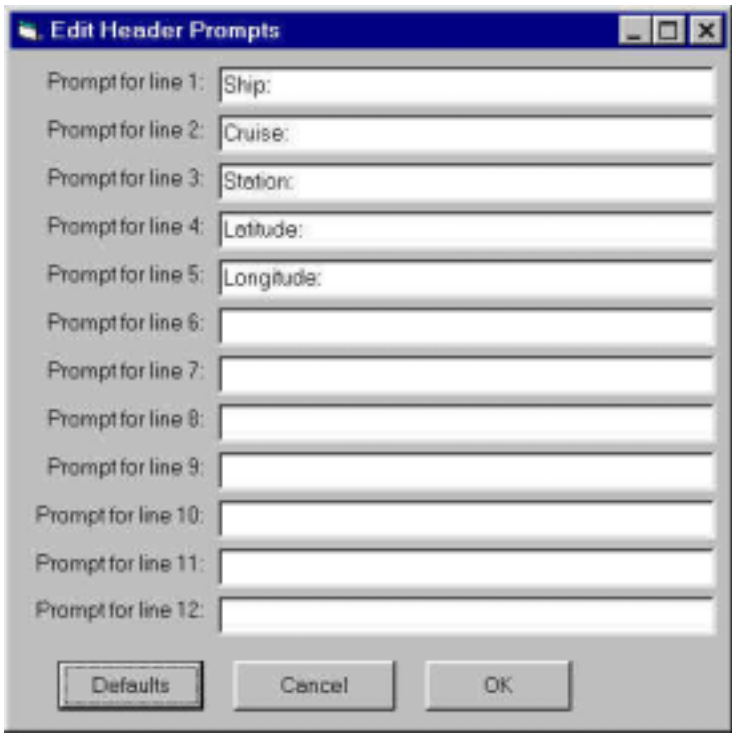
3. Click on the Header Information tab. The dialog box looks like this:



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

Select the desired header information option. Click OK to overwrite an existing configuration file, or click Save As to save the configuration as a new filename.

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. Turn on power to the NMEA Interface Box. Type @ to access the NMEA interface setup menu. Type *1* and press the Enter key to echo characters from the SBE 21. Type @ to exit the setup menu.

6. Click Connect on the Toolbar to begin communications with the SBE 21. The display looks like this:

```
S>*ds
SC21, 3164, 4.0b, 206, 1,6, N
S>
```

   This shows that correct communications between the computer and the SBE 21 has been established.
   If the system does not respond as shown above:
   - Click Connect again.
   - Check cabling between the computer and the SBE 21.
   - Verify the correct instrument was selected and the COM settings were entered correctly in the Configure menu.

7. Display SBE 21 status information by clicking Status on the Toolbar. The display looks like this:

```
SEACAT THERMOSALINOGRAPH V4.0b SERIAL NO. 3166 01/15/2002 14:02:13
ioper = 50.7 ma   vmain = 11.4,   vlith = 8.8
samples = 50000, free = 1346736
sample interval = 5 seconds
sample external SBE 38 temperature sensor
no. of volts samples = 0
output format = SBE21
start sampling when power on = no
logging data = no
voltage cutoff = 7.5 volts
```

8. If the status reply indicates that the SBE 21 is still logging, command the SBE 21 to stop data logging by pressing the Enter key and sending the **QL** command. You may need to send the command several times.

9. If *output format = SBE16* in the status display, and you intend to use Sea-Bird data processing software, send the **F1** command to change the output format to SBE 21. Verify *output format = SBE21* by sending the **DS** command again.

10. Click the Upload button on the Toolbar to upload stored data in a form that Sea-Bird's data processing software can use. SEATERM responds as follows:
    A. SEATERM sends the status (**DS**) command, displays the response, and writes the command and response to the upload file. This command provides with information regarding the number of samples in memory, scan interval, etc.
    B. SEATERM sends the header (**DH**) command, displays the response, and writes the command and response to the upload file. This command provides information regarding the number of samples in each *cast* (SBE 21 writes a header each time sampling is restarted, as well as every 1000 scans), the date and time the cast was started, and the sample interval.
    C. **If you selected *By scan number range* in the Configuration Options dialog box (Configure menu)** – a dialog box requests the range. Enter the desired value(s), and click OK.
    D. **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.
    E. In the Open dialog box, enter the desired upload file name and click OK. The upload file has a .hex extension.
    F. SEATERM sends the data upload command (**DDb,e**).
    G. When the data has been uploaded, SEATERM shows the **S>** prompt.

11. Ensure all data has been uploaded from the SBE 21 by reviewing and processing the data:
    A. Use **SEASAVE** (Win 95/98/NT) to display the *raw* hexadecimal data from the SBE 21 in engineering units (see SEASAVE's manual and/or Help files for details on displaying archived data).
    B. Use **SBE Data Processing** (Win 95/98/NT) to process and plot the data (see SBE Data Processing's manual and/or Help files for details).

Notes:
To prepare the SBE 21 for re-deployment:
1. After all data has been uploaded, send the **IL** command. If this command is not sent and logging is started with the **RL** command or by applying power, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.
1. Send the **QS** command to put the SBE 21 in quiescent (sleep) state until ready to restart logging.
1. Turn off power to the NMEA Interface Box.

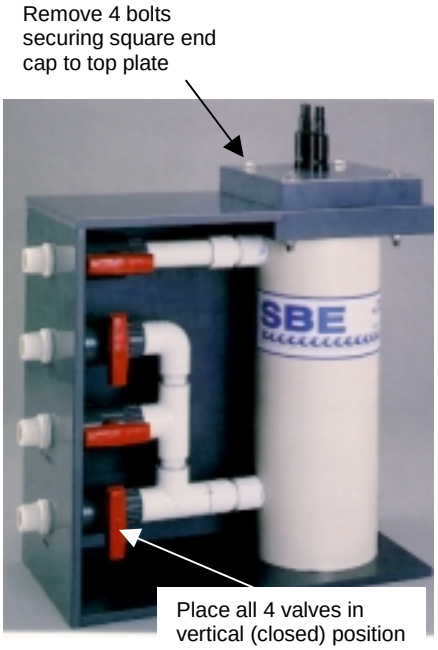
Section 7: Routine Maintenance and Calibration

This section reviews corrosion precautions, conductivity cell cleaning and storage, sensor calibration, and replacement of anti-foul cylinders. The accuracy of the SBE 21 is sustained by the care and calibration of the sensors and by establishing proper handling practices.

Corrosion Precautions

All hardware exposed to seawater is titanium; the housing is plastic. No corrosion precautions are required. The SBE 21 should be cleaned as described below after use and prior to storage.

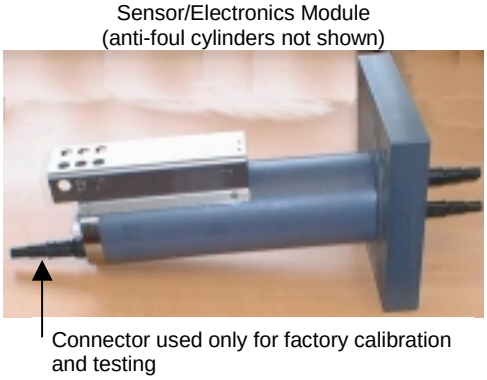
Removing Sensor/Electronics Module from SBE 21 Water Jacket



1. Close all 4 valves (valve is closed when the handle is vertical).

2. Remove sensor/electronics module from water jacket:
   A. Remove the 4 bolts, washers, and nuts securing the square end cap to the SBE 21 top plate.
   B. Lift the square end cap straight up, removing the sensor/electronics module from the water jacket.
   C. Protect the o-ring on the top plate from damage or contamination.

3. When desired, replace the sensor/electronics module in the water jacket:
   A. Inspect the top plate o-ring 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-ring and mating surfaces.
   B. Carefully replace the sensor/electronics module in the water jacket, aligning the bolt holes on the square end cap and top plate.
   C. Reinstall the 4 bolts, washers, and nuts to secure the end cap to the top plate.



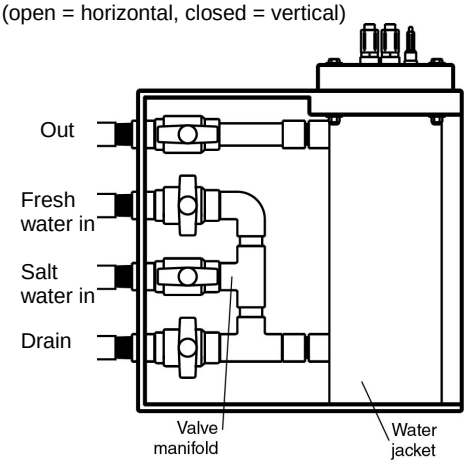
Cleaning and Storage

CAUTION:
The SBE 21's conductivity cell is shipped dry to prevent freezing in shipping and depletion of the anti-foul cylinders. **Do not store the SBE 21 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.

Clean the SBE 21 and conductivity cell:
- Monthly (during sustained use)
- Before periods of non-use – If the cell is not rinsed between usage, salt crystals may form on the platinized electrode surfaces. When the instrument is used next, sensor accuracy may be temporarily affected until these crystals dissolve.
- If the data looks incorrect –
  - Unusually *noisy* data may be caused by debris going through the cell.
  - Unusually *smooth* data may be caused by a blockage in the flow path or in the cell.
  - Shifted data may be caused by fouling inside the cell.

Follow this cleaning procedure:

Valves shown in *Normal Use* position
(open = horizontal, closed = vertical)



Step 1: Flush with Fresh Water and Drain

A. Flush the system with fresh water by placing the SBE 21 valves in the following positions:
Out - open
Fresh water in - open
Salt water in - closed
Drain - closed

B. Place the valves in the following positions and allow the water to drain:
Out - closed
Fresh water in - closed
Salt water in - closed
Drain - open

Step 2: Inspect Water Jacket

A. Close all four valves.

B. Remove the sensor/electronics module from the water jacket.
See *Removing Sensor/Electronics Module from SBE 21 Water Jacket* for details.

C. Use a flashlight to inspect the inside of the water jacket for debris, fine deposits, or oil film. If this is a routine monthly maintenance, and there is no evidence of debris, fine deposits or oil film, proceed to *Step 5: Reinstall Sensor/Electronics Module*.

Step 3: Clean Water Jacket

A. Use paper towels to remove any deposits inside the water jacket.

Step 4: Flush Inside of Conductivity Cell

WARNING!
- **Wear gloves if touching or handling the Tygon tubing/ anti-foul cylinders.**
- **Use protective eyewear and wear gloves when working with hydrochloric acid. Avoid breathing the acid fumes.** Dilute and rinse any spills with fresh water, or neutralize large spills with baking soda (sodium bicarbonate powder).

CAUTION:
Do not put a brush or any object inside the conductivity cell to clean it or dry it. Touching and bending the electrodes can change the calibration. Large bends and movement of the electrodes can damage the cell.

A. Remove the Tygon tubing/anti-foul cylinder from each end of the conductivity cell (see *Replacing Anti-Foul Cylinders* below for details).

B. Clean the inside of the conductivity cell with a series of flushes, using Tygon tubing.
   i. Fresh water to remove debris and deposits.
   ii. 1 liter of 1-normal hydrochloric acid, slow flow through the cell (Produce 1-normal hydrochloric acid as follows: Start with muriatic acid, which is 31.45% HCl (20 degrees Baume) by weight. Dilute 0.1 liters of muriatic acid into 0.9 liters of fresh water.)
   iii. 10 liters of fresh water to rinse the acid.
   iv. (optional) 1 liter of 1% solution of Triton X-100 (Triton X-100 is included with shipment).

   If fouling remains in the conductivity cell after these procedures, return the sensor/electronics module to Sea-Bird for cleaning and recalibration.

C. Rinse the exterior of the instrument to remove any spilled acid from the surface.

D. If the SBE 21 is being stored, remove larger droplets of water by blowing through the conductivity cell. **Do not use compressed air**, which typically contains oil vapor.

Step 5: Reinstall Sensor/Electronics Module

A. See *Removing Sensor/Electronics Module from SBE 21 Water Jacket* for details on reinstalling the module.

B. If you will not be immediately using the SBE 21, leave all the valves in the closed position.
   For Normal use, place the valves in these positions:
   Out - open
   Fresh water in - closed
   Salt water in - open
   Drain - closed

CAUTION:
To remove the electronics from the housing for troubleshooting, see *Appendix II: Electronics Disassembly/Reassembly* for details.

If the data still looks incorrect after cleaning, it may be caused by:
- a problem with the electrical connections
- a problem with the PCBs inside the sensor/electronics module housing
- internal fouling in the conductivity cell that was not removed by flushing
- sensors that need to be recalibrated

Replacing Anti-Foul Cylinders

WARNING!

- **Anti-foul cylinders contain tri-butyl tin oxide (TBTO). Handle the Tygon tubing/cylinder with gloves. If the cylinder comes in contact with skin, wash with soap and water immediately. Dispose of gloves properly. Refer to the Material Safety Data Sheet in the shipment for details.**
- Anti-foul cylinders are **not** classified by the U.S. DOT or the IATA as hazardous material, in the quantities used by Sea-Bird.

The SBE 21's anti-foul assembly consists of an anti-foul cylinder installed in a short section of Tygon tubing. An anti-foul assembly is placed at each end of the conductivity cell. A new SBE 21 is shipped with the anti-foul assembly pre-installed. A replacement cylinder comes as an assembly, pre-installed in Tygon tubing.

The anti-foul cylinders have a useful deployment life in the SBE 21 of approximately 6 months. Sea-Bird recommends that you keep track of how long the cylinders have been deployed, to allow you to purchase and replace the cylinders when needed.

Notes:

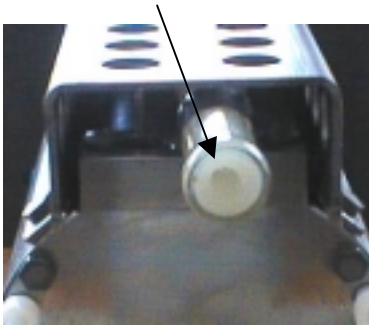
- Please remove the anti-foul assembly from the end of the conductivity cell before returning an SBE 21 to Sea-Bird.
- Store removed anti-foul assemblies in a plastic bag, and keep them in a cool place.

Handling the anti-foul assembly with gloves, follow this procedure to replace each anti-foul cylinder (two):

1. Remove the sensor/electronics module from the SBE 21 water jacket (see *Removing Sensor/Electronics Module from SBE 21* above).
2. Carefully slide the existing anti-foul assembly from the end of the conductivity cell, and replace with the new anti-foul assembly.
3. Replace the sensor/electronics module in the SBE 21 water jacket.

Anti-foul cylinder

Anti-foul assembly consists of anti-foul cylinder in Tygon tubing; tubing slips over end of conductivity cell (both ends)



Sensor Calibration

Notes:
- Please remove anti-foul assemblies from the ends of the conductivity cell before returning an SBE 21 to Sea-Bird. Store removed anti-foul assemblies in a plastic bag, and keep them in a cool place.
- After recalibration, Sea-Bird 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 the Configure menu in SEASAVE or SBE Data Processing.

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 and temperature sensors on the SBE 21 are supplied fully calibrated, with coefficients printed on their respective Calibration Certificates (see back of manual).

We recommend that the SBE 21's sensor/electronics module be returned to Sea-Bird for calibration (see *Removing Sensor/Electronics Module from SBE 21* above).

Conductivity Sensor Calibration

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 sensor be calibrated before and after deployment, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

Temperature Sensor Calibration

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.

Section 8: Troubleshooting

This section reviews common problems in operating the SBE 21, and provides the most common causes and solutions.

Each SBE 21 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.

Problem 1: Unable to Communicate with NMEA Interface Box

The NMEA Interface Box setup message indicates that communications between the NMEA Interface Box and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by typing @ several times.

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

Problem 2: Unable to Communicate with SBE 21

The **S>** prompt indicates that communications between the SBE 21 and computer have been established. Before proceeding with troubleshooting, attempt to establish communications again by clicking the Connect button on SEATERM's toolbar or hitting the Enter key several times.

Cause/Solution 1: The I/O cable connection may be loose. Check the cabling between the SBE 21 and NMEA Interface Box 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 21 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 communication settings entered in SEATERM may not match the dip switch settings in the NMEA Interface Box. Select the SBE 21 in the Configure menu and verify the settings in the Configuration Options dialog box. If necessary, change the communication settings or the dip switch settings.

Cause/Solution 3: The I/O cable connecting the SBE 21 to the NMEA Interface Box may not be the correct one. Verify the cable is the correct one.

Problem 3: No Data Recorded

Cause/Solution 1: The SBE 21's memory may be full; once the memory is full, no further data will be recorded. Verify that the memory is not full using the **DS** command (*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, use the **IL** command to reset the memory. After the memory is reset, the **DS** command will show *samples = 0*.

Problem 4: Nonsense or Unreasonable Data

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

Cause/Solution 1: An uploaded data file with nonsense values may be caused by incorrect instrument configuration in the .con file. Verify the settings in the instrument .con file match the instrument Configuration Sheet.

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

Problem 5: Salinity Lower than Expected

Cause/Solution 1: A fouled conductivity cell will report lower than correct salinity. Large errors in salinity indicate that the cell is extremely dirty, has something large lodged in it, or is broken. Proceed as follows:

1. Clean the conductivity cell as described in *Cleaning and Storage* in *Section 7: Routine Maintenance and Calibration*.
2. Remove larger droplets of water by blowing through the conductivity cell. **Do not use compressed air**, which typically contains oil vapor.
3. Running the SBE 21 in air, collect some data in SEASAVE and look at the raw conductivity frequency. It should be within 1 Hz of the zero conductivity value printed on the conductivity cell Calibration Sheet. If it is significantly different, the cell is probably damaged.

Problem 6: Program Corrupted

Note:
Performing a reset affects the SBE 21's memory.

- Download all data in memory before performing the reset.
- After performing the reset, set the date and time (**ST**) and initialize logging (**IL**). Other setup parameters are unaffected.

Cause/Solution 1: In rare cases, a severe static shock or other problem can corrupt the program that controls the SBE 21's microprocessor. This program can be reset by removing the J1 jumper on the Power PCB. Proceed as follows to initialize:

1. Remove the sensor/electronics module from the water jacket, and remove the electronics from the housing (see *Appendix II: Electronics Disassembly/Reassembly* for details).
2. Remove the J1 jumper from the Power PCB (top board in the PCB assembly). This jumper is used to disconnect the back-up lithium battery from the electronics. Leave the jumper off for several minutes.
3. Reinstall the J1 jumper.
4. Reinstall the electronics in the housing, and replace the sensor/electronics module in the water jacket.
5. Establish communications with the SBE 21 (see *Section 4: Setting Up the SBE 21* for details). Initialize logging with the **IL** command, and set the date and time with the **ST** command. Use the **DS** command to verify that the date and time and sample number are correct.

Glossary

Anti-foul cylinder – Expendable device saturated with a tri-butyl-tin based toxin placed inside Tygon tubing, located at each end of the conductivity cell.

Fouling – Biological growth in the conductivity cell during deployment.

PCB – Printed Circuit Board.

SBE Data Processing – Sea-Bird's WIN 95/98/NT data processing software, which calculates temperature and conductivity, as well as data from auxiliary sensors, and derives variables such as salinity and sound velocity.

Scan – One data sample containing temperature and conductivity, as well as data from auxiliary sensors.

SEACAT – High-accuracy conductivity, temperature, and pressure recorder. The SEACAT is available as the SBE 16*plus* (moored applications), SBE 19*plus* (profiling or moored applications), and SBE 21 (thermosalinograph, no pressure).

SEASAVE – Sea-Bird's WIN 95/98/NT software used to acquire, convert, and display real-time or archived raw data.

SEASOFT-DOS – Sea-Bird's complete DOS software package, which includes software for communication, real-time data acquisition, and data analysis and display. **SEASOFT-DOS also includes NMEA navigation device simulation programs that you can use when troubleshooting problems with NMEA data.** SEASOFT-DOS modules for real-time data acquisition and data analysis are not compatible with the data output format of the SBE 21.

SEASOFT-Win32– Sea-Bird's complete Win 95/98/NT software package, which includes software for communication, real-time data acquisition, and data analysis and display. SEASOFT-Win32 includes **SEATERM**, SeatermAF, **SEASAVE**, **SBE Data Processing**, and PLOT39.

SEATERM – Sea-Bird's Win 95/98/NT terminal program used to communicate with the NMEA Interface Box and SBE 21. SEATERM can send commands to the SBE 21 to provide status display, data acquisition setup, data display and capture, and diagnostic tests.

TCXO – Temperature Compensated Crystal Oscillator.

Triton X-100 – Concentrated liquid non-ionic detergent, used for cleaning the conductivity cell.

Appendix I: Functional Description

Sensors

The SBE 21 embodies the same sensor elements (3-electrode, 2-terminal, borosilicate glass cell and pressure-protected thermistor) previously employed in Sea-Bird's modular SBE 3 and SBE 4 sensors and in the original SEACAT design. The current version of the SBE 21 differs from older versions of the SBE 21 in that it uses two independent channels to digitize temperature and conductivity concurrently. Multiplexing is not used for these channels.

Sensor Interface

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

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

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 12-bit A/D converter.

Real-Time Clock

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

Power

The Power PCB contains three series-connected lithium cells (1/2 AA non-hazardous) which are diode OR'd with the external power source. The lithium supply is capable of supporting all SBE 21 functions and serves to permit orderly shutdown in the event of failure or removal of external power. External power can be removed without disturbing memory or the real-time clock.

Appendix II: Electronics Disassembly/Reassembly

Note:
Do not disassemble the SBE 21 electronics to send the sensors or PCBs to Sea-Bird for recalibration or repair. Package the sensor/electronics module for shipment, after removing the anti-foul cylinders (see *Section 7: Routine Maintenance and Calibration*).

Do not disassemble the SBE 21 electronics unless you are troubleshooting a problem, and need to access the PCBs.

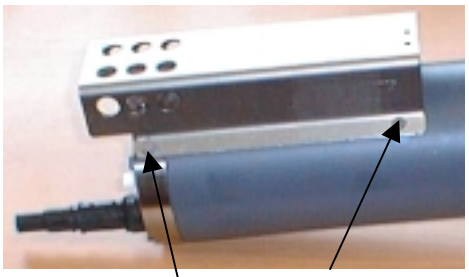
Sea-Bird provides a jackscrew kit with the SBE 21, to assist in removal of the electronics end cap. The kit contains:

- 2 Allen wrenches
- 3 jackscrews

Jackscrew kit

Disassembly

1. As a precaution, upload any data in memory before beginning. See *Uploading Data from Memory* in *Section 6: Operating the System* for details.



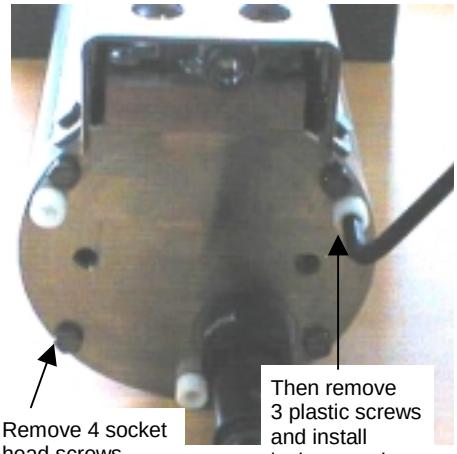
Do not remove socket head screw attaching guard to sensor end cap (2 places)

Remove slotted head screw (2 places)

2. Remove the SBE 21 sensor/electronics module from the water jacket, as described in *Removing Sensor/Electronics Module from SBE 21 Water Jacket* in *Section 7: Routine Maintenance and Calibration*.

3. Remove the 2 slotted head screws securing the sensor guard to the housing. **Do not remove the 2 screws holding the conductivity cell guard to the sensor end cap.**

4. Remove the sensor end cap (with attached conductivity cell and cell guard) and electronics as follows:



Remove 4 socket head screws

Then remove 3 plastic screws and install jackscrews in their place

   A. Wipe the outside of the sensor end cap and housing dry, being careful to remove any water at the seam between them.
   B. Remove the 4 socket head screws securing the end cap to the housing.
   C. Remove the 3 plastic hex head screws from the end cap using the larger Allen wrench. Insert the three jackscrews in these three holes in the end cap. When you begin to feel resistance, use the smaller Allen wrench to continue turning the screws. Turn each screw 1/2 turn at a time. As you turn the jackscrews, the end cap will push away from the housing.
   D. When the end cap is loosened, carefully slide the end cap and attached electronics out of the housing.
   E. Remove any water from the o-rings and mating surfaces inside the housing with a lint-free cloth or tissue.
   F. Disconnect the Molex connectors connecting the PCB assembly to the housing.
   G. Be careful to protect the o-rings from damage or contamination.

CAUTION:
Avoid getting anything on the PCB, which can be damaged by water or other materials.

Reassembly

Note:
Before delivery, a desiccant package is placed in the housing, and the housing is filled with dry Argon. These measures help prevent condensation. **If the electronics are exposed to the atmosphere for more than an hour, allow the desiccating process to continue inside the reassembled housing for one week before performing calibrations or other critical work. If this is not done, conductivity readings may be in error by as much as 0.001 S/m.**

1. 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 as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to O-rings and mating surfaces.

2. Reconnect the Molex connectors to the PCB assembly.

3. Carefully fit the PCB assembly into the housing, aligning the holes in the end cap and housing, and the holes in the conductivity cell guard and housing.

4. Reinstall the 4 socket head screws to secure the end cap to the housing.

5. Reinstall the 3 plastic screws in the end cap.

6. Reinstall the 2 slotted screws to secure the conductivity cell guard to the housing.

Appendix III: Command Summary

CATEGORY	COMMAND	DESCRIPTION
Status	**DS**	Display status and setup parameters.
Setup	**ST**	Set real-time clock date and time.
	BAUD=x	**x=** baud rate (1200, 2400, 4800, 9600, 19200, or 38400). Default 9600.
	SBE38=x	**x=Y**: Sample SBE 38 secondary temperature sensor. **x=N**: Do not.
	SBE3=x	**x=Y**: Sample SBE 3 secondary temperature sensor. **x=N**: Do not.
	SVx	**x=0, 1, 2, 3, or 4**: Sample 0, 1, 2, 3, or 4 external voltages.
	Fx	**x=1**: output raw data in SBE 21 format. **x=2**: output raw data in SBE 16 format.
	FLASHINIT	Map bad blocks and erase FLASH memory, **which destroys all data in SBE 21**.
	QS	Enter quiescent (sleep) state.
Logging	**SI**	Set interval (seconds) between sample averages (3 - 600 seconds). SBE 21 takes as many samples as possible (each 0.25 seconds apart) during this interval, and then averages samples.
	IL	After all previous data has been uploaded, send this command before starting to log to make entire memory available for recording. If not sent, data stored after last sample. Equivalent to **SAMPLENUMBER=0** command.
	SAMPLENUMBER=x	**x=** sample number for first sample when logging begins. After all previous data has been uploaded, set to 0 before starting to log to make entire memory available for recording. If not reset to 0, data stored after last sample. Equivalent to **IL** command.
	HEADERNUMBER=x	**x**= header number for first header when logging begins.
	GL	Start logging now. SBE 21 starts logging at beginning of memory, overwriting any samples already in memory.
	RL	Resume logging now, placing data in memory *after* last sample (SBE 21 does not overwrite any samples in memory).
	AUTORUN=x	**x=Y:** Automatically start logging when power applied. **x=N:** Do not automatically start logging when power applied.
	QL	Stop logging. Press Enter key to get **S>** prompt before entering command. Must stop logging before uploading data.
Data Upload	**DDb,e**	Upload data beginning with scan b, ending with scan e. Stop logging before sending this command.
	DH	Upload all headers. Stop logging before sending this command.
Sampling	**SS**	Output last sample from buffer.
	TS	Take sample, store data in buffer, output data.

Note:
Use the Upload button 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 in the correct format for processing by SBE Data Processing.

CATEGORY	COMMAND	DESCRIPTION
Diagnostics Outputs 100 samples for each test; data not stored in FLASH memory. Press Esc key or Stop button to stop test.	**FR**	Display frequencies: raw temperature A/D counts, raw conductivity frequency, temperature frequency converted to match older SBE 21 (firmware version < 4.0), conductivity frequency converted to match older SBE 21 (firmware version < 4.0), and external frequency.
	VR	Display external voltages with offset and scale factors applied: external voltage 0, 1, 2, and 3; and diagnostics for factory use.
	T38	Display output from SBE 38 remote temperature sensor.
Coefficients Calibration coefficients for conductivity and primary temperature sensor, and for auxiliary sensors, are stored in (.con) file. View and/or modify coefficients using Configure menu in SEASAVE or SBE Data Processing.	**DCAL**	Display calibration coefficients: voltage channel offsets and slopes, conductivity zero frequency, and external frequency scale factor for SBE 3 remote temperature sensor.

Appendix IV: Replacement Parts

Part Number	Part	Application Description	Quantity in SBE 21
24012	Anti-foul attachments (2)	Anti-foul cylinder in short section of Tygon tubing, for placement at ends of conductivity cell	2
30200	Bolt, 3/8-16 x 3 3/4 Hex, stainless steel	Secures square end cap to SBE 21 top plate	4
30210	Nut, 3/8-16 nylon stop, stainless steel	Use with 30200	4
30257	Washer, 3/8 flat, stainless steel, 7/8 OD max	Use with 30200	8
30092	O-ring, Parker 2-363N674-70	O-ring between SBE 21 top plate and square end cap	1
30444	Bolt, 10-24 x 1/2 hex head, titanium	Attaches conductivity cell guard to sensor/electronics module end cap	2
30491	Machine screw, 8-32 x 5/16 slot, titanium	Attaches conductivity cell guard to sensor/electronics module housing	2
30493	Machine screw, 10-24 x 1 1/4 hex head, titanium	Attaches sensor/electronics module end cap to housing	4
30815	O-ring, Parker 2-233E603-70	Seal for sensor/electronics module end cap	1
50091	Triton X-100	Conductivity cell cleaning solution	1
80438	4-pin I/O cable (10 m)	From SBE 21 to NMEA Interface Box	1
50298	Spare hardware/ O-ring kit for SBE 21 compatible with SBE 38 remote temperature sensor	Assorted hardware and O-rings	-
50107	Spare hardware/ O-ring kit for SBE 21 compatible with SBE 3 remote temperature sensor	Assorted hardware and O-rings	-

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