SEACAT SBE 16

CONDUCTIVITY AND TEMPERATURE RECORDER

OPERATING MANUAL

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vers. 16.10

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This manual is intended to be used with SBE 16 SEACATs with firmware versions 4.0h and later.

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 which are recovered and the data retrieved from the SBE 16. The SEACAT can 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 sent it to the RS-232C interface. A third mode is for the controller to passively listen for the next sample which is taken and automatically sent to the RS-232C interface.

Communication with SEACAT is over a 3 wire RS-232C link. There are over 20 different 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 with SEACAT, retrieve data, and to calculate and display temperature, conductivity and derived variables such as salinity and sound velocity. SEASOFT as supplied 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.

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 +31 °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:

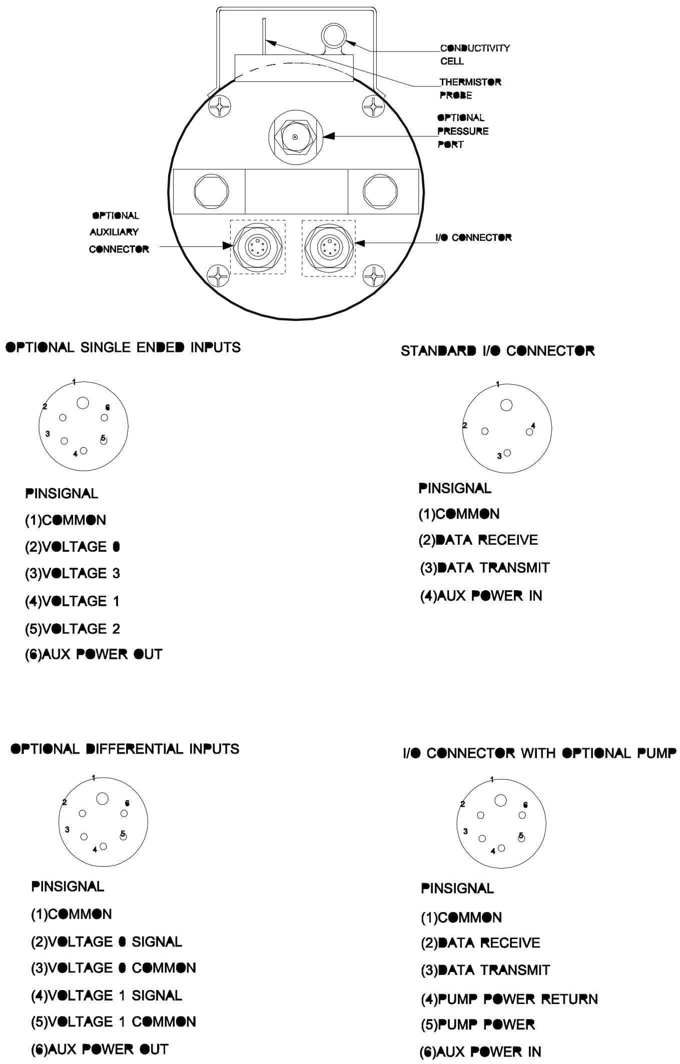
Standard configuration with 6 alkaline 'D'-cells
Optional configurations with 9 or 12 alkaline 'D'-cells are available.
Standard 3.4 volt lithium batteries <u>cannot</u> be installed as individual cells in any SBE 16 configuration. Severe damage will occur from over voltage of components.

Materials:

600 Meter Pressure Case Acetal copolymer (plastic)
10,500 Meter Pressure Case Titanium

2-1 CONFIGURATION OPTIONS

The SBE 16 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 will be 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.



The SBE 16 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.

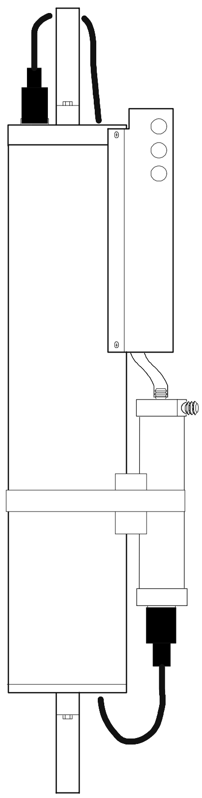


Figure2 SBE 16 with optional SBE 5T pump.

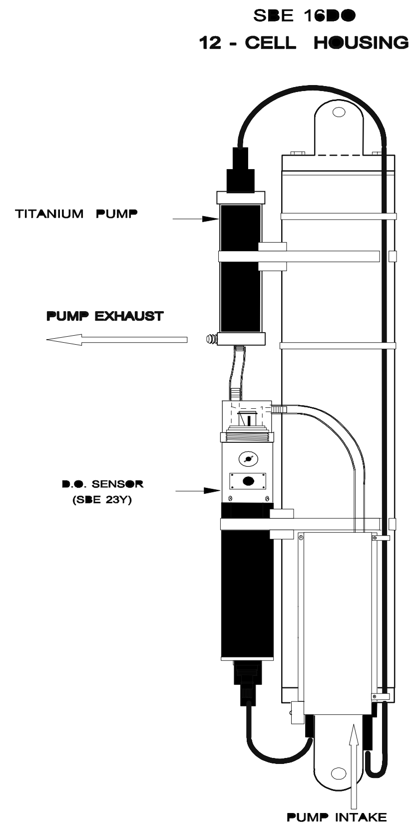


Figure3 SBE 16 with optional SBE 5T pump and SBE 23 Dissolved Oxygen Sensor.

Figure 3 shows a SBE 16 SEACAT configured with an SBE 5T pump and the optional 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.

3-1.1 CONNECTION TO A COMPUTER OR TERMINAL

1. Remove the rubber cap from SEACAT's I/O bulkhead connector by unscrewing the locking sleeve and then pulling the cap 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 set-up 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

TERM1621 is a terminal emulation program designed to communicate with the SBE 16 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 will create 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 be the instrument will be displayed 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 will 'go to sleep' after two minutes without receiving any commands from the computer.
F7	Change the baud rate that the terminal program is talking at.
F9	Upload data from the instrument. The upload parameters are configured in the set up menu.
F10	Exit to DOS.
CTRL-C	Sends to the instrument to halt the 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 the current baud rate

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

The function keys are used to control different features of the terminal programs and to send commands to the instruments for data uploading, initialization, and status information. If communications or instrument problems are encountered the instrument hardware manual should be consulted for the diagnostic and data commands appropriate for that instrument.

In particular if the terminal program is not able to establish communications with the instrument by cycling through the baud rates and comm ports, the baud rate as documented on the configuration page in the hardware manual should be set with the F7 function key and the set up parameters accessed through the F2 function key should be verified. Subsequent attempts at communicating with the instrument can be made by pressing the enter key or via the F6 function key.

3-1.2.1 TERMINAL SET UP FORM

```
+----------------------------------------------------------------------------+
| SBE 16/21 Terminal Program  4.214          Thursday  June 29, 1995  7:46 am |
+----------------------------------------------------------------------------+
+----------------------------------------------------------------------------+
|                         TERM1621 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 your instrument manual and also displayed in the first line of the reply to the display status (Function Key 3) reply.

The Communication Set Up Form is:

```
+----------------------------------------------------------------------------+
| SBE 16/21 Terminal Program  4.214          Thursday  June 29, 1995  7:47 am |
+----------------------------------------------------------------------------+
+----------------------------------------------------------------------------+
|                         TERM1621 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 |
+------------------------------------------------------------------------------+
+------------------------------------------------------------------------------+
|                        TERM1621 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 will send the 'DD' (dump data) command to the instrument. One file will be written.

Upload Data By Scan Number Range:
The terminal program will prompt the user for the beginning and ending scan number and then send the 'DD' (dump data) command to the instrument. One file will be written.

The 'Echo During Upload' Choices are:

Echo Data During Upload:
The HEX data from the instrument is displayed on the screen as it is received

Display One '.' Every 16th scan during Upload:
Will shorten 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 (Function Key 9). 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 will be 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 will be displayed for the user to fill in. If header = 'Include Default Header', only this form will be 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 2.1 is a summary of these commands.

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

Table 2.1 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 to SEACAT may be entered in upper or lower case letters. Responses made by SEACAT are indicated in bold type. SEACAT will send **#** whenever an invalid command is entered. If a new command is not received within 2 minutes after completion of the last command, SEACAT will return to the standby mode. Communications can be reestablished by using the F6 key or typing 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
^	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 will send **^C** whenever a Escape Function is received.

* Commands followed by an asterisk (*) alter SEACAT 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.

3-1.6 DIAGNOSTIC COMMANDS

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

CAUTION: After execution of the FR command, SEACAT 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 batteries during this time.

Example: FR(CR) SEACAT will send:

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
ccccc.ccc is the frequency generated by the temperature sensor
ddddd.ddd is the frequency generated by the conductivity cell
eeeee.eee is the corrected temperature frequency
fffff.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 the VR command, SEACAT 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 batteries during this time.

Example: VR(CR) SEACAT will send:

2.437
2.437
2.437

Response for SBE 16 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 SBE 16 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 will display:

ram test passed with no errors

TM(CR)*^C 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 standby current (in microamperes) will be displayed after about 7 seconds.

Example: J(CR) SEACAT will send:
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 which 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 will send:
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 will respond 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. At this time the SEACAT is drawing only the quiescent current of approximately 50 milliamps.

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 it's 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 will appear 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 will change when this command has been invoked. When the SEACAT is placed in latched DO mode the voltage delay should be set 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 will read **mode = normal** after this command has been entered.

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 15 seconds. The maximum sample period is 32767 seconds (9.1 hours).

Example: SI(CR) SEACAT will send:

sample interval (seconds) = 60(CR)

sample interval = 60 sec

The sample interval is set to 60 seconds. Data logging will start 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) This command is used to 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 page of the manual will contain the number of voltages that were set to be acquired when the SEACAT 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 normally four if single ended amplifiers were specified or two 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 will show 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) 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:

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 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.

VDnnnn(CR) This command is used to set the delay time before the acquisition of external voltages. The number **nnnn** is the amount of time to add to the default voltage delay value. All example headers in this manual are SEACATS with 4.0h EPROMs.

If the SEACAT has been supplied with the optional A/D converter and the SV command has been used to enable the acquisition of the data from external sensors the following line will appear 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

The SEACAT provides power to the external sensor (OBS-3, transmissometer, fluorometer, dissolved oxygen or other sensor) through its auxiliary connector. This delay provides a means of adjusting the amount of time that will elapse between the power turn on and the acquisition of the output from the external sensor by the SEACAT. In the case of a Sea Tech Fluorometer which has a internal filter with a time constant of 3 seconds, the delay should be set to 15 seconds (15000 milliseconds).

For the latched DO mode there is special circuitry that powers the oxygen sensor for two minutes prior to acquiring the data. In this mode the voltage delay is used to control the amount of time that the pump is powered prior to taking a sample. In latched DO mode the voltage delay should be set to 15 seconds (15000 milliseconds). This will insure that the SBE 5 pump runs for enough time to draw a fresh sample of water into the oxygen sensor before the output of the oxygen sensor is measured.

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

EPROMs less than or equal to 4.0g
VD11250 will add 11250 msec to the 3750 msec default value for a total delay of 15000 msec

EPROMs greater than or equal to 4.0h
VD11 will add 11 seconds to the 4 seconds default value for a 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) This command is used to change the baud rate used by the SEACAT during normal communications.

Upon initial power up or reset the SEACAT will default 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 will immediately change its baud rate and all subsequent communication will be at the new baud rate. This baud rate will be 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 will be written over, whether the memory has been initialized or not. SEACAT will display 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 will transmit at each sample period the data that was collected at the previous sample period.

QL(CR)* Quit logging

Example:

S > ql
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) will not be used. Previously recorded data will not be overwritten. SEACAT will display 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 will send 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 = sqrt(cccc * 2100 + 6250000) (standard range conductivity)
Actual conductivity frequency = sqrt(cccc * 244 + 7562500) (narrow range conductivity)

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 = 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'** will be displayed.

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

Example: DH(CR) SEACAT will send:

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 will send:

#ttttccccssss

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

a carriage return and line feed follows 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. The data is not stored in memory. Normally used while not logging data. The SEACAT will automatically power off 0.25 seconds after transmitting the data.

Example: TS(CR) After approximately 8 seconds SEACAT 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

3-2 SEASOFT SOFTWARE CONFIGURATION FILES

The program TERM1621 is used to communicate with and retrieve data from SEACAT. TERM1621 creates the file TERM16.CFG to store its set up parameters so they do not have to be reentered every time. The file TERM16.CFG, with typical set-up parameters for using your SEACAT (assuming installation on C: drive) is included on the SEASOFT distribution disks that accompanied your SBE 16.

The program 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 correct copy of this file should have been included on the software distribution disks that accompanied your SBE 16. If the instrument is recalibrated or the configuration is changed (such as adding external sensors), SEACON must be run to either enter the new calibration information or to modify the instrument configuration settings.

Refer to the instrument "configuration page" and/or calibration certificates in this manual, and the SEASOFT software manual for additional information.

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 will send 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 function key 10 [return to DOS]

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

Enter (CR). SEACAT will send 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 will verify 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 will verify 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 function key 10 [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. If a floppy disk is to be used to acquire SEACAT data, the disk must be formatted. Enter (CR), wait approx. 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 the **term1621** program, the F2 function key is used to configure the parameters to upload data from the SEACAT. The F9 function key is used to actually create a computer file of SEACAT data. This file can then be displayed using the SEASAVE program or converted into an ASCII file of engineering unit parameters using the DATCNV program. Consult the SEASOFT manual for detailed information on the set up 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 = sqrt(C * 2100 + 6250000)

Conductivity (narrow range)

1. C = decimal equivalent of bbbb
2. Conductivity frequency = 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 will appear 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
uuuvvvxxxyyy	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 = sqrt(C * 2100 + 6250000)

Conductivity (narrow range)

1. C = decimal equivalent of bbbb
2. Conductivity frequency = sqrt(C * 244 + 7562500)

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.

Strain Gauge Pressure:

1. P = decimal equivalent of bits 0 through 13 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. Pressure number = P.

EXAMPLE

aaaabbbbuuuvvvpppp = 69CC43223450590A79

aaaa = 69CC, T = 27084, Temperature Frequency = 3525.474
bbbb = 4322, C = 17186, Conductivity Frequency = 6506.970
uuu = 345, V0 = 837, Voltage 0 = 1.022
vvv = 059, V1 = 89, Voltage 1 = 0.109
pppp = 0A79, P = 2681, 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 will appear 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 = (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 2.3-4 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 SBE 16 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. The voltage delay (VD command) should be set to 15 seconds to insure that the pump runs for an adequate amount of time.

The SBE 16 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, 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 not take a sample but will fill the data scan in memory with a 5A5A5A5A pattern and return to the quiescent state. If at the next sample interval it again finds the main battery voltage below 5.4 volts, it will repeat the 5A5A5A5A pattern and return to the quiescent state. It will repeat this for a total of ten cycles before assuming that the main batteries have failed. At this point it will stop any attempts to log data and will remain in the quiescent state until communications are established with the **TERM1621** program. During this quiescent period the "exhausted" main batteries will normally have sufficient power to maintain memory. If they fail completely however, the lithium batteries mounted on the circuit boards will keep memory alive for a 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 will power 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 will store 260,817 C - T pairs.

4-1.5 DATA I/O

SEACAT receives set-up 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 which are unrestricted for shipping purposes) are provided to backup 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 SBE 16 with a Digiquartz pressure sensor draws on the average about 115 milliamps during each 4 second sampling interval. The SBE 16 specification sheet says for conductivity and temperature there is a draw of 130 milliamps, to be conservative. The quiescent current drain approximately 50 microamps.

Assuming a 130 milliamp sampling current, 48 samples per day for 2 years, 730 days, the capacity requirement works out as follows:

Quiescent Current:	0.00005 amps * (730 days * 24 hours) = 0.876 amp hours
Total Sampling Time:	730 days * 48 samples/day * 4 sec/sample = 140,160 sec = 38.93 hours
Sampling Current:	0.13 amps * 38.93 hours = 5.06 amp hours
Total Capacity:	0.876 amp hours + 5.06 amp hours = 5.936 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 will provide memory backup power until it falls below 3.2 volts. At that point, the on-board lithium batteries will continue to support memory for over one year.

4-1.7 HOUSING AND MECHANICAL DESIGN

The SEACAT main 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 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 which 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) which 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 shut-down 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 will 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 X 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 will be in quiescent mode drawing 50 microamperes or less. The initialization routines described below will have been performed at the factory and the real-time clock will be 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 and will be used for testing, connect the power supply to the 4 pin bulkhead connector (see Section 2-1 for hook-up instructions).

Power will be drawn from either 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, will 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 will be intermittent**. Check for battery voltage (approx 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 the **TERM1621** program.

2. Enter the ST command to reset the date and time, SEACAT will prompt:

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 will automatically occur. When SEACAT is in quiescent mode, (CR) will re-establish command mode and cause the S> to appear.

If SEACAT is to be stored for long periods, the batteries should be left in place, but removed, discarded, and replaced each year before use. So long as the main batteries are in place, no current will be 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, any trapped air in the dummy cover should be removed by gently squeezing the cover near the top and moving the fingers towards the end cap. Then remove the distilled-water filled Tygon tubing looped end-to-end around the conductivity cell.

6-1.4 ANTI-FOULANT ATTACHMENTS

The SBE 4-AF anti-foulant attachments, PN 24012, are optional, and are recommended for moored applications where biological activity is anticipated. These small porous cylinders are impregnated with a toxic material, and are attached to each end of the conductivity cell, so that any water which enters the cell is treated. The SBE 4-AF attachments are effective for 6 months to 1 year, depending upon the biological activity and upon the water flow velocity past the instrument.

The antifoulant used is a biological poison. Unnecessary handling of treated surfaces should be avoided, and your hands washed thoroughly after contact.

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, A MALFUNCTIONING INSTRUMENT SHOULD BE TREATED 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 RETAINING SCREWS 1/2 TURN. IF THERE IS INTERNAL PRESSURE, THE END CAP WILL `FOLLOW' 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 distilled-water filled 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 will hold up 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 separate 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 should provide years of service if treated properly. SEACAT should be rinsed with fresh water after use and prior to storage.

7-1.2 CONDUCTIVITY CELL STORAGE

When possible, keep the conductivity cell in distilled water during periods of non-use by looping a length of water-filled Tygon tubing end to end. If it is not practical to leave the conductivity cell stored with distilled water in it (due to the danger of freezing, for example) merely rinse the cell with distilled water after each use (to remove salt water), then blow lightly through the cell to insure that no water is trapped inside. This is easily done using the Tygon tubes supplied. Loop the tubing end to end of the cell to keep out airborne contaminants. If the cell has been stored dry, wet with a 1% solution of Triton X100 (or other non-ionic detergent) before use.

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.

SEACAT 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 SEACAT will always yield a temperature calibration as well.

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 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, and it is for this reason that storage in distilled water is suggested.

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 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.

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 will suffice. It will usually be 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 which 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 200 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 that the connector socket holes are lined up 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