


## **Module 11**

# **Setup of Moored Instruments**

## Overview



**Setup of Moored Instruments**

- In this module we will discuss:
  - Sample theory (briefly)
  - Seaterm, the user interface
  - Status reports, header listings, and data formats
  - Preparing for deployment
  - Conversion of data to a format used by SBE Data Processing

In this module we will discuss setup of moored instruments for deployment, considering sampling theory, the user interface, and instrument status reports.

By the end of this module, you should be able to:

- Understand what sort of time-scale phenomena you can observe with a given sampling rate
- Judge your instrument's readiness for deployment based on its status report
- Prepare your instrument for deployment
- Convert data from your instrument to a format that can be processed by SBE Data Processing

## The Sampling Theorem

**SBE**  
*ocean*

### Measuring Periodic Signals

- Sampling theorem:
  - Given a time or space varying signal,  $x(t)$ , where  $x(t)$  is bandlimited with  $X(\omega)=0$  for  $|\omega| > \omega_m$ .
  - Then  $x(t)$  will be uniquely determined by its samples  $x(nT)$ ,  $n = 0, \pm 1, \pm 2 \dots$
  - if  $\omega_s > 2\omega_m$  Where:  $\omega_s = 2\pi/T$
- Sampling theorem in English:
  - You can observe changes in parameters that occur only half as fast as you are sampling
  - This holds true for distance as well as time

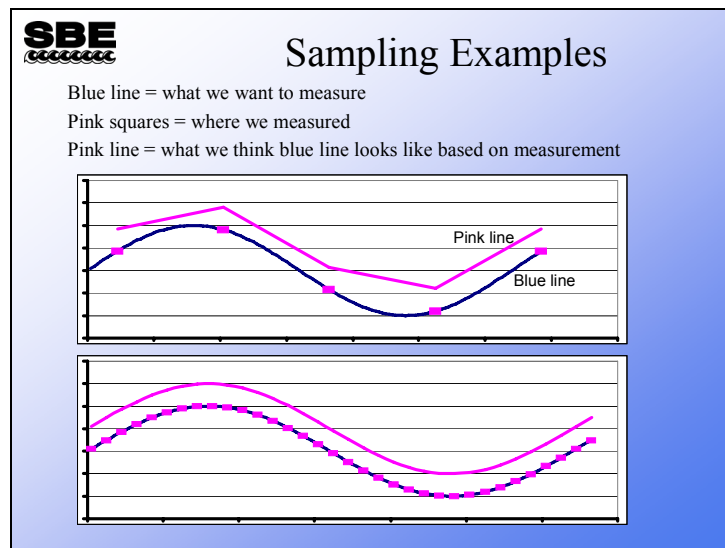
It is rather difficult to understand what this has to do with making measurements in the ocean by looking at the math.

The sampling theorem tells us how much information we can extract from a signal, given the rate at which we sample. In this case, the signal is any of the parameters we measure in the ocean. The sample rate is the rate at which the instrument makes a measurement or takes a scan.

The sampling theorem states *the highest frequency of information we can extract from a signal is half the frequency that we sample*. This means that if you sample at once an hour you can resolve signals that occur with a 2 hour period.

This holds true for distance as well as time. If we place instruments 10 meters apart on out mooring, we can resolve signals that have a length scale of 20 meters.

## Sampling Theorem: Sampling Examples




### ***Top Illustration - Under Sampled:***

Suppose we wish to measure a sine wave that has 16 cycles per hour. However, our sampling equipment is only capable of taking a measurement 5 times per hour. The upper line is our estimate of what the sine wave looks like.

### ***Bottom Illustration - Properly Sampled:***

This signal is properly sampled; the upper line is a complete representation of the lower line.

## Resolution and Sampling Theory



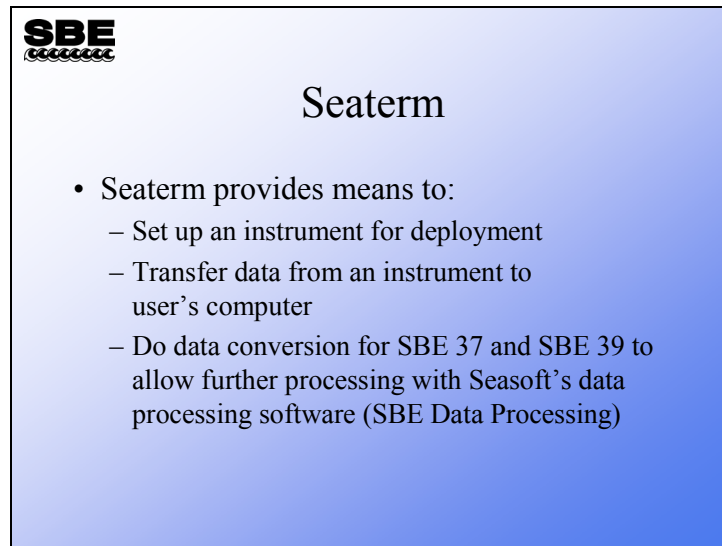
**Resolution and Sampling Theory**

- You can only resolve events that happen at half the frequency you sample
- You can only resolve length scales that are twice the size of your mooring spacing

In the profiling section of the course, you will recall we spent some time considering what sort of events or characteristics in the ocean we could expect to resolve given the sensor characteristics, sampling rates, and the lowering speed of the instrument package. The situation with moored instruments is simpler by virtue of the fact that they stay in one place (hopefully) and their sampling rates are usually slow enough that sensor characteristics are not an issue. Thus, you can resolve events that occur on time scales of 10 seconds to 18 hours given sample rates of 5 seconds to 9 hours.

In the length domain, the characteristics you can resolve depend on the spacing of instruments on the mooring and the space between moorings. As in the time domain, you can resolve characteristics that occur on scales that are twice your spacing on the mooring.

## Seaterm: User Interface

A slide with a blue gradient background. In the top left corner is the SBE logo. The title "Seaterm" is centered. Below the title is a bulleted list of functions.


**SBE**  
*seasoft*

### Seaterm

- Seaterm provides means to:
  - Set up an instrument for deployment
  - Transfer data from an instrument to user's computer
  - Do data conversion for SBE 37 and SBE 39 to allow further processing with Seasoft's data processing software (SBE Data Processing)

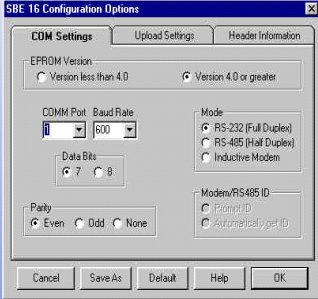
Even in moorings that use inductive telemetry, the data that is stored in the instrument is of interest. There may be occasions where the link between the surface buoy and the ground station malfunctioned, or the telemetered data may be a subset of that collected by the remote instrument. Seaterm provides the facility for data transfer and for the conversion of SBE 37 and SBE 39 data to a format that can be used by the processing programs in Seasoft.

## Setting up Seaterm for Communications



### Setting Up Seaterm Communications

- Set firmware revision for SBE 16
- Set appropriate communication mode for instrument
- Except SBE 16, all moored instruments have 8 data bits and no parity



For the SBE 16, older versions of firmware (EPROM version) do not support a shift to higher baud rate during data transfers. If the firmware selection is not properly set, the data transfer will fail.

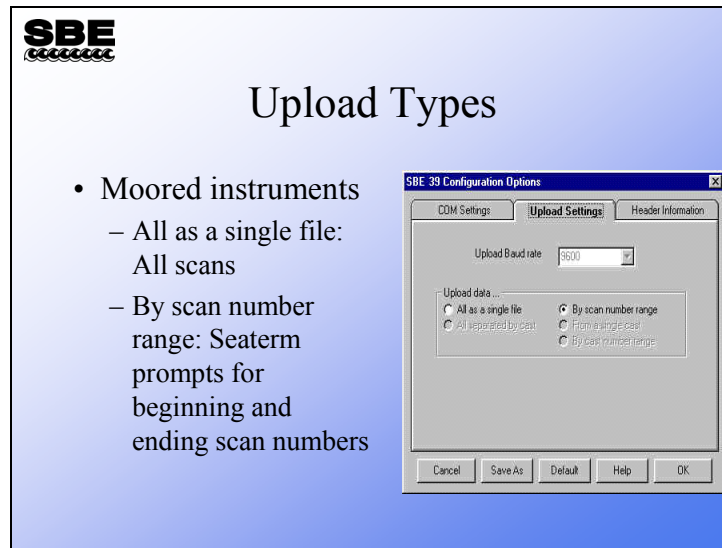
The SBE 16*plus*, 37, and 39 do not support the shift to higher baud rate for data transfer; the user sets the baud rate with the *baud=* command. Also, only 8 data bits, 1 stop bit, and no parity is used for these instruments.

Note that three different types of serial communication are supported in Seaterm:

- RS-232
- RS-485, which allows instruments to be wired in parallel and addressed by ID number
- Inductive modem, which we discussed in the previous module

The SBE 37 and 16*plus* are available in models to support each of the three types of serial communication; the SBE 39 is available in both RS-232 and inductive modem models.

## Seaterm: Upload Types



The screenshot shows the 'SBE 39 Configuration Options' dialog box with the 'Upload Settings' tab selected. The 'Upload Baud rate' is set to 3600. Under 'Upload data...', the following options are visible:

- All as a single file
- By scan number range
- All separated by cast
- From a single cast
- By scan number range

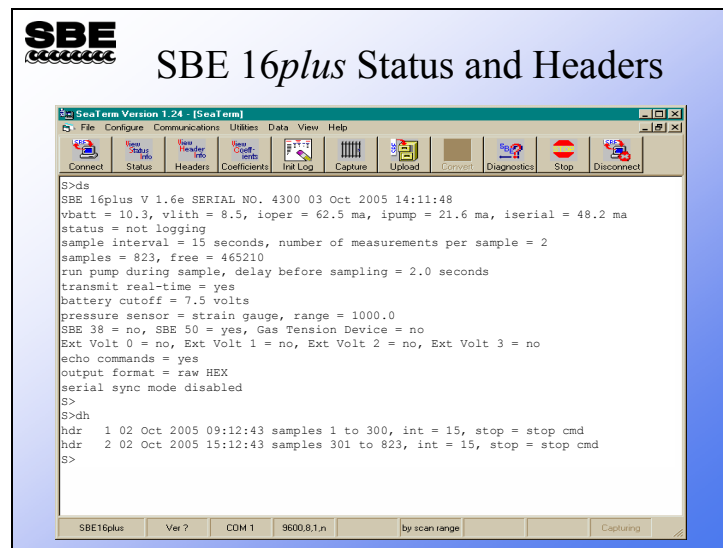
Buttons at the bottom include Cancel, Save As, Default, Help, and OK.

- Moored instruments
  - All as a single file:  
All scans
  - By scan number range: Seaterm prompts for beginning and ending scan numbers

Profiling instruments usually transfer data in casts. Moored instruments typically dump all their stored data at once.



## SBE 16*plus* Status Report and Data Headers




The 16*plus* status report has:

- Firmware revision, serial number, date and time.
- Battery voltage, back-up battery voltage, and operating current.
- Status: logging or not.
- Sample interval and number of measurements that are averaged to make a sample.
- Number of samples stored and amount of space free.
- Parameters related to the pump and auxiliary sensors -
  - pump mode (no pump, run for 0.5 sec before each sample, or run during each sample)
  - delay before sampling (seconds after switching on power that auxiliary sensor measurement is made)
- Transmit real-time data or not.
- Battery cut-off voltage.
- Pressure sensor type and range.
- Whether an external SBE 38, SBE 50, or GTD is attached.
- Which external voltages are sampled.
- Show entered commands on screen as you type?
- Output data format -
  - raw frequencies and voltages in hexadecimal
  - data converted to scientific units but output in hexadecimal
  - raw frequencies and voltages in decimal
  - data converted to scientific units output in decimal; whether salinity and sound velocity output
 Note that uploads initiated via SeaTerm's toolbar are always uploaded in raw frequencies expressed in hexadecimal.
- Serial synchronization mode enabled or disabled.

Header entries have start date and time, sample range, and sample interval as well as the reason for ending data collection.

## Data Format: SBE 16



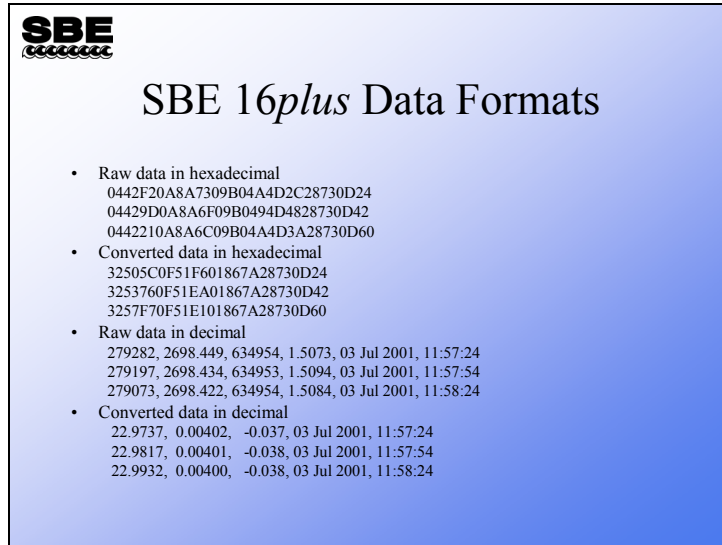
SBE 16 Data

- Data is in hexadecimal format, T and C only
- Adding auxiliary sensors add bytes to the scan

```
S>dd31,10
8A7503DB
8A7D03DB
8A9203DB
8A8D03DB
8ABB03DB
8AD803DB
8AE103DB
8AF603DC
8B0503DC
8B0603DB
S>
```

This data is an ASCII representation of hexadecimal numbers. This representation allows the data file to be readable with any text editor.

## Data Format: SBE 16plus



The slide features the SBE logo in the top left corner. The title "SBE 16plus Data Formats" is centered at the top. Below the title, there are four bullet points, each describing a different data format with corresponding examples:

- Raw data in hexadecimal  
0442F20A8A7309B04A4D2C28730D24  
04429D0A8A6F09B0494D4828730D42  
0442210A8A6C09B04A4D3A28730D60
- Converted data in hexadecimal  
32505C0F51F601867A28730D24  
3253760F51EA01867A28730D42  
3257F70F51E101867A28730D60
- Raw data in decimal  
279282, 2698.449, 634954, 1.5073, 03 Jul 2001, 11:57:24  
279197, 2698.434, 634953, 1.5094, 03 Jul 2001, 11:57:54  
279073, 2698.422, 634954, 1.5084, 03 Jul 2001, 11:58:24
- Converted data in decimal  
22.9737, 0.00402, -0.037, 03 Jul 2001, 11:57:24  
22.9817, 0.00401, -0.038, 03 Jul 2001, 11:57:54  
22.9932, 0.00400, -0.038, 03 Jul 2001, 11:58:24

A complete description of these formats is found in the manual.

- **Raw data in hexadecimal example:**

SBE 16plus with strain gauge pressure sensor and two external voltages sampled,  
example scan = tttttccccccppppppvvvvvvvvvvvsssssss  
= 0A53711BC7220C14C17D820305059425980600

- **Converted data in hexadecimal example:**

SBE 16plus with strain gauge pressure sensor and two external voltages sampled,  
example scan = tttttccccccppppppvvvvvvvvvvvsssssss  
= 3385C40F42FE0186DE0305059425980600

Note that some of the hexadecimal numbers are scaled. For example, in the raw hexadecimal data, the conductivity frequency is multiplied by 256. In the converted hexadecimal data, temperature is multiplied by 100,000 and conductivity by 1,000,000.

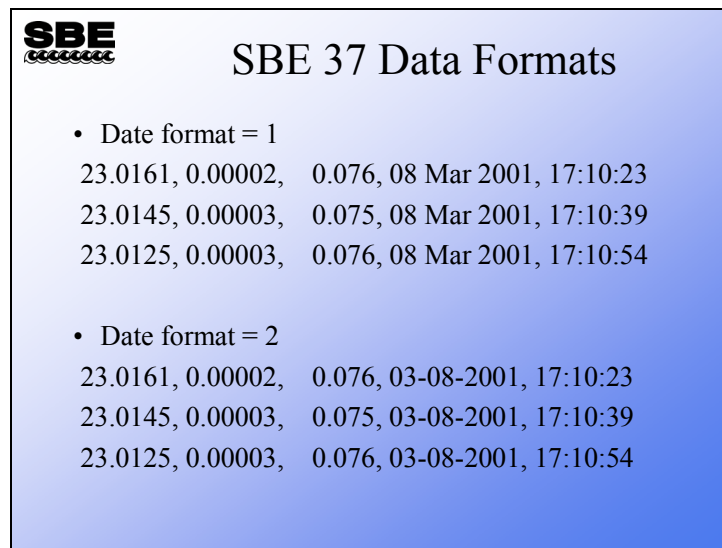
- **Raw data in decimal example:**

SBE 16plus with strain gauge pressure sensor and two external voltages sampled,  
example scan =  
ttttt, cccc.ccc, pppppp, v.vvvv, v.vvvv, v.vvvv, dd mmm yyyy, hh:mm:ss  
= 676721, 7111.133, 791745, 2.4514, 0.0590, 0.1089, 12 nov 2000, 12:23:05

- **Converted data in decimal:**

SBE 16plus with strain gauge pressure sensor and two external voltages sampled,  
example scan = ttt.tttt, cc.ccccc, pppp.ppp, v.vvvv, v.vvvv, dd mmm yyyy, hh:mm:ss  
= 23.7658, 0.00019, 0.062, 0.0590, 0.1089, 12 nov 2000, 12:23:05

## Data Format: SBE 37



The slide features the SBE logo in the top left corner. The title 'SBE 37 Data Formats' is centered at the top. Below the title, there are two bulleted sections. The first section, 'Date format = 1', lists three data rows: '23.0161, 0.00002, 0.076, 08 Mar 2001, 17:10:23', '23.0145, 0.00003, 0.075, 08 Mar 2001, 17:10:39', and '23.0125, 0.00003, 0.076, 08 Mar 2001, 17:10:54'. The second section, 'Date format = 2', lists three data rows: '23.0161, 0.00002, 0.076, 03-08-2001, 17:10:23', '23.0145, 0.00003, 0.075, 03-08-2001, 17:10:39', and '23.0125, 0.00003, 0.076, 03-08-2001, 17:10:54'.

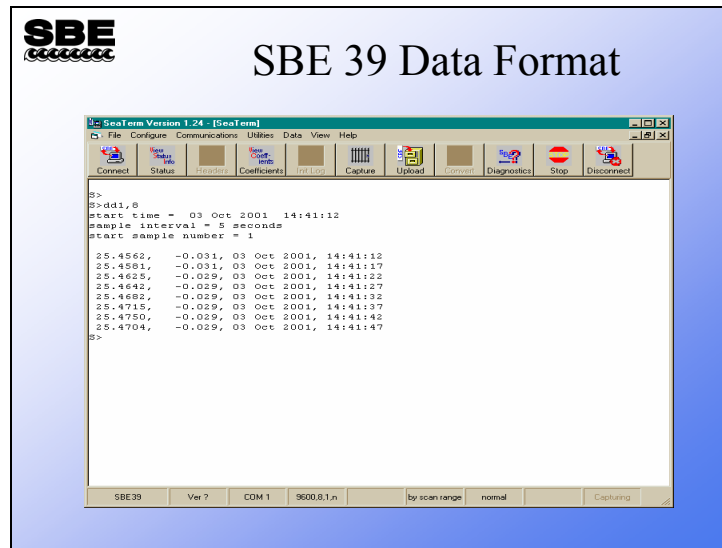
The basic SBE 37 data format is temperature, conductivity, pressure (if installed), date and time. The SBE 37 offers two date formats in the data output:

- dd mmm yyyy
- mm-dd-yyyy.

This is selected with the **format=** command. Note that there are some differences in output format, depending on the specific model of SBE 37 MicroCAT:


- 37-IM and 37-IMP: The **format=** command also affects the output units for conductivity: S/m for **format=1** and mS/cm for **format=2**.
- 37-SM and 37-SMP: Can also output salinity and/or sound velocity if desired, with the use of the appropriate setup commands. Can suppress storage and output of date and time with the use of the appropriate setup command.
- 37-SI and 37-SIP: Can also output depth, salinity, sound velocity, and/or density sigma if desired, with the use of the appropriate setup commands. Can suppress output of date and time with the use of the appropriate setup command.

## Data Format: SBE 39



The SBE 39 data format is temperature, pressure (if installed), date and time.

## Converting Sensor Output to Scientific Units




**Converting Sensor Output to Scientific Units**

- SBE 16 stores and reports data as frequencies and voltages
  - Use Data Conversion utility
- SBE 16*plus* can report data in scientific units, or as frequencies and voltages
  - Data uploaded as hex, use Data Conversion
- SBE 37 and 39 report data in scientific units
  - Use Seaterm or DOS conversion utility to make a *.cnv* file

- The SBE 16 requires the same sort of data processing as was discussed in the previous part of the course, beginning with Data Conversion and ending with Bin Averaging.
- The SBE 16*plus* can report data in scientific units. However, when Seaterm's toolbar is used to retrieve data, Seaterm sets the output format to raw hexadecimal data, to provide a file that is compatible with SBE Data Processing. This data requires conversion with the Data Conversion module in SBE Data Processing.
- The SBE 37 and 39 report data in scientific units and Seaterm retrieves the data in this format.

## ASCII Data Conversion Utilities




**Converting ASCII Data for Processing with Seasoft**

- Data from the SBE 37 and SBE 39 can be “converted” to the .cnv format for further processing with Seasoft data processing applications
  - Convert button in Seaterm
  - DOS utilities CNV37 and CNV39

SBE 37s and 39s report data in scientific units in a format that is not compatible with Seasoft’s post processing utilities. If you wish to do any processing of this data with SBE Data Processing, you have to convert it to the .cnv file format. There is a utility that is part of Seaterm or DOS utilities to perform this conversion.

## Preparing for Deployment



**Preparing for Deployment**


- Install fresh batteries
- Clear memory of old data
- Check temperature and conductivity and other sensors
- Set internal clock
- Set ID for instruments using inductive modems or RS-485
- Check all cabling, and lubricate and reset underwater connections

We are going to discuss preparation for deployment next. Some of these items need little explanation, while others require more consideration.

Sea-Bird instruments stop recording data when the memory is full. It is very important to clear the memory before you start.



## Preparing for Deployment: Sensor Check




**Pre-Deployment Sensor Check**

- Use the **TS** command to check nominal functionality of all sensors
- Check conductivity zero frequency against calibration sheet

Before you invest a great deal of time and effort deploying a mooring, it is a great idea to send your instrument in for calibration. It is an excellent check on its functionality, not to mention its accuracy. If you are unable to do this, check to see that all the sensors are presenting nominally correct output. Sea-Bird moored instruments, with the exception of the SBE 16, have calibration coefficients stored internally and are able to output measurements in scientific units.

The best spot check for the conductivity cell is to observe its zero conductivity frequency. To do this, rinse the cell in distilled or de-ionized water and shake any remaining drops out. The sensor should read very close to the zero conductivity reading on the calibration sheet. If it does not, the cell may be dirty or damaged. Try cleaning it with a non-ionic detergent such as Triton X.

## Preparing for Deployment: Clocks



### Clock Drift

- All internal clocks use a 32,767 Hz crystal oscillator
  - 32,767 is divided by a binary counter for a 1 Hz clock tick
- The frequency of the crystal is affected by temperature
- SBE 37 and old SBE 39 clocks are calibrated and corrected for the temperature effect
- SBE 16*plus* and new SBE 39s offers a temperature-compensated oscillator with extremely low drift

All clocks drift. If you put 10 instruments on a mooring, all set to the same time, and come back 1 year later, they will all report different times. This can lead to some difficulties when you process the data. Clocks drift because of instability of the crystal oscillator that the clocks use to keep time. A small change in oscillator frequency will translate into a clock that runs fast or slow.

For this reason, Sea-Bird calibrates the clock frequency versus temperature and corrects for drift each time an SBE 37 or older 39 wakes to take a sample. To ensure the time between samples is consistent, each time the instrument wakes and takes a sample, the time to the next sample is set to be the calibrated time interval between samples, not the next clock time. This ensures a data series that is evenly spaced in time. Otherwise, the time between samples would vary depending on temperature's effect on the oscillator.

The SBE 16*plus* and newer SBE 39s use a temperature-compensated oscillator that provides a very stable time base. Previously these were not available in a small enough package to make them practical for a moored instrument.


## Preparing for Deployment: Cables



### Check Your Connectors and Cables

- Check all the cabling
- Remove the cables from their bulkhead connectors
  - Inspect the bulkhead connectors and mating pieces
  - Clean and lubricate the bulkhead connectors
  - Burp all air out of the connectors when they are reseated

## Preparing for Deployment: SBE 16*plus* Pump Operating Modes



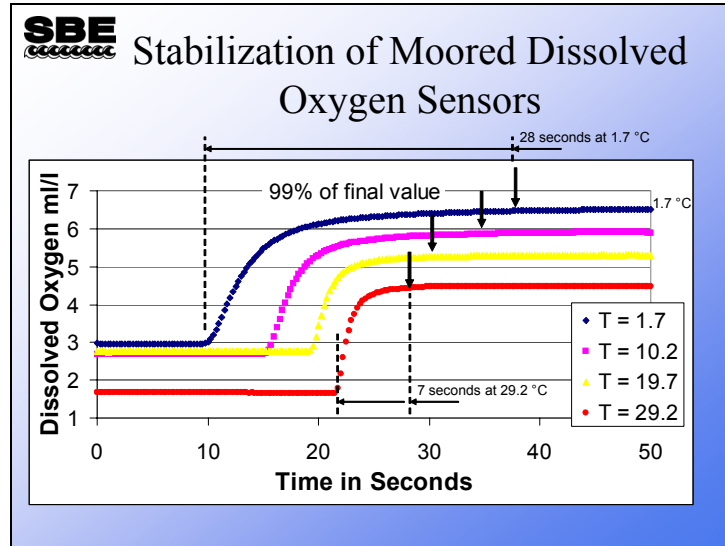
SBE 16*plus* Pump Modes

- No pump
  - No mystery here
- Pump for 0.5 seconds before sample
  - T & C only, ventilates the cell, saves power
- Pump on for entire sample period
  - For auxiliary sensors with long time constants
    - Dissolved oxygen
    - Fluorometer

Experience with the SBE 41 ALACE CTD has led Sea-Bird to adopt the protocol of ventilating the conductivity cell for a short time before measuring the conductivity, and then turning the pump off. This saves power and has the additional benefit of reducing bio-fouling inside the cell while the pump is off and the instrument is waiting for the next sample. With this protocol the power requirement is small enough to allow long-term deployment at reasonably short sampling intervals (e.g., 15 minutes).

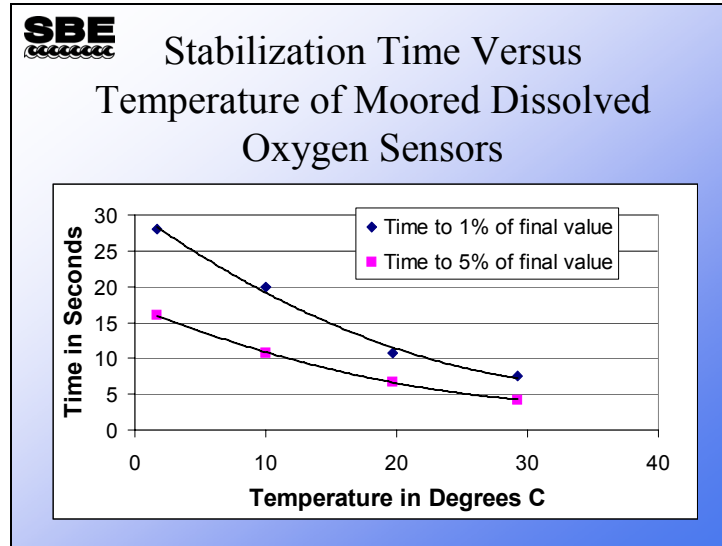
If you are using sensors with a comparatively long time constant, run the pump throughout the sample interval. Recall from the slide that showed the 16*plus* status report, you can set the delay from the start of the sampling period to the moment when the auxiliary sensor is measured. This allows you to give a slow sensor 5 or 6 time constants to equilibrate.

## Preparing for Deployment: Setting Up for Dissolved Oxygen Sensors




Oxygen sensors installed in moorings are always pumped and are typically plumbed between the pump and conductivity sensor of an SBE 16*plus*. Between samples the pump does not run and water ceases to move past the oxygen electrode. As we have discussed, the electrode of the SBE 43 oxygen sensor is powered by an internal battery. When the water becomes still, the electrode depletes it of oxygen; if the 16*plus* were to continue logging data you would observe oxygen concentration inside the sensor plenum approaching a steady state well below the ambient oxygen levels. When the 16*plus* initiates a normal sampling interval by turning on the pump, you would observe a curve similar to the ones shown above. The water flow establishes a normal boundary layer above the oxygen electrode and the sensor equilibrates to the ambient oxygen level. The time required to reach 99% of the final equilibrium value depends on temperature, warmer water allowing faster equilibration. The arrows on the plot show the point at which the sensor has achieved 99% of the final value at each temperature.

## Preparing for Deployment: Setting Up for Dissolved Oxygen Sensors (*continued*)



This plot is derived from the preceding plot and may be used to determine the time required from power up and pump turn on to the availability of an acceptable dissolved oxygen sample. For example, if you were working in 20° C water and wanted your oxygen data to be better than 1% of actual ambient oxygen concentrations, you would want the sample interval to be longer than 11 seconds. Set the SBE 16*plus* pump mode to pump during the entire sample time (**mooredpumpmode=2**), and set the delay before sampling to 15 seconds (**delaybeforesampling=15**). We have allowed 4 extra seconds in our sampling time; this ensures that if the instrument finds itself in colder than expected water, that the sample will still be good. Note that longer pump times reduce battery endurance.

## Preparing for Deployment: Starting Logging




### Log Data Now or Later?

- Use the **startnow** command to begin logging data immediately
- To begin logging later:
  1. Use the **startmddy=** command to enter a date to start logging
  2. Use the **starthhmmss=** command to enter a start time on the date entered above
  3. Use the **startlater** command to begin logging on the date and time entered above

You have the option of setting a logging start time and date, allowing you to begin data collection once the mooring is in place. The risk you run is that you might not place the mooring when you planned to. There are always some risks in life. The alternative is to trim off data that is meaningless at the beginning of the file.

## Preparing for Deployment: Inductive Modem Systems




### Inductive Modem IDs

- Valid range for ID numbers is 00 – 99
- There must be only one instrument on the loop when setting IDs
- IM receiver is very sensitive; instruments not on the loop, but near the loop, will receive the ID change

Do not change the ID of an inductive modem equipped instrument when another instrument is on the same loop; this will cause both instruments to take the same ID. The telemetry system will not work properly for those instruments, because they will try to use the link at the same time. The inductive modem receiver in the instruments is very sensitive. Two instruments that are side-by-side will take the same ID even if one of them is not connected to the loop. You must separate IM instruments by at least a meter when you change IDs.



## Preparing for Deployment: Inductive Modem Systems (continued)




**Getting Data to the Surface and the Shore**

- You are responsible for the communications link between the surface buoy and the shore
  - Satellite
  - Cell phone
  - Radio modem
- You are responsible for a buoy computer that requests data from the moored instruments

The complete inductive mooring system requires a computer at the surface, to send commands to the instruments via the surface inductive modem and to communicate with the shore. Sea-Bird has customers that use ARGOS satellites, some that use cell phones, and some that use radio modems. It is your responsibility to develop the hardware and software to perform these duties.

## Preparing for Deployment: Inductive Modem Systems (continued)




### Requesting Data from Moored Instruments

- **pwron** causes the buoy modem to send a wake-up tone down the inductive link
- **gdata** tells the moored instruments to prepare a data scan for transmission
- **dataii** requests the instrument with the ID **ii** to transmit the scan
- **pwroff** causes all instruments on the mooring to go to sleep

Communication with the moored instruments is simple. Sending **pwron** to the surface modem's serial port causes it to wake all the remote instruments with a 4800 Hz tone. Once awakened, the **gdata** command causes the modems on the moored instruments to request the last sample or an average of the samples taken from their instruments (depending on the instrument and its setup). Then each instrument in turn is queried for a sample with the **dataii** command, with **ii** being the instrument ID (for example, **data01** queries the instrument with ID=01). Finally, **pwroff** puts all the instruments to sleep. If no **pwroff** is issued, the instruments go to sleep after 2 minutes. Thus, if the sampling protocol requires more than 2 minutes, a **pwron** must be issued to make sure that none of the moored instruments has gone to sleep.

## Preparing for Deployment: Inductive Modem Systems (continued)



### Inductive Telemetry Troubleshooting

- Inductive communication is one way at a time (half duplex)
- Instruments with the same ID will compete for the link
- If request for data occurs during data acquisition, the request will be ignored

The inductive link is half duplex. This means that only one device on the link may be actively transmitting data at a time. If the situation occurs where two devices are trying to transmit, the communication will be corrupt.

If two devices have the same ID, the above problem will occur whenever that ID is used.

Usually, moored instruments sample on schedule. If the inductive link becomes active while an instrument is sampling, a request for data may be ignored. This can occur because of clock drift in the buoy. If the buoy is equipped with a GPS, the GPS is a good source of time.

A final note on preparing moored instruments for deployment: Application Note 83 provides a checklist for moored instruments, intended as a guideline to assist you in developing a checklist specific to your operation and instrument setup.

## Activity



### Activity: Setup and Logging

- Cable your computer to an SBE 37
- Execute the commands shown in your notes
- Start logging with the **startnow** command to collect a bench mooring
- Stop logging with the **stop** command
- Upload and check out the data

#### Command

\*cn

mmddy=

hhmmss=

interval=30

samplenum=0

format=1

storetime=y

txrealtime=y

syncmode =n

ds

#### Description

Take instrument out of calibrate mode

Set date, month day year

Set time hour minute second

Set sampling interval

Reset memory

Set date format to dd mmm yyyy

Store sample time with each sample

Transmit sample as it is taken

Disable serial sync mode

Get instrument status to verify setup