

# **SBE 21**

# **SEACAT THERMOSALINOGRAPH**

# **OPERATING MANUAL**

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## SBE 21 Manual Addendum (Commands for Firmware Version 4.0a and Later)

Sea-Bird has upgraded the electronics and firmware for the SBE 21. These modifications resulted in changes that have not yet been incorporated in the manual (version 21.10). Use the information in the manual to set up and operate the SBE 21, with the following exceptions:

- Standard memory is now 8 Mb FLASH RAM
- Optional ability to use SBE 38 (RS-232) in place of SBE 3 as remote temperature sensor was added.  
Note: If using SBE 38, set up SBE 21 configuration (.con) file as if using SBE 3, and enter the following values for the calibration coefficients:  $G = 4.0e-3$ ,  $H = 2.0e-4$ ,  $I = 0$ ,  $J = 0$ , and  $f_0 = 1000$ .
- Some commands used to set up and operate SBE 21 are changed. Listed below are -
  - Commands identical to older SBE 21 firmware (refer to manual for details)
  - Commands in older SBE 21 firmware that are no longer valid (cross out in manual)
  - New commands or commands with revised output

### Commands identical to older SBE 21 firmware (refer to manual for details)

Type	Command	Command Description
Status	Ds	Display status.
	Qs	Quit session (quiescent power).
Setup	St	Set date and time.
	Si	Set sample interval.
	Sv	Set number of external voltages to record.
	F1	Set real-time data output format to SBE 21.
	F2	Set real-time data output format to SBE 16.
Logging	Gl	Start logging data.
	Rl	Resume logging data.
	Ql	Quit logging data.
Data Retrieval	Dd	Upload data in raw format.
	Dh	Upload headers.
	Ss	Send last recorded sample.
	Ts	Take sample, send results (do not store in memory).

### Commands in older SBE 21 firmware that are no longer valid (cross out in manual)

Type	Command	Command Description	Comments
Diagnostic	Fr	Display corrected and uncorrected frequencies	Command still available but output changed; see fr command in new command list below.
	J	Measure standby current	Feature no longer available.
	Tm	Extended memory test	Feature no longer available.
	Tm	Memory test	Feature no longer available.
	Vr	Display voltages	Command still available but output changed; see vr command in new command list below.
Setup	Ir	Initialize RAM	Replaced by flashinit command in new command list below.
	Lw	Set number of msec to wait after each line	Feature no longer available - was typically needed for really old computers.
	Xy and Xn	Enable and disable external temperature option	Replaced by sbe3= and sbe38= commands in new command set below.
	Ti	Enter start times and sample interval lengths (allowed multiple start times with different sample intervals)	Feature no longer available.
	Wh	Write header	Feature no longer available. SEATERM software allows you to add a header when uploading data from SBE 21, so this command is not needed.

## New Commands or Commands with Revised Output

Type	Command	Command Description
<b>Diagnostic</b> (Take and output 100 samples; data not stored in memory. Press Esc key or Stop to stop test)	<b>Fr</b>	Display frequencies: <u>Column</u> <u>Output</u> 1            raw temperature A/D counts 2            raw conductivity 3            converted temperature 4            converted conductivity frequency 5            external frequency (if SBE 3 remote temperature sensor installed)
	<b>Vr</b>	Display four external voltages with offset and scale factors applied.
	<b>T38</b>	Display output from SBE 38 remote temperature sensor.
<b>Setup</b>	<b>Sbe3=x</b>	x=Y: measure SBE 3 remote temperature. x=N: do not.
	<b>Sbe38=x</b>	x=Y: measure SBE 38 remote temperature. x=N: do not.
	<b>Autorun=x</b>	x=Y: automatically start sampling when power applied. x=N: do not.
	<b>Baud=x</b>	x=baud rate (600, 100, 2400, 4800, 9600, 19200, or 38400).
	<b>Il</b>	Initialize logging - after all previous data has been uploaded from SBE 21's memory, 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. If these are not set to 0, data will be stored after last recorded sample if you send gl command. Do not send il until existing data has been uploaded.
	<b>Samplenumber=x</b>	x= sample number for first sample when logging begins. Typically only used to recover data if you accidentally initialize logging (using il) before uploading existing data.
	<b>Headernumber=x</b>	x= header number for when logging begins. Typically only used to recover data if you accidentally initialize logging (using il or samplenumber=0) before uploading existing data.
<b>Calibration</b> (Entered at factory; F=floating point number)	<b>Dcal</b>	Display calibration coefficients.
	<b>Cf0=F</b>	F=raw conductivity <i>zero</i> frequency.
	<b>Extfreqsf=F</b>	F=external frequency (SBE 3 remote temperature sensor) scale factor.
	<b>Voffset0=F</b>	F=voltage 0 offset.
	<b>Voffset1=F</b>	F=voltage 1 offset.
	<b>Voffset2=F</b>	F=voltage 2 offset.
	<b>Voffset3=F</b>	F=voltage 3 offset.
	<b>Vslope0=F</b>	F=voltage 0 slope.
	<b>Vslope1=F</b>	F=voltage 1 slope.
	<b>Vslope2=F</b>	F=voltage 2 slope.
<b>Vslope3=F</b>	F=voltage 3 slope.	

### Note:

When logging, enter <Ctrl-Z> followed by <Enter> to get the command prompt (S>).

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vers. 21.10

This manual is intended to be used with SBE 21 Thermosalinographs with titanium end caps and cell trays and that have firmware versions 3.1i or greater.

## 1.0 INTRODUCTION

The SEACAT Thermosalinograph (SBE 21) is designed for shipboard determination of sea surface (pumped-water) temperature and salinity at high levels of accuracy and resolution. Data is simultaneously transmitted to a computer's serial port and stored in memory allowing both real time data acquisition and independent data logging. The sampling interval is software selectable from once each 5 seconds to once each 18 hours. An optically-isolated junction box with NMEA 0183 input port connects the SBE 21 to the user's computer and provides power to the SBE 21. An internal lithium back-up battery supports memory and the real time clock whenever the main power supply is off. Navigation data from a GPS receiver in NMEA 0183 format can be acquired by the junction box.

The SBE 21 comes standard with the capability to record the output of a remote temperature sensor (Model SBE 3S). Further information on this feature is contained in section 3.3.

The SBE 21 includes an auxiliary A/D converter which is capable of recording up to four single ended or two differential 0 to 5 volt DC analog signals from auxiliary sensors (e.g. fluorometer). Additional information on this can be found in section 3.4.

Sea-Bird's SEASOFT software package is supplied with the SBE 21, and provides for the display and logging of real time data, and display, analysis, and conversion to ASCII format of archived data. Detailed information on the operation and setup of the SEASOFT program modules is contained in the separate SEASOFT manual that was supplied with your SBE 21.

## 2.0 INSTALLATION AND CHECK OUT PROCEDURES

Before plumbing the Thermosalinograph into the ship's saltwater system, the electrical and operating characteristics can be confirmed using the cables supplied, and with the water jacket dry. Figure 1 shows the interconnections between the various elements that comprise the Thermosalinograph system. If the Sea-Bird supplied software is to be used to communicate with and record data from the SBE 21 it will be necessary to install this software on the IBM personal computer XT/AT/386/486 or compatible being used for this purpose (see SEASOFT software manual).

Once data logging is initiated the SBE 21 both stores the data in its internal memory and sends the data real time over its RS-232C serial interface. If a dedicated computer is available, the SEASAVE program can be used to display and record the real time data. Otherwise a computer can be periodically connected to the SBE 21 and the stored data uploaded to a disk file. The terminal program TERM1621 is used to communicate with the SBE 21 to initiate data logging, retrieve stored data and for instrument setup. The program SEASAVE is used to display and record real time data and to display archived data. Consult section 3 and the SEASOFT manual for additional instructions concerning the installation and operation of this software.

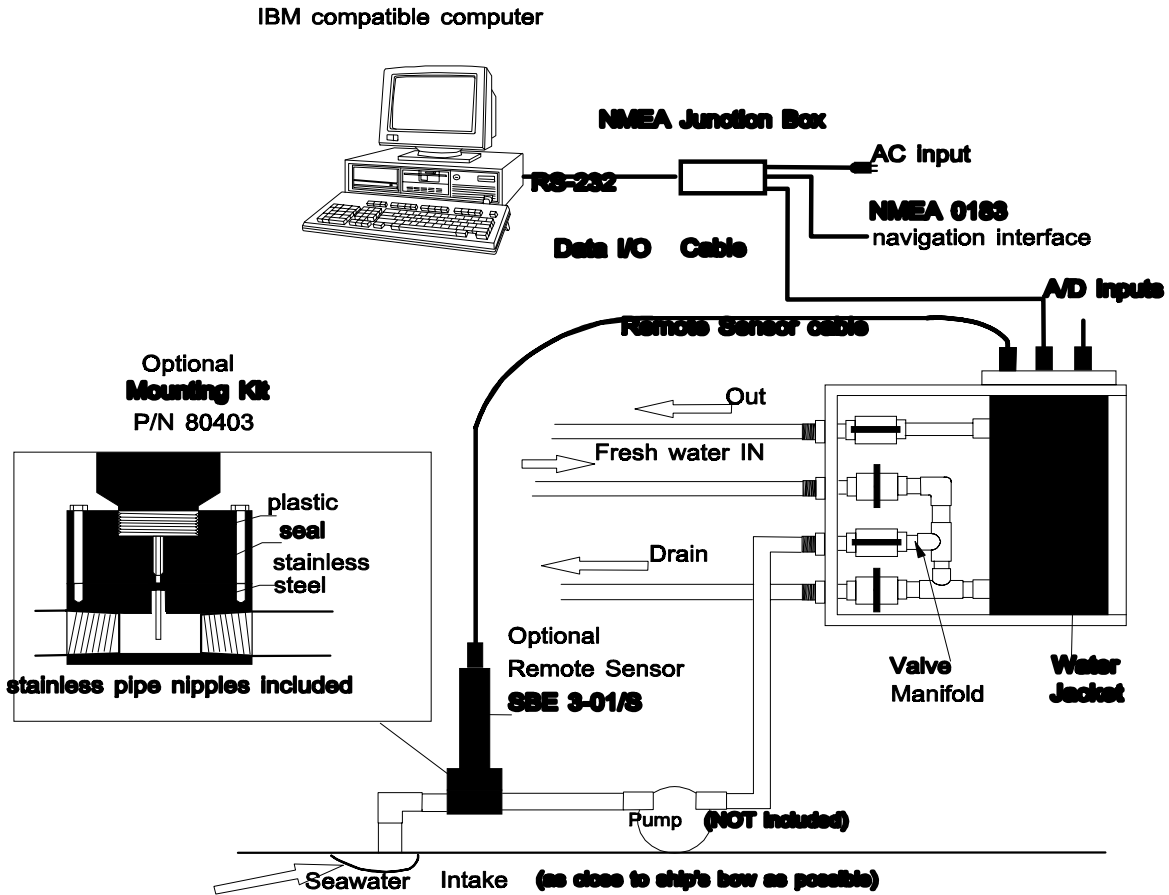


Figure 1. Installation diagram of the SBE 21 Thermosalinograph showing connections between the various components of the system.

## 2.1 ELECTRICAL PRE-CHECK

For electrical check-out, connect the 4-pin molded connector on the Water Jacket Assembly to the NMEA junction box using the neoprene-jacketed RMG-4FS to MS cable. Connect the junction box to your computer's serial port using the DB-25S/DB-25P cable (use the DB25/DB9 adapter with laptop or 'AT' computers).

Connect the junction box to an appropriate source of AC mains power (see section 2.4.1). The program TERM1621 should be run to establish communications with the SBE 21. The display of the **S>** prompt indicates that proper communications have been established and that the SBE 21 is waiting for user input. (See SEASOFT software manual for operation of TERM1621 terminal program.)

Section 3.1 contains information on the commands used to setup, initiate logging and retrieve data from the SBE 21 using TERM1621.

## 2.2 MECHANICAL PRE-CHECK

The electronics and sensor housing is permanently attached to the water jacket end cap. The end cap seals to the main thermosalinograph assembly with 4 machine bolts. To disassemble the unit the machine bolts are removed and the end cap is lifted free of the main water jacket assembly. This procedure may be used to clean the thermosalinograph, or to re-calibrate and repair the electronics/sensor module. Figure 2 shows the electronics and sensor module removed from the water jacket assembly. The antifoul cylinders were installed at the factory and should protect the conductivity cell from excessive biological fouling for six months or more.

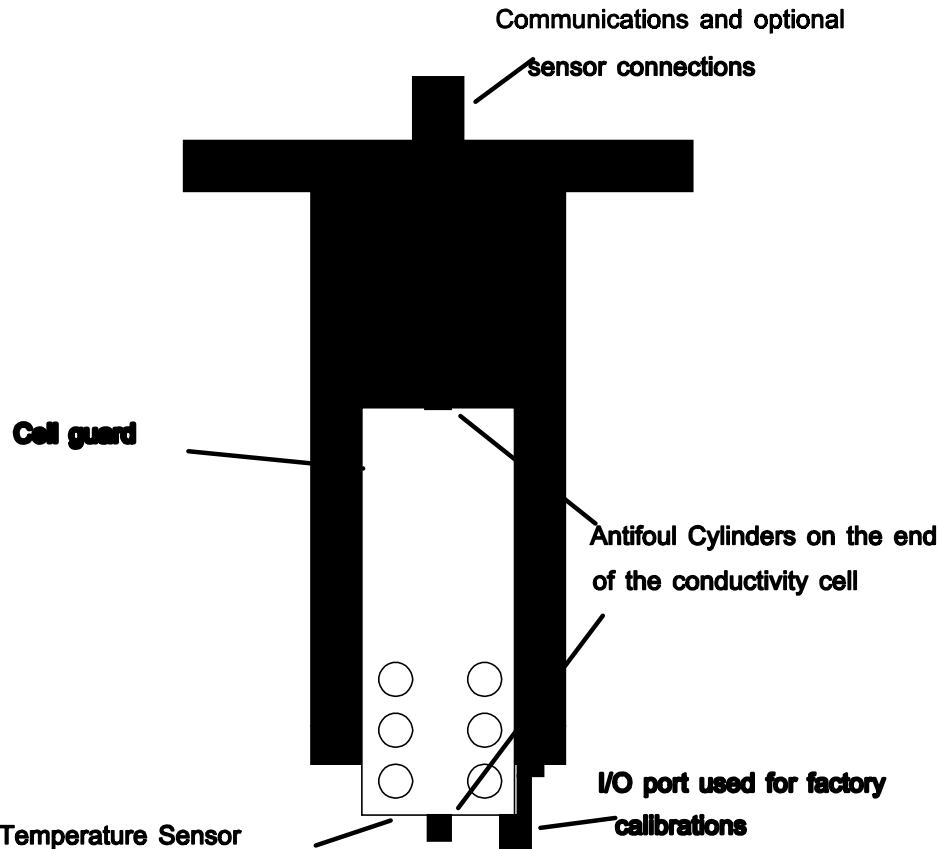


Figure 2. The electronics and sensor module shown removed from the water jacket assembly

## 2.3 MECHANICAL INSTALLATION and OPERATION

**CAUTION - THE WATER JACKET HAS A 50 PSI ( $3.45 \times 10^5 \text{ N-m}^{-2}$ ) INTERNAL PRESSURE LIMIT!**

Drill the PVC base or back plate to mount to the ship using machine bolts; the electrical bulkhead connectors should be up. When mounting the thermosalinograph, provide clearance for removal of the electronics/sensor module and for cleaning of the main assembly.

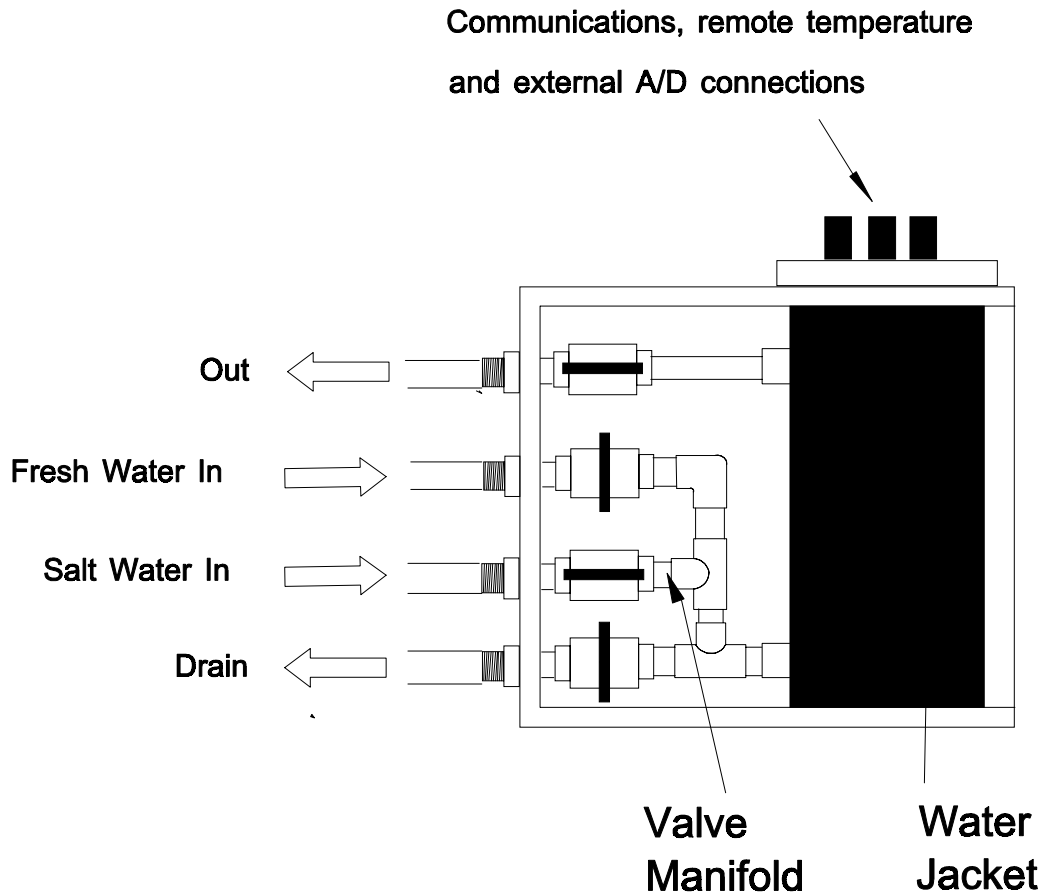


Figure 3. Plumbing connections for the SBE 21 Thermosalinograph

The water connections to the thermosalinograph are PVC pipes with 1 inch 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.

Connect the OUT fitting to shipboard drain or to low pressure side of salt water supply.

Connect SALT WATER IN fitting to shipboard sea surface water intake line.

Connect FRESH WATER IN fitting to shipboard fresh water supply.

Connect DRAIN fitting to shipboard drain (optional).

The valves are open when their handles are horizontal, and closed when vertical. For **normal** use, the valves should be set as follows:

OUT	Open
FRESH WATER IN	Closed
SALT WATER IN	Open
DRAIN	Closed

For **fresh water flushing** prior to periods of non-use, set the valves as follows:

OUT	Open
FRESH WATER IN	Open
SALT WATER IN	Closed
DRAIN	Closed

For **storage, cleaning, or during removal of the electronics/sensor module**, set the valves as follows:

OUT	Closed
FRESH WATER IN	Closed
SALT WATER IN	Closed
DRAIN	Closed

## 2.4 ELECTRICAL INSTALLATION

The electrical installation of the SBE 21 involves connecting the Thermosalinograph to

1. the NMEA junction box which provides power and optical isolation of the data signals
2. the external temperature sensor if it is being used
3. any additional auxiliary sensors that are being recorded with the A/D converter.

In addition the NMEA junction box must be connected to the computer being used with the SBE 21.

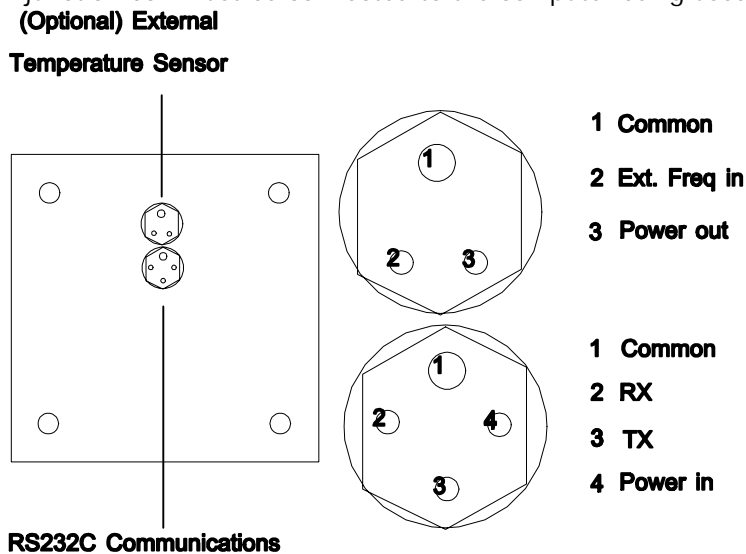


Figure 4a. Electrical connections for the SBE 21 without the A/D converter option installed.

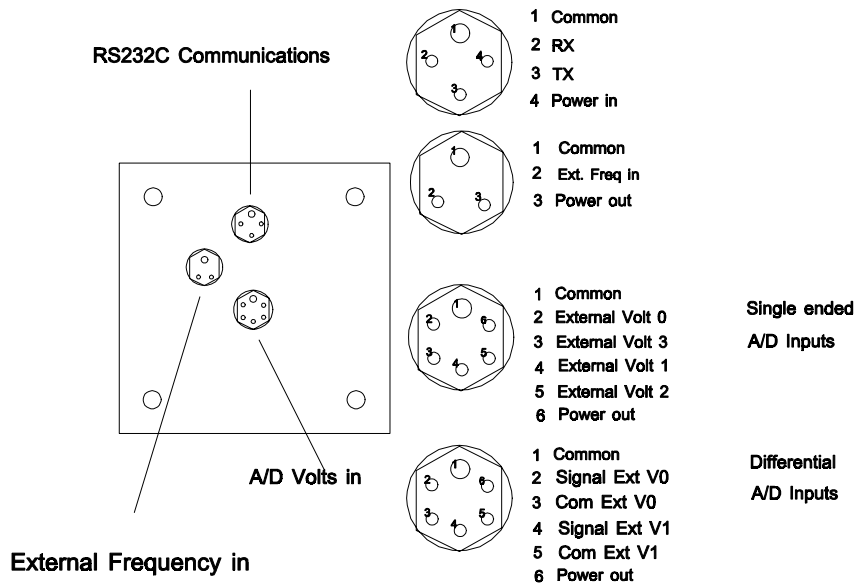


Figure 4b. Electrical connections for the SBE 21 with the A/D converter option installed.

### 2.4.1 INSTALLATION WITH SBE SUPPLIED CABLING

The SBE 21 is shipped with complete cabling to interconnect the system components. The standard cable supplied to connect the SBE 21 and junction box is 10 meters in length. Section 2.4.2 contains detailed information on interfacing the SBE 21 to another cable that is longer or already in place.

Connect the system with the cables supplied by Sea-Bird, as follows:

1. Connect the 4-pin underwater connector on the 10 meter cable to the 4-pin I/O bulkhead connector on the SBE 21. Mate the rubber cable connector, aligning the raised bump on the side of the connector with the large pin on the I/O bulkhead connector. Thread the locking sleeve into place. Connect the MS style metal shell connector on the other end of this cable to the junction box.
2. Connect the junction box to the computer using the DB25 jumper cable provided.
3. Using the UL/IEC approved power cord supplied, plug the junction box into a standard 3-prong grounded AC outlet. The junction box operates at 85 - 270 VAC.
4. Refer to the "NMEA Section" of this manual for connection and NMEA setup instructions.
5. The remote temperature sensor and other sensors that are using the 0 to 5 volt A/D inputs should be connected to the appropriate connector on the SBE 21 if data from these sensors are to be recorded.
6. Confirm communications, diagnostics and logging as described in section 3.1.

## 2.4.2 INSTALLATION WITH PRE-EXISTING SHIPS CABLING

If cable previously installed in the ship is going to be used to connect the SBE 21 to the NMEA junction box, the standard 10 meter cable (PN 80438) provided with the SBE 21 can be cut and spliced into the ship's cable. Refer to the Drawings Section, drawing number 31063.

1. Connect the 4-pin underwater connector on the 10 meter cable to the 4-pin I/O bulkhead connector on the SBE 21. Mate the rubber cable connector, aligning the raised bump on the side of the connector with the large pin on the I/O bulkhead connector. Thread the locking sleeve into place. Connect the MS style metal shell connector on the other end of this cable to the junction box.

2. Splice the leads from the rubber connector to the shipboard cable run leading to the computer location. This 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.

3. Locate the junction box near the computer position. Make sure that the wiring continuity is maintained up to the junction box as per drawing number 31063.

4. Connect the junction box to your computer's serial port using the DB-25 jumper cable supplied. The cable wiring is as follows:

DB-25P	DB-25S	DB-9S (optional)
2	2	3
3	3	2
7	7	5

5. Using the UL/IEC approved power cord supplied, plug the junction box into a standard 3-prong grounded AC outlet. The junction box operates at any AC voltage between 85 - 270 VAC.

6. The remote temperature sensor and other sensors that are using the 0 to 5 volt A/D inputs should be connected to the appropriate connector on the SBE 21 if data from these sensors are to be recorded.

7. Confirm communications, diagnostics, and logging as described in Section 3.1.

## 3.0 OPERATION

Sea-Bird's software package SEASOFT was supplied with the SBE 21. This collection of software programs is designed to be used with the family of Sea-Bird products and contains the necessary programs to communicate with and acquire data from the SBE 21. There are also programs to display and perform advanced analysis on the data. SEASOFT is designed to be run on IBM XT/AT/386/486 computers or compatible. Section 3.1 contains a discussion on the use of the SBE 21 with SEASOFT.

**IMPORTANT NOTE: ALWAYS stop logging with the QL command, and then send the QS command, BEFORE switching power off. Failure to do so will cause rapid exhaustion of the lithium back up battery.**

It is also possible to acquire and analyze the data using software written by the user. Section 3.2 contains additional information on interfacing a computer and software to the SBE 21.

### 3.1 OPERATION WITH SEASOFT SOFTWARE

The SEASOFT software should be installed on the IBM PC or compatible computer following the instructions in the SEASOFT manual.

The SEASOFT module TERM1621 is the program that is used to communicate with the SBE 21 to perform diagnostics, to initiate or terminate data logging and to retrieve data stored in the SBE 21's memory. This program uses a configuration file, TERM1621.CFG, to store information concerning the baud rate, communications port number and other set up parameters needed to establish communications with the SBE 21. The settings in the configuration file can be viewed and changed if needed by using the F2 function key while in the main TERM1621 screen.

The program SEASAVE is used to acquire and display real time data from the SBE 21 and to display archived data. SEASAVE uses a file, SEASOFT.CON, to determine the instrument configuration and the calibration coefficients for the SBE 21. A correctly configured copy of this file was supplied with the SEASOFT software. The SEASOFT.CON file can be accessed and modified using the SEACON program.

What follows is a brief summary of the important steps that need to be taken to communicate with and acquire data from the SBE 21. Detailed information concerning the software modules are contained in the SEASOFT manual. A complete description of the commands that are used to set up, start and stop logging, and perform diagnostics with the SBE 21 are contained in section 3.2 of this manual.

#### 3.1.1 ESTABLISHING COMMUNICATIONS

Connect the junction box to the SBE 21 and to the computer RS232C communications port. Apply power to the junction box and run the TERM1621 program. The program will attempt to establish communications with the SBE 21 and will indicate success by displaying the 'established communications' message on the screen. When the SBE 21 is active it will return the **S>** prompt whenever the enter key is pressed. At this point the SBE 21 is waiting for a command.

#### 3.1.2 BASIC COMMANDS

The following is a list of the basic commands needed to setup, control logging and retrieve archived data from the SBE 21. Section 3.2 contains complete descriptions of these and the other commands that are used to control the functions of the SBE 21. The carriage return or enter key is designated by (CR) and user entries are in [highlighted text](#).

##### ST SET DATE AND TIME

Example:

**S>** [st\(CR\)](#) The SBE 21 will prompt for the date and time

**date** (MMDDYY) = [040687\(CR\)](#)

**time** (HHMMSS) = [081030\(CR\)](#)

The date is set to April 6, 1987. The time is set to 08:10:30.

## DS DISPLAY STATUS

Example:

S> ds(CR) The SBE 21 will send:

```
SEACAT THERMOSALINOGRAPH V3.1i SERIAL NO. 625 01/27/94 14:04:48.258
SEIKOFREQ = 2097152.0 R400 = 399.840 R5000 = 4975.124
clk = 32768.000 iop = 108 vmain = 10.4 vlith = 5.6
samples = 0 free = 31976 lwait = 0 msec
sample interval = 10 sec
```

```
SW1 = 41H, no. of volts sampled = 0
output format = SBE21
logdata = NO
```

## SI SET RECORDING INTERVAL (SCAN RATE)

Example:

S> si(CR) The SBE 21 will prompt:

sample interval (seconds) = 15(CR)

sample interval = 15 sec

interval ok (y/n) ? = y(CR) Enter 'y' to accept the interval, any other response will allow

The sample interval is set to 15 seconds. Data logging will start 30 seconds after the GL or RL command is entered. The minimum sample interval is 5 seconds if the remote temperature option is not enabled and 6 seconds if it is enabled.

## GL START (GO) LOGGING

This command will start logging data at the beginning of the memory; any previously recorded data will be written over.

Example:

S> gl(CR) The SBE 21 will prompt:

start Logging Y/N ? y(CR)

are you sure ^Y/N ? hold down the control key and press the y key in response to this prompt

sample interval = 15 sec

sample interval ok Y/N ? y(CR)

start data logging

no samples stored yet no data transmitted on first scan

B11303DC real time data in SBE 21 format, no external voltages and

B0EA03DC no remote temperature being recorded

If the sample interval has been set for 15 seconds, the first data (a line of ASCII HEX characters) will appear 30 seconds after the GL command. Subsequent scans will appear at 15 second intervals.

**NOTE:** The real-time HEX data transmitted over the RS-232C link represents data from the **previous** scan. See section 3.5 for the HEX data format. For example; if the sample interval is 10 seconds:

<b>time</b>	<b>action</b>
0 sec	gl (go log command is entered)
10 sec	first sample is acquired
20 sec	second sample is acquired, first sample is displayed
30 sec	third sample is acquired, second sample is displayed, etc.

## **QL QUIT LOGGING**

Example:

```
S> ql(CR)           The SBE 21 will prompt:  
quit Logging Y/N ? y(CR)  
are you sure ^Y/N ? hold down the control key and press the y key in response to this prompt
```

### **3.1.3 REAL-TIME DATA DISPLAY AND COMPUTER DATA LOGGING**

Whenever the SBE 21 takes a data sample it both places the previous sample into a memory location, and transmits it via the RS-232C serial interface. If a computer is available to be dedicated to receiving this data over the serial interface, the SEASAVE program can be used to display and log this data to a disk file in real time.

The SBE 21 must be commanded to begin logging data before the SEASAVE program is started. Establish communications with the SBE 21 using the TERM1621 program, set the sample interval with the SI command and initiate data logging with the GL command.

After data logging has begun, run the SEASAVE program and chose the 'Display Real-Time Data' option in the main menu. Configure the display type and variables. Since SEASAVE is to receive data from the SBE 21 the communications port must be configured correctly. Select the miscellaneous run parameters form in the SEASAVE menu. In this form is a 'COMM Port Configuration' form which should be selected and modified as necessary. The standard communications set up for a SBE 21 Thermosalinograph is 9600 baud, 7 data bits, even parity. Once the set up is complete, function key F10 is used to start real-time data acquisition and display, and optionally, data logging to a disk file.

### **3.1.4 LOGGING DATA IN SBE 21 MEMORY**

Run the TERM1621 program and establish communications with the SBE 21. Set the sample interval with the SI command and enter header information if desired with the WH command. Verify the set up parameters with the DS command and then initiate data logging with either the GL or RL commands. The SBE 21 will then begin to acquire data and both store it in internal memory and sent it out real time via the RS232C interface. Once memory has been filled data logging will continue but no additional data will be written to memory.

### 3.1.5 DATA RETRIEVAL USING SEASOFT

The procedure for logging data described in Section 3.1.4 should have been previously implemented, and sufficient time to acquire several samples elapsed. If a floppy disk is to be used to acquire SBE 21 data, the disk must be formatted.

Run the TERM1621 program and establish communications with the SBE 21. While the unit is logging data only the QL, and DS command are accepted. You should see HEX data appear on the screen at sample interval previously set by the SI command. Enter the QL command to terminate logging data:

**IMPORTANT NOTE: ALWAYS stop logging with the QL command, and then send the QS command, BEFORE switching power off. Failure to do so will cause rapid exhaustion of the lithium back up battery.**

```
S> ql(CR)                quit logging data
quit logging Y/N ? y(CR)    enter y(CR)
are you sure ^Y/N ?         enter control y

S> ds(CR)                display status, note the number of samples recorded
```

```
SEACAT THERMOSALINOGRAPH V3.1i SERIAL NO. 625    01/27/94 14:04:48.258
SEIKOFREQ = 2097152.0  R400 = 399.840  R5000 = 4975.124
clk = 32768.000  iop = 108  vmain = 10.4  vlith = 5.6
samples = 0  free = 31976  lwait = 0 msec
sample interval = 6 sec
SW1 = 41H, no. of volts sampled = 0
output format = SBE21
logdata = NO
```

Use the function key F2 to verify the data upload and communications set up parameters. Then use the function key F9 to upload the data into the specified file. This file (with an extension of \*.HEX) will contain data in hexadecimal format as it is stored in the SBE 21 memory. The data in this file can be viewed using the SEASAVE program (display archived data). A file containing engineering unit parameters (temperature and salinity) can be created from the \*.HEX file with the DATCNV program (see SEASOFT manual).

### 3.2 NON-SEASOFT INTERFACING TO THE SBE 21

This section discusses the interfacing and command protocol required when interfacing the SBE 21 to non-IBM PC/compatible computers, or when using software other than SEASOFT.

Connect the 4-pin communications connector on the SBE 21 to the junction box using the neoprene-jacketed cable (RMG-4FS to MS) supplied. Connect the junction box to your computer's serial port using the DB-25P to DB-25S (use the DB-25P to DB-9S adapter supplied with the SBE 21 if using a laptop or 'AT' type computer). Connect the junction box to a suitable source of mains power. Turn on the junction box by pressing the red power switch; the switch should light up.

Any computer equipped with a 9600 baud serial port may be used to program, upload data, and perform diagnostics on the SBE 21. SBE 21 is factory configured for: 9600 BAUD, 7 Data Bits, 1 Stop Bit, Even Parity. A terminal (or computer running a terminal emulation routine other than the TERM1621 program supplied by Sea-Bird) using this protocol may be used to communicate with the SBE 21.

There are 25 commands that are used to control the functions of the SBE 21. Table 3.1 is a summary of these commands.

Table 3.1 Summary of SBE 21 commands.

Type	Command	Description
Diagnostic	FR	Display corrected and uncorrected frequencies
	VR	Display voltages
	TM	Memory test
	TE	Extended memory test
	J	Measure standby current
Status	DS	Display status
	QS	Quit session
Set-Up	ST	Set date and time
	IR	Initialize ram
	WH	Write header
	SI	Set sample Interval
	TI	Enter start times and sample interval lengths
	LW	Set number of msec to wait after each line (LW0 sets delay to 0)
	SV	Set the number of external voltages to record
	XY	Enable the external temperature option
	XN	Disable the external temperature option
	F1	set real time data output format to SBE 21
F2	set real time data output format to SBE 16	
Logging	GL	Start logging data
	RL	Resume logging data
	QL	Quit logging data
Data Retrieval	DD	Display data in raw format
	DH	Display headers
	SS	Send last recorded sample
	TS	Take sample and send results

### 3.2.1 COMMAND FORMAT

Commands to the SBE 21 may be entered in upper or lower case letters. Responses made by the SBE 21 are indicated in **bold** type and user entries are in highlighted text. The SBE 21 will send # whenever an invalid command is entered.

The following table describes the keyboard symbols used in this manual:

Symbol	Description	ASCII	HEX	Key Sequence
(CR)	Carriage Return	CR	0D	Return
^	Control Key	--	--	Ctrl
^C	Escape Function	ETX	03	Ctrl + C <u>or</u>
^C	Escape Function	ESC	1B	Esc

When running TERM1621 the Esc Key must be used to perform the Escape Function.

The SBE 21 will send ^C whenever an Escape Function is received and the SBE 21 is in terminal mode.

\* Commands followed by \* alter the SBE 21 memory and will prompt the user twice before executing. (\* is not part of the command) To execute the command enter Y in response to 'message' Y/N then hold down the Ctrl key and enter Y in response to **are you sure** ^Y/N. Any other responses will abort the command.

[] Braces indicate optional parameters of the command. Items enclosed in braces need not be entered.

### 3.2.2 EDITING

The following keys are used to edit entries to the SBE 21.

Description	ASCII	HEX
Carriage return: enters the command or line	CR	0D
Backspace: deletes the previous character	BS	08
Kill line: Ctrl X	CAN	18
Kill line: Escape	ESC	1B
Kill line: Ctrl C	ETX	03

### 3.2.3 DIAGNOSTIC COMMANDS

**FR(CR)^C** Display corrected and uncorrected frequencies.

**CAUTION:** After sending the FR command, the SBE 21 will run continuously until the Escape key is pressed. If the junction box or other external power source is not being used, the normal 80 ma operating current will be drawn from the lithium back up battery. This condition will shorten the life of the lithium back up battery.

Example:

S> fr(CR) the SBE 21 will send:

aaaaa.aaa bbbbb.bbb ccccc.ccc ddddd.ddd eeeee.eee fffff.fff rrrrr.rrr

aaaaa.aaa is the 400 ohm reference resistor frequency  
bbbbb.bbb is the 5000 ohm reference resistor frequency  
cccc.ccc is the frequency generated by the temperature sensor  
dddd.ddd is the frequency generated by the conductivity cell  
eeee.eee is the corrected temperature frequency  
ffff.fff is the corrected conductivity frequency  
rrrr.rrr is the remote temperature frequency (if enabled)

**VR(CR)^C** Display voltages. Voltages read by the Analog to Digital converter are displayed.

**CAUTION:** After execution of the VR command, the SBE 21 will run continuously until the Escape Function is implemented. Unless an external power source is being used, the normal 80 ma current will be drawn from the battery during this time.

Example:

S> vr(CR) the SBE 21 will send:

**V0 V1 V2**

V0 corresponds to main supply voltage. Main supply voltage =  $V0 * CFACT$

V1 corresponds to operating current. Operating current =  $V1 * 48.5$  ma.

V2 corresponds to lithium battery voltage. Lithium voltage =  $V2 * CFACT$

CFACT = 3.982 if the SBE 21 is NOT recording pressure or external voltages.

CFACT = 8.514 if the SBE 21 is recording pressure or external voltages.

If the SBE 21 has been configured to record external voltages these will be displayed following the battery voltages listed above.

**TM(CR)\*^C** Memory test. **WARNING, ALL DATA IN THE SBE 21 WILL BE DESTROYED!** Same as extended memory test except that the test concludes after pass 0 is completed.

**TE(CR)\*^C** Extended memory test. **WARNING, ALL DATA IN THE SBE 21 WILL BE DESTROYED!** An incrementing pattern is written into all locations of each RAM. Data in the RAM is then compared to the pattern. Each pass the pattern is incremented by one. The test concludes after 10 passes. This test takes approximately 1 minutes. For each pass the SBE 21 sends the following message (128k memory):

pass x  
ram0, ok  
ram1, ok  
ram2, ok  
ram3, ok

At the conclusion of the test or when an Escape Function character is received the SBE 21 will display:

ram test passed with no errors

**J(CR)** Measure standby current. The standby current (in microamperes) will be displayed after about 3 seconds.

### 3.2.4 STATUS COMMANDS

**DS(CR)** Display operating status

Example:

S> ds(CR) the SBE 21 will send:

```
SEACAT THERMOSALINOGRAPH V3.1i SERIAL NO. 625    01/27/94 14:04:48.258
SEIKOFREQ = 2097152.0 R400 = 399.840 R5000 = 4975.124
clk = 32768.000 iop = 108 vmain = 10.4 vlith = 5.6
samples = 10 free = 31966 lwait = 0 msec
sample interval = 15 sec
SW1 = 41H, no. of volts sampled = 0
output format = SBE21
logdata = NO
```

These values represent:

SEACAT THERMOSALINOGRAPH V3.1i  
SERIAL NO. 625  
01/27/94 14:04:48.258  
SEIKOFREQ = 2097152.0  
R400 = 399.840 R5000 = 4975.125  
clk = 32768.000  
iop = 108  
vmain = 10.4  
vlith = 5.6  
samples = 10  
free = 31966  
lwait = 0 msec  
  
sample interval = 15 sec  
SW1 = 41H  
no. of volts sampled = 0  
output format = SBE 21  
sample interval = 10 sec  
logdata = NO  
data

Seacat Thermosalinograph with firmware version 3.1i  
Lineal serial number is 625  
Current date and time stored in the SBE 21 memory  
SEIKO oscillator frequency as stored in the firmware  
Values of the 500 and 4000 ohm reference resistors  
real time clock oscillator frequency  
operating current in milliamperes  
main battery voltage (input power from junction box)  
backup lithium battery voltage  
number of samples stored in memory  
number of free samples available in memory  
number of milliseconds to wait after carriage return -  
line feed (LW command sets this parameter)  
number of seconds being samples  
setting of internal switch  
the number of external volts being sampled  
type of data format for real time data  
current sample interval entered with SI command  
indication of whether the SBE 21 is currently logging

QS(CR) Quit session. Main power is turned off; data logging and memory retention are not affected.

### 3.2.5 SETUP COMMANDS

ST(CR) Set date and time as prompted

Example:

S> st(CR) the SBE 21 will prompt

date (MMDDYY) = 112790(CR)

time (HHMMSS) = 081030(CR)

The date is set to November 27, 1990. The time is set to 08:10:30.

IR(CR)\*^C Initialize ram: **WARNING, ALL DATA WILL BE DESTROYED!** All data are set to 0. Sample number and data pointers are set to 0. Allow 1 minute to reset the entire memory.

Knowledge of the initial memory contents can be used to cross-check the SBE 21 when data is retrieved.

**WHstr(CR)** Write header: enter string of ASCII characters to identify data. For example, enter WHDeployed at 47 deg 20.5'N, 130 deg 40.5'W, 1000 m depth(CR).

**Deployed at 47 deg 20.5'N, 130 deg 40.5'W, 1000 m depth**

will be sent whenever the DH command is entered. The string may contain up to 80 characters.

**SI(CR)** Set sample interval. Data logging will start interval seconds after the GL (go log) or RL (resume logging) command is entered. The minimum sample interval is 5 seconds if the remote temperature option is disabled and 6 seconds if the remote temperature option is being recorded.

Example:

S> si(CR) The SBE 21 will prompt

sample interval (seconds) = 10(CR)

sample interval = 10 sec

interval ok (y/n) ? = y(CR)

Enter 'y' to accept the interval, any other response will allow you to start over.

The sample interval is set to 10 seconds. Data logging will start 10 seconds after the GL or RL command is entered.

**TI(CR)** Used to enter start time and changes in sample interval. If these features are not desired use the SI command.

10 or fewer sampling intervals may be entered by the user. The prompts are:

**date (MMDDYYHH)** = date and hour to start new sample interval (month, day, year, hour)

**interval (seconds)** = interval between successive samples

The maximum number of samples that can be stored in a SBE 21 with 64K memory is 15627 samples; with 256K memory, 64799 samples

Enter carriage return in response to the **date (MMDDYY)** prompt to quit entering intervals.

Example:

S> ti(CR)      The SBE 21 will prompt

date (MMDDYYHH) = 09019012(CR)

sample interval (seconds) = 900(CR)

date (MMDDYYHH) = 12019000(CR)

sample interval (seconds) = 120(CR)

date (MMDDYYHH) = 03159112(CR)

sample interval (seconds) = 900(CR)

date (MMDDYYHH) = (CR)

at 09/01/90 12:00:00.000 sample interval = 900 sec

at 12/01/90 00:00:00.000 sample interval = 120 sec

at 03/15/91 12:00:00.000 sample interval = 900 sec

start time = 09/01/90 12:00:00.000

times and intervals ok (y/n) ? y(CR)

Enter 'y' to accept the times and intervals, any other response will allow you to start over.

**NOTE:** The GL (go log) command will use the start time. The RL (resume log) command will use the appropriate interval provided that at least one sample has been previously logged. Otherwise RL will use the start time. The TI command does not have to be reentered when resuming data logging.

**SVn(CR)**      This command is used to set the number of external voltages that are to be acquired.

If the SBE 21 was delivered with the A/D converter installed, this command is enabled. The configuration page of the manual will contain the number of voltages that were set to be acquired when the SBE 21 left the factory. This command allows the user to change this setting, either to add additional external sensors or to limit memory usage if an external sensor is not going to be used. The minimum number of voltages is zero, the maximum number of voltages is four if single ended amplifiers are installed or two if differential amplifiers are installed. The configuration page at the beginning of the SBE 21 manual contains the configuration for each SBE 21.

Example:

S> ds(CR)

SEACAT THERMOSALINOGRAPH V3.1i SERIAL NO. 625 01/27/94 14:04:48.258  
SEIKOFREQ = 2097152.0 R400 = 399.840 R5000 = 4975.124  
clk = 32768.000 iop = 108 vmain = 12.0 vlith = 5.6  
samples = 0 free = 31976 lwait = 0 msec  
sample interval = 10 sec

SW1 = 41H, no. of volts sampled = 1 number of voltages to sample is set to 1  
output format = SBE21  
logdata = NO

S> sv0(CR) Set the number of external voltages acquired to zero

S> ds(CR)

SEACAT THERMOSALINOGRAPH V3.1i SERIAL NO. 625 01/27/94 14:04:48.258  
SEIKOFREQ = 2097152.0 R400 = 399.840 R5000 = 4975.124  
clk = 32768.000 iop = 108 vmain = 12.0 vlith = 5.6  
samples = 0 free = 31976 lwait = 0 msec  
sample interval = 10 sec

SW1 = 41H, no. of volts sampled = 0 number of voltages to sample is set to 0  
output format = SBE21  
logdata = NO

**XY(CR)** Enable the recording of the external temperature option.

The SBE 21 comes standard with the interfacing to record the output of a SBE 3 temperature sensor which can be mounted in a position close to the water intake in the ships hull. The temperature of the water that reaches the SBE 21 has been changed as it has flowed through the plumbing in the interior of the ship. By mounting a second temperature sensor close to the hull a temperature that is more representative of the actual water temperature at the depth of the intake can be recorded. This command instructs the SBE 21 to acquire the signal from the remote temperature sensor and to save the resulting data.

**XN(CR)** Disable the recording of the external temperature option.

If the external temperature option is not being used disabling the recording of the option will reduce the memory used by each scan of data.

**NOTE:** When using the SV, XY, and XN commands the number of bytes in a data sample will be altered. If using SEASOFT software a corresponding change must be made in the instrument configuration section of the SEASOFT.CON file using the SEACON program. If this change is not made SEASOFT will not interpret the data correctly.

**F1(CR)** Set real time data output format to SBE 21

This is the default setting of the SBE 21. In this mode the format of the real time data that is automatically sent via the RS232C port will be:

ttttcccc where tttt is 2 bytes of temperature data and cccc is 2 bytes of conductivity data.

ttttccccrrrrr If the remote temperature option is enabled tttt and cccc are as explained above and rrrrrr is 3 bytes of remote temperature data

ttttccccvvvvv If two external voltages are enabled the format would be this where tttt and cccc are as explained above and vvvvvv are 3 bytes containing V0 and V1.

See section 3.5 for a complete description of the various data formats.

**F2(CR)** Set real time data output format to SBE 16

In this mode the format of the real time data that is automatically sent via the RS232C port will be:

#ttttccccnnnn where # is an attention character, tttt is 2 bytes of temperature data, cccc is 2 bytes of conductivity data and nnnn is a lineal count starting at 0. If the optional external volts are enabled or the remote temperature sensor is enabled the format would be as explained under the F1 command with the leading # character and the trailing nnnn

See section 3.5 for additional information concerning data formats.

### 3.2.6 LOGGING COMMANDS

**NOTE:** To minimize battery drain, data from the previous sample is not stored until the current sample is acquired. For example if the sample interval is one minute:

time	action
0 min	gl (go log command is entered)
1 min	first sample is acquired
2 min	second sample is acquired, first sample is stored
3 min	third sample is acquired, second sample is stored, etc.

**GL(CR)\*** Start logging data, first sample is set to 0, so any previously recorded data will be written over, whether the memory has been initialized or not. The SBE 21 will display the sample interval (SI command) or the sampling times and intervals (TI command) and then ask if they are ok before proceeding.

Example:

S> ql(CR)                    The SBE 21 will prompt:  
start logging Y/N ? y(CR)  
are you sure ^Y/N ? hold down the control key and press the y key in response to this prompt  
sample interval = 15 sec  
sample interval ok Y/N ? y(CR)

start data logging            confirms that logging has been initiated

QL(CR)\*                    Quit logging

Example:

S> ql(CR)                    The SBE 21 will prompt:  
quit logging Y/N ? y(CR)  
are you sure ^Y/N ? hold down the control key and press the y key in response to this prompt

RL(CR)\*                    Resume logging: sample number is not reset. Start time (if set by TI command) will not be used. Previously recorded data will not be overwritten. The SBE 21 will display the sample interval (SI command) or the sampling times and intervals (TI command) and then ask if they are ok before proceeding.

Example:

S> rl(CR)                    The SBE 21 will prompt:  
resume logging Y/N ? y(CR)  
are you sure ^Y/N ? hold down the control key and press the y key in response to this prompt  
sample interval = 15 sec  
sample interval ok Y/N ? y(CR)

start data logging            confirms that logging has been initiated

### 3.2.7 DATA RETRIEVAL COMMANDS

DD[[n1],n2](CR)^C        Raw data is displayed in HEX. If n1 and n2 are omitted all logged data are displayed. If only n1 is entered data for sample n1 are displayed. Entering n1,n2 displays samples n1 through n2.

Example:

S> [dd100\(CR\)](#) A SBE 21 that is recording temperature and conductivity only will send:

ttttccc

tttt is the corrected temperature frequency for sample 100

cccc is the corrected conductivity for sample 100

Section 3.5 contains information on the conversion of the hexadecimal data to engineering units.

**DH[[n1],n2](CR)^C** Display headers. If n1 and n2 are omitted all headers are displayed. If only n1 is entered, header number n1 is displayed. Entering n1 and n2 displays headers n1 through n2. If no headers have been stored the message '**no headers written**' will be displayed.

A new header is written when:

Data logging is started or resumed, the sample interval changes, or 500 samples (125 samples for 64K memory) have been recorded since the last header was written.

Example:

S> [dh\(CR\)](#) The SBE 21 will send:

**Header string entered by user**

**MM/DD HH:MM:SS samples X to Y interval = I sec**

MM/DD HH:MM:SS month, day, hour, minutes, seconds read from real time clock when the first sample for this header was stored in RAM.

X first sample in this header  
Y last sample in this header, updated every sample  
I interval between samples in seconds

Example:

S> [dh\(CR\)](#)

**Sea-Bird bench test**

**04/18 17:00:10 samples 0 to 19 interval = 60 sec**

**04/20 23:40:10 samples 20 to 499 interval = 3600 sec**

**04/20 07:20:10 samples 500 to 999 interval = 900 sec**

Line 1 contains the header string.

Line 2 contains the header written when the first sample was stored in RAM. (The sample number range is updated as samples are stored in memory).

Line 3 is written when the sample interval changes from once every minute to once every 60 minutes.

Line 4 is written when the total number of samples is a multiple of 500.

**SS(CR)** Transmit last recorded sample (does not affect sampling program).

Example:

S> ss(CR) If the SBE 21 has been set to SBE 21 real time data format via the F1 command the following data will be sent

**ttttccc**

tttt is the corrected temperature frequency  
cccc is the corrected conductivity frequency

S> ss(CR) If the SBE 21 has been set to SBE 16 real time data format via the F2 command the following data will be sent

**#ttttccccssss**

# is an attention character  
tttt is the corrected temperature frequency  
cccc is the corrected conductivity frequency  
ssss is the number of the sample being sent.

If the optional external voltages or remote temperature are enabled there data would appear as described in section 3.5. Section 3.5 also contains information concerning the conversion of this data to engineering units.

**TS(CR)** Take a sample and transmit the results. The data is not stored in memory. Normally used while not logging data.

Example:

S> ts(CR) After approximately 8 seconds the SBE 21 will send

#ttttcccc

# always sent as an attention character  
tttt corrected temperature frequency  
cccc corrected conductivity frequency  
a carriage return and line feed follows the data

The output format setting (F1 and F2 commands) has no affect on the format of the data sent via this command.

### 3.3 REMOTE TEMPERATURE RECORDING

The SBE 21 has the capability of recording the output of an external SBE 3 temperature sensor. Often the SBE 21 is mounted in the interior of the vessel. In this configuration the salinity that is recorded is correct, but the water temperature has changed as it has passed through the plumbing system. With the remote temperature capability, a second temperature sensor can be placed in a location that allows more accurate measurement of the sea surface (outside) water temperature. The data from this secondary temperature sensor is fully supported in the software that is provided with the SBE 21.

#### 3.3.1 ENABLING THE REMOTE TEMPERATURE OPTION

Unless specified otherwise at the time of purchase the SBE 21 is supplied with the external temperature feature disabled. The XY command as documented in section 3.2.5 can be used to enable this option.

To enable the remote temperature feature in SEASAVE, the program SEACON must be run to change the instrument configuration section of the SEASOFT.CON file (refer to SEASOFT manual).

The correct configuration for a SBE 21 with remote temperature is:

Number of Ext Freq Sampled (standard= 0) = 1  
Number of Ext Volt Sampled (standard= 0) = 0  
Sample Interval (seconds) = **user defined with the SI command**  
Data Format =  
Frequency 0 = temperature  
Frequency 1 = conductivity  
Frequency 2 = temperature, secondary

The Calibration coefficients for the remote temperature sensor should be entered into the SEASOFT.CON file using the SEACON program.

The data from the remote temperature sensor are displayed using the secondary temperature sensor variable in SEASAVE.

### 3.4 EXTERNAL A/D OPTION

Most SBE 21s with firmware versions greater than 3.1d were supplied with the connector and interfacing electronics necessary to acquire up to four 0 to 5 volt analog signals from auxiliary sensors such as dissolved oxygen, fluorescence and light transmission. The SV command is used to enable and disable the recording of the external voltages. If this option is enabled the SBE 21 will acquire and record the signals from the number of voltages specified in the SV command. The voltages are acquired in order starting with voltage 0. They will appear in the data stream after the primary temperature and conductivity frequencies and after the remote temperature frequency if enabled.

If the number of voltages is changed with the SV command a corresponding change must be made to the instrument configuration section of the SEASOFT.CON file using the SEACON program.

For example the correct configuration for a SBE 21 with remote temperature and two external volts recording dissolved oxygen is:

Number of Ext Freq Sampled (standard= 0) = 1  
Number of Ext Volt Sampled (standard= 0) = 2  
Sample Interval (seconds) = user defined with the SI command  
Data Format =

Frequency 0 = temperature  
Frequency 1 = conductivity  
Frequency 2 = temperature, secondary  
Extrnl Volt 0 oxygen, current  
Extrnl Volt 1 oxygen, temperature

### 3.5 DATA CONVERSION TO ENGINEERING UNITS

The data that is stored in the SBE 21 and which is transmitted over the serial interface is in units of scaled frequencies for temperature and conductivity, actual frequency for the remote temperature option, and A/D counts for the external voltages.

#### 3.5.1 TEMPERATURE AND CONDUCTIVITY

The primary temperature and conductivity frequencies recorded by the SBE 21 are scaled and offset to optimize use of the RAM. Using the HEX values (ttttccc) displayed in Section 3.2.7 above:

Actual temperature frequency =  $tttt / 19 + 2100$   
Actual conductivity frequency = square root  $((cccc * 2100) + 6250000)$

If ttttccc = A80603DA

tttt = decimal equivalent of A806 HEX or 43014

$$\text{Actual Temperature Frequency} = (43014/19) + 2100 = 4363.89 \text{ Hz}$$

The temperature calibration sheet supplied with the SBE 21 shows the relationship between 'actual temperature frequency', the calibration coefficients a, b, c, d, and F0, and temperature in degrees Celsius.

cccc = decimal equivalent of 03DA HEX or 986

$$\text{Actual Conductivity Frequency} = ((986*2100) + 6250000)^{0.5} = 2884.545 \text{ Hz}$$

The conductivity calibration sheet supplied with the SBE 21 shows the relationship between 'actual conductivity frequency' (divide by 1000 to obtain kHz as required by the calibration equation), the calibration coefficients a, b, c, d, and m, and conductivity in Siemens/meter.

### 3.5.2 REMOTE TEMPERATURE

If the remote temperature option is enabled, 6 ASCII HEX characters representing 3 bytes of data will be appended to the data format described in section 3.2.7.

**tttccccxxxxx**

ttt = four HEX characters representing 2 bytes of temperature data

cccc = four HEX characters representing 2 bytes of conductivity data

xxxxx = six HEX characters representing 3 bytes of remote temperature data

Temperature and conductivity are converted as shown in section 3.5.1.

Remote Temperature:

1. E = decimal equivalent of xxxxx
2. External Temperature frequency =  $E / 256$

Example:

$$\text{tttccccxxxxx} = 69\text{CC}4322260305$$

$$\text{ttt} = 69\text{CC}, T = 27084, \text{Temperature frequency} = 3525.474$$

$$\text{cccc} = 4322, C = 17186, \text{Conductivity frequency} = 6506.970$$

$$\text{xxxxx} = 260305, E = 2491141, \text{Remote Temperature frequency} = 9731.020$$

Conversion of the remote temperature frequency to engineering units is done using the equation and coefficients that are on the calibration sheet provided with the SBE 3 remote temperature sensor.

### 3.5.3 EXTERNAL A/D VOLTAGES

If the SBE 21 is configured with the optional A/D converter, it has the capability to record up to four external voltages. (See the SV command in section 3.2.5 for additional information on enabling the recording of these voltages.) If enabled, the voltage data will appear after the conductivity and the remote temperature data (if remote temperature is enabled). The data format for the voltages is:

Ouuu            one voltage

uuuvvv two voltages

uuuvvvOxxx    three voltages

uuuvvvxxxxyyy four voltages

The O character is used to make an even number of characters in the cases of one and three voltages.

uuu = three hex characters representing voltage 0 data

vvv = three hex characters representing voltage 1 data

xxx = three hex characters representing voltage 2 data

yyy = three hex characters representing voltage 3 data

Voltage 0:

1. V0 = decimal equivalent of uuu
2. Voltage 0 = V0 / 819.

Voltage 1:

1. V1 = decimal equivalent of vvv
2. Voltage 1 = V1 / 819.

Voltage 2:

1. V2 = decimal equivalent of xxx
2. Voltage 2 = V2 / 819.

Voltage 3:

1. V3 = decimal equivalent of yyy
2. Voltage 3 = V3 / 819.

Example (with two external voltages):

ttttccccxxxxxuuuvvv = 69CC43222603051F5A21

tttt = 69CC, T = 27084, Temperature frequency = 3525.474

cccc = 4322, C = 17186, Conductivity frequency = 6506.970

xxxxxx = 260305, E = 2491141, External Temperature frequency = 9731.020

uuu = 1F5, V0 = 501, External Voltage 0 = 0.0612 volts

vvv = A21, V1 = 2593, External Voltage 1 = 3.166 volts

## 4.0 FUNCTIONAL DESCRIPTION

### 4.1 SENSORS

The SBE 21 (like all members of the SEACAT product family) embodies the sensor elements (Pyrex cell and pressure-protected thermistor) and Wien-bridge oscillator interface technique previously employed in Sea-Bird's modular SBE 3 and SBE 4 sensors, but differs in using multiplexing to allow a single oscillator to service both temperature and conductivity measurements.

### 4.2 SENSOR INTERFACE

Temperature or conductivity dependent variable frequencies generated by the Wien-bridge are acquired (digitized) using a hybrid period counting technique (AP Counter) like that used in the Sea-Bird SBE 9 CTD. The AP Counter determines integer and fractional cycles of the variable frequency during a fixed time interval of 0.125 seconds (this period, and therefore the count accuracy, is determined using a precision quartz TCXO) and the resulting count is offset and scaled in preparation for storage in CMOS static RAM.

Drift associated with changes in ambient temperature or component aging is compensated in the SBE 21 by switching stable resistors (Vishay types) into the Wien-bridge oscillator immediately prior to temperature and conductivity measurement. The resulting frequencies (representing the approximate upper and lower frequency limits of the oscillator) are measured and used to correct circuit drift; consequently, the accuracy of the SBE 21 electronics is limited only by the stability of the Vishay resistors and time-base quartz crystal.

### 4.3 REAL-TIME CLOCK

To minimize battery current drain, a low power 'watch' crystal is used as the real-time-clock frequency source. Initial error, ambient temperature-induced drift, and aging of the 'watch' crystal is compensated by measuring its actual frequency against the TCXO each time a reading of temperature and conductivity is made. The measured discrepancy (if any) is used to arithmetically correct the low power clock.

#### **4.4 MEMORY**

Data storage is in low standby-power CMOS static RAM (1024K bytes). Each sample of temperature and conductivity uses 4 bytes, and 3029 bytes are reserved of scratch-pad use, including storage of user-defined acquisition routines and header notes. The SBE 21 will store 255,240 C-T samples.

#### **4.5 DATA I/O**

The SBE 21 receives set-up instructions and outputs diagnostic information, real-time, or previously recorded data via a 3-wire RS-232C link, and is factory configured for 9600 baud, 7 data bits, 1 stop bit, and even parity. RS-232 levels generated and accepted by the SBE 21 are directly compatible with standard serial interface cards.

#### **5.0 HOUSING AND MECHANICAL DESIGN**

The SBE 21 electronics housing is a cylindrical pressure vessel having an outside diameter of 99 mm (3.9 inches) and flat end-caps. The sensor end cap is retained by stainless steel machine screws. The connector end cap is welded to the flat PVC plate which serves also as the top of the water jacket. The I/O connector is an Impulse XSG-4BCL (HP) designed to mate with RMG-4FS female molded pigtails.

The SBE 21 water jacket is a PVC welded assembly designed to mount the temperature and conductivity sensors in a small vertical chamber through which sea-water is circulated. Valves are provided for seawater circulation and freshwater flushing. The electronics housing/sensor assembly may be removed from the water chamber for recalibration or cleaning.

## 6.0 SPECIFICATIONS

<b>Sample rate</b>	1 sample every 5 seconds if remote temperature is not enabled or every 6 seconds if remote temperature is enabled up to 1 sample every 32772 seconds in 1 second steps	
<b>Measurement Range</b>	Temperature	-5 to + 35 °C
	Conductivity	0 to 6.5 S/m
<b>Accuracy</b>	Temperature	0.01 °C/6 months
	Conductivity	0.001 S/m/month
<b>Resolution</b>	Temperature	0.001 °C
	Conductivity	0.0001 S/m
<b>Sensor Calibration</b>	Temperature	-1 to + 31 °C
	Conductivity	0 to 6.5 S/m. Physical calibration 1.4 to 6 S/m, plus zero (air).
<b>Counter time-base</b>	Quartz TCXO, +/- 2 ppm per year aging; +/- 2 ppm vs. temperature (- 5 to + 30 °C).	
<b>Memory:</b>	CMOS static RAM, 64K byte; battery backed for minimum 2 years data retention.	
<b>Real-time clock:</b>	Watch-crystal type 32,768 Hz; battery backed for minimum of 2 years unpowered operation. Corrected for drift and aging by comparison to the SBE 21 counter time-base to produce overall +/- 5 ppm accuracy (+/- 2.6 minutes/year).	
<b>Materials:</b>	Titanium end cap; PVC housing, water jacket, piping, and valves.	

**CAUTION - THE WATER JACKET HAS A 50 PSI (3.45 X 10<sup>5</sup> N-m<sup>-2</sup>) INTERNAL PRESSURE LIMIT!**

## 7.0 ROUTINE MAINTENANCE

The SBE 21 should be flushed with fresh water periodically. The anti-foul cylinder ends (SBE P/N 24012) should be replaced every 6 months. If prolonged storage is anticipated, the sensor/electronics module should be removed from the water jacket. Loop a short length of deionized water-filled tygon tubing from one end of the cell to the other. Then re-install the module in the main assembly. It is best to store the unit connected to the junction box and with power applied. This will keep the small internal pc board mounted batteries from becoming exhausted (they have a two year life with the Interface Junction Box not connected and powered).

## **8.0 SENSOR CALIBRATION**

Sea-Bird sensors are calibrated by subjecting them to known physical conditions, and measuring the sensor responses. Then coefficients are 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. The SBE 21 electronics/sensor module may be returned to Sea-Bird for calibration through the Northwest Regional Calibration Center, sent directly to NRCC, or calibrated using standard laboratory equipment and methods. If the latter two approaches are elected, Sea-Bird can supply software for coefficient generation.

Because temperature is varied to yield a wide range of conductivities from baths of just two salinities, performance of a conductivity calibration on the SBE 21 will always yield a temperature calibration as well.

### **8.1 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 will output 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; the effect is to change the cell geometry resulting in a shift in cell constant. A second drift mechanism is associated with change in the quality of the platinized electrodes, and this effect is also induced by fouling. Accordingly, the most important determinant of long-term sensor accuracy is the state of cleanliness of the cell. We recommend that the conductivity sensors be calibrated at least once per year, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

### **8.2 TEMPERATURE SENSOR CALIBRATION**

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

## 9.0 DISASSEMBLY/REASSEMBLY INSTRUCTIONS

### CAUTION - COMPLETE DISASSEMBLY WILL DESTROY ANY DATA STORED IN THE SBE 21!

Down-load any data presently stored in the SBE 21. Use the QS command to put the SBE 21 in the quiescent mode, then turn off the power at the Interface Junction Box. Unmate the 4-pin rubber molded connector from the thermosalinograph assembly. Remove the electronics/sensor module from the main water jacket assembly by removing the four 3/8-16 hex head bolts.

## 9.1 DISASSEMBLY/REASSEMBLY OF ELECTRONICS/SENSOR MODULE

Disassembly of the electronics/sensor module will destroy any data stored in the SBE 21.

Great care must be taken during assembly and reassembly to avoid breaking the conductivity cell. The cell is robust and well protected when the instrument is intact, but becomes extremely vulnerable during the disassembly/reassembly procedure.

Remove the four machine screws retaining the sensor guard to the PVC cylindrical housing and set the guard aside. Now remove the four screws retaining the sensor end-cap to the cylindrical housing. The end-cap and attached electronics chassis may now be slid out of the pressure cylinder. The Molex connector toward the I/O connector end of the analog electronics board (the board to which the yellow lithium batteries are mounted) must be unmated before the chassis/end-cap assembly may be fully removed.

For reassembly, reverse the disassembly process, being careful that the mating surfaces are clean and the 'O'-ring greased, undamaged, and properly positioned. Use a new desiccant package. Re-mate the Molex connector (be careful that the connector socket holes are lined up properly with respect to the mating header pins).

## 10.0 O-RING SIZES

I/O end cap to main water jacket assembly: Parker 2-363N674-70 Sea-Bird Part Number 30092

I/O bulkhead connector: Parker 2-017N674-70 Sea-Bird Part Number 30072

Sensor end-cap (piston) seal: Parker 2-233N674-70 Sea-Bird Part Number 30088

Sensor end-cap connector: Parker 2-017N674-70 Sea-Bird Part Number 30072

Conductivity cell (face seal): Parker 3-904N674-70 Sea-Bird Part Number 30070