



SEA-BIRD
SCIENTIFIC

User Manual

Release Date: 02/12/2015

SBE Sea-Bird
Electronics

SBE 35RT Digital Reversing Thermometer



Manual version
Firmware version
Software versions

- 013
- 2.0a & later
- Seasave V7 7.23.2 & later
- SBE Data Processing 7.23.2 & later



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Limited Liability Statement

Extreme care should be exercised when using or servicing this equipment. It should be used or serviced only by personnel with knowledge of and training in the use and maintenance of oceanographic electronic equipment.

SEA-BIRD ELECTRONICS, INC. disclaims all product liability risks arising from the use or servicing of this system. SEA-BIRD ELECTRONICS, INC. has no way of controlling the use of this equipment or of choosing the personnel to operate it, and therefore cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers involved in operating this equipment. Therefore, acceptance of this system by the customer shall be conclusively deemed to include a covenant by the customer to defend, indemnify, and hold SEA-BIRD ELECTRONICS, INC. harmless from all product liability claims arising from the use or servicing of this system.

Declaration of Conformity

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005 USA

DECLARATION OF CONFORMITY

Manufacturer's Name: Sea-Bird Electronics
Manufacturer's Address: 13431 NE 20th Street
Bellevue, WA 98005, USA

The Authorized Representative located within the Community is:
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Device Description: Various Data Acquisition Devices and Sensors

Model Numbers:

3S	3F	3plus	4C	4M	5T	5P	5M	7
8	9plus	11plus	14	16plus V2	16plus-IM V2		17plus V2	18
19plus V2	21	25plus	26plus	27	29	32	32C	32SC
33	35	35RT	36	37-IMP	37-IM	37-SMP	37-SM	37-SIP
37-SI	38	39	39-IM	39plus	41	41CP	43	43F
44	45	49	50	52-MP	53BPR		55	56
63	SIM	ICC	IMM	PDIM	AFM	90488	90204	90402
90504	Glider Payload CTD		NiMH Battery Charger and Battery Pack					

Applicable EU Directives: Machinery Directive 98 / 37 /EC
EMC Directive 2004 / 108 /EC
Low Voltage Directive (73 / 23 /EEC) as amended by (93 / 68 /EEC)

Applicable Harmonized Standards:
EN 61326-1:2006 Class A Electrical Equipment for Measurement, Control, and Laboratory Use, EMC Requirement – Part 1: General Requirements
(EN 55011:2007 Group 1, Class A)

EN 61010-1:2001, Safety Requirements for Electrical Equipments for Measurement, Control, and Laboratory Use – Part 1: General Requirements

Declaration based upon compliance to the Essential Requirements and Letter of Opinion from CKC Certification Services, LLC., Notified Body 0976

I, the undersigned, hereby declare that the equipment specified above conforms to the above European Union Directives and Standards.

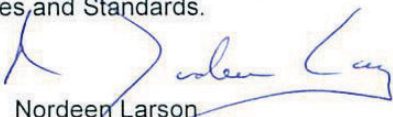
Authorized Signature: 
Name: Nordeen Larson
Title of Signatory: President
Date: 3 September 2013
Place: Bellevue, WA

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Section 1: Introduction

This section includes contact information and photos of a typical SBE 35RT shipment.

About this Manual

This manual is to be used with the SBE 35RT Digital Reversing Thermometer. It is organized to guide the user from installation through operation and data collection. We've included detailed specifications, command descriptions, maintenance and calibration information, and helpful notes throughout the manual.

Sea-Bird welcomes suggestions for new features and enhancements of our products and/or documentation. Please contact us with any comments or suggestions (seabird@seabird.com or 425-643-9866). Our business hours are Monday through Friday, 0800 to 1700 Pacific Standard Time (1600 to 0100 Universal Time) in winter and 0800 to 1700 Pacific Daylight Time (1500 to 0000 Universal Time) the rest of the year.

Unpacking SBE 35RT

Shown below is a typical SBE 35RT shipment.



SBE 35RT



Optional Interface Box



Optional SBE 35RT to Interface Box cable



Optional Interface Box to computer cable



Optional AC power cord for Interface Box



Software, and Electronic Copies of Software Manuals on CD-ROM

Section 2: Description of SBE 35RT

This section describes the functions and features of the SBE 35RT, including specifications, dimensions, and connectors.

System Description



Note:
Each sample consists of **NCycles=** measurements (1 – 127), with the average of the measurements stored and/or transmitted as applicable.

The SBE 35RT is an accurate, ocean-range temperature sensor that is capable of measuring temperature in the ocean to depths of 6800 meters (22,300 ft). The SBE 35RT communicates via a standard RS-232 interface at 300 baud, 8 data bits, no parity.

The SBE 35RT is used with the SBE 32 Carousel Water Sampler and one of the following CTD systems:

- **Real-Time Operation**
 - SBE *9plus* CTD with SBE *11plus* Deck Unit, **or**
 - SBE 19, *19plus*, *19plus* V2, 25, or *25plus* CTD with SBE 33 Deck Unit
- **Autonomous Operation** (details not documented in this manual)
 - SBE *9plus* CTD with SBE *17plus* V2 Searam, **or**
 - SBE 19, *19plus*, *19plus* V2, 25, or *25plus* CTD with Auto Fire Module (AFM)

Real-Time Operation:

11plus—*9plus* CTD — Carousel
35RT

33—Carousel—19/*19plus*/*19plus* V2/25/*25plus* CTD
35RT

Autonomous Operation:

9plus CTD — *17plus* — Carousel
35RT

19/*19plus*/*19plus* V2/25/*25plus* CTD—AFM—Carousel
35RT

The SBE 35RT makes a temperature measurement each time a bottle fire confirmation is received, and stores the value in EEPROM. Each stored value contains the time and bottle position in addition to the temperature data, allowing comparison of the SBE 35RT record with CTD and water bottle data. Using one SBE 35RT eliminates the need for reversing thermometers, and provides higher accuracy temperature readings at lower cost.

Calibration coefficients stored in EEPROM allow the SBE 35RT to transmit data in engineering units. When configured in a real-time system, the SBE 35RT can use the system modem channel for two-way communications; it is not necessary to change cable connections to communicate with and retrieve data from the SBE 35RT.

Commands can be sent to the SBE 35RT to provide status display, data acquisition setup, data retrieval, and diagnostic tests.

The SBE 35RT can be supplied with an optional Interface Box for setup and lab use. The Interface Box provides continuous, isolated power to the SBE 35RT and buffers the serial communication lines to minimize noise input to the SBE 35RT from external sources. When used with the Interface Box, user-selectable operating modes are:

- Sample continuously and output the real-time data (data is not stored in EEPROM), or
- Take a single sample, store the data in EEPROM, and output the real-time data.

The SBE 35RT is supplied with a powerful Windows software package, **Seasoft V2**, which includes:

- **Seaterm** and **SeatermV2** – terminal programs for easy communication and data retrieval.
- **Seasave V7** – real-time data acquisition and display.
- **SBE Data Processing** – program for calculation and plotting of CTD parameters and derived variables.

Notes:

- Help files provide detailed information on the software.
- Separate software manuals on CD-ROM contain detailed information on the setup and use of Seasave V7 and SBE Data Processing.
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our website. See our website for the latest software version number, a description of the software changes, and instructions for downloading the software.

SBE 35RT Specifications

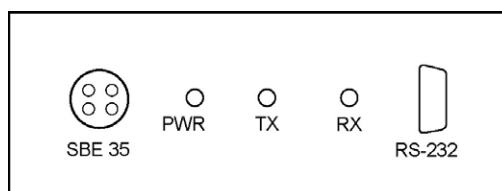
Measurement Range	-5 to +35 °C
Initial Accuracy	± 0.001 °C
Typical Stability (per year)	0.001 °C
Resolution	0.000025 °C
Sensor Calibration	-1.5 to + 32.5 °C
Data Storage	Up to 179 samples (each an average of NCycles = measurements [1 - 127])
Real-Time Clock	Watch-crystal type
External Power	9-16 VDC
Current	<i>On power application (approximately 1 minute):</i> 140 – 160 mA <i>Operating:</i> 60 – 70 mA
Materials	Aluminum pressure case rated at 6,800 meters (22,300 feet)
Weight	In water: 0.3 kg (0.7 lbs) In air: 0.7 kg (1.5 lbs)

Optional Interface Box Specifications

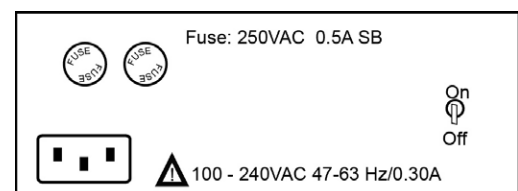
Power Requirement	100-240 VAC / 47-63Hz / 0.30A The Interface Box should always be used with a three-terminal outlet that includes a protective earth.
Fuse	3AG, 250VAC Slow-Blow, 0.5 Amp
Dimensions	178 x 127 x 57 mm (7 x 5 x 2.25 inch)
Weight	1.1 kg (2.5 lbs)
Installation Environment	Interface Box operates properly under following conditions: <ul style="list-style-type: none"> • Indoor use • Altitude up to 2000 meters • Temperature from 5 °C to 40 °C • Maximum relative humidity 80% • Mains supply voltage ±10%

Optional Interface Box Connectors, Switches, and LEDs

- *Connections:*
 - *RS-232* - connects to computer
 - *SBE 35* - connects to SBE 35RT
 - *AC Input* - connects to 100-240 VAC power supply
- *Power switch and LED* - switch turns power to Interface Box on/off. Red *PWR* LED turns on to indicate power is on.
- *LEDs* - indicate if the Interface Box is communicating with other parts of the system:
 - Yellow *TX* LED - flashes when message is received from SBE 35RT
 - Green *RX* LED - flashes when message is transmitted to SBE 35RT

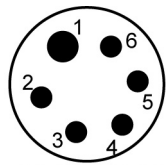


Interface Box (front)

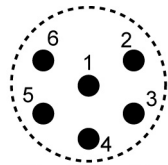


Interface Box (back)

Dimensions and End Cap Connector

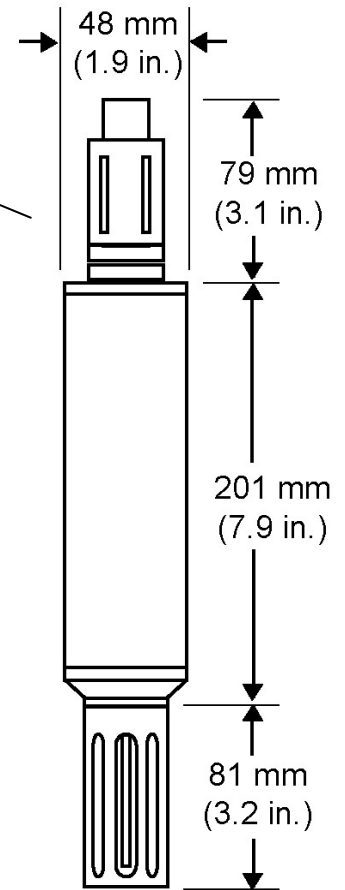


AG-306-HP-SS



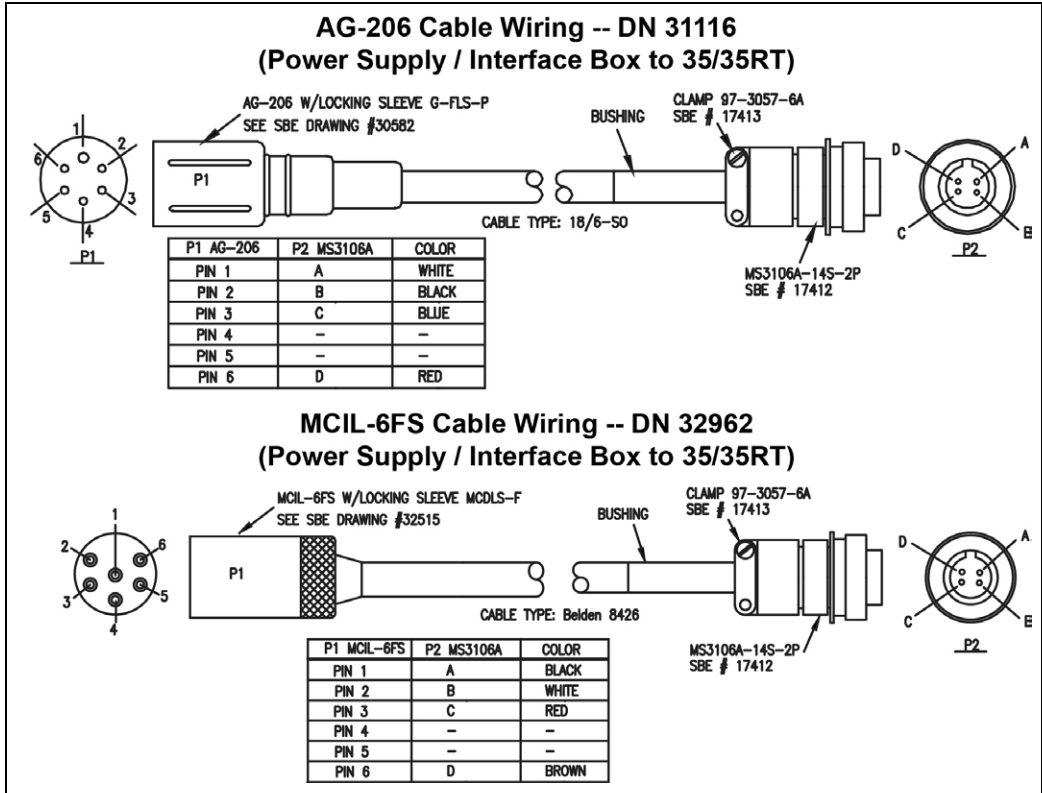
Wet-Pluggable
MCBH-6MP (WB), AL
(3/8" length base, 1/2-20 thread)

Pin	Signal
1	Ground
2	Receive from SBE 9plus, SBE 33, or Interface Box
3	Transmit
4	N/C
5	Bottle fire confirmation from Carousel
6	Power +9 to +16V

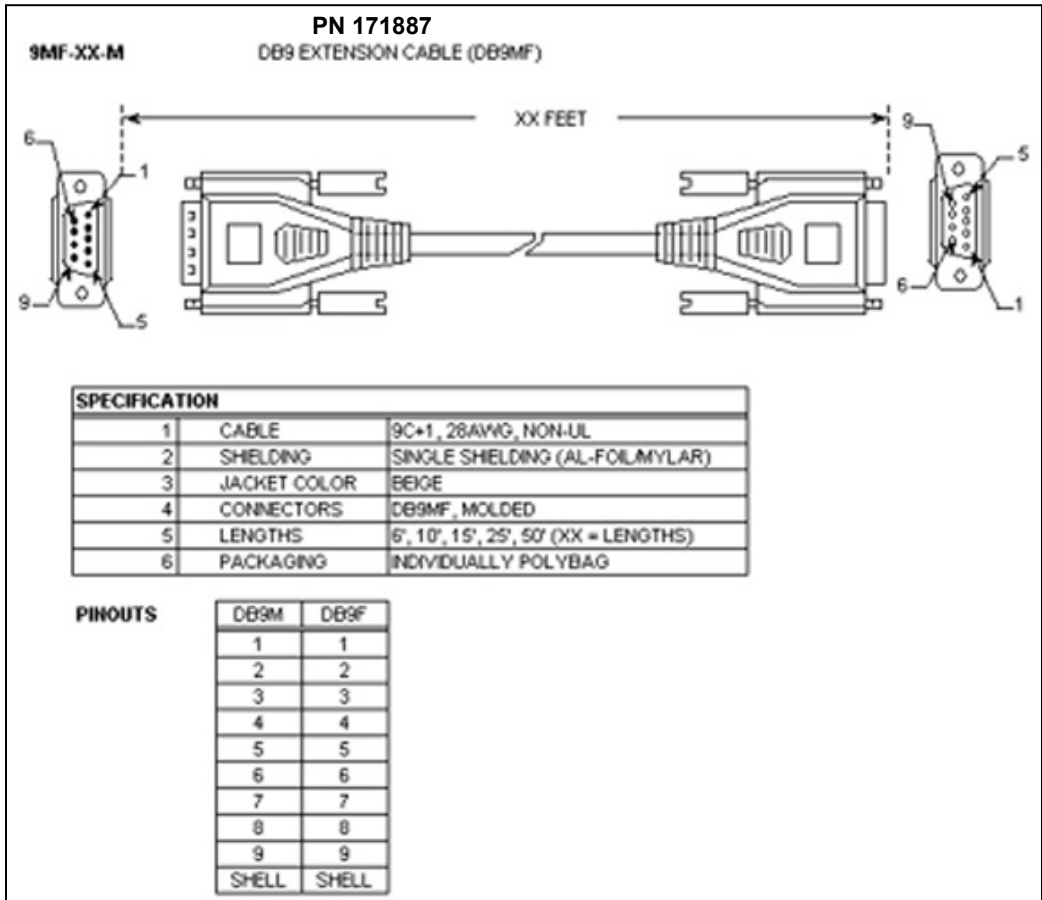


Cables and Wiring

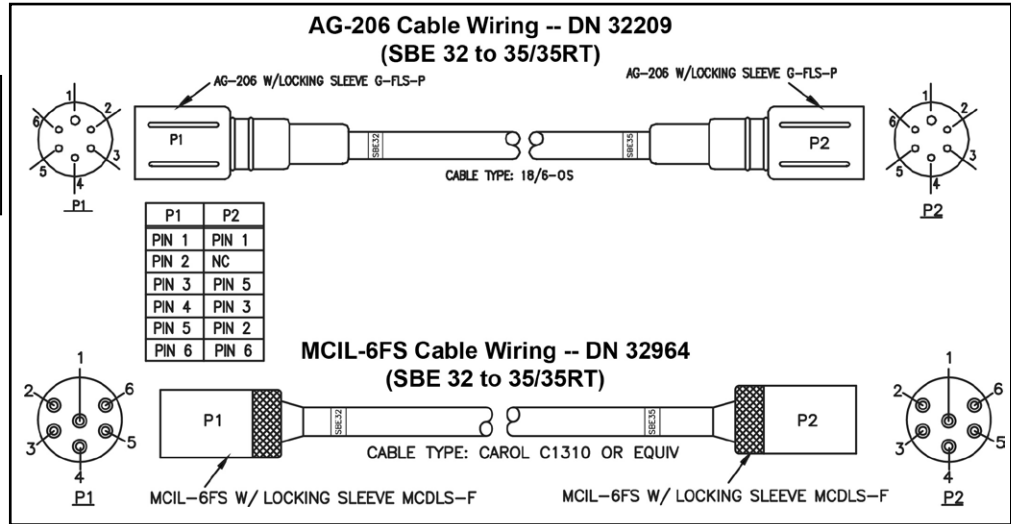
**6-pin to MS cable –
SBE 35RT to Power
Supply / Interface Box**



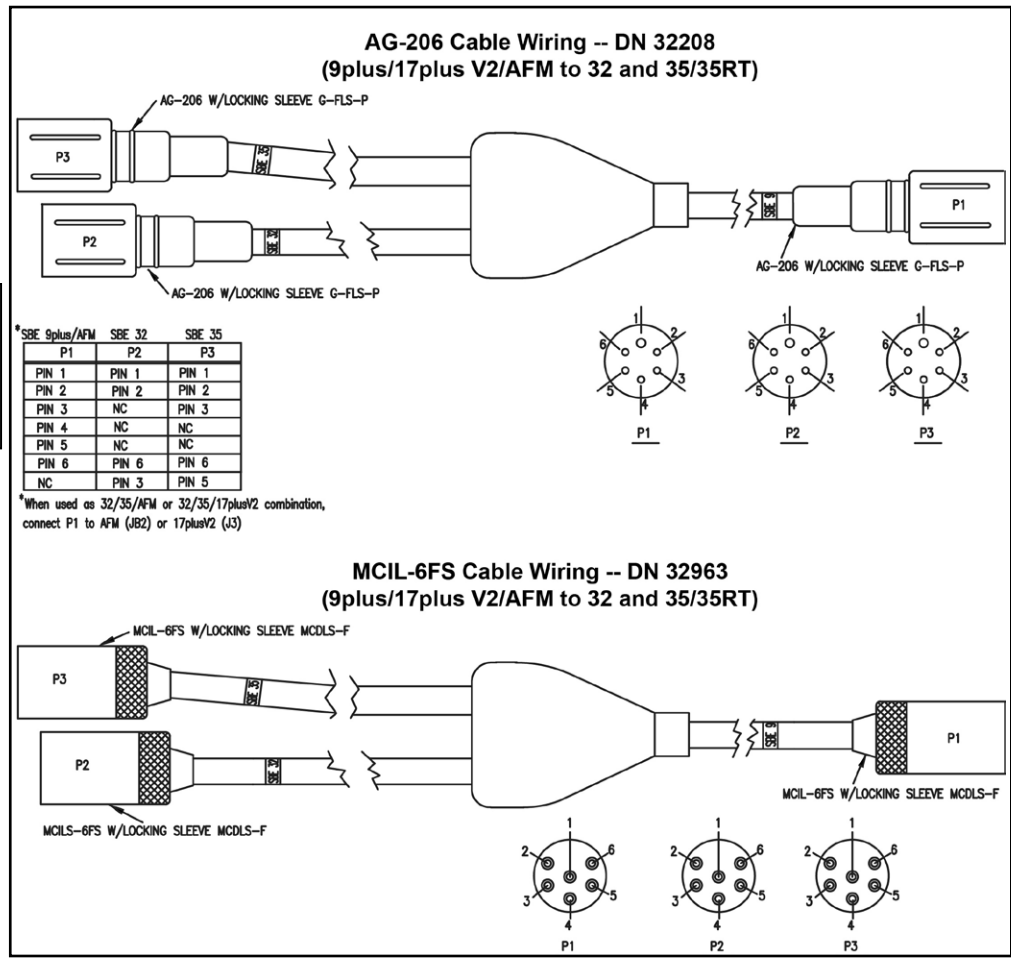
**DB9 to DB9 cable –
Power Supply /
Interface Box
connector to
computer**



6-pin to 6-pin cable –
SBE 35RT to SBE 32,
when used with SBE 33
Deck Unit



Y- cable – SBE 35RT to
SBE 32 and 9plus, or
SBE 35RT to SBE 32 and
17plus V2, or SBE 35RT
to SBE 32 and AFM



Section 3: Preparing for Deployment

This section describes software installation, testing and setting up the SBE 35RT, commands, and data formats.

Software Installation

Seasoft V2 was designed to work with a PC running Windows XP service pack 2 or later, Windows Vista, or Windows 7 (32-bit or 64-bit).

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

1. Insert the CD in your CD drive.
2. Install software: Double click on **SeasoftV2.exe**. Follow the dialog box directions to install the software. The installation program allows you to install the desired components. Install all the components, or just install Seaterm (terminal program), SeatermV2 (terminal program for use when directly communicating with an SBE *19plus V2* or *25plus*), Seasave V7 (real-time data acquisition), and SBE Data Processing (data processing).

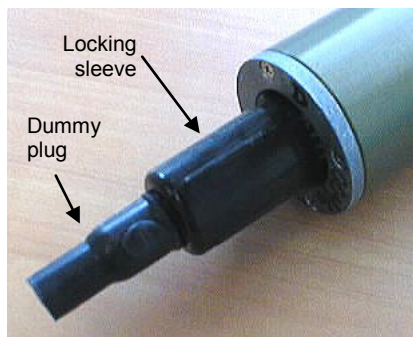
The default location for the software is c:\Program Files\Sea-Bird. Within that folder is a sub-directory for each program.

Notes:

- It is possible to use the SBE 35RT without Seaterm by sending direct commands from a dumb terminal or terminal emulator, such as Windows HyperTerminal.
- Help files provide detailed information on the software.
- Separate software manuals on CD-ROM contain detailed information on the setup and use of the software.
- Sea-Bird supplies the current version of our software when you purchase an instrument. As software revisions occur, we post the revised software on our website. See our website for the latest software version number, a description of the software changes, and instructions for downloading the software.

Power and Communications Test

Test Setup



Note:

For Steps 3, 4, and 5:
For the AG-306 bulkhead connector on the SBE 35RT, align the raised bump on the side of the cable connector with the large pin (pin 1 - ground) on the SBE 35RT.

Note:

For details on wiring, setup, and operation of the entire system, see the SBE 11*plus* or SBE 33 manual as applicable. Only details relating to the use of the SBE 35RT are covered here.

You can communicate with and program the SBE 35RT:

- Through an optional Interface Box (for easy setup in the lab)
- Through an SBE 11*plus* Deck Unit (connected to the SBE 9*plus* CTD and SBE 32 Carousel Water Sampler)
- Through an SBE 33 Deck Unit (connected to an SBE 32 Carousel Water Sampler)

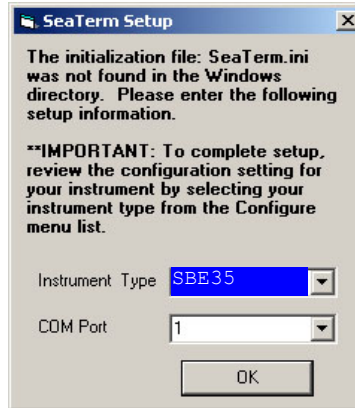
Setup for each of these options is described below.

1. By hand, unscrew the locking sleeve from the SBE 35RT's bulkhead connector. **If you must use a wrench or pliers, be careful not to loosen the bulkhead connector instead of the locking sleeve.**
2. Remove the dummy plug from the SBE 35RT's bulkhead connector by pulling the plug firmly away from the connector.
3. For use with the optional Interface Box:
 - A. Connect the SBE 35RT to *SBE 35* on the Interface Box using the Sea-Bird cable supplied with the Interface Box (drawing 31116 for AG connector on SBE 35RT; drawing 32962 for MCBH connector on SBE 35RT).
 - B. Connect *RS-232* on the Interface Box to your computer's serial port using the DB 9P / DB 9S cable.
 - C. Connect the Interface Box to a standard, 3-prong, grounded AC outlet, using the UL/IEC-approved power cord (AC voltage between 100-240 VAC). Turn on power to the Interface Box.
4. For use with the SBE 11*plus* Deck Unit:
 - A. Connect the SBE 35RT to the SBE 9*plus* JT7 and SBE 32 Carousel Water Sampler JB2 using the Sea-Bird Y-cable (drawing 32208 for XSG / AG connectors on all three instruments; drawing 32963 for MCBH connector on all three instruments). The three arms of the cable are labeled *SBE 9*, *SBE 32*, and *SBE 35*. Connect each arm to the proper instrument.
 - B. Connect the SBE 9*plus* to the SBE 11*plus* Deck Unit, and the SBE 11*plus* to the computer. Turn on power to the SBE 11*plus*.
5. For use with the SBE 33 Deck Unit:
 - A. Connect the SBE 35RT to the SBE 32 Carousel Water Sampler JB2 using the Sea-Bird cable (drawing 32209 for XSG / AG connectors on both instruments; drawing 32964 for MCBH connectors on both instruments). Connect the end labeled *SBE 35* to the SBE 35RT and the end labeled *SBE 32* to the Carousel.
 - B. Connect the SBE 32 to the SBE 33 Deck Unit, and the SBE 33 to the computer. Turn on power to the SBE 33.

Test

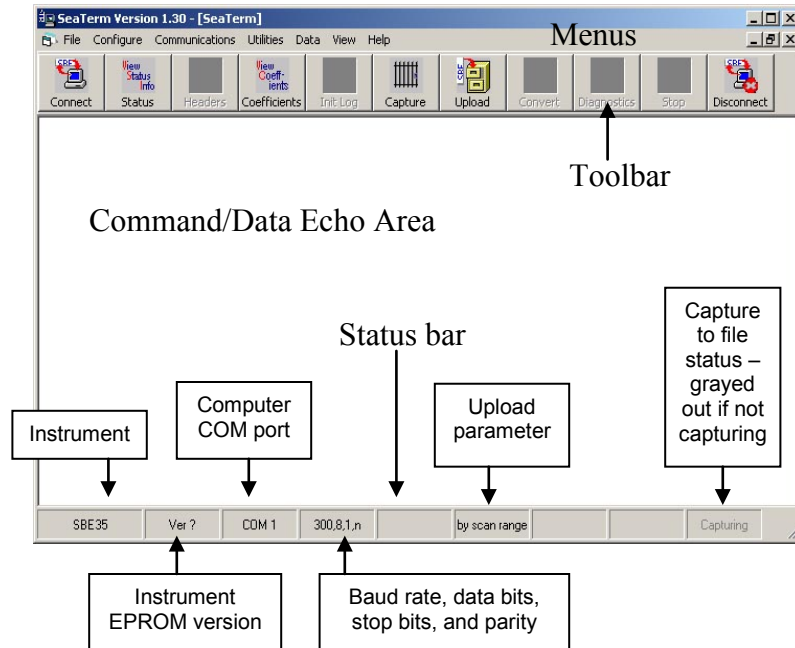
Proceed as follows:

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



Select the instrument type (*SBE 35*) and the computer COM port for communication with the SBE 35RT. Click OK.

2. The main screen looks like this:



Note:
See Seaterm's help files.

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

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

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

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

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

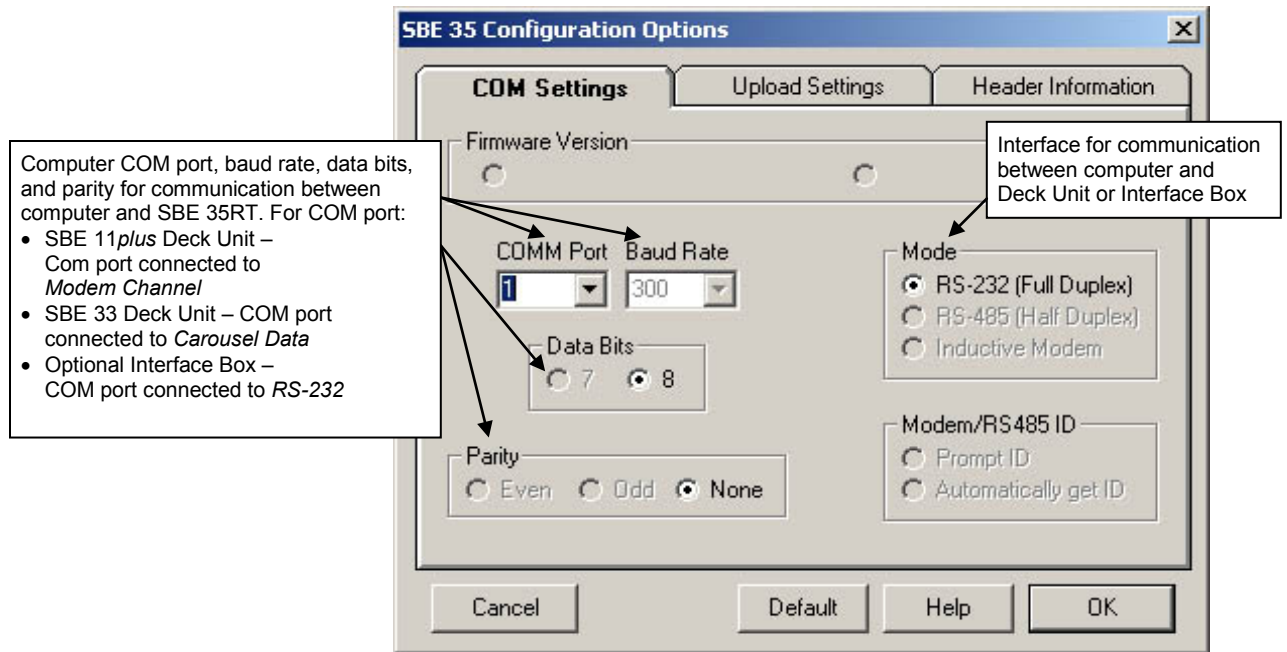
- **Menus** – Contains tasks and frequently executed instrument commands.
- **Toolbar** – Contains buttons for frequently executed tasks and instrument commands. All tasks and commands accessed through the Toolbar are also available in the Menus. To display or hide the Toolbar, select View Toolbar in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

Following are the Toolbar buttons applicable to the SBE 35RT:

Toolbar Button	Description	Equivalent Command*
Connect	Re-establish communications with SBE 35RT. Computer responds with S> prompt.	(press Enter key)
Status	Display instrument setup and status (number of measurements to take and average per sample, number of samples in memory, etc.).	DS
Coefficients	Display calibration coefficients.	DC
Capture	Capture instrument responses on screen to file. File has .cap extension. Press Capture again to turn off capture. Capture status displays in Status bar.	—
Upload	Upload data stored in SBE 35RT's memory, along with status, calibration coefficient, and user-input header information. Uploaded file has .asc extension. Before using Upload: <ul style="list-style-type: none"> • Configure upload and header parameters in Configure menu. • Remove power to stop sampling. 	DDb,e (use Upload to include status, calibration coefficient and user-input header information in file)
Disconnect	Free computer COM port used to communicate with SBE 35RT. COM port can then be used by another program.	—

*See *Command Descriptions* in this section.

3. In the Configure menu, select *SBE 35*. The dialog box looks like this:



Note:

When you click OK, Seaterm saves the Configuration Options settings to the SeaTerm.ini file in your Windows directory. SeaTerm.ini contains the last saved settings for each instrument (SBE 35, 37, etc.). When you open Seaterm and select the desired instrument in the Configure menu, the Configuration Options dialog box shows the last saved settings for that instrument.

Make the selections in the Configuration Options dialog box:

- **COMM Port:** COM 1 through COM 10, as applicable
- **Baud Rate:** 300
- **Data Bits:** 8
- **Parity:** None
- **Mode:** RS-232 (Full Duplex)

Click OK to save the settings.

4. (If using the optional Interface Box) Click Connect on the Toolbar.
5. The display looks like this:

S>

This shows that correct communications between the computer and the SBE 35RT has been established.

If the system does not respond as shown above:

- (If using the optional Interface Box) Click Connect again.
- Verify the correct instrument was selected in the Configure menu and the COM setting was entered correctly in the Configuration Options dialog box. Note that the baud rate's factory setting is documented on the front cover of this manual.
- Check the cabling between all components of the system.

6. Display SBE 35RT status information by clicking Status on the Toolbar. The display looks like this:

```
SBE 35 V 2.0a SERIAL NO. 0013 07 Dec 2012 08:49:08
number of measurement cycles to average = 8
number of data points stored in memory = 2
bottle confirm interface = SBE 911plus
```

7. Command the SBE 35RT to take a sample by typing **TS** and pressing the Enter key. The display looks like this:

```
197.20 1047481 289795.4 15 35 29 289955.4 22.654745
```

where

- 197.20 = average of raw **reference zero** readings taken during a measurement
- 1047481 = average of raw **reference resistor full scale** readings taken during a measurement
- 289795.4 = average of raw thermistor readings taken during a measurement
- 15 = (maximum – minimum) raw **reference zero** reading during a measurement (provides a measure of the amount of variation during the measurement)
- 35 = (maximum – minimum) raw **reference resistor full scale** reading during a measurement (provides a measure of the amount of variation during the measurement)
- 29 = (maximum – minimum) raw thermistor reading during a measurement (provides a measure of the amount of variation during the measurement)
- 289955.4 = average raw thermistor reading, corrected for *zero* and *full scale* reference readings
- 22.654745 = average corrected raw thermistor reading, converted to engineering units (°C [ITS-90])

These numbers should be reasonable; i.e., the thermistor should be reading room temperature.

The SBE 35RT is ready for programming and deployment.

Note:

See *Data Formats* for detailed descriptions of each output parameter.

Command Descriptions

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

When entering commands:

Note:

***rtctest** and ***eetest** are case sensitive, and must be entered as shown. All other commands can be entered in upper or lower case.

- Input commands to the SBE 35RT in upper or lower case letters and register commands by pressing the Enter key.
- The SBE 35RT sends ? CMD if an invalid command is entered.
- If the system does not return an S> prompt after executing a command, press the Enter key to get the S> prompt.
- Establish communications by clicking Connect on the Toolbar or pressing the Enter key to get an S> prompt.

Status Command

DS

Display setup parameters.
Equivalent to Status on Toolbar.

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

- firmware version, serial number, date and time [**MMDDYY=** and **HHMMSS=**]
- number of measurements to take and average per sample [**NCycles=**]
- number of samples in memory [**SampleNum=**]
- interface for use with SBE 32 Carousel Water Sampler [**Interface=**] – *SBE 911plus* (for use with SBE *9plus* CTD, SBE *11plus* Deck Unit, and SBE 32 Carousel Water Sampler)
or
SBE 32 with serial interface (for use with SBE 19, *19plus*, *19plus V2*, *25*, or *25plus* CTD; SBE 33 Deck Unit; and SBE 32 Carousel Water Sampler)

Example: Display status for SBE 35RT (user input in bold).

S>**DS**

SBE 35 V 2.0a SERIAL NO. 0013 07 Dec 2012 08:49:08
number of measurement cycles to average = 8
number of data points stored in memory = 2
bottle confirm interface = SBE 911plus

[**MMDDYY=** and **HHMMSS=**]
[**NCycles=**]
[**SampleNum=**]
[**Interface=**]

Setup Commands

Notes:

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

MMDDYY=mmddySet real-time clock month, day, year. Must be followed by **HHMMSS=** to set time.**DDMMYY=ddmmyy**Set real-time clock day, month, year. Must be followed by **HHMMSS=** to set time.**HHMMSS=hhmmss**

Set real-time clock hour, minute, second.

Example: Set current date and time to 10 January 2014 12:00:00 (user input in bold).

S>**MMDDYY=011014**S>**HHMMSS=120000**

or

S>**DDMMYY=100114**S>**HHMMSS=120000****Note:**

See *Data Formats* for more details on how **NCycles** affects the measurement.

NCycles=x

x= number of measurements to take and average per sample (1 – 127).
Time required for each measurement is 1.1 seconds; therefore, total time for each sample is (1.1 seconds * **NCycles**).
Averaged data is stored in EEPROM and/or transmitted real-time, depending on sampling mode.

In a thermally quiet environment, temperature noise standard deviation is:
 $0.000029 * \sqrt{8 / \text{NCycles}}$ (°C)

Interface=x

x=911plus: SBE 35RT used with SBE *9plus* CTD, SBE *11plus* Deck Unit, and SBE 32 Carousel Water Sampler.

x=32serial: SBE 35RT used with SBE 19, *19plus*, *19plus V2*, *25*, or *25plus* CTD; SBE 33 Carousel Deck Unit; and SBE 32 Carousel Water Sampler.

Note:

SampleNum=0 does not delete data; it just resets the data pointer. **If you accidentally send this command before uploading, recover data as follows:**

1. Set **SampleNum=a**, where **a** is your estimate of number of samples in memory.
2. Upload data. If **a** is more than actual number of samples, data for non-existent samples will be bad, random data. Review uploaded data file carefully and delete any bad data.
3. If desired, increase **a** and upload data again, to see if there is additional valid data in memory.

SampleNum=x

x= sample number for first sample when sampling begins. After all previous data has been uploaded from SBE 35RT, set sample number to 0 before starting to sample again to make entire memory available for recording. If **SampleNum** is not reset to 0, data will be stored after last recorded sample.
SBE 35RT can store up to 179 samples.

Sampling Commands

The SBE 35RT samples when commanded by the user (**Cal**, **Run**, or **TS**), or *automatically* upon receipt of a valid bottle fire confirmation sequence (when used with an SBE 32 Carousel Water Sampler).

- When the SBE 35RT receives a valid bottle fire confirmation sequence (a character with decimal value 6 followed by a character with decimal value greater than 48 and less than 84), it takes a measurement **NCycles** in duration and stores the data in EEPROM.

Notes:

- Data format varies, depending on the sampling command. See *Data Formats* after these *Command Descriptions*.
- To capture real-time data from **Cal**, **Run**, or **TS** to a file, do this *before* starting sampling:
 - A. Click Capture on Toolbar.
 - B. Enter desired file name in dialog box. *Capture* status displays in status bar at bottom of screen.

Cal

Start data sampling continuously now, outputting real-time raw data. Data is not stored in EEPROM. To stop sampling, press Esc key or type Ctrl C, and then press Enter key.

Time from start of one sample to start of next is:

$[(1.1 * \mathbf{NCycles}) + 2.7]$ seconds

The 2.7 seconds is required for transmitting real-time data.

Run

Start data sampling continuously now, outputting real-time raw data as well as computed temperature (°C). Data is not stored in EEPROM. To stop sampling, press Esc key or type Ctrl C, and then press Enter key.

Time from start of one sample to start of next is:

$[(1.1 * \mathbf{NCycles}) + 2.7]$ seconds

The 2.7 seconds is required for converting measured values to computed temperature and transmitting real-time data.

TS

Take one sample (consisting of **NCycles** measurements), store average in EEPROM, and transmit average real-time.

Notes:

- To save data to a file, click Capture on the Toolbar before entering **DDb,e**.
- See *Data Formats* after these *Command Descriptions*.
- **Use Upload on the Toolbar or Upload Data in the Data menu to write SBE 35RT setup, calibration coefficients, and a user-input header along with uploaded data to a .asc file.**

Data Upload Command

DDb,e

Upload data from memory, from sample **b** to sample **e**. First sample is number 1. If **DD** is sent, all samples are uploaded.

Examples: Upload data from EEPROM (user input in bold):
(Click Capture on Toolbar and enter desired filename in dialog box before beginning upload.)

S>**DD1, 16** (Upload scans 1 through 16)

S>**DD1, 1** (Upload scan 1)

S>**DD** (Upload all scans in memory)

Testing Commands

Note:

***rtctest** and ***eetest** are case sensitive, and must be entered as shown.

***rtctest**

Test battery-backed static RAM in real-time clock module. **Test resets date and time to default (01 Jan 1980 00:00:00)**, but does not reset other setup parameters or destroy sampling data in memory. SBE 35RT requires you to enter command twice, to provide verification before it proceeds.

***eetest**

Test EEPROM memory. Allow 30 seconds for test. **Test destroys all sampling data and setup parameters** (calibration coefficients, **NCycles**, etc.) stored in EEPROM. SBE 35RT requires you to enter command twice, to provide verification before it proceeds.

Calibration Coefficients Commands

Notes:

- Date shown is when calibration was performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificate shipped with SBE 35RT.
- See individual Coefficient Commands below for definitions of the data in the example.

DC

Display calibration coefficients.
Equivalent to Coefficients on Toolbar.

Example: Display coefficients for SBE 35RT (user input in bold).

```
S>DC
SBE35  V 2.0a  SERIAL NO. 0011
08-Dec-10
A0 = 5.156252707e-03
A1 = -1.430180396e-03
A2 = 2.092145355e-04
A3 = -1.156278215e-05
A4 = 2.446454055e-07
SLOPE = 1.000000
OFFSET = 0.000000
```

The individual Coefficient Commands listed below modify a particular coefficient or date:

Note:

F = floating point number.
S = string with no spaces.

CalDate=S

S=Temperature calibration date.

TA0=F

F=Temperature A0.

TA1=F

F=Temperature A1.

TA2=F

F=Temperature A2.

TA3=F

F=Temperature A3.

TA4=F

F=Temperature A4.

Slope=F

F=Temperature calibration slope.

Offset=F

F=Temperature calibration offset.

Data Formats

Each sample consists of the following measurement scheme repeated **NCycles** times:

- Raw **reference zero** - Raw A/D reading of 16 samples with circuit ground switched in place of the thermistor.
- Raw **reference full scale** - Raw A/D reading of 16 samples with a hermetically sealed precision resistor switched in place of the thermistor.
- Raw **thermistor** - Raw A/D reading of 16 samples with the thermistor in the circuit.

For example, if **NCycles** is 8, the total number of readings is 128 (= 8 * 16) reference zero readings, 128 reference full scale readings, and 128 thermistor readings. The reported values are the simple average of the 128 readings. The (maximum – minimum) values are the maximum value read during the 128 readings minus the minimum value read during the 128 readings.

The average raw thermistor value, corrected for *zero* and *full scale* reference readings, is:

$$\frac{1048576 * (\text{raw thermistor average} - \text{raw reference resistor } \textit{zero} \text{ average})}{(\text{raw reference resistor } \textit{full scale} \text{ average} - \text{raw reference resistor } \textit{zero} \text{ average})}$$

Plugging this value into the calibration equation yields the computed temperature in engineering units (°C [ITS-90]).

Data Uploaded from EEPROM

Note:

For all data formats, each line of output is followed by a carriage return and line feed.

Data is placed in the SBE 35RT's EEPROM:

- Each time the SBE 35RT receives a valid bottle fire confirmation sequence when used with the SBE 32 Carousel Water Sampler
- When the user sends **TS** (typically for lab use)

Data is uploaded (using Seaterm's Upload button or **DDb,e**) in the following format:

Column	Description
1	sample number
2	date (DD MMM YYYY – day, month, year). The month is a 3-character alphabetic abbreviation; e.g., jan, feb, mar, etc.)
3	time (HH:MM:SS – hour, minute, second)
4	bn = bottle position number (bottle position number is 0 if sample was taken in response to TS)
5	diff = (maximum – minimum) raw thermistor reading during a measurement (provides a measure of the amount of variation during the measurement)
6	val = average raw thermistor reading, corrected for <i>zero</i> and <i>full scale</i> reference readings
7	t90 = average corrected raw thermistor reading, converted to engineering units (°C [ITS-90])

Example: SBE 35RT at room temperature (user input in bold)

S>**DD1,2**

```
1 06 Dec 2012 16:15:13 bn=8 diff=19 val=284583.3 t90=23.133510
2 06 Dec 2012 16:15:41 bn=6 diff=21 val=284568.0 t90=23.134886
```

Real-Time Data from Cal Command

When the user sends **Cal**, real-time data is output in the following format:

Column	Description
1	average of raw reference zero readings taken during a measurement
2	average of raw reference resistor full scale readings taken during a measurement
3	average of raw thermistor readings taken during a measurement
4	(maximum – minimum) raw reference zero reading during a measurement (provides a measure of the amount of variation during the measurement)
5	(maximum – minimum) raw reference resistor full scale reading during a measurement (provides a measure of the amount of variation during the measurement)
6	(maximum – minimum) raw thermistor reading during a measurement (provides a measure of the amount of variation during the measurement)
7	average raw thermistor reading, corrected for <i>zero</i> and <i>full scale</i> reference readings

Example: SBE 35RT at room temperature (user input in bold)

S>**CAL**

197.64 1047488 269139.8 13 37 52 269275.4

191.77 1047493 268895.0 12 35 57 269030.4

197.12 1047501 268859.8 14 27 48 268988.9

Real-Time Data from Run or TS Command

When the user sends **Run** or **TS**, real-time data is output in the same format as for **Cal**, with the addition of an eighth column for average corrected raw thermistor reading, converted to engineering units (°C [ITS-90]).

Example: SBE 35RT at room temperature (user input in bold)

S>**RUN**

197.64 1047488 269139.8 13 37 52 269275.4 24.556287

191.77 1047493 268895.0 12 35 57 269030.4 24.579808

197.12 1047501 268859.8 14 27 48 268988.9 24.583787

Section 4: Deploying and Operating SBE 35RT

Note:

Operation of an autonomous water sampler system (i.e., without conducting cable) with the SBE 35RT is not detailed in this manual.

This section provides instructions for operating the SBE 35RT with a CTD, Deck Unit, and SBE 32 Carousel Water Sampler, and discusses:

- Deployment
- Recovery
- Uploading data from the SBE 35RT
- Comparing SBE 35RT data to CTD data

The SBE 35RT can act as a stand-alone substitute for a reversing thermometer, recording temperature with each bottle closing. The SBE 35RT is mounted in a secure area on the water sampler frame, where the water flushes freely and there is minimal contamination from the passive thermal mass of the metal frame or active thermal dissipation from electronic instruments.

Note:

For details on creation of a .ros file, see *Comparing SBE 35RT Data to CTD Data* below.

The SBE 35RT has a time constant of 0.5 seconds, so it lags the SBE 3 (temperature sensor on SBE *9plus*, *25*, and *25plus* CTDs) if temperature is changing during the measurement interval. For a first order correction, determine the temporal gradient during the measurement interval from the SBE 3 temperature data in the .ros file:

gradient-corrected SBE 35RT temperature = measured SBE 35RT temperature + 0.5g

where

g = temperature gradient [°C/second]

Deployment with SBE 9*plus* CTD, SBE 11*plus* Deck Unit, and SBE 32 Carousel Water Sampler

Note:

For details on wiring, setup, and operation of the entire system, see the SBE 11*plus* manual. Only details relating to the use of the SBE 35RT are covered here.

1. Mount the SBE 35RT in a secure area on the water sampler frame, where the water flushes freely and there is minimal contamination from the passive thermal mass of the metal frame or active thermal dissipation from electronic instruments.
2. Connect the SBE 35RT to the SBE 9*plus* JT7 and SBE 32 Carousel Water Sampler JB2 using the Sea-Bird Y-cable (drawing 32208 for XSG / AG connectors on all three instruments; drawing 32963 for MCBH connector on all three instruments). The three arms of the cable are labeled *SBE 9*, *SBE 32*, and *SBE 35*. Connect each arm to the proper device. See *Connector Mating and Maintenance* in *Section 5: Routine Maintenance and Calibration* for information on lubricating and burping the connectors.
3. Turn on power to the SBE 11*plus* Deck Unit.
4. Double click on Seaterm.exe to verify communications and setup:
 - A. In the Configure menu, select *SBE 35*. Select the Com port that is connected to *Modem Channel* on the back of the SBE 11*plus* Deck Unit (the SBE 35RT uses the modem channel for communications). Click OK.
 - B. Click Status on the Toolbar (**DS** command) to verify communication with the SBE 35RT and check setup parameters. Change any parameters if desired (see *Command Descriptions* in *Section 3: Preparing for Deployment*), and resend the status command to verify the changes.
 - C. Ensure all data has been uploaded, and then type **SampleNum=0** and press the Enter key to make the entire memory available for recording. If **SampleNum** is not reset to zero, data will be stored after the last recorded sample.
 - D. Click Disconnect on the Toolbar to free the computer Com port.
 - E. Close Seaterm.
5. Double click on Seasave.exe to acquire the CTD cast:
 - A. Set up the system and display windows.
 - B. In the Real-Time Data menu, select *Start*. Make the desired selections in the Start Real-Time Data Acquisition dialog box, and then click the *Start* button.
 - C. Fire bottles as desired. Each time it receives a bottle confirmation, the SBE 35RT takes a sample and stores the data in EEPROM. If the next bottle is fired before the SBE 35RT finishes sampling (time required / sample = $1.1 * \mathbf{NCycles} + 2.7$ seconds), the SBE 35RT ignores the next bottle confirmation.
 - D. When the cast is complete, in the Real-Time Data menu select *Stop*. Turn off power to the SBE 11*plus* Deck Unit.

Deployment with SBE 19, 19plus, 19plus V2, 25, or 25plus CTD; SBE 33 Deck Unit; and SBE 32 Carousel Water Sampler

Note:

For details on wiring, setup, and operation of the entire system, see the SBE 33 and the CTD manuals. Only details relating to the use of the SBE 35RT are covered here.

1. Mount the SBE 35RT in a secure area on the water sampler frame, where the water flushes freely and there is minimal contamination from the passive thermal mass of the metal frame or active thermal dissipation from electronic instruments.
2. Connect the SBE 35RT to the SBE 32 Carousel Water Sampler JB2 using the Sea-Bird cable (drawing 32209 for XSG / AG connectors on both instruments; drawing 32964 for MCBH connectors on both instruments). Connect the end labeled *SBE 35* to the SBE 35RT and the end labeled *SBE 32* to the Carousel. See *Connector Mating and Maintenance* in *Section 5: Routine Maintenance and Calibration* for information on lubricating and burping the connectors.
3. Turn on power to the SBE 33 Deck Unit.
4. Double click on Seaterm.exe to verify communications and setup:
 - A. In the Configure menu, select *SBE 35*. Select the Com port that is connected to *Carousel Data* on the back of the SBE 33 Deck Unit (the SBE 35RT uses the Carousel data channel for communications). Click OK.
 - B. Click Status on the Toolbar (**DS** command) to verify communication with the SBE 35RT and check setup parameters. Change any parameters if desired (see *Command Descriptions* in *Section 3: Preparing for Deployment*), and resend the status command to verify the changes.
 - C. Ensure all data has been uploaded, and then type **SampleNum=0** and press the Enter key to make the entire memory available for recording. If **SampleNum** is not reset to zero, data will be stored after the last recorded sample.
 - D. Click Disconnect on the Toolbar to free the computer Com port.
 - E. Close Seaterm.
5. Double click on Seasave.exe to acquire the CTD cast:
 - A. Set up the system and display windows.
 - B. In the Real-Time Data menu, select *Start*. Make the desired selections in the Start Real-Time Data Acquisition dialog box, and then click the *Start* button.
 - C. Fire bottles as desired. Each time it receives a bottle confirmation, the SBE 35RT takes a sample and stores the data in EEPROM. If the next bottle is fired before the SBE 35RT finishes sampling (time required / sample = $1.1 * \mathbf{NCycles} + 2.7$ seconds), the SBE 35RT ignores the next bottle confirmation.
 - D. When the cast is complete, in the Real-Time Data menu select *Stop*. Turn off power to the SBE 33 Deck Unit.

Recovery

WARNING!

If the SBE 35RT stops working while underwater, is unresponsive to commands, or shows other signs of flooding or damage, carefully secure it away from people until you have determined that abnormal internal pressure does not exist or has been relieved. Pressure housings may flood under pressure due to dirty or damaged o-rings, or other failed seals. When a sealed pressure housing floods at great depths and is subsequently raised to the surface, water may be trapped at the pressure at which it entered the housing, presenting a danger if the housing is opened before relieving the internal pressure. Instances of such flooding are rare. However, a housing that floods at 5000 meters depth holds an internal pressure of more than 7000 psia, and has the potential to eject the end cap with lethal force. A housing that floods at 50 meters holds an internal pressure of more than 85 psia; this force could still cause injury.

If you suspect the SBE 35RT is flooded, point the SBE 35RT in a safe direction away from people, and loosen the bulkhead connector very slowly, at least 1 turn. This opens an o-ring seal under the connector. Look for signs of internal pressure (hissing or water leak). If internal pressure is detected, let it bleed off slowly past the connector o-ring. Then, you can safely remove the end cap.

Rinse the SBE 35RT and the other underwater instruments with fresh water, and dry thoroughly.

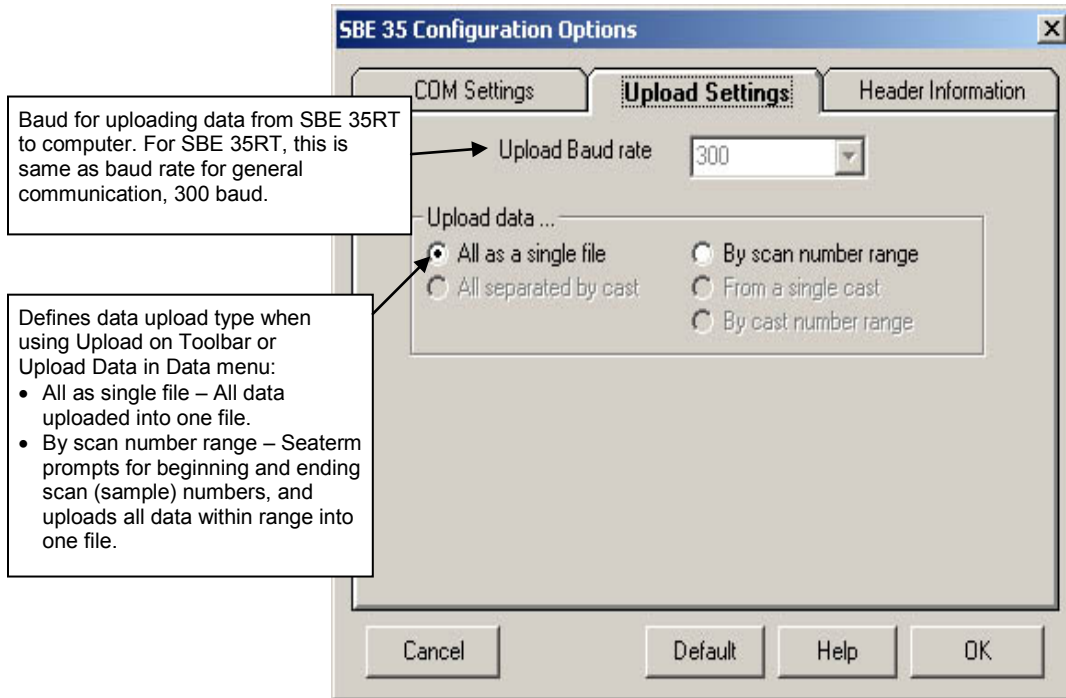
Uploading Data from SBE 35RT

Note:

Set up **Upload Settings**, **Header Information**, and/or **Header Form** (Steps 4 through 6):

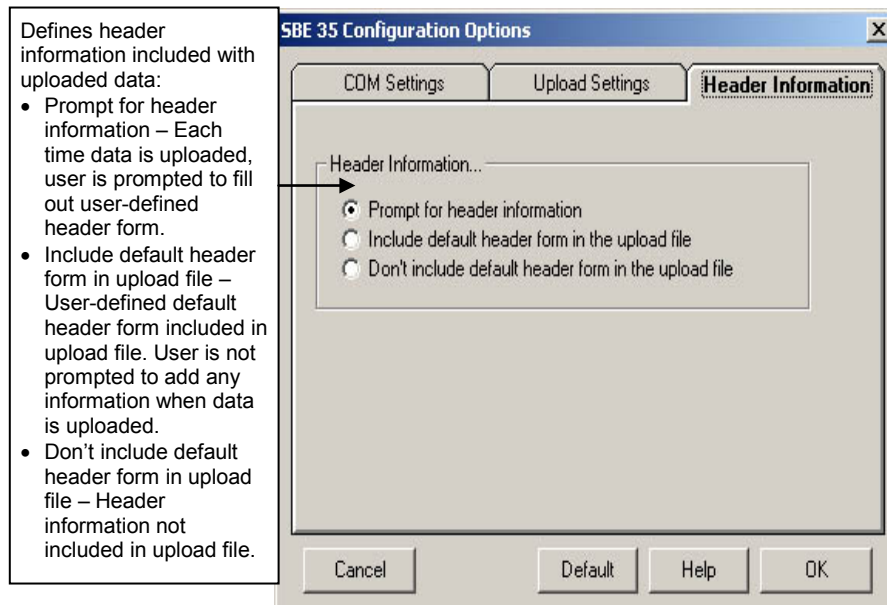
- The first time you upload data, and
- If you want to change upload or header parameters.

1. With the SBE 35RT still connected to the system, turn on power to the Deck Unit.
2. Double click on SeaTerm.exe. The display shows the main screen.
3. In the Configure menu, select *SBE 35*. On the COM Settings tab, select the COM port that is connected to *Modem Channel* (SBE 11*plus* Deck Unit) or *Carousel Data* (SBE 33 Deck Unit), as applicable.
4. Click on the Upload Settings tab. The dialog box looks like this:



Make the selection for Upload Settings.

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



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

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

The entries are free form, 0 to 12 lines long. This dialog box establishes:

- the header prompts that appear for the user to fill in when uploading data, if *Prompt for header information* was selected in the Configuration Options dialog box (Step 5)
- the header included with the uploaded data, if *Include default header form in upload file* was selected in the Configuration Options dialog box (Step 5)

Enter the desired header/header prompts. Click OK.

7. Click Upload on the Toolbar to upload stored data from the SBE 35RT. Seaterm responds as follows:
- Seaterm sends the status (**DS**) command, displays the response, and writes the command and response to the upload file. This provides you with information regarding setup and the number of samples in memory.
 - If you selected *By scan number range in the Configuration Options dialog box (Configure menu)*** – a dialog box requests the range. Enter the desired value(s), and click OK.
 - Seaterm sends the calibration coefficients (**DC**) command, displays the response, and writes the command and response to the upload file. This provides the calibration coefficients.
 - If you selected *Prompt for header information in the Configuration Options dialog box (Configure menu)*** – a dialog box with the header form appears. Enter the desired header information, and click OK.
 - In the Open dialog box, enter the desired upload file name and click OK. The upload file has a .asc extension.
 - Seaterm sends the data upload command (**DDb,e**).
 - When the data has been uploaded, Seaterm shows the *S>* prompt.
8. Ensure all data has been uploaded by reviewing the data.

Note:

To prepare for re-deployment: After all data has been uploaded, send **SampleNum=0**. If this command is not sent, new data will be stored after the last recorded sample, preventing use of the entire memory capacity.

Comparing SBE 35RT Data to CTD Data

Notes:

- For complete details on use of SBE Data Processing, see the SBE Data Processing manual or Help files. Only details relating to the use of the SBE 35RT are covered here.
- Seasave and SBE Data Processing versions 7.20a introduced .xmlcon files (in XML format). Versions 7.20a and later allow you to open a .con or .xmlcon file, and to save it to a .con or .xmlcon file. Seasave and SBE Data Processing use the same file.

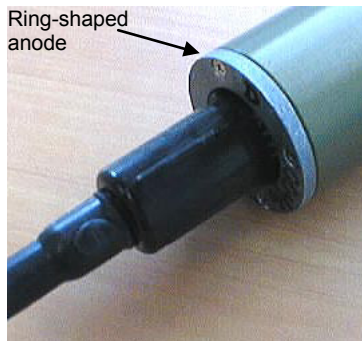
To compare the uploaded SBE 35RT .asc data file to the CTD data file (.hex or .dat), process **the CTD data** in SBE Data Processing:

1. Double click on SBEDataProc.exe.
2. Create a .ros bottle file, which contains CTD data for a user-selected range of scans before and after each bottle firing:
 - A. In SBE Data Processing's Run menu, select Data Conversion.
 - B. On the File Setup tab, select the configuration (.xmlcon or .con) file and data (.dat or .hex) file for your CTD.
 - C. On the Data Setup tab, set the following:
 - Create file types* = create both data and bottle file **or** bottle file only
 - Source of scan range data* = scans marked with bottle confirm bit
 - Scan range offset* = 0
 - Scan range duration* = $1.1 * \text{NCycles}$
 - D. See the SBE Data Processing manual or Help files for selection of other parameters on the File Setup and Data Setup tabs.
 - E. Click Start Process. SBE Data Processing creates a .cnv file with all the CTD data (if *create both data and bottle file* was selected in Step 2C), and a .ros file with CTD data for the scans associated with each bottle.
3. Create a .btl bottle summary file, which contains averaged values as well as optional minimum, maximum, and standard deviation, for each bottle:
 - A. In SBE Data Processing's Run menu, select Bottle Summary.
 - B. On the File Setup tab, select the configuration (.xmlcon or .con) file and .ros file for your CTD.
 - C. On the Data Setup tab, set the following:
 - Output min/max values for averaged variables* – select to obtain minimum, maximum, and standard deviation for each parameter
 - Select Averaged Variables* – click to select parameters to process
 - Select Derived Variables* – click to select parameters to calculate from input parameters
 - D. Click Start Process. SBE Data Processing creates a .btl file with summary CTD data for the scans associated with each bottle firing.

Section 5: Routine Maintenance and Calibration

This section reviews corrosion precautions, connector mating and maintenance, O-ring maintenance, and sensor calibration. The SBE 35RT's accuracy is sustained by the care and calibration of the sensors and by establishing proper handling practices.

Corrosion Precautions



Rinse the SBE 35RT with fresh water after use and prior to storage.

All stainless steel screws that are exposed to salt water have been generously lubricated with Blue Moly™. After each cruise, remove these screws and re-lubricate. **This compound is electrically conductive; use care to ensure it does not get on PCBs.**

A ring-shaped zinc anode is attached to the connector end of the SBE 35RT housing. Check the anode periodically to verify that it is securely fastened and has not been eaten away.

Avoid direct attachment of metal objects to the housing.

Connector Mating and Maintenance

Note:

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

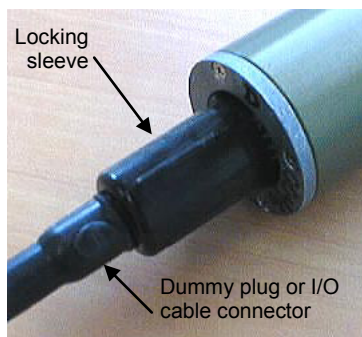
CAUTIONS:

- **Do not use WD-40** or other petroleum-based lubricants, as they will damage the connectors.
- For wet-pluggable MCBH connectors: **Silicone lubricants in a spray can** may contain ketones, esters, ethers, alcohols, or glycols in their propellant. **Do not use these sprays, as they will damage the connector.**

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

When remating:

1. Lightly lubricate the inside of the dummy plug/cable connector with silicone grease (DC-4 or equivalent).
2. **AG Connector** - Install the plug/cable connector, aligning the raised bump on the side of the plug/cable connector with the large pin (pin 1 - ground) on the SBE 35RT. Remove any trapped air by *burping* or gently squeezing the plug/connector near the top and moving your fingers toward the end cap. **OR**
MCBH Connector – Install the plug/cable connector, aligning the pins.
3. Place the locking sleeve over the plug/cable connector. Tighten the locking sleeve finger tight only. **Do not overtighten the locking sleeve and do not use a wrench or pliers.**



Verify that a cable or dummy plug is installed for each connector on the system before deployment.

Cleaning Interface Box

To clean the optional Interface Box:

1. Disconnect the power and any other cables from the Interface Box.
2. Using a soft cotton cloth dampened with warm water, clean the exterior of the Interface Box with gentle pressure. Use special care cleaning around any connectors, to avoid getting water into them.
3. Wait until the Interface Box is completely dry before reconnecting power cables and other electrical connections.

O-Ring Maintenance

Note:

For details on recommended practices for cleaning, handling, lubricating, and installing O-rings, see the *Basic Maintenance of Sea-Bird Equipment* module in the Sea-Bird training materials on our website.

Recommended inspection and replacement schedule:

- SBE 35RT's O-rings are not normally disturbed. We recommend inspection and replacement approximately every 3 to 5 years.

Remove any water from the O-rings and mating surfaces in the housing with a lint-free cloth or tissue. Inspect O-rings and mating surfaces for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to O-rings and mating surfaces.

CAUTION:

Do not use Parker O-Lube, which is petroleum based; use only Super O-Lube.

Calibration

SBE 35RTs are calibrated to ITS-90 temperature using Sea-Bird's computer-controlled calibration baths. Extremely well insulated, the baths provide a uniform toroidal circulation yielding an overall transfer accuracy against an SPRT within 0.00025 °C. Repeatability at each of eleven individually mapped sensor positions is better than 0.0001 °C. Sea-Bird's metrology laboratory underpins the temperature calibration baths. Following consultation with the U.S. National Institute of Standards and Technology, the metrology lab was configured to achieve temperature precision of 50 µK and accuracy of 0.0005 °C. To obtain this performance, premium primary references including four Jarrett water triple-point cells (with maintenance bath) and an Isotech gallium melt cell are operated in conjunction with two YSI 8163 standards-grade platinum resistance thermometers and an ASL F18 Automatic Temperature Bridge.

Glossary

Note:

All Sea-Bird software listed was designed to work with a computer running Windows XP service pack 2 or later, Windows Vista, or Windows 7 (32-bit or 64-bit).

PCB – Printed Circuit Board.

SBE 35RT – High-accuracy digital reversing thermometer.

SBE Data Processing – Sea-Bird’s Windows data processing software, which calculates and plots conductivity, temperature, pressure, data from auxiliary sensors, and derived variables.

Scan – One data sample.

Seasave V7 – Sea-Bird’s Windows real-time data acquisition software, used to acquire, convert, and display real-time or archived raw data.

Seasoft V2 – Sea-Bird’s complete Windows software package, which includes software for communication, real-time data acquisition, and data analysis and display. Seasoft V2 includes **Seaterm**, **SeatermV2**, **Seasave V7**, **SBE Data Processing**.

Seaterm – Sea-Bird’s Windows terminal program used to communicate with:

- SBE 35RT
- SBE 19, 19*plus*, or 25 CTD
- SBE 11*plus* or 33 Deck Unit








SeatermV2 – Windows terminal program *launcher*. Depending on the instrument selected, it launches Seaterm232 (RS-232 instruments), Seaterm485 (RS-485 instruments), or SeatermIM (inductive modem instruments). SeatermV2 is used to communicate with SBE 19*plus* V2 or 25*plus* CTD.

Seaterm232 – Windows terminal program used with Sea-Bird instruments that communicate via an RS-232 interface, and that were developed or redesigned in 2006 and later. The common feature of these instruments is the ability to output data in XML.

SeatermAF V2 – Windows software used to communicate with Sea-Bird instruments with auto-fire capability, such as SBE 17*plus* V2 or AFM.

Safety and Electrical Symbols

Some or all of the following symbols may be used on the optional Interface Box:

Symbol	Description
	Potentially hazardous voltage.
	Hazardous! Voltage > 30 VDC may be present.
	Attention! There is a potential hazard; consult the manual before continuing.
	DC (Direct Current).
	Double insulated. The metal enclosure of the Interface Box is isolated such that protection from electrical shock is provided through reinforced electrical insulation.
	Static awareness. Static discharge can damage part(s).
	Protective earthing terminal.

Appendix I: Functional Description

Measurement Cycle

The SBE 35RT determines temperature by applying a 1.2 kHz AC excitation to a reference resistor, zero ohms, and an ultrastable thermistor and digitizing the output from each with a 20-bit delta-sigma A/D converter. The reference resistor is a hermetically sealed VISHAY VHP202K inside a temperature-controlled oven. The switches are *All-Position* mercury wetted reed relays with a stable contact resistance. AC excitation and ratiometric comparison using a common processing channel removes measurement errors due to parasitic thermocouples, offset voltages, leakage currents, and gain errors. Maximum power dissipated in the thermistor is 5×10^{-7} watts.

$$\text{Sensor output} = 1048576 * (NT - NZ) / (NR - NZ)$$

where

NR = output from the reference resistor

NZ = output from zero ohms

NT = output from the thermistor

The process for each acquisition cycle is:

1. Select zero ohms, wait 0.1 seconds for the output to stabilize.
2. Average for 0.267 seconds; this is NZ.
3. Select reference resistor, wait 0.1 seconds for the output to stabilize.
4. Average for 0.267 seconds; this is NR.
5. Select thermistor, wait 0.1 seconds for the output to stabilize.
6. Average for 0.267 seconds; this is NT.

The total time per cycle is 1.1 seconds.

The number of acquisition cycles per sample is user-programmable (**NCycles**). Increasing the number of cycles per sample increases the time to acquire the sample, while reducing the RMS temperature noise from the sensor. The following RMS noise values are typical for an SBE 35 in a Triple Point of Water cell:

Note:

The SBE 35 and 35RT have the same circuitry, so the SBE 35 RMS noise values are also valid for the SBE 35RT.

NCycles	Acquisition Time	Standard Deviation (°C)
8	8.8 seconds	0.000029
32	35.2 seconds	0.000014

Temperature is computed using the Steinhart-Hart polynomial for thermistors (Steinhart and Hart, 1968; Bennett, 1972) as follows (n = output from SBE 35):

$$t_{90L} = \frac{1.0}{a0 + a1 \ln(n) + a2 \ln^2(n) + a3 \ln^3(n) + a4 \ln^4(n)} - 273.15$$

$$t_{90} = \text{slope} * t_{90L} + \text{offset} \quad [^{\circ}\text{C}, \text{ITS-90}]$$

Carrying the polynomial to the fourth order captures the non-linearity of the SBE 35RT thermistor output to better than ± 0.0001 °C.

Real-Time Clock

A low power *watch* crystal is used as the real-time-clock frequency source.

Memory

Data

The SBE 35RT stores up to 179 samples in EEPROM. EEPROM memory is non-volatile, and data in the memory is not lost as a result of removal of external power.

Timekeeping

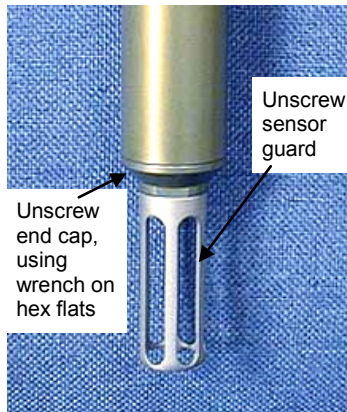
Time is stored in the real-time clock with a back-up lithium battery. Time is kept when external power is removed.

Settings

Calibration coefficients and setup and operating parameters (**SampleNum**, **NCycles**, etc.) are written to EEPROM and are non-volatile. These settings do not change if external power is removed.

Appendix II: Electronics Disassembly/Reassembly

Disassembly



1. **As a precaution, before beginning:**
Upload any data in memory, and
Record the setup parameters from the **DS** command response.
2. Remove the sensor end cap and electronics:
 - A. Wipe the outside of the sensor end cap and housing dry, being careful to remove any water at the seam between them.
 - B. To access the hex flats for unscrewing the end cap, first unthread the sensor guard by rotating counter-clockwise. Carefully, remove the sensor guard.
 - C. Unthread the end cap by rotating counter-clockwise, using a wrench on the hex flats if necessary.
 - D. Slide the end cap and attached electronics out of the housing. Note that the electronics are electrically connected to the bulkhead connector.
 - E. Remove any water from the O-ring and mating surface inside the housing with a lint-free cloth or tissue.
 - F. Be careful to protect the sensor and O-ring from damage or contamination.

Reassembly

Note:

Before delivery, a desiccant package is placed in the housing, and the housing is filled with dry Argon gas. These measures help prevent condensation. To ensure proper functioning:

1. Install a new desiccant bag each time you open the housing. If a new bag is not available, see *Application Note 71: Desiccant Use and Regeneration (drying)*.
2. If possible, dry gas backfill each time you open the housing. If you cannot, wait at least 24 hours before redeploying, to allow the desiccant to remove any moisture from the housing.

CAUTION:

Do not use Parker O-Lube, which is petroleum based; use only Super O-Lube.

1. Reinstall the sensor end cap and electronics:
 - A. Remove any water from the O-ring and mating surface in the housing with a lint-free cloth or tissue. Inspect the O-ring and mating surface for dirt, nicks, and cuts. Clean or replace as necessary. Apply a light coat of O-ring lubricant (Parker Super O Lube) to the O-ring and mating surface.
 - B. Carefully fit the end cap and electronics into the housing and rethread the end cap into place. Use a wrench on the hex flats to ensure the end cap is tightly secured.
 - C. Carefully fit the sensor guard over the sensor. Tighten the sensor guard. **Do not overtighten the sensor guard and do not use a wrench or pliers.**
2. Check the instrument setup using **DS** (see *Section 3: Preparing for Deployment*), and if necessary re-enter the desired parameters.

Appendix III: Command Summary

Note:

See *Command Descriptions* in *Section 3: Preparing for Deployment* for detailed information and examples.

CATEGORY	COMMAND	DESCRIPTION
Status	DS	Display setup parameters.
Setup	MMDDYY=mmddy	Set real-time clock month, day, year. Must follow with HHMMSS= .
	DDMMYY=ddmmyy	Set real-time clock day, month, year. Must follow with HHMMSS= .
	HHMMSS=hmmss	Set real-time clock hour, minute, second.
	NCycles=x	x= number of measurements to take and average per sample (1 – 127).
	Interface=x	x=911plus: SBE 35RT used with SBE 9plus CTD, SBE 11plus Deck Unit, and SBE 32 Carousel Water Sampler. x=32serial: SBE 35RT used with SBE 19, 19plus, 19plus V2, 25, or 25plus CTD; SBE 33 Carousel Deck Unit; and SBE 32 Carousel Water Sampler.
	SampleNum=x	x= sample number for first sample when sampling begins. After all data has been uploaded, set to 0 before starting to sample to make entire memory available for recording. If not reset to 0, data stored after last sample.
Sampling	Cal	Start sampling continuously now, outputting real-time raw data. Data not stored in EEPROM.
	Run	Start sampling continuously now, outputting real-time raw data as well as computed temperature (°C). Data not stored in EEPROM.
	TS	Take one sample; store in EEPROM and output real-time.
Data Upload	DDb,e	Upload data from sample b to e .
Testing (these commands are case sensitive, and must be entered as shown)	*rtctest	Test battery-backed static RAM in real-time clock module. Test resets date and time to default.
	*eetest	Test EEPROM memory. Allow 30 seconds for test. Test destroys all sampling data and setup parameters (calibration coefficients, etc.) stored in EEPROM.
Coefficients (F=floating point number; S=string with no spaces) Date shown is when calibration was performed. Calibration coefficients are initially factory-set and should agree with Calibration Certificate shipped with SBE 35RT.	DC	Display calibration coefficients; all coefficients and date listed below are included. Use individual commands below to modify a particular coefficient or date.
	CalDate=S	S=Temperature calibration date.
	TA0=F	F=Temperature A0.
	TA1=F	F=Temperature A1.
	TA2=F	F=Temperature A2.
	TA3=F	F=Temperature A3.
	TA4=F	F=Temperature A4.
	Offset=F	F=Temperature offset.
Slope=F	F=Temperature slope.	

Note:

Use Upload on the Toolbar or Upload Data in the Data menu to write SBE 35RT setup, calibration coefficients, and a user-input header along with uploaded data to a .asc file.

Appendix IV: References

Steinhart, J.S. and Hart, S.R. (1968) "Calibration Curves for Thermistors", Deep-Sea Research, 15, p.497.

Bennett, A.S. (1972) "The Calibration of Thermistors over the Temperature range 0-30 °C", Deep-Sea Research, 19, p.157.

Appendix V: Replacement Parts

Part Number	Part	Application Description	Quantity in SBE 35RT
23013C	Aluminum temperature sensor guard	Screws to end cap to protect temperature sensor	1
90248	Interface Box	For lab use with SBE 35RT	1
171887	DB-9P to DB-9S I/O cable, 3.0 m (10 ft) long	Connect Interface Box to computer	1
17015	AC power cable	For Interface Box	1
80555	6-pin AG-206 to 4-pin MS3106A-14S-2P cable, 2.4 m (8 ft) long *	Connect SBE 35RT to Interface Box	1
17047.1	6-pin AG-206 dummy plug with locking sleeve *	For SBE 35RT connector	1
17043	Plastic locking sleeve *	For cable/dummy plug	1
171220	6-pin AG-206 to 6-pin AG-206 to 6-pin AG-206 Y-cable *	From SBE 35RT to SBE 32 Carousel Water Sampler and: • SBE <i>9plus</i> CTD, • AFM, or • SBE <i>17plus</i> V2 Searam	-
171221	6-pin AG-206 to 6-pin AG-206 cable, 2.4 m (8 ft) long *	From SBE 35RT to SBE 32 Carousel Water Sampler (for use with SBE 19, <i>19plus</i> , <i>19plus</i> V2, 25, or <i>25plus</i> CTD and SBE 33 Carousel Deck Unit)	-
801534	6-pin MCIL-6FS wet-pluggable connector to 4-pin MS3106A-14S-2P cable, 2.4 m (8 ft) long	Connect SBE 35RT to Interface Box	1
171498.1	6-pin MCDC-6-F wet-pluggable dummy plug with locking sleeve	For SBE 35RT connector	1
171192	Plastic locking sleeve for wet-pluggable connector	For cable/dummy plug	1
171995	6-pin MCIL-6FS to 6-pin MCIL-6FS to 6-pin MCIL-6FS (wet-pluggable) Y-cable	From SBE 35RT to SBE 32 Carousel Water Sampler and: • SBE <i>9plus</i> CTD, • AFM, or • SBE <i>17plus</i> V2 Searam	-
171996	6-pin MCIL-6FS to 6-pin MCIL-6FS (wet-pluggable) cable, 2.4 m (8 ft) long	From SBE 35RT to SBE 32 Carousel Water Sampler (for use with SBE 19, <i>19plus</i> , <i>19plus</i> V2, 25, or <i>25plus</i> CTD and SBE 33 Carousel Deck Unit)	-
23041	Anode ring	For corrosion resistance; connector end of housing	1
30126	4-40 x 3/8 flat head, stainless steel screws	Secure anode ring to housing	4
30806	LS021 L-seal	O-ring placed in end cap groove	1
50309	Mount kit	For mounting SBE 35RT on SBE 32C (Compact) or 32SC (Sub-Compact) Carousel Water Sampler	-

* For XSG / AG connectors

Appendix VI: Manual Revision History

Manual Version	Date	Description
006	12/02	<ul style="list-style-type: none"> • Rewrite
007	12/03	<ul style="list-style-type: none"> • Add wet-pluggable connector drawing. • Update Rosette Summary to Bottle Summary (change in SBE Data Processing). • Update Seaterm screens.
008	10/04	<ul style="list-style-type: none"> • Add wet-pluggable cable/plug equivalents. • Update part numbers.
009	03/07	<ul style="list-style-type: none"> • Incorporate Seasave V7. • Update wet-pluggable callout – switched to WB. • Update Recovery Warning. • Add information on maximum allowable value of Ncycles (127). • Update description of 171220 & 171995 Y-cables -- can also use for 35RT to AFM/Carousel, & 35RT to 17plus/Carousel. • Add more explanation of raw reference readings in Data Output Formats section.
010	02/09	<ul style="list-style-type: none"> • Correct maximum number of samples -- 179, not 170. • Update to include 19plus V2. • Add information about compatibility with Vista. • Add reference to SeatermV2. • Update connector maintenance information for consistency with application note 57.
011	11/10	<ul style="list-style-type: none"> • Redesign interface box and update manual to meet CE requirements. • Add information about .xmlcon configuration file. • Update address.
012	04/13	<ul style="list-style-type: none"> • Update to include SBE 25<i>plus</i>. • Add Declaration of Conformity. • Add cable wiring drawings. • Update software compatibility information. • Fix typos.
013	02/15	<ul style="list-style-type: none"> • Clarify that accuracy specifications are \pm. • Correct case for <i>*rtctest</i> and <i>*eetest</i> commands; they are case sensitive. • Update Declaration of Conformity. • Add information on O-ring maintenance. • Add caution regarding using spray can lubricants on MCBH connectors. • Add caution regarding using Parker Super O Lube, not Parker O Lube (which is petroleum based). • Remove <i>standard</i> and <i>optional</i> language related to SBE 35RT features. • Update language on where to find software on website. • Switch to Sea-Bird Scientific cover.

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