

SBE 16 SEACAT

**Conductivity and Temperature Recorder
(optional Pressure)**

User's Manual

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Firmware Version 4.0h and later**

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SBE 16 SEACAT Conductivity and Temperature Recorder

TABLE OF CONTENTS

1-1	INTRODUCTION	1
1-2	SPECIFICATIONS	2
2-1	CONFIGURATION OPTIONS	3
3-1	COMMUNICATING WITH THE SEACAT	4
3-1.1	CONNECTION TO A COMPUTER OR TERMINAL	5
3-1.2	OPERATION USING TERM1621	5
3-1.2.1	TERMINAL SET UP FORM	7
3-1.2.2	DATA UPLOAD SET UP FORM	8
3-1.3	EDITING	10
3-1.4	COMMANDS	10
3-1.5	COMMAND FORMAT	12
3-1.6	DIAGNOSTIC COMMANDS	12
3-1.7	STATUS COMMANDS	14
3-1.8	SETUP COMMANDS	15
3-1.9	LOGGING COMMANDS	21
3-1.10	DATA RETRIEVAL COMMANDS	22
3-2	SEASOFT SOFTWARE CONFIGURATION FILES	24
3-3	DATA LOGGING, RETRIEVAL AND FORMATS	25
3-3.1	LOG DATA (SI command to set interval)	25
3-3.2	LOG DATA (TI command to set sample times and intervals)	26
3-3.3	RETRIEVE DATA	28
3-3.4	DATA FORMATS	29
3-3.5	REAL-TIME DATA	33
3-3.6	LATCHED DISSOLVED OXYGEN OPERATION	33
3-3.7	RECOVERY FROM MAIN BATTERY FAILURE	34
4-1	FUNCTIONAL DESCRIPTION	34
4-1.1	SENSORS	34
4-1.2	SENSOR INTERFACE	35
4-1.3	REAL-TIME CLOCK	35
4-1.4	MEMORY	35
4-1.5	DATA I/O	35
4-1.6	BATTERIES	36
4-1.7	HOUSING AND MECHANICAL DESIGN	36

5-1	DESCRIPTION OF SEACAT CIRCUITRY	37
5-1.1	BATTERY WIRING AND POWER SUPPLY	37
5-1.2	SENSOR MULTIPLEXING	37
5-1.3	WEIN-BRIDGE OSCILLATOR	38
5-1.4	SQUARING CIRCUITS AND AP COUNTER.....	38
5-1.5	A/D CONVERTER (INTERNAL DIAGNOSTICS)	38
5-1.6	CPU AND DATA I/O	38
5-1.7	REAL-TIME CLOCK	39
5-1.8	MEMORY	39
6-1	INSTALLATION AND OPERATING INSTRUCTIONS	39
6-1.1	BATTERY INSTALLATION	40
6-1.2	INITIALIZATION AFTER DISASSEMBLY	40
6-1.3	DEPLOYMENT	41
6-1.4	ANTI-FOULANT ATTACHMENTS.....	41
6-1.5	RECOVERY	41
7-1	ROUTINE MAINTENANCE AND CALIBRATION.....	42
7-1.1	CORROSION PRECAUTIONS.....	42
7-1.2	CONDUCTIVITY CELL STORAGE.....	42
7-1.3	SENSOR CALIBRATION.....	42
7-1.3.1	CONDUCTIVITY SENSOR CALIBRATION	43
7-1.3.2	TEMPERATURE SENSOR CALIBRATION	43
7-1.3.3	PRESSURE SENSOR CALIBRATION (STRAIN-GAUGE SENSOR)	43
7-1.3.4	PRESSURE SENSOR CALIBRATION (DIGIQUARTZ SENSOR).....	43
8-1	DISASSEMBLY/REASSEMBLY INSTRUCTIONS.....	44
8-2	O-RING SIZES	44
	APPENDIX I: AF24173 ANTI-FOULANT DEVICE	45

1-1 INTRODUCTION

The SBE 16 SEACAT is designed to measure and record temperature and conductivity at high levels of accuracy while deployed in either a fixed or moored application. Powered by internal batteries, SEACAT is capable of recording data for periods of a year or more. Data may be acquired at intervals of 15 seconds to 8 hours in one-second increments. This interval can be changed at up to 9 pre-determined dates. SEACAT's precision time-base is accurate to within 3 minutes per year. An internal battery back-up supports memory and the real-time clock in the event of failure or exhaustion of the main battery supply.

The SEACAT can be used as a self-contained temperature-conductivity recorder deployed on autonomous moorings; when the SEACAT is recovered the data can be retrieved. The SEACAT can also be used in a polled mode where a surface controller interrogates the SEACAT and either requests the last sample that was taken or asks the SEACAT to take a new sample and to send it to the RS-232C interface. A third mode is for the controller to passively listen for the next sample that is taken and automatically send it to the RS-232C interface.

Communication with SEACAT is over a 3 wire RS-232C link. There are over 20 commands that can be sent to SEACAT that provide for status display, data acquisition setup, data retrieval, and diagnostic tests.

Supplied with SEACAT is a powerful software package, SEASOFT, which enables the user to communicate, retrieve data, and calculate and display temperature, conductivity and derived variables such as salinity and sound velocity. SEASOFT is designed to run on IBM XT/AT/386/486 or compatible computers. A separate software manual contains additional information on the setup and use of SEASOFT.

Note: This manual details use of the DOS version of SEASOFT with the SBE 16. A Windows software package, SEASOFT-Win32, is also available, and is compatible with the SBE 16. SEASOFT-Win32 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 and plotting of conductivity, temperature, pressure, auxiliary sensor data, and derived variables such as salinity and sound velocity.

Help files provide detailed information on the software use. Separate software manuals are also available for SEASAVE and SBE Data Processing.

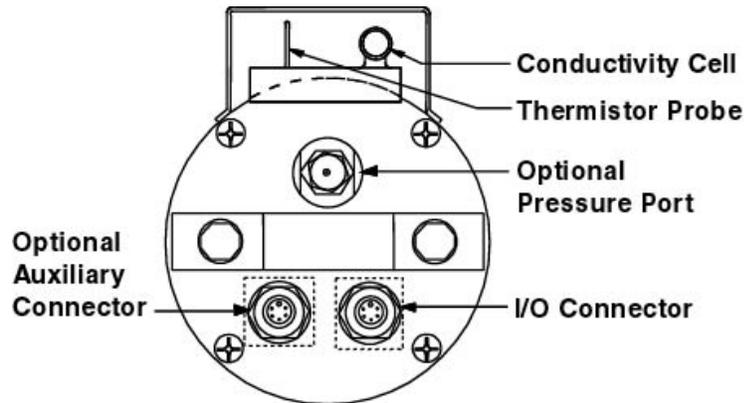
1-2 SPECIFICATIONS

Measurement Range:	Temperature Conductivity	-5 to +35 °C 0 to 7 S/m (0 to 70 mmho/cm)
Accuracy:	Temperature Conductivity	0.01 °C 0.001 S/m
Resolution:	Temperature Conductivity	0.001 °C 0.0001 S/m
Sensor Calibration:	Temperature Conductivity	+1 to +32 °C 0 to 7 S/m. Physical calibration over the range 1.4 to 6 S/m, plus zero conductivity (air).
Counter time-base:		Quartz TCXO, ± 2 ppm per year aging; ± 2 ppm vs. temperature (- 5 to + 30 °C).
Memory:		CMOS static RAM, 1024K byte; battery backed for minimum 2 years data retention.
Real-time clock:		Watch-crystal type 32,768 Hz; battery backed for minimum of 2 years operation irrespective of condition of main battery. Corrected for drift and aging by comparison to SEACAT counter time-base to produce overall ± 5 ppm accuracy (± 2.6 minutes/year)
Batteries:		Standard configuration with 6 alkaline D-cells Optional configurations with 9 or 12 alkaline D-cells are available. Standard 3.4-volt lithium batteries <u>cannot</u> be installed as individual cells in any SEACAT configuration. Severe damage will occur from over voltage of components.
Materials:		600 Meter Pressure Case Acetal copolymer (plastic) 10,500 Meter Pressure Case Titanium

2-1 CONFIGURATION OPTIONS

The SEACAT can be configured in several ways. The standard input/output connector is a 4-pin XSG-4BCL-HP connector. If a pump is installed, the 4-pin connector is replaced with a 6-pin AG306-HP connector. As an option, a second 6-pin connector AG306-HP connector can be installed to serve as the input port for auxiliary sensors such as an oxygen sensor. The possible wiring of these connectors is shown below.

**Figure 1.
End Cap
Connectors**



Optional Single-Ended Inputs



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

Standard I/O Connector



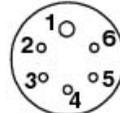
Pin	Signal
1	Common
2	Data Receive
3	Data Transmit
4	Aux Power In

Optional Differential Inputs



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

I/O Connector with Optional Pump



Pin	Signal
1	Common
2	Data Receive
3	Data Transmit
4	Pump Power Return
5	Pump Power
6	Aux Power In

The SEACAT can be configured with the SBE 5T pump to ensure that a new sample of water has passed through the cell and optional dissolved oxygen sensor before taking a sample. Figure 2 is a drawing of the plumbing arrangement and sensor mounting of a SEACAT equipped with a pump.

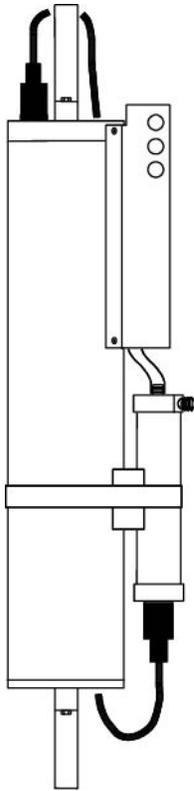


Figure 2. SEACAT with optional SBE 5T pump

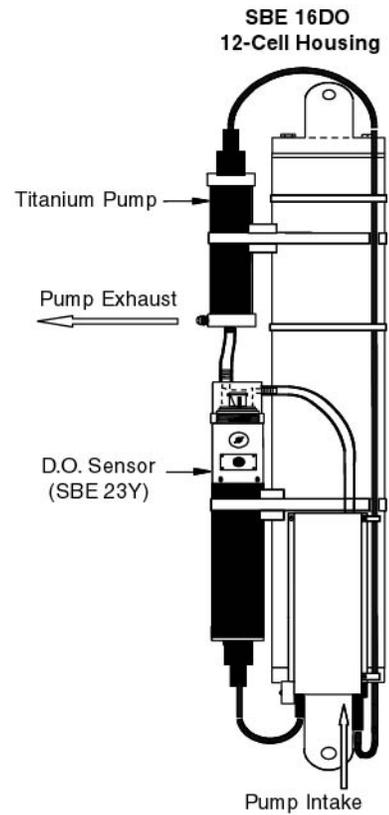


Figure 3. SEACAT with optional SBE 5T pump and SBE 23 Dissolved Oxygen Sensor

Figure 3 shows a SEACAT configured with an SBE 5T pump and SBE 23 dissolved oxygen sensor.

3-1 COMMUNICATING WITH THE SEACAT

The SEACAT communicates via a 3-wire RS-232C link and is factory configured for 600 baud, 7 data bits, 1 stop bit, and even parity. Connection can be made directly to a terminal or to the serial port of a computer. Supplied with the SEACAT is a communications program, **TERM1621**, which can be used on an IBM XT/AT/386/486 or compatible to set-up and retrieve data from the SEACAT.

Note: If desired, **use SEATERM instead of TERM1621 (DOS) software to setup and upload data from the SEACAT.** See the SEATERM Help files for details. SEATERM is part of our SEASOFT Windows software suite.

3-1.1 CONNECTION TO A COMPUTER OR TERMINAL

1. Remove the dummy plug from SEACAT's I/O bulkhead connector by unscrewing the locking sleeve and then pulling the plug firmly away from the connector.
2. Install the Sea-Bird cable connector, aligning the raised bump on the side of the connector with the large pin on the SEACAT connector.

Power: Optional 10-15 Volts DC, permits leisurely setup and data read-out without sacrifice of battery capacity.

Transmit: RS-232C transmit from SEACAT to computer (DB-25 pin 3)

Receive: RS-232C receive data transmitted from computer (DB-25 pin 2)

Common: System ground; power and computer (DB-25 pin 7)

Refer to section 2.1 for pin configuration of the I/O bulkhead connector.

3-1.2 OPERATION USING TERM1621

Note: If desired, use **SEATERM** instead of **TERM1621 (DOS)** to setup and upload data from the **SEACAT**. See the SEATERM Help files for details. SEATERM is part of our SEASOFT Windows software suite.

TERM1621 is a terminal emulation program designed to communicate with the SEACAT; characters typed on the keyboard are sent to the SEACAT and characters sent by the SEACAT are displayed on the console. TERM1621 expects to find the file TERM16.CFG in the current directory. If this file is not in the current directory, it creates a new file.

The main terminal screen is shown below:

```
+-----+
| SBE 16/21 Terminal Program 4.214           Thursday June 29, 1995 7:46 am |
+-----+
| <F1> Help      <F2> Setup    <F3> Status   <F4> Headers  <F5> Capture |
| <F6> Wake Up   <F7> Baud Rate  <F9> Upload  <F10> Exit |
|                                     |
|                                     |
|                                     |
+-----+
| <F1>Help      <Ctrl-C>Halt Instrument           Baud = 600  Capt = No |
+-----+
```

Press <F2> and select *Communication Set Up* to set the COMM port and baud rates (see section 3-1.2.1). Exit the Set Up form (press ESC) and press F6 to establish communications with the instrument. To abort the attempt to establish communications, press the ESC key.

Once communications have been established, characters transmitted by the instrument display in the center portion of the main screen.

The active function keys are:

- F1** Display help screens.
- F2** Display the terminal set up form.
- F3** Display instrument status.
- F4** Display instrument headers.
- F5** Capture instrument responses to a file.
- F6** Re-establish communications with the instrument. The instrument *goes to sleep* after 2 minutes without receiving any commands from the computer.
- F7** Change the baud rate.
- F9** Upload data from the instrument. Upload parameters are configured in the setup menu (F2).
- F10** Exit to DOS.
- CTRL-C** Sends Ctrl-C to the instrument to halt display voltages and display frequencies diagnostic.
- CTRL-F10** Stop instrument from logging. Sends NULL character to the instrument.
- HOME** Stop instrument from logging. Sends NULL character to the instrument.

On the bottom status line:

Baud = Displays current baud rate

Capt = Displays capture to file status. If YES, all replies from the instrument are being written to a file.

The function keys are used to control different features of the terminal program and to send commands to the instrument for data upload, initialization, and status information. If communications or instrument problems are encountered, refer to Section 3-1.4 for diagnostic and data commands.

If the terminal program is not able to establish communications with the instrument by cycling through the baud rates and comm ports, set the baud rate (as documented on the configuration page) with the F7 key and verify the setup parameters accessed through the F2 key. Subsequent attempts at communicating with the instrument can be made by pressing the Enter key or via the F6 key.

3-1.2.1 TERMINAL SET UP FORM

```

+-----+
| SBE 16/21 Terminal Program  4.214           Thursday June 29, 1995  7:46 am |
+-----+
|                                     TERMI621 Set Up Parameters |
+-----+
| SBE 16 or 21 EPROM (Firmware) Version = 4.0 or greater |
| Communication Set Up =                               <Press Enter To Modify> |
| Data Upload Set Up Parameters =                     <Press Enter To Modify> |
| Header =                                             Prompt for Header Information |
| Header Form =                                       <Press Enter To Modify> |
+-----+
|                                     <F1> Help; <Esc> Exit; <Enter> Modify the field |
+-----+

```

The EPROM Version is recorded on the configuration sheet of the manual and also displayed in the first line of the reply to the display status (F3) reply.

The Communication Set Up Form is:

```

+-----+
| SBE 16/21 Terminal Program  4.214           Thursday June 29, 1995  7:47 am |
+-----+
|                                     TERMI621 Set Up Parameters |
+-----+
| SBE 16 or 21 EPROM (Firmware) Version = 4.0 or greater |
| Communi |                                     Communication Set Up = |
| Data Up | Serial Port =                               COM1 |
| Header  | Baud Rate =                                 600 |
| Header  | Data Upload Baud Rate = 9600 |
|         | Data Bits =                               7 Data Bits |
|         | Parity =                                   Even Parity |
+-----+
|                                     <F1> Help; <Esc> Exit; <Enter> Modify the field |
+-----+

```

Standard instruments are set to 7 data bits, even parity.

Firmware Versions 3.2e or lower:

- baud rate = 9600
- upload baud rate = 9600

Firmware Versions 4.0 or greater:

- baud rate = 600
- upload baud rate is programmable to 600, 1200, 9600, 19200, or 38400

Use slower upload baud rates with slow computers and long cables.
 Use 38400 baud with short cables and 386- or 486-based PCs.

3-1.2.2 DATA UPLOAD SET UP FORM

```
+-----+
| SBE 16/21 Terminal Program 4.214           Thursday June 29, 1995 7:47 am |
+-----+
|                                     TERMS1621 Set Up Parameters |
+-----+
|                                     Data Upload Set Up Parameters = |
+-----+
| Upload =                               Upload All Data as One File |
| Echo During Upload =                   Display One '.' Every 16th Scan |
| Output HEX Data File Path =            C:\CTDDATA\ |
| Upload File Name Choice =              Prompt for File Name |
| Default Upload File Name [.HEX] =      upld |
| Upload Session Number [0-99] =         0 |
+-----+
|                                     <F1> Help; <Esc> Exit; <Enter> Modify the field |
+-----+
```

Data Upload choices are:

Upload All Data as One File:

The terminal program sends the *DD* (dump data) command to the instrument. One file is written.

Upload Data By Scan Number Range:

The terminal program prompts the user for the beginning and ending scan number and then sends the *DD* (dump data) command to the instrument. One file is written.

Echo During Upload Choices are:

Echo Data During Upload:

The HEX data from the instrument displays on the screen as it is received.

Display One '.' Every 16th scan during Upload:

Shortens the time required to upload the data.

Output HEX Data File Path =

Enter the path where you wish the uploaded HEX file to be written.

Upload File Name Choice:

Use Default File Name:

The user is not prompted for the file name. The upload session number and cast number are added to the default file name to form the actual file name.

Default Upload File Name [.HEX] =

If the upload file name choice is *Use Default File Name*, then this default file name is used along with the upload session number and the cast number to form the complete upload file. The maximum length for the default file name is 4 characters. The file name extension need not be entered.

NNNNXXYY.HEX where

NNNN is the default upload file name (one to four characters)

XX is the upload session number

YY is the cast number

Upload Session Number [0 - 99] =

The upload session number is incremented each time data is uploaded (F9). It is reset by setting this field to 0.

Prompt for File Name:

The user is prompted for the file name.

Header:

Include Default Header in Upload File:

The default header form is included in the upload file. The user is not prompted to add any information.

Prompt For Header Information:

Each time a cast is uploaded the user is prompted to fill out the header form

Don't Include Header in Upload File:

Header information is not included in the upload file

Header Form:

The header form is customized by editing this form. The entries are free form and 0 to 12 lines may be entered. If header = *Prompt for Header Information*, this form displays for the user to fill in. If header = *Include Default Header*, only this form is included in the upload file.

3-1.3 EDITING

The following keys are used to edit entries to SEACAT.

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

3-1.4 COMMANDS

There are over 20 commands that are used to control the functions of the SEACAT. Table 3.1 is a summary of these commands.

If SEACAT has been completely disassembled for any reason, set the date and time with the ST (set time) command before further set-up, diagnostics, or other communications functions are undertaken.

Table 3.1 Summary of SEACAT commands.

Type	Command	Description
Diagnostic	FR	Display corrected and uncorrected frequencies
	VR	Display voltages
	TE	Extended memory test
	TM	Memory test
	J	Measure standby current
Status	DS	Display status
	QS	Quit session
Set-Up	CN	Set conductivity channel to narrow range (fresh water)
	CS	Set conductivity channel to standard range (salt water)
	ML	Set mode to latched DO
	MN	Set mode to normal operations
	LW	Set time to wait after transmitting a line of data
	ST	Set date and time
	IL	Initialize logging
	IR	Initialize RAM
	SI	Set sample Interval
	TI	Enter start times and sample interval lengths
	VD	Set delay for acquisition of external voltages
	SV	Set number of external voltages to acquire
	SB	Set communications baud rate
Logging	GL	Start logging data
	QL	Quit logging data
	RL	Resume logging data
Data Retrieval	DD	Display data in raw format
	DH	Display headers
	SS	Send last recorded sample
	TS	Take sample and send results

3-1.5 COMMAND FORMAT

Commands may be entered in upper or lower case letters. Responses made by SEACAT are indicated in bold type. SEACAT sends # whenever an invalid command is entered. If a new command is not received within 2 minutes after completion of the last command, SEACAT returns to the standby mode. Communications can be reestablished by using the F6 key or pressing the Enter key twice while in the terminal program TERM1621.

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

Symbol	Description	ASCII	HEX	Key Sequence
(CR)	Carriage Return	CR	0D	Return
NULL	Null Character	NULL	00	Home Key
^	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.

SEACAT sends ^C whenever an Escape Function is received.

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

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

3-1.6 DIAGNOSTIC COMMANDS

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

CAUTION: After execution of FR, SEACAT runs continuously until the Escape Function is implemented. Unless an external power source is being used, the normal sampling current is drawn from the batteries during this time.

Example: FR(CR) SEACAT sends:

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

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

VR(CR)^C

Display voltages. Voltages read by the Analog-to-Digital converter are displayed.

CAUTION: After execution of VR, SEACAT runs continuously until the Escape Function is implemented. Unless an external power source is being used, the normal sampling current is drawn from the batteries during this time.

Example:VR(CR) SEACAT sends:

2.437

2.437

2.437

Response for SEACAT with temperature and conductivity only.

Main supply voltage = $VM * 3.892$ volts, where $VM = 2.437$

0.954 3.241 2.789 1.999 0.000 0.881 4.649

0.954 3.241 2.789 1.999 0.000 0.881 4.649

0.954 3.241 2.789 1.999 0.000 0.881 4.649

Response for SEACAT with pressure and/or with voltages.

Main supply voltage = $VM * 8.514$, where $VM = 0.954$

A/D channel 0 voltage = 3.241 (if enabled)

A/D channel 1 voltage = 2.789 (if enabled)

A/D channel 2 voltage = 1.999 (if enabled)

A/D channel 3 voltage = 0.000 (if enabled)

Pressure temperature voltage = 0.881 (if strain gauge pressure is installed)

Pressure voltage = 4.649 (if strain gauge pressure is installed)

These values may differ from actual instrument readings.

TE(CR)*^C

Extended memory test. **WARNING, ALL DATA IN SEACAT 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. Each pass takes approximately 30 seconds. For each pass SEACAT sends the following message (1024K memory):

pass x

ram 0, OK

ram 1, OK

ram 2, OK

.

.

ram 30, OK

ram 31, OK

At the conclusion of the test or when an Escape Function character is received, SEACAT displays:

ram test passed with no errors

TM(CR)^AC Memory test. **WARNING, ALL DATA IN SEACAT WILL BE DESTROYED!** Same as extended memory test except that the test concludes after pass 1 is completed.

J(CR) Measure standby current. The current (in microamperes) displays after about 7 seconds.

Example: J(CR) SEACAT sends:
wait 7 seconds
quiescent current = 48 microamps

3-1.7 STATUS COMMANDS

DS(CR) Display operating status: firmware version, serial number and current time; real-time clock oscillator frequency, operating current (milliamperes), main battery voltage and voltage of the lithium backup batteries with a 180 ohm load. Sample interval; number of samples already logged, number of additional samples that may be logged before memory is full, number of milliseconds to wait after sending a carriage return line feed (providing extra time for slow computers). The setting of the internal CPU switch and the battery cut off voltage are displayed on the next line. The following lines contain the number of external A/D voltages that have been enabled, the operating mode and the data logging status.

Example: DS(CR) SEACAT with temperature and conductivity only sends:

SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:43:42.838
clk = 32767.789, iop = 104, vmain = 8.9, vlith = 5.9
sample interval = 360 sec
samples = 0, free = 260821, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.6 volts
no. of volts sampled = 0
mode = normal
logdata = NO

If the optional strain gauge pressure sensor is installed, SEACAT responds with an additional line containing pressure sensor information:

SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:52:52.082
strain gauge pressure sensor: S/N = 155554, range = 3000 psia, tc = 0
clk = 32767.789, iop = 103, vmain = 8.9, vlith = 5.9
sample interval = 360 sec
samples = 0, free = 173880, lwait = 0 msec
SW1 = C2H, battery cutoff = 5.6 volts
no. of volts sampled = 0
mode = normal
logdata = NO

QS(CR) Quit session. Main power is turned off; data logging and memory retention are not affected. SEACAT draws only the quiescent current of approximately 50 microamps.

3-1.8 SETUP COMMANDS

CN(CR) Set SEACAT to narrow range conductivity for fresh water use. This command changes the internal scaling of the conductivity to maximize the resolution of the conductivity channel at the expense of its range. The range is changed from 0 to 6.5 S/m to 0 to 0.6 S/m while resolution is increased from 0.0001 to 0.000015 S/m. If the SEACAT is set to narrow range conductivity, a line appears in the response to the display status, DS, command:

```
SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:51:10.741
Narrow Range Cond
clk = 32767.789, iop = 103, vmain = 8.9, vlith = 5.9
sample interval = 360 sec
samples = 0, free = 260821, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.6 volts
no. of volts sampled = 0
mode = normal
logdata = NO
```

CS(CR) Set SEACAT to standard range (0 to 6.5 S/m) conductivity.

IL(CR)* Initialize logging. Use this command to reset data pointers **after existing data has been removed from the SEACAT** and prior to recording new data.

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 SEACAT when data is retrieved.

LWN(CR) Set wait interval of N milliseconds after each line of data; normally N = 0; increase for slower computers. N maximum is 65536.

ML(CR)

Set operating mode to latched DO. This is used to configure the firmware operation to support special hardware that can be ordered to support a moored dissolved oxygen (DO) SEACAT. This command will not function correctly unless the DO option was specified at the time the SEACAT was purchased. The **mode =** line in the display status response changes when this command has been invoked. When the SEACAT is placed in latched DO mode, set the voltage delay to 15 seconds using the VD command to insure that the SBE 5 pump is powered for a long enough period to draw a fresh sample of water into the dissolved oxygen sensor.

SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:53:17.530
clk = 32767.797, iop = 104, vmain = 8.9, vlith = 5.9
sample interval = 360 sec
delay before measuring volts = 15 seconds
samples = 0, free = 149040, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.6 volts
no. of volts sampled = 2
mode = latched DO
logdata = NO

MN(CR)

Set operation mode to normal operation. This command is used to disable the latched DO mode of operation in specially ordered SEACATs. The **mode =** line in the display status response reads **mode = normal** after this command has been entered.

SI(CR)

Set sample interval. Data logging starts interval seconds after the GL (go log) or RL (resume logging) command is entered. The minimum sample interval is 15 seconds. The maximum sample period is 32767 seconds (9.1 hours).

Example: SI(CR) SEACAT sends:

sample interval (seconds) = 60(CR)

sample interval = 60 sec

The sample interval is set to 60 seconds. Data logging starts 60 seconds after the GL or RL command is entered.

ST(CR)

Set date and time as prompted.

Example:

st(CR)

date (MMDDYY) = 071495(CR)

time (HHMMSS) = 100950(CR)

The date is set to July 14, 1995. The time is set to 10:09:50.

SVn(CR)

Set the number of external voltages that are to be acquired.

If the SEACAT was ordered with the optional A/D converter, this command is enabled. The configuration sheet contains the number of voltages that were set to be acquired when the SEACAT left the factory. This command allows the user to change the setting, either to add additional external sensors or to limit memory usage if an external sensor will not be used. The minimum number of voltages is 0, the maximum number of voltages is normally 4 if single ended amplifiers were specified or 2 if differential amplifiers were specified.

Example:

```
S>ds
SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:57:22.617
clk = 32767.789, iop = 102, vmain = 8.8, vlith = 5.8
sample interval = 360 sec
delay before measuring volts = 4 seconds
samples = 0, free = 173880, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.6 volts
no. of volts sampled = 1
mode = normal
logdata = NO
S>
S>sv0
S>ds
SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:57:40.139
clk = 32767.789, iop = 103, vmain = 8.8, vlith = 5.8
sample interval = 360 sec
samples = 0, free = 260821, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.6 volts
no. of volts sampled = 0
mode = normal
logdata = NO
S>
```

The number of external voltages sampled was changed from 1 to 0.

Voltage acquisition is always in order with voltage 0 acquired first. Consult the end cap drawing in the schematic section of the manual for the end cap wiring for this instrument. This drawing shows which pin on the 6-pin auxiliary connector is wired to which A/D voltage channel.

If the number of voltages being acquired is changed with the SV command, a corresponding change must be made in the SEASOFT.CON file using the SEACON program.

TI(CR)

Set the 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:

interval # N	current interval number
date (MMDDYY)	date to start new sample interval (month, day, year)
time (HHMMSS)	time to start new sample interval (hour, minute, second)
sample interval (seconds)	interval between successive samples

The maximum number of samples that can be stored in SEACAT with 1024K memory is 260817 samples.

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

Example:

```
interval # 1
  date (MMDDYY) = 090190
  time (HHMMSS) = 120000
  sample interval (seconds) = 900
```

```
interval # 2
  date (MMDDYY) = 120190
  time (HHMMSS) = 000000
  sample interval (seconds) = 120
```

```
interval # 3
  date (MMDDYY) =
```

```
at 09/01/90 12:00:00.000 sample interval = 900 sec
at 12/01/90 00:00:00.000 sample interval = 120 sec
```

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

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

VDnnnn(CR)

Set the delay time before acquisition of external voltages. **nnnn** is the time to add to the default delay value. All example headers in the manual are SEACATs with 4.0h EPROMs. If the SEACAT has the optional A/D converter and SV has been used to enable acquisition of data from external sensors, one of the following appears in the status display:

EPROMs less than or equal to 4.0g
delay before measuring volts = 3750 msec

EPROMs greater than or equal to 4.0h
delay before measuring volts = 4 seconds

Power to the external sensor (OBS-3, transmissometer, fluorometer, DO, etc.) is provided through the SEACAT's auxiliary connector. VD allows you to adjust the elapsed time between power turn on and acquisition of external sensor output by the SEACAT. For a Sea Tech Fluorometer, which has an internal filter with a 3-second time constant, set the voltage delay to 15 seconds (15000 milliseconds).

In latched DO mode, special circuitry powers the oxygen sensor for 2 minutes before acquiring data. VD controls the time that the pump is powered before taking a sample. Set the voltage delay to 15 seconds (15000 milliseconds) so that the pump runs for enough time to draw a fresh water sample into the oxygen sensor before its output is measured.

For SEACATs with a pump but without the optional A/D converter, VD is used to control the time that the pump is on prior to the SEACAT taking a new sample.

EPROMs less than or equal to 4.0g
 VD11250 adds 11250 msec to 3750 msec default value for total delay of 15000 msec.

EPROMs greater than or equal to 4.0h
 VD11 adds 11 seconds to 4 second default value for total delay of 15 seconds.

Example:

```
S>ds
SEACAT V4.0h SERIAL NO. 1814 07/14/95 10:00:38.662
clk = 32767.797, iop = 104, vmain = 8.8, vlith = 5.7
sample interval = 360 sec
delay before measuring volts = 4 seconds
samples = 0, free = 149040, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.6 volts
no. of volts sampled = 2
mode = normal
logdata = NO
S>vd11
vdel = 11 seconds
S>ds
SEACAT V4.0h SERIAL NO. 1814 07/14/95 10:00:53.337
clk = 32767.797, iop = 103, vmain = 8.8, vlith = 5.7
sample interval = 360 sec
delay before measuring volts = 15 seconds
samples = 0, free = 149040, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.6 volts
no. of volts sampled = 2
mode = normal
logdata = NO
```

SBn(CR)

Change the baud rate used by the SEACAT during normal communications.

Upon initial power up or reset, the SEACAT defaults to communicating at 600 baud. This command allows the user to change this baud rate to one of the values listed below. When this command is given, the SEACAT immediately changes its baud rate and all subsequent communication are at the new baud rate. This baud rate is retained by the SEACAT until power is removed from the circuit boards (cause by disassembly or by using the reset button located on the battery bulkhead) or until a new SB command is entered. The new baud rate is retained while the SEACAT is in quiescent mode between samples. This setting does not affect the baud rate controlled by the DD command for uploading data from the SEACAT.

The possible values are:

- n = 1 600 baud
- n = 2 1200 baud
- n = 3 9600 baud

Example:

S>sb3 set baud rate to 9600

3-1.9 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.

While SEACAT is logging data only the DS, QL and QS commands are active.

GL(CR)* Start logging data, first sample is set to 0, so any previously recorded data is written over, whether the memory has been initialized or not. SEACAT displays the sample interval (SI command) or the sampling times and intervals (TI command).

Example:

```
S>gl
start logging Y/N? y
are you sure ^Y/N ?
sample interval = 15 sec
```

```
start data logging
no samples stored yet
```

```
#995D03DC0000
```

```
#995E03DC0001
```

```
#996003DC0002
```

Once data logging has begun, the SEACAT transmits at each sample period the data that was collected at the previous sample period.

QL(CR)* Quit logging

Example:

```
S>q|
quit logging Y/N ? y
are you sure ^Y/N ?
S>
```

RL(CR)* Resume logging: sample number is not reset. Start time (if set by TI command) is not used. Previously recorded data is not be overwritten. SEACAT displays the sample interval (SI command) or the sampling times and intervals (TI command).

Example:

```
S>rl
resume logging Y/N? y
are you sure ^Y/N ?
sample interval = 15 sec

start data logging
```

3-1.10 DATA RETRIEVAL COMMANDS

In TERM1621 data retrieval is determined by the set up of the configuration file. TERM1621 communicates with SEACAT using the following commands. The SEACAT is capable of dumping data at the following baud rates:

B = 1	600 baud	B = 2	1200 baud
B = 3	9600 baud	B = 4	19,200 baud
B = 5	38,400 baud		

B is the number used below to specify to SEACAT what baud rate to use to dump data.

DD[B[n1],n2](CR)^C Raw data is displayed in HEX at the baud rate specified by B. If B, n1 and n2 are omitted, all logged data is displayed at the default baud rate. Entering n1,n2 displays samples n1 through n2. The data format is described in section 3-3.4.

Example: DD1100(CR) SEACAT sends at 600 baud:

ttttcccc

tttt is the corrected temperature frequency for sample 100
cccc is the corrected conductivity frequency for sample 100

The frequencies and voltages are scaled and offset to optimize use of the RAM.

Actual temperature frequency = $tttt / 19 + 2100$

Actual conductivity frequency = $\text{sqrt}(\text{cccc} * 2100 + 6250000)$ (standard range)

Actual conductivity frequency = $\text{sqrt}(\text{cccc} * 244 + 7562500)$ (narrow range)

If $ttttcccc = A80603DA$

$tttt$ = decimal equivalent of A806 HEX or 43014

Actual temperature frequency = $43014 / 19 + 2100 = 4363.89$ Hertz

$cccc$ = decimal equivalent of 03DA HEX or 986

Actual conductivity frequency = $\text{sqrt}(986 * 2100 + 6250000) = 2884.525$ Hertz

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* displays.

A new header is written when data logging is started or resumed, sample interval changes, or 1000 samples have been recorded since the last header was written.

Example: DH(CR) SEACAT sends:

HDR 0 MM/DD HH:MM:SS samples X to Y interval = W 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
W interval between samples in seconds

Sample:DH(CR)

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 1499 interval = 3600 sec

Line 1 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 2 is written when the sample interval changes from once every minute to once every 60 minutes.

Line 3 is written when the total number of samples is a multiple of 1000.

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

Example: SS(CR) SEACAT sends:

#ttttccccssss

: always sent as an attention character
tttt : corrected temperature frequency
cccc : corrected conductivity frequency
ssss : sample number

A carriage return and line feed follow the data.

The frequencies are scaled and offset as described in the dump data (DD) command.

TS(CR) Take a sample and transmit the results. Data is not stored in memory. Normally used while not logging. SEACAT automatically powers off 0.25 seconds after transmitting the data.

Example: TS(CR) After approximately 8 seconds, SEACAT sends:

#ttttcccc

: always sent as an attention character
tttt : corrected temperature frequency
cccc : corrected conductivity frequency

A carriage return and line feed follow the data.

3-2 SEASOFT SOFTWARE CONFIGURATION FILES

TERM1621 is used to communicate with and retrieve data from SEACAT. TERM1621 creates the file TERM16.CFG to store its setup parameters, so they do not have to be reentered every time. TERM16.CFG, with typical setup parameters for using your SEACAT (assuming installation on C: drive) is included on the SEASOFT disks that accompanied your SEACAT.

SEACON creates or modifies a file SEASOFT.CON, which is used by SEASOFT modules to obtain calibration coefficients and instrument configuration information. For new instruments this information was entered at the factory, and a copy of this file was included on the software disks that accompanied your SEACAT. If the SEACAT is recalibrated or the configuration is changed (such as adding external sensors), run SEACON to enter new calibration information or modify configuration settings. Refer to the instrument *configuration page* and/or calibration certificates in this manual, and the SEASOFT software manual for additional information.

Note: If desired:

- Use **SEATERM** instead of **TERM1621 (DOS)** to setup and upload data from the SEACAT.
- Use the **Configure** menu in **SEASAVE** or **SBE Data Processing** instead of **SEACON (DOS)** to modify the instrument configuration file.

SEATERM, SEASAVE, and SBE Data Processing are part of our SEASOFT Windows software suite. See the software Help files for details.

3-3 DATA LOGGING, RETRIEVAL AND FORMATS

Connect SEACAT test cable to the RS-232C port on an IBM XT/AT/386/486 or compatible. Type **TERM1621** to load the SEACAT terminal program on the computer. SEACAT responses are in **bold face**, comments are enclosed in brackets [].

3-3.1 LOG DATA (SI command to set interval)

Enter (CR). SEACAT sends back **S>**.

S>ds(CR) [display status]

SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:55:44.259
clk = 32767.570, iop = 103, vmain = 8.8, vlith = 5.8
sample interval = 3600 sec
samples = 0, free = 260821, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.4 volts
no. of volts sampled = 0
mode = normal
logdata = NO

Check that serial number, date and time are correct, and that the measured value of the main battery supply voltage is reasonable for the intended use.

S>si(cr) [enter sample interval]

sample interval (seconds) = 60 [interval = 1 minute]
sample interval = 60 sec

S>gl(CR) [start logging]

start logging Y/N ? y(CR) [confirm]
are you sure ^Y/N ? ^y(CR) [second confirm]

sample interval = 60 sec [interval = 1 minute]

start data logging [SEACAT confirmation]

wait 5 sec enter (CR) [wake up SEACAT]

S>ds(CR) [display status; verify that log = YES, interval is correct, samples = 0]

SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:55:44.259

clk = 32767.570, iop = 103, vmain = 8.8, vlith = 5.8

sample interval = 60 sec

samples = 0, free = 260821, lwait = 0 msec

SW1 = 40H, battery cutoff = 5.4 volts

no. of volts sampled = 0

mode = normal

logdata = YES

S>qs(CR) [quit session; SEACAT in low power standby between samples]

press F10 key [return to DOS]

3-3.2 LOG DATA (TI command to set sample times and intervals)

Enter (CR). SEACAT sends back **S>**.

S>ds(CR) [display status]

SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:55:44.259

clk = 32767.680, iop = 102, vmain = 8.8, vlith = 5.9

sample interval = 3600 sec

samples = 0, free = 260821, lwait = 0 msec

SW1 = 40H, battery cutoff = 5.4 volts

no. of volts sampled = 0

mode = normal

logdata = NO

Check that serial number, date and time are correct, and that the measured value of the main battery supply voltage is reasonable for the intended use.

S>ti(cr) [enter sample times and intervals]

interval # 1

date (MMDDYY) = 080495

[start time is 8 am, August 4, 1995]

time (HHMMSS) = 080000

[interval = 30 seconds]

sample interval (seconds) = 30

interval # 2

date (MMDDYY) = 081095

[at 1 pm, August 10 1995]

time (HHMMSS) = 130000

[interval changes to 5 minutes]

sample interval (seconds) = 300

interval # 3

date (MMDDYY) = (CR)

[press Enter here to quit]

at 08/04/95 08:00:00.000 interval = 30 sec

[SEACAT verifies choices]

at 08/10/95 13:00:00.000 interval = 300 sec

start time = 08/04/95 08:00:00.000

S>gl(CR) [start logging]

start logging Y/N ? y(CR) [confirm]
are you sure ^Y/N ? ^y(CR) [second confirm]

sampling times and intervals:
at 08/04/95 08:00:00.000 interval = 30 sec [SEACAT verifies choices]
at 08/10/95 13:00:00.000 interval = 300 sec

start time = 08/04/95 08:00:00.000

start data logging [SEACAT confirmation]

wait 5 sec enter (CR) [wake up SEACAT]

S>ds(CR) [display status; verify that log = YES, the interval is correct, samples = 0]

SEACAT V4.0h SERIAL NO. 1814 07/14/95 10:34:30.656
clk = 32767.680, iop = 102, vmain = 8.5, vlith = 5.9
at 08/04/95 08:00:00.000 sample interval = 30 sec
at 08/10/95 13:00:00.000 sample interval = 300

start time = 08/04/95 08:00:00.000

delay before measuring volts = 15 seconds
samples = 0, free = 260821, lwait = 0 msec
SW1 = C1H, battery cutoff = 5.4 volts
no. of volts sampled = 0
mode = normal
logdata = YES

S>qs(CR) [quit session; SEACAT in low power standby until data acquisition begins August 4, 1995]

press F10 key [return to DOS]

3-3.3 RETRIEVE DATA

The procedure for logging data described in Section 3-2.1 or 3-3.2 should have been previously implemented, and sufficient time to acquire several samples elapsed. Enter (CR), wait approximately 3 seconds. Repeat until **S>** is displayed.

S>ds(CR) [display status, note the number of scan recorded]

SEACAT V4.0h SERIAL NO. 1814 07/14/95 09:55:44.259

clk = 32767.680, iop = 102, vmain = 8.5, vlith = 5.9

sample interval = 60 sec

samples = 0, free = 260821, lwait = 0 msec

SW1 = C1H, battery cutoff = 5.4 volts

no. of volts sampled = 0

mode = normal

logdata = YES

S>

S>ql(CR) [quit logging data]

Repeat until you see **quit logging Y/N ? y** (CR)

are you sure ^Y/N ? ^y

In **TERM1621**, the F2 key is used to configure the parameters to upload data from the SEACAT. The F9 key is used to actually create a computer file of SEACAT data. This file can then be displayed using SEASAVE or converted into an ASCII file of engineering unit parameters using DATCNV. Consult the SEASOFT manual for detailed information on the setup and use of SEASOFT programs.

3-3.4 DATA FORMATS

DATA FORMATS - temperature, conductivity only

8 ASCII HEX characters representing 4 bytes are stored per CTD scan. A carriage return line feed follows the data from the last CTD scan.

The data format for CTD scans is:

aaaabbbb

aaaa = four HEX characters representing 2 bytes of temperature data

bbbb = four HEX characters representing 2 bytes of conductivity data

Temperature:

1. T = decimal equivalent of aaaa
2. Temperature frequency = $T / 19 + 2100$

Conductivity (standard range)

1. C = decimal equivalent of bbbb
2. Conductivity frequency = $\text{sqrt}(C * 2100 + 6250000)$

Conductivity (narrow range)

1. C = decimal equivalent of bbbb
2. Conductivity frequency = $\text{sqrt}(C * 244 + 7562500)$

EXAMPLE

aaaabbbb = 69CC4322

aaaa = 69CC, T = 27084, Temperature Frequency = 3525.474

bbbb = 4322, C = 17186, Conductivity Frequency = 6506.970 (standard range conductivity)

DATA FORMATS - temperature, conductivity with optional external voltages and strain gauge pressure

12 ASCII HEX characters representing 6 bytes are stored per CTD scan. A carriage return line feed follows the data from the last CTD scan.

The data format for CTD scans is:

aaaabbbbpppp

aaaa = four HEX characters representing 2 bytes of temperature data

bbbb = four HEX characters representing 2 bytes of conductivity data

pppp = four HEX characters representing 2 bytes of strain gauge pressure data

If the SEACAT was ordered from the factory with the optional A/D converter, it has the capability to record up to four external voltages. (See the SV command in section 2.2-4 for additional information on enabling the recording of these voltages.) If enabled, the voltage data appears after the conductivity and before the pressure data (if pressure is present). The data format for the voltages is:

0uuu one voltage

uuuvvv two voltages

uuuvvv0xxx three voltages

uuuvvvxxxxyyy four voltages

The 0 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

Temperature:

1. T = decimal equivalent of aaaa
2. Temperature frequency = $T / 19 + 2100$

Conductivity (standard range)

1. C = decimal equivalent of bbbb
2. Conductivity frequency = $\text{sqrt}(C * 2100 + 6250000)$

Conductivity (narrow range)

1. C = decimal equivalent of bbbb
2. Conductivity frequency = $\text{sqrt}(C * 244 + 7562500)$

Voltage 0:

1. $V0 = \text{decimal equivalent of } uuu$
2. $\text{Voltage } 0 = V0 / 819.$

Voltage 1:

1. $V1 = \text{decimal equivalent of } vvv$
2. $\text{Voltage } 1 = V1 / 819.$

Voltage 2:

1. $V2 = \text{decimal equivalent of } xxx$
2. $\text{Voltage } 2 = V2 / 819.$

Voltage 3:

1. $V3 = \text{decimal equivalent of } yyy$
2. $\text{Voltage } 3 = V3 / 819.$

Strain Gauge Pressure:

1. $P = \text{decimal equivalent of bits } 0 \text{ through } 13 \text{ of } pppp.$ Bit 14 is the sign bit. If bit 14 is 0 the number is positive, if it is 1 the number is negative.
2. $\text{Pressure number} = P.$

EXAMPLE

$aaaabbbbuuuvvpppp = 69CC43223450590A79$

$aaaa = 69CC, T = 27084, \text{Temperature Frequency} = 3525.474$

$bbbb = 4322, C = 17186, \text{Conductivity Frequency} = 6506.970$

$uuu = 345, V0 = 837, \text{Voltage } 0 = 1.022$

$vvv = 059, V1 = 89, \text{Voltage } 1 = 0.109$

$pppp = 0A79, P = 2681, \text{Pressure number} = 2681$

DATA FORMATS - temperature, conductivity, Digiquartz pressure and optional external voltages.

18 ASCII HEX characters representing 9 bytes are stored per CTD scan. A carriage return line feed follows the data from the last CTD scan.

The data format for CTD scans is:

aaaabbbbppppppcccc

aaaa = four HEX characters representing 2 bytes of temperature data

bbbb = four HEX characters representing 2 bytes of conductivity data

pppppp = six HEX characters representing 3 bytes of Digiquartz pressure data

cccc = four HEX characters representing 2 bytes of pressure temperature data

If the SEACAT was ordered from the factory with the optional A/D converter, it has the capability to record up to four external voltages. (See the SV command in section 2.2-4 for additional information on enabling the recording of these voltages.) If enabled, the voltage data appears between the pressure and the pressure temperature data.

The data format for temperature, conductivity and external voltages is the same as the previous example.

Pressure (Digiquartz):

1. P = decimal equivalent of pppppp
2. Pressure frequency = $P / 256.0$

Pressure Temperature:

1. C = decimal equivalent of cccc
2. Pressure Temperature Voltage = $C / 819.0$
3. Pressure Temperature = $(\text{Voltage} + 9.7917) * 23.6967 - 273.15$ (degrees Centigrade)

EXAMPLE

aaaabbbbpppppp0uuucccc = 69CC43228D1B80003008AA

aaaa = 69CC, T = 27084, Temperature Frequency = 3525.474

bbbb = 4322, C = 17186, Conductivity Frequency = 6506.970

pppppp = 8D1B80, P = 9247616, Pressure frequency = 36123.5

uuu = 0030, V0 = 48, Voltage 0 = 0.059

cccc = 08AA, C = 2218, Pressure Temperature = 23.0

3-3.5 REAL-TIME DATA

SEACATs with EPROM versions 3.2a and higher transmit real-time data at each sample. The value that is sent is actually the data from the previous sample. The format of the real-time data is as follows:

#aaaabbbbssss

= attention character

aaaa = four HEX characters representing 2 bytes of temperature data

bbbb = four HEX characters representing 2 bytes of conductivity data

ssss = the sample number

If the SEACAT has optional external voltages or pressure, this data is also transmitted real-time with the addition of the attention character at the beginning and the sample number at the end. See section 3.3-4 for additional information regarding data format.

EXAMPLE

S>gl

start logging Y/N ? y

are you sure ^Y/N ?

sample interval = 15 sec

start data logging

no samples stored yet

#8E0C03DB0000

#8E1503DB0001

#8DFA03DB0002

#8DFF03DB0003

#8DF303DB0004

3-3.6 LATCHED DISSOLVED OXYGEN OPERATION

If ordered with the latched DO option, the SEACAT can be used to take moored measurements of dissolved oxygen and other parameters. This option provides special circuitry that provides power to the oxygen sensor for 120 seconds before a sample is taken, allowing the oxygen sensor to polarize and come to a stable reading. During most of this period, power is not applied to the rest of the SEACAT circuitry thereby minimizing battery power usage. The latched DO option also includes an externally mounted SBE 5 pump. This pump is used to draw a fresh sample of water into the oxygen sensor before the oxygen sensor output is measured. Set the voltage delay (VD command) to 15 seconds to insure that the pump runs for an adequate amount of time.

The SEACAT with latched DO option uses a 12-battery housing. When using alkaline batteries, a total of at least 10,000 samples can be obtained. This would permit a 20-day deployment at the minimum sampling interval of 3 minutes, or more than 200 days at a more typical sampling interval of 30 minutes.

With the latched DO option the minimum sampling interval is 3 minutes. Do not set the sampling interval (SI command or TI command in SEACAT) to a period less than 180 seconds!

3-3.7 RECOVERY FROM MAIN BATTERY FAILURE

At the beginning of each sample, SEACAT measures the main battery voltage to insure it has sufficient power to take a sample. If it finds the battery voltage below 5.4 volts, it does not take a sample but fills the data scan in memory with a 5A5A5A5A pattern and returns to the quiescent state. If at the next sample interval it again finds the main battery voltage below 5.4 volts, it repeats the 5A5A5A5A pattern and returns to the quiescent state. It repeats this for a total of ten cycles before assuming that the main batteries have failed. At this point it stops any attempts to log data and remains in quiescent state until communications are established with **TERM1621**. During this quiescent period the *exhausted* main batteries normally have sufficient power to maintain memory. If they fail completely however, the lithium batteries mounted on the circuit boards keep memory alive for over a year.

If the main batteries fail during a deployment, attempts at communicating with the instrument may fail with the message **!!low battery voltage!!**. This indicates that there is insufficient power available in the main batteries for the SEACAT to wake up and power its circuits. The preferred recovery from this situation is to apply an external source of 10 to 15 volts DC power to the I/O connector (see section 3-1.1). This powers SEACAT while the data in memory is recovered. It is also possible to replace the main batteries with new ones and then recover the data.

4-1 FUNCTIONAL DESCRIPTION

4-1.1 SENSORS

SEACAT embodies the sensor elements (Pyrex cell and pressure-protected thermistor) and Wein-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.

4-1.2 SENSOR INTERFACE

Temperature or conductivity dependent variable frequencies generated by the Wein-bridge are acquired (digitized) using a hybrid period counting technique (AP Counter) like that used in the 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 count accuracy, is determined using a precision quartz TCXO). 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 SEACAT by switching stable resistors (Vishay types) into the Wein-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 SEACAT electronics is limited only by the stability of the Vishay resistors and time-base quartz crystal.

4-1.3 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.

4-1.4 MEMORY

Data storage is in low standby-power CMOS static RAM (1024K byte). The SEACAT memory board contains locations for eight 128K X 8 RAM chips. Each sample of temperature and conductivity uses 4 bytes, and 5308 bytes are reserved of scratch-pad use, including storage of user-defined acquisition routines and annotation (header string). A header containing sample number, data pointer, and time/date is recorded each 1000th sample.

SEACAT sample capacity may be predicted by use of the following relationships:

M = memory size = 1,048,576 (1024K) bytes
Z = scratch-pad reserved area = 5308 bytes
B = bytes per sample (4 standard)
S = #samples = (M - Z) / B

A standard SEACAT with 1024K memory stores 260,817 C - T pairs.

4-1.5 DATA I/O

SEACAT receives setup instructions and outputs diagnostic information or previously recorded data via a 3-wire RS-232C link, and is factory-configured for 600 baud, 7 data bits, 1 stop bit, and even parity. Other baud rates may be selected using the SB command in Section 3-1.8. RS-232 levels generated and accepted by SEACAT are directly compatible with standard serial interface cards.

4-1.6 BATTERIES

The standard SEACAT uses 6 D-cell batteries (alkaline standard). Optionally, 9 or 12 cells are used for applications where a higher voltage is needed for auxiliary sensors (e.g., fluorometer, Latched DO). **Lithium D-cells with their higher terminal voltage may not be used.** On board lithium batteries (non-hazardous units that are unrestricted for shipping purposes) are provided to back up the memory and the real-time clock in the event of main battery failure or exhaustion. An auxiliary power source (10 - 15 volts) may be connected to the main I/O bulkhead to permit testing and data retrieval without affecting battery capacity. The main batteries may be replaced without affecting either the real-time clock or memory.

The following table provides power draws for various configurations:

Pressure?	Sampling Current	Sampling Time	Optional SBE 5M Pump Current and Time
None	130 milliamps	5 seconds	300 milliamps for 4.7 seconds
Paine sensor	180 milliamps	5 seconds	300 milliamps for 4.7 seconds
Digiquartz sensor	245 milliamps	6.7 seconds	300 milliamps for 6.3 seconds

The quiescent current drain is approximately 50 microamps.

Example: Assuming a 130 milliamp sampling current, no pump, 48 samples per day for 2 years, 730 days, the capacity requirement works out as follows:

Quiescent Current: $0.00005 \text{ amps} * (730 \text{ days} * 24 \text{ hours}) = 0.876 \text{ amp-hours}$

Total Sampling Time: $730 \text{ days} * 48 \text{ samples/day} * 5 \text{ sec/sample} = 175,200 \text{ sec} = 48.67 \text{ hours}$

Sampling Current: $0.13 \text{ amps} * 48.67 \text{ hours} = 6.33 \text{ amp-hours}$

Total Capacity Required: $0.876 \text{ amp hours} + 6.33 \text{ amp hours} = 7.2 \text{ amp-hours}$

The estimated useable capacity of 6 Duracell D-cells is about 8 amp-hours at 20 degrees Celsius and about 5 amp-hours at 0 degrees Celsius. Even after the main battery fails to support data sampling, it provides memory backup power until it falls below 3.2 volts. At that point, the on-board lithium batteries continue to support memory for over one year.

4-1.7 HOUSING AND MECHANICAL DESIGN

The SEACAT main housing is a cylindrical pressure vessel with an outside diameter of 99 mm (3.9 inches) and flat end caps. The sensor end cap is retained by titanium screws. The battery end cap is threaded on. Pad eyes at top and bottom permit mounting of the vertical cell units; do not apply tension of more than about 50 kg to the pad eyes. Vertical cell units have sensor end cap piston seals. All types have both battery end cap piston seals and battery end cap face seals.

I/O connectors are Impulse XSG-4BCL (HP) designed to mate with RMG-4FS female molded pigtails.

Plastic SEACATs have titanium end caps, conductivity cell trays, and sensor guards. These are rated for depths up to 600 meters

Titanium SEACATs are designed to be used to depths of up to 10,500 meters.

5-1 DESCRIPTION OF SEACAT CIRCUITRY

SEACAT circuitry is contained on three rectangular (approximately 75 X 250 mm) printed boards supporting analog, CPU, and memory functions. The CPU and memory boards are interconnected at several points by means of pin and socket SIP connectors to form a digital *module*. A single DIP inter-board connector is used to carry the 26 lines between the analog board and the digital module.

5-1.1 BATTERY WIRING AND POWER SUPPLY

SEACAT's main battery is a series connection of D-cells, which drop into the battery compartment as a cluster of three end-to-end pairs. The positive battery connections are contact areas on double-thick printed circuit disks, which form the internal bulkhead and battery retainer plates. Battery negative contacts are heavy beryllium-copper springs. The three cell pairs are aligned by plastic insulated aluminum spacers that also serve as electrical interconnects.

The battery - circuit card connection is made by means of a Molex-type 6-pin pc board connector (J6).

The Analog board contains two series-connected lithium cells (1/2 AA non-hazardous) that are diode OR'd with the main battery (and external power source, if used). The lithium supply is capable of supporting all SEACAT functions and serves to permit orderly shutdown in the event of failed or exhausted main batteries.

Battery voltage is connected to a low-power regulator chip (Intersil 7663) used to supply 5 volts (+ 5C) to the real-time clock (RTC) and memory circuits. When a conductivity/temperature sample is to be taken, the RTC *wakes up* the CPU by switching on MOSFET Q2 to connect battery voltage to the main supply regulator (National Semiconductor LM2950, + 5 volts). The CPU checks that main battery voltage is adequate (minimum 5.4 volts) before proceeding with the measurement routine.

5-1.2 SENSOR MULTIPLEXING

The conductivity cell, thermistor, and two reference resistors are sequentially connected to a single Wein-bridge oscillator circuit by means of mercury-wetted relays (RL1-4) driven by NPN saturated switches under control of the CPU. The relays retain their low (0.1 ohm) initial contact resistance within 0.005 ohms throughout a life-time of 200×10^6 operations minimum (380 years continuous operation of SEACAT).

Relay coil power is derived directly from the unregulated battery line through emitter-follower Q7. The advantage is that the system regulator is not required to handle the (relatively) large and intermittent relay coil current.

5-1.3 WEIN-BRIDGE OSCILLATOR

The Wein-bridge oscillator (WBO) is configured as a controlled-gain amplifier using high-frequency bipolar transistors and low-valued load resistors to achieve minimum phase shift. An input FET provides high impedance to the WBO frequency-determining components (two fixed capacitors, a fixed resistor, and the unknown sensor resistance) while an emitter follower presents a low driving impedance to the MOSFET gain control element.

The WBO output of 0.16 volts p-p (small enough to avoid significant self-heating in the SEACAT's sensors) is amplified to supply the higher AC level (approximately 1.2 volts p-p) needed to activate the AGC detector.

5-1.4 SQUARING CIRCUITS AND AP COUNTER

The amplified WBO output is squared by CMOS inverters connected as Schmidt-triggers. While the squared WBO signal is selected by the CPU controlled MUX, the AP counter circuit (on the Memory board) is used to count its frequency. A 12-bit CMOS counter (4040) acquires the integer count during a 0.125-second interval, while a second 4040 counts the TCXO frequency (2.097 MHz) to yield a number representing the *fractional* cycle of the input frequency. The CPU uses the two counts to compute a single number representative of WBO frequency, at a resolution equal to $1/(0.125 \times 2.097e6)$ or 1/262,000. This is comparable to the counter resolution obtained with other Sea-Bird CTD equipment.

5-1.5 A/D CONVERTER (INTERNAL DIAGNOSTICS)

A 12-bit plus sign A/D converter (National Semiconductor ADC1205) is used on the CPU board to obtain diagnostic information relating to SEACAT status and functionality. A pre-amplifier and buffer (Precision Monolithics OP220) are used to condition the internal signal levels selected by the MUX. Main supply current is determined by measuring the voltage across a 0.5 ohm resistor, while main unregulated and lithium back-up voltages are sensed using resistive dividers. To assure ability of the back-up lithium supply to power SEACAT functions, its voltage is measured under typical load. SEACAT quiescent current (RTC and memory only supported) is also measured by the A/D.

5-1.6 CPU AND DATA I/O

SEACAT's CPU is configured around an 80C85 CMOS 8-bit microprocessor (CPU board), with program storage in CMOS EPROM (27C256, Memory Board). Communication with SEACAT is via RS-232 interface to the XR88C681 UART (CPU Board), while level conversion is handled by a LT1081; this chip serves a double role in supplying a source of ± 12 v power used to drive the A/D converter's precision 5 volt reference (PMI REF02).

A time-out signal is generated, which resets the CPU after 5 seconds of CPU inactivity; the time-out feature is intended to protect against inadvertent incapacitation resulting from some unforeseen software *loop*. The reset inhibit is detected on the CPU Board in response to periodically imbedded lines of code, which cause a write instruction to location C1 HEX.

5-1.7 REAL-TIME CLOCK

RTC oscillator circuitry (Memory Board transistor oscillator, CMOS buffer/squaring) is on the Memory Board. A flip-flop converts the 3 v p-p squared oscillator output to the 5 volt level required for SEACAT's digital circuitry. The RTC oscillator frequency is counted during each data acquisition cycle using SEACAT's precision TCXO. The results are used to arithmetically correct the inter-sample interval and recorded time.

The clock/calendar chip is on the CPU Board (National Semiconductor MM58167A). CPU Board uses tri-state buffers to protect the clock/calendar from inadvertent wake-alarm rewrite during power-up.

5-1.8 MEMORY

Eight low-power CMOS static RAM chips (Memory Board, Hitachi HM628128) are used for main data memory. Bank switching is used, and memory contents protected on power-up by tri-state latches.

6-1 INSTALLATION AND OPERATING INSTRUCTIONS

Standard SEACATs are shipped with alkaline batteries installed; SEACAT is in quiescent mode drawing 50 microamperes or less. The initialization routines described below are performed at the factory and the real-time clock is running (set to Pacific Time).

To gain experience with SEACAT communications protocol, the Sample Set-up Sessions described in Section 3-2 may be followed at this time.

If a separate power supply is available to be used for testing, connect the power supply to the 4-pin bulkhead connector (see Section 2-1 for hook-up instructions).

Power is drawn from the main batteries, the external power source, or the internal printed circuit-mounted lithium back-up cells (5.6 volts), depending on which voltage source is highest. The back-up cells have 1.2 ampere-hour capacity, which is sufficient to run the real-time clock and preserve data in memory for more than two years. In the normal logging modes, SEACAT will not operate unless the main or external power source is present. However, the diagnostic routines such as fr and vr, once begun, continue even if the main supplies are exhausted. SEACAT can then quickly exhaust the lithium back-up cells.

6-1.1 BATTERY INSTALLATION

Unthread the battery compartment end cap (this is the end cap without any connectors on it). Remove the three Phillips-head machine screws from the battery retainer plate immediately inside the pressure housing. Lift this plate clear.

Batteries are installed with the + terminal against the flat battery contacts, and the - terminal against the spring contacts. Tilt the housing to allow the cells to slide out. Drop the new batteries into their respective slots. Align the retainer plate so that the flat and spring contacts are over the + and - battery contacts respectively, and re-install the plate. **These screws must be fully tightened or else the battery power to the circuitry is intermittent.** Check for battery voltage (approximately 9 volts) at the screw heads marked BAT POS and BAT NEG.

Check the O-ring(s) and their mating surfaces for dirt and debris. Make sure they are clean and lightly lubricated. Rethread the battery compartment end cap into place.

6-1.2 INITIALIZATION AFTER DISASSEMBLY

After a complete disassembly (for repair, or other servicing), it is necessary to initialize SEACAT.

1. Establish communications with the SEACAT with **TERM1621**.
2. Enter the ST command to reset the date and time, SEACAT prompts:

date (MMDDYY) = enter month, day and year
time (HHMMSS) = enter hour, minutes and seconds

Verify that date and time are correct by entering the ds (display status) command.

The commands described in Section 2 may now be executed. If further communication with SEACAT is not desired at this time, enter qs(CR) to quit the session and place SEACAT in quiescent mode. In quiescent mode battery current consumption is less than 50 microamperes: depletion of battery capacity is insignificant (less than 0.5 amp-hour/year) unless extended storage is planned. If SEACAT is in command mode (S> displayed) and no commands are entered within two minutes, reversion to quiescent mode automatically occurs. When SEACAT is in quiescent mode, (CR) re-establishes command mode and cause the S> to appear.

If SEACAT is to be stored for long periods, leave the batteries in place, but remove, discard, and replace them each year before use. If the main batteries are in place, no current is drawn from the lithium back-up cells.

6-1.3 DEPLOYMENT

Check that the hardware and external fittings are secure.

Refer to Section 2 for information on programming SEACAT for the desired operating routine, and confirm that memory capacity is sufficient. Make sure that the self-diagnostic voltage and current levels are proper. A screen dump (to a printer) of SEACAT's responses to the DS command makes a useful record of the instrument's pre-deployment condition.

Before putting SEACAT in the water, insure that the dummy cover and locking cap have been placed over SEACAT's bulkhead connector I/O port. Before installing the locking cap, remove any trapped air in the dummy cover by gently squeezing the cover near the top and moving the fingers towards the end cap. Then remove the Tygon tubing looped end-to-end around the conductivity cell.

6-1.4 ANTI-FOULANT ATTACHMENTS

Anti-foulant device attachments and expendable AF24173 Anti-Foulant Devices are available for each end of the conductivity cell, for moored applications where biological activity is anticipated. See Appendix I for handling details. Also see *Application Note 70: Installing Anti-Foulant Device Mount Kit on SBE 4, 16, 19, and 21 Conductivity Cells*.

6-1.5 RECOVERY

CAUTION!! Improperly sealed pressure housings may flood in such a way as to trap and compress the air inside. If this happens, a potentially life threatening explosion can occur when the instrument is brought to the surface.

Accordingly, treat a malfunctioning instrument with great caution until it has been determined that abnormal internal pressure does not exist or has been relieved.

If the SEACAT is unresponsive to I/O commands or shows other signs of flooding or damage, loosen each of the sensor end cap retaining screws 1/2 turn. If there is internal pressure, the end cap follows the screws out, and the screws will not become easier to turn. In this event, loosen the I/O bulkhead connector at least two turns to relieve any internal pressure.

Rinse the conductivity sensor with fresh water, and replace the Tygon tubing.

Remove the dummy cover from the I/O port, and connect SEACAT to a computer serial port. It is best (and if the main batteries are exhausted, necessary) to use an external power source connected to SEACAT's I/O port.

If immediate re-deployment is not required, it is best to leave SEACAT in quiescent mode so that data is retained; re-initialize memory only after determining that the archived data set is satisfactory. The cost in usage of the lithium back-up cells is very small, and even an *exhausted* main battery holds the memory for long periods (months).

Sea-Bird's SEASOFT CTD data acquisition software may be used to tabulate and plot the archived data set. See the SEASOFT manual for further information.

7-1 ROUTINE MAINTENANCE AND CALIBRATION

7-1.1 CORROSION PRECAUTIONS

Current production SEACATs have titanium sensor end caps, cell trays and cell guards and either Celcon plastic or titanium pressure housings. These units are highly resistant to corrosion and provide years of service if treated properly. Rinse the SEACAT with fresh water after use and prior to storage.

7-1.2 CONDUCTIVITY CELL STORAGE

Refer to Application Note 2D for conductivity cell cleaning and storage procedures and materials.

7-1.3 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 SEACAT are supplied fully calibrated, with coefficients printed on their respective Calibration Certificates.

We recommend that the SEACAT be returned to Sea-Bird for calibration.

If SEACAT is recalibrated, enter the new calibration coefficients in the instrument configuration file.

7-1.3.1 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 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; 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 before and after deployment, but particularly when the cell has been exposed to contamination by oil slicks or biological material.

7-1.3.2 TEMPERATURE SENSOR CALIBRATION

The primary source of temperature sensor calibration drift is the aging with time of the thermistor element. This is usually 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.

7-1.3.3 PRESSURE SENSOR CALIBRATION (STRAIN-GAUGE SENSOR)

The optional strain-gauge pressure sensor is a semi-conductor type with an initial static error band of 0.10%, and is consequently capable of meeting SEACAT's 0.25% error specification with some allowance for aging and ambient-temperature induced drift. For demanding applications, or where the sensor's air ambient pressure response has changed significantly, calibration using a dead-weight generator is recommended. The end cap's 5/16-24 straight thread permits mechanical connection to the pressure source.

7-1.3.4 PRESSURE SENSOR CALIBRATION (DIGIQUARTZ SENSOR)

The Digiquartz pressure sensor is so stable and immune to environmental effects that much less frequent checks suffice. It is usually enough to check that the 0 pressure (air) reading has not shifted. For especially critical work, check the full scale response using a dead-weight tester on an annual schedule.

To recalibrate the pressure transducer, remove the nylon fitting (with short attached 1/8-inch OD plastic tube) from the lower end cap of the sensor housing. There is silicon oil in this fitting, so there will be some spillage. The end cap is tapped with a 5/16-24 straight thread to accept your pressure fitting. Use a fitting that has an O-ring face seal, such as Swagelok-200-1-OR. After calibration, turn the instrument so the lower end cap is facing up, remove the fitting and fill the cavity with silicon oil (such as Dow Corning DC200 fluid, with 20 centistoke viscosity). Use a 2-inch long, 21-gauge hypodermic needle (supplied, with syringe) inserted as far as it will go into the small hole at the bottom of the cavity. Then replace the nylon fitting. The oil in the cavity should fill the nylon fitting and 1/8-inch tube as the fitting is screwed in. The purpose of the nylon fitting and plastic tube is to prevent any salt water from getting into the end cap penetration. The pressure transducer itself is protected from salt water by the oil-filled stainless capillary tube connecting it to the lower end cap.

8-1 DISASSEMBLY/REASSEMBLY INSTRUCTIONS

COMPLETE DISASSEMBLY WILL DESTROY ANY DATA PREVIOUSLY STORED IN SEACAT!

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 housing and set the guard aside. 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 battery 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 to line up the connector socket holes properly with respect to the mating header pins).

8-2 O-RING SIZES

Battery end cap (piston) seal:	Parker 2-234E603-70	Sea-Bird Part Number	30816
Battery end cap (face) seal:	Parker 2-153N674-70	Sea-Bird Part Number	30090
I/O bulkhead connectors:	Parker 2-017N674-70	Sea-Bird Part Number	30072
Conductivity cell face seal:	Parker 2-110E540-80	Sea-Bird Part Number	30802
Sensor end cap (piston) seal:	Parker 2-233E603-70	Sea-Bird Part Number	30815
Sensor end cap (crush) seal:	Parker 5-374E603-70	Sea-Bird Part Number	30801

Appendix I: AF24173 Anti-Foulant Device

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

AF24173 ANTI-FOULANT DEVICE

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

ACTIVE INGREDIENT:

Bis(tributyltin) oxide..... 53.0%

OTHER INGREDIENTS: 47.0%

Total..... 100.0%

DANGER

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

Net Contents: Two anti-foulant devices

Sea-Bird Electronics, Inc.
1808 - 136th Place Northeast
Bellevue, WA 98005

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

AF24173 Anti-Foulant Device

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

ACTIVE INGREDIENT:

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

DANGER

See Precautionary Statements for additional information.

FIRST AID	
If on skin or clothing	<ul style="list-style-type: none"> • Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If swallowed	<ul style="list-style-type: none"> • Call poison control center or doctor immediately for treatment advice. • Have person drink several glasses of water. • Do not induce vomiting. • Do not give anything by mouth to an unconscious person.
If in eyes	<ul style="list-style-type: none"> • Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing eye. • Call a poison control center or doctor for treatment advice.
HOT LINE NUMBER	
Note to Physician	Probable mucosal damage may contraindicate the use of gastric lavage.
Have the product container or label with you when calling a poison control center or doctor, or going for treatment. For further information call National Pesticide Telecommunications Network (NPTN) at 1-800-858-7378.	

Net Contents: Two anti-foulant devices

Sea-Bird Electronics, Inc.
 1808 - 136th Place Northeast
 Bellevue, WA 98005

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

PRECAUTIONARY STATEMENTS

HAZARD TO HUMANS AND DOMESTIC ANIMALS

DANGER

Corrosive - Causes irreversible eye damage and skin burns. Harmful if swallowed. Harmful if absorbed through the skin or inhaled. Prolonged or frequently repeated contact may cause allergic reactions in some individuals. Wash thoroughly with soap and water after handling.

PERSONAL PROTECTIVE EQUIPMENT

USER SAFETY RECOMMENDATIONS

Users should:

- Remove clothing immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing.
- Wear protective gloves (rubber or latex), goggles or other eye protection, and clothing to minimize contact.
- Follow manufacturer's instructions for cleaning and maintaining PPE. If no such instructions for washables, use detergent and hot water. Keep and wash PPE separately from other laundry.
 - Wash hands with soap and water before eating, drinking, chewing gum, using tobacco or using the toilet.

ENVIRONMENTAL HAZARDS

Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or other waters unless in accordance with the requirements of a National Pollutant Discharge Elimination System (NPDES) permit and the permitting authority has been notified in writing prior to discharge. Do not discharge effluent containing this product to sewer systems without previously notifying the local sewage treatment plant authority. For guidance contact your State Water Board or Regional Office of EPA. This material is toxic to fish. Do not contaminate water when cleaning equipment or disposing of equipment washwaters.

PHYSICAL OR CHEMICAL HAZARDS

Do not use or store near heat or open flame. Avoid contact with acids and oxidizers.

DIRECTIONS FOR USE

It is a violation of Federal Law to use this product in a manner inconsistent with its labeling. For use only in Sea-Bird Electronics' conductivity sensors. Read installation instructions in the applicable Conductivity Instrument Manual.

STORAGE AND DISPOSAL

PESTICIDE STORAGE: Store in original container in a cool, dry place. Prevent exposure to heat or flame. Do not store near acids or oxidizers. Keep container tightly closed.

PESTICIDE SPILL PROCEDURE: In case of a spill, absorb spills with absorbent material. Put saturated absorbent material to a labeled container for treatment or disposal.

PESTICIDE DISPOSAL: Pesticide that cannot be used according to label instructions must be disposed of according to Federal or approved State procedures under Subtitle C of the Resource Conservation and Recovery Act.

CONTAINER DISPOSAL: Dispose of in a sanitary landfill or by other approved State and Local procedures.