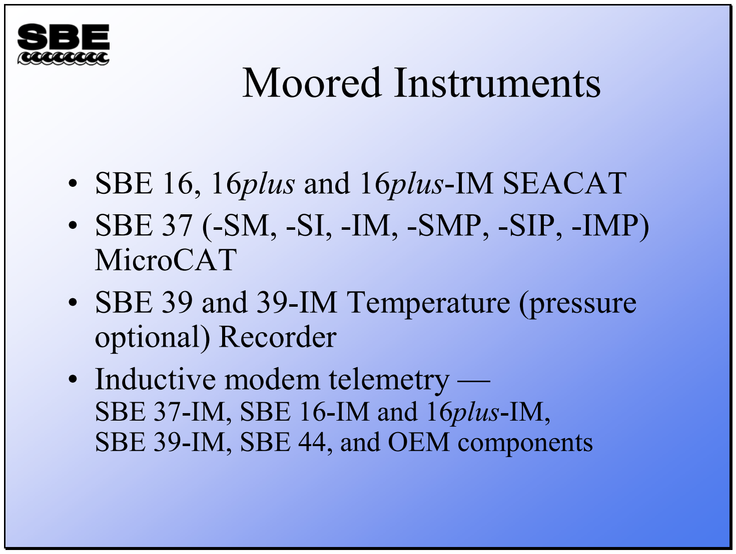
Module 10

Moored Instruments

Overview



In this module we will present Sea-Bird instrumentation intended for mooring.

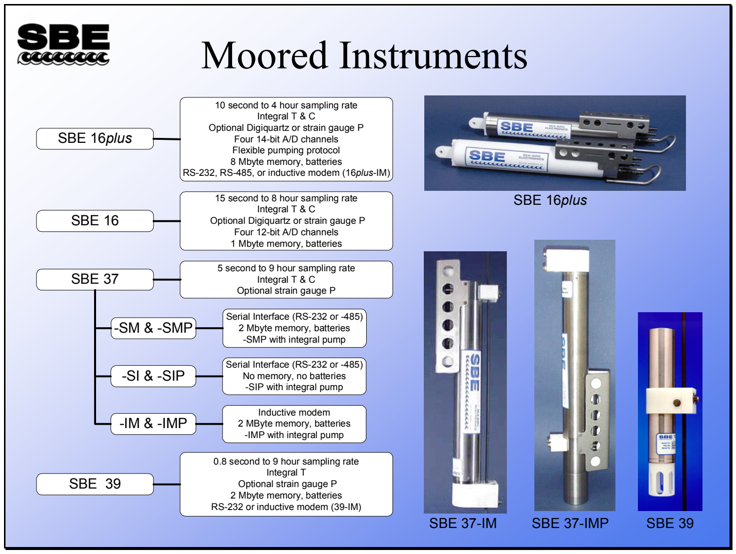
The SBE 16 family provides power and A/D inputs for auxiliary sensors.

The MicroCAT family is smaller and less expensive, but does not have power for external sensors nor auxiliary A/D inputs, while the SBE 39 family has only temperature and pressure. As an accessory to our moored instruments, Sea-Bird offers inductive telemetry for mooring. This technology allows communication with moored instruments in real-time without cable breakouts. The SBE 44 is a stand-alone modem meant for interfacing other manufacturer's instrumentation to the inductive mooring string.

When we complete this module you should:

- Be aware of the instrument platforms available for moored applications
- Understand the means of telemetering real-time data from the mooring to the land-based receiving station

Introduction to SBE 16, 16*plus*, 37, and 39



The SBE 16 and 16*plus* are moored versions of the SBE 19 and 19*plus*. The 16*plus* is actually a 19*plus* in moored mode, with optional pressure sensor. The 16 and 16*plus* have the capability to power external sensors and log analog A/D data from them. This is the instrument of choice if you require more data than C, T, and P. The 16*plus* is available with serial interface (RS-232 or RS-485) or inductive modem interface (16*plus*-IM).

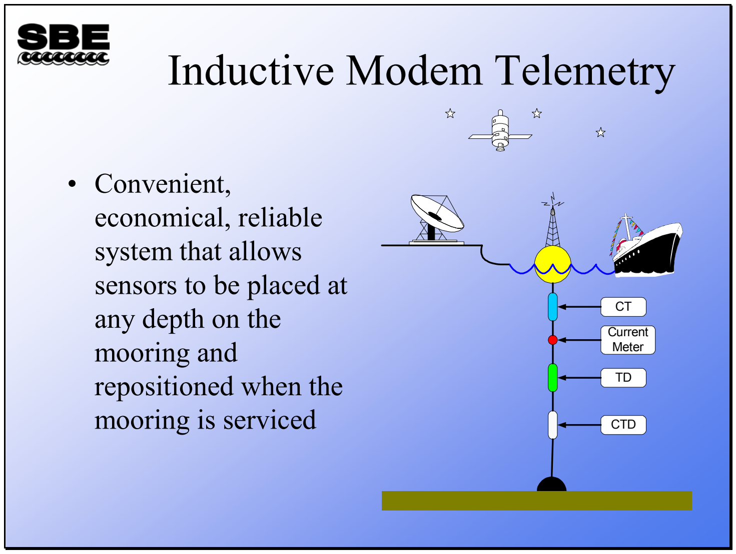
Like the 16 and 16*plus*, the MicroCAT has integral T and C sensors, and may also be equipped with a pressure sensor. The MicroCAT comes in three main types:

- The SM has memory, batteries, and a serial interface (RS-232 or RS-485). It is meant for moorings that do not require communication with the surface during deployment.
- The SI has no memory and no batteries, but does have a serial interface (RS-232 or RS-485). It is intended for ROVs, submarines, etc. as a companion for instruments requiring T and C, such as acoustic Doppler profilers or optical instruments.
- The IM has memory, batteries, and an inductive modem for communications in real-time with the surface.

All three types of MicroCAT are available with an integral pump (SMP, SIP, and IMP).

The SBE 39 is a temperature recorder, and may also be equipped with a pressure sensor. An example of its use is mounted on bottom trawls to measure bottom depth, time on bottom, and temperature. The SBE 39 is available with serial interface (RS-232) or inductive modem interface (39-IM).

Inductive Modem Telemetry

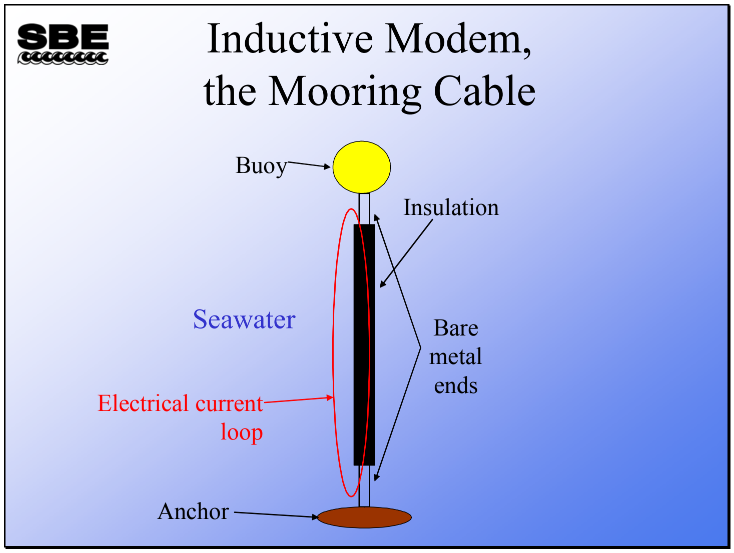


An inductive modem uses electrical current loops to transmit information. Recall from physics class, electrical current flowing in a wire loop induces current to flow in a loop that passes through it. You can think of these loops as links in a chain. The first loop is in the surface buoy. The second loop is formed by the mooring cable and the seawater. The third loop is at the instrument, underwater. Because all coupling is done in loops, no cable breakouts are required.

The communications link is one way only, meaning that if the surface modem is transmitting to the remote instruments, then the remote instruments must all be listening. Conversely, if one of the remote instruments is transmitting, then the surface modem must be listening. To achieve this, all instruments have a unique two-digit address from 00 to 99.

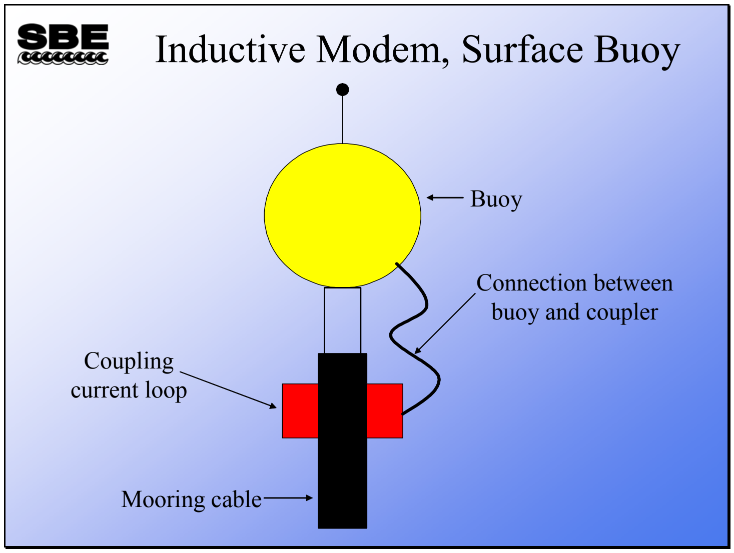
The electrical current carries an AC signal that is phase-shift-keyed. Digital data is encoded by the transmitting modem into an AC signal that is impressed on the current loop, and it is received and decoded by the remote modem’s receiver.

Inductive Modem Telemetry (*continued*)



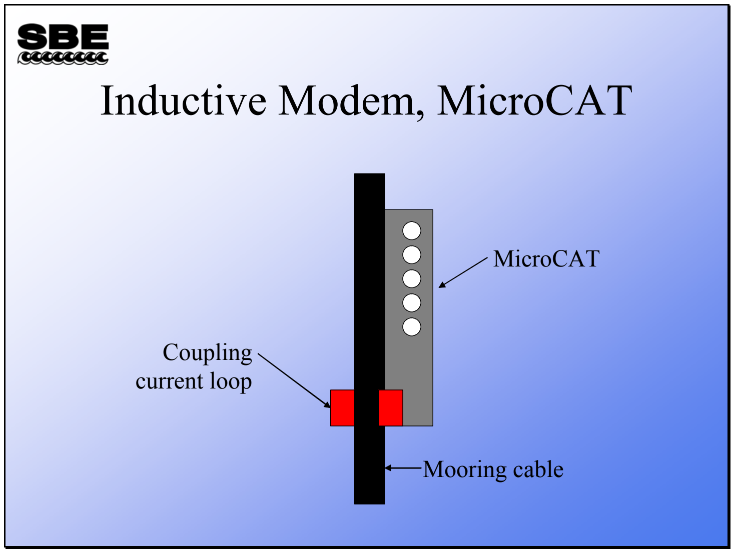
The first current loop is made by the mooring cable itself and seawater. The cable is bare metal on the top and bottom and insulated in the middle.

Inductive Modem Telemetry (*continued*)



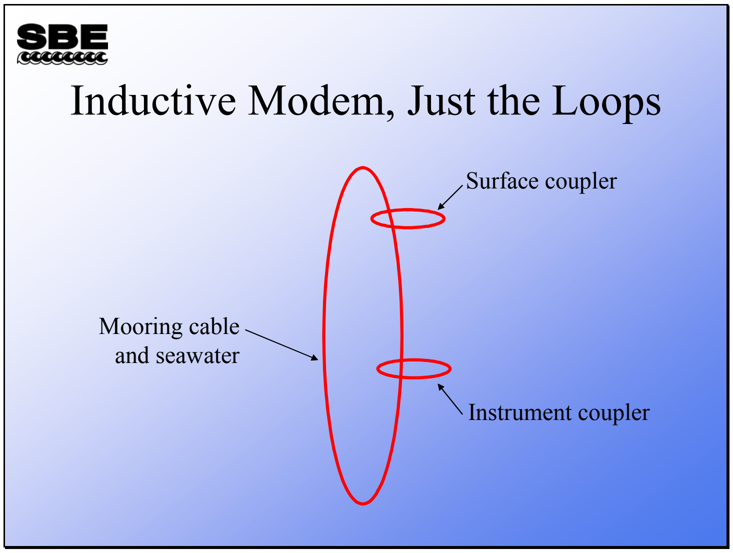
The second current loop is made around the mooring cable. The coupler is a ferrite donut. Ferrite is the stuff that magnetic tape is made from. The electrical current that flows around the coupler induces a current that flows through the mooring cable and the seawater. Thus, the modem signal is transmitted by the surface buoy into its coupler, and the coupler induces a current in the seawater and mooring cable.

Inductive Modem Telemetry (*continued*)



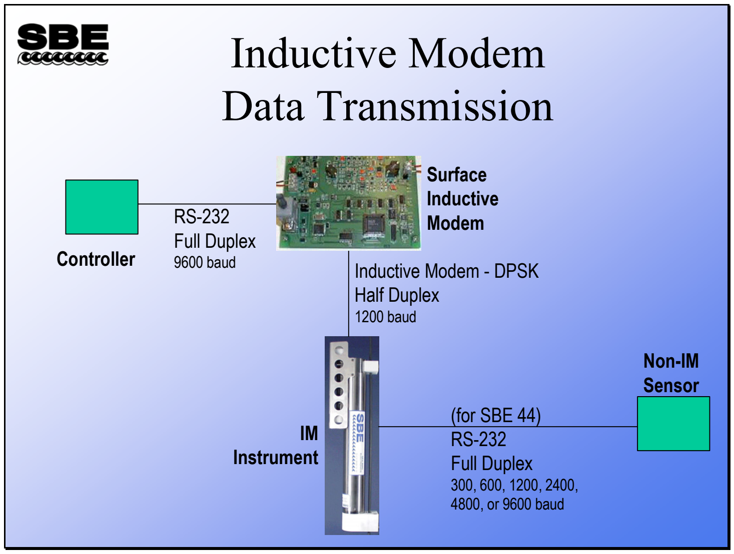
The last loop is at the remote instrument. It has a coupler just like the surface buoy. The current that the surface buoy has induced in the seawater mooring cable loop in turn induces a current in the remote instrument's coupler. The modem in the remote instrument receives and decodes the signal. If the information contained in the signal is addressed to the remote instrument it behaves accordingly, e.g., transmitting a data scan or a status report.

Inductive Modem Telemetry (*continued*)



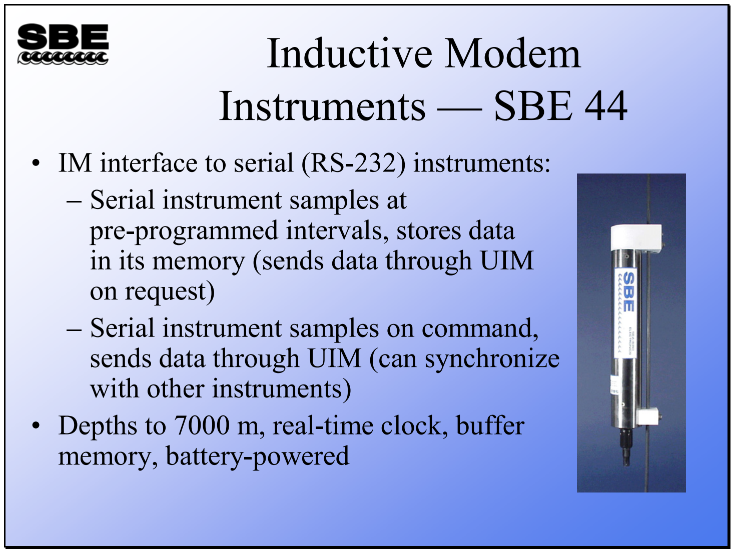
Here is a very simple view of the communication links. Note that there can be up to 100 instrument couplers on the mooring cable – seawater loop.

Inductive Modem Telemetry (*continued*)



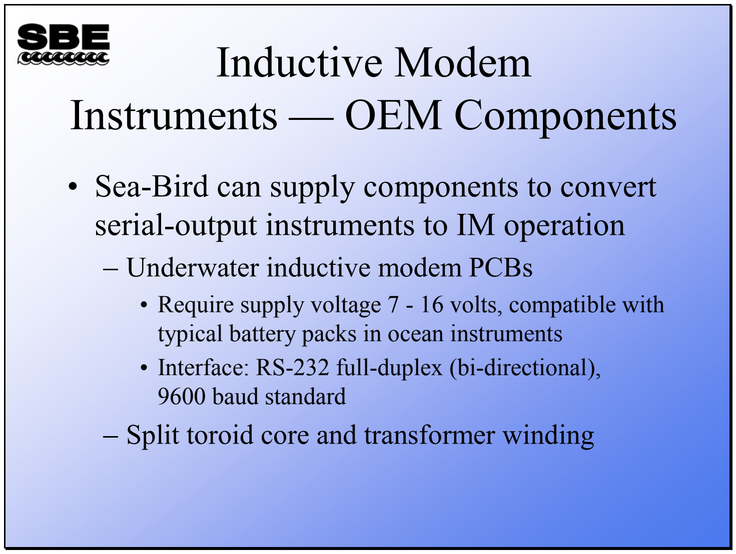
Here are all the players in inductive modem data transmission. The controller is user-supplied and should be able to switch power to the surface inductive modem (SIM). The inductive modem DPSK is via the mooring cable. If you want to use sensors with serial data output made by another manufacturer, the SBE 44 is a stand-alone inductive modem supporting common baud rates with buffering sufficient for most applications.

Inductive Modem Instruments

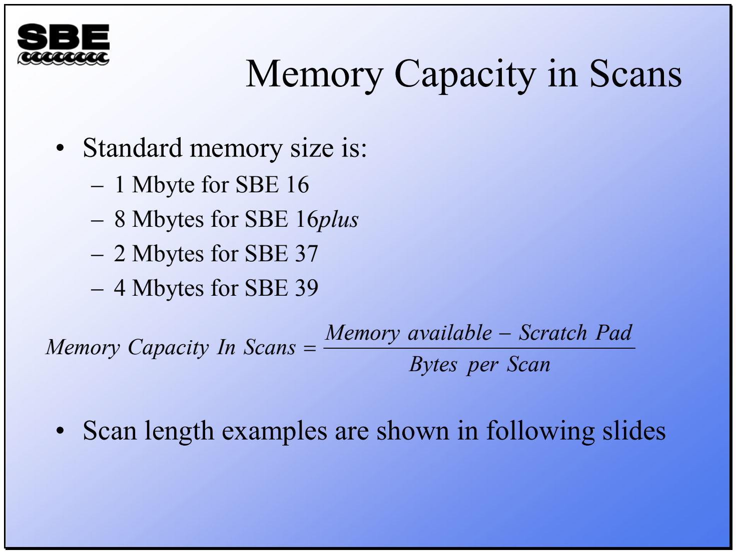


The SBE 44 is meant to allow the use of instruments that have a serial interface and the capability to sample on demand to be used with an inductive telemetry mooring. The SBE 44 has an internal 9 volt, 7.2 amp-hour battery and can provide power to the external device. Alternatively, the external device can provide power to the 44. The inductive link operates at 1200 baud. This restricts the data rate of the external instrument; however the SBE 44 has data buffers that allow the external instrument to transmit small amounts of data at a higher rate.

Inductive Modem Instruments (*continued*)

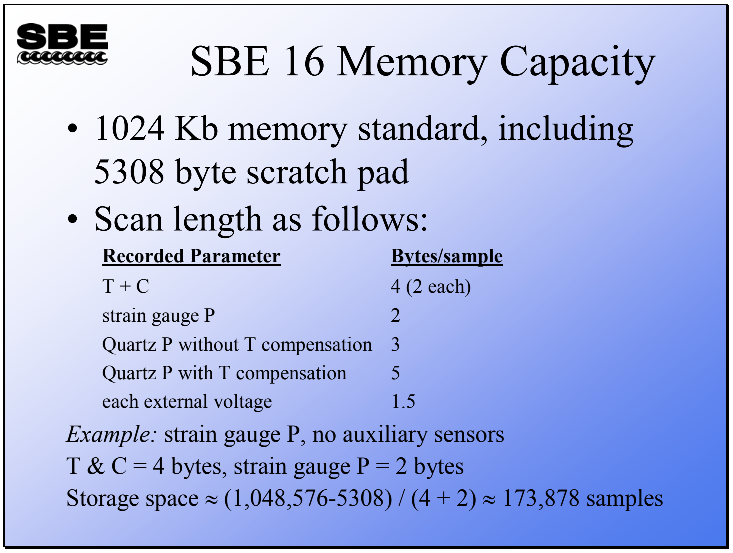


Memory Capacity



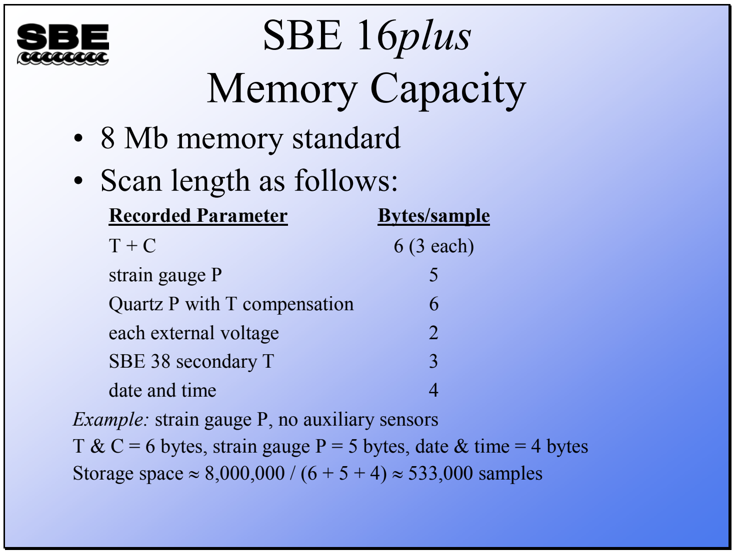
Memory capacity calculations are basically the same as seen for profiling instruments. Refer to Module 1, page 9 for an overview of this calculation; examples for specific instruments are on the following pages.

Memory Capacity: SBE 16



The SBE 16 has battery backed-up semiconductor memory of 1 Mbyte. Actual capacity in scans depends on how the instrument is configured.

Memory Capacity: SBE 16*plus*



The SBE 16*plus* has considerably more memory than the 16, with 8 Mbytes of non-volatile flash memory. Again, memory capacity depends on the configuration of the instrument.

Memory Capacity: SBE 37 MicroCAT

SBE

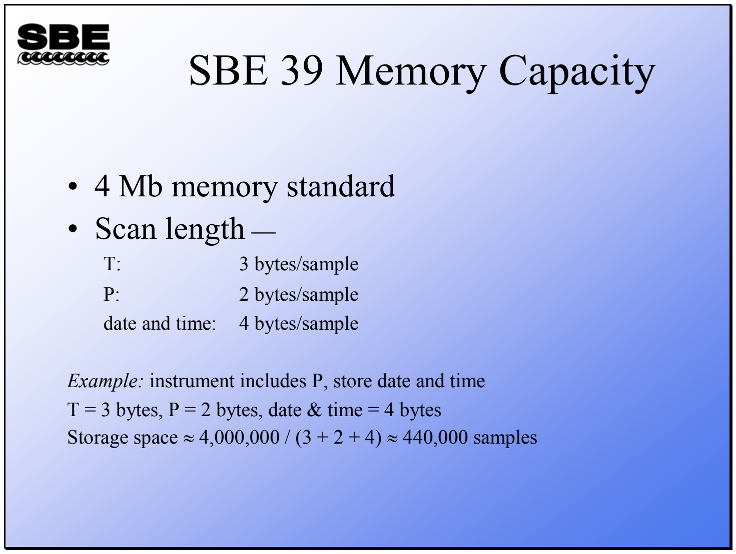
SBE 37 (-SM, -SMP, -IM, -IMP)
MicroCAT Memory Capacity

- 2048 Kb memory standard
- Scan length —

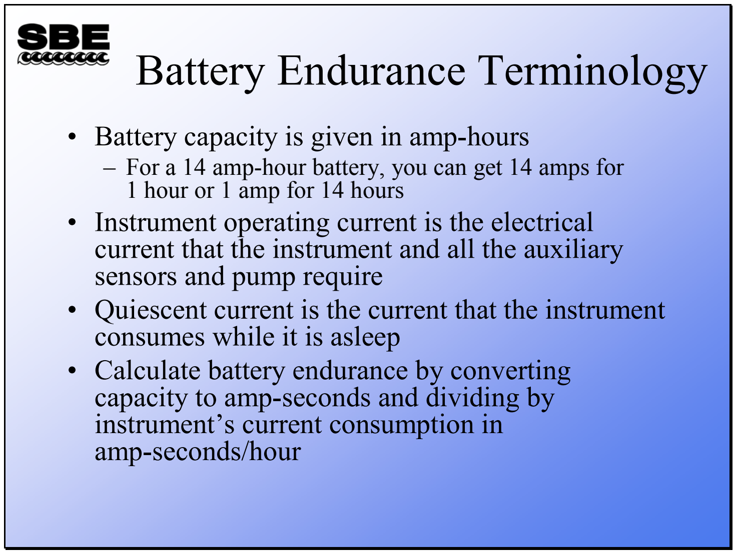
T + C:	5 (2.5 each) bytes/sample
P:	2 bytes/sample
date and time:	4 bytes/sample

Example: instrument includes P, store date and time
T & C = 5 bytes, P = 2 bytes, date & time = 4 bytes
Storage space ≈ 2,048,000 / (5 + 2 + 4) ≈ 185,000 samples

Memory Capacity: SBE 39



Battery Endurance

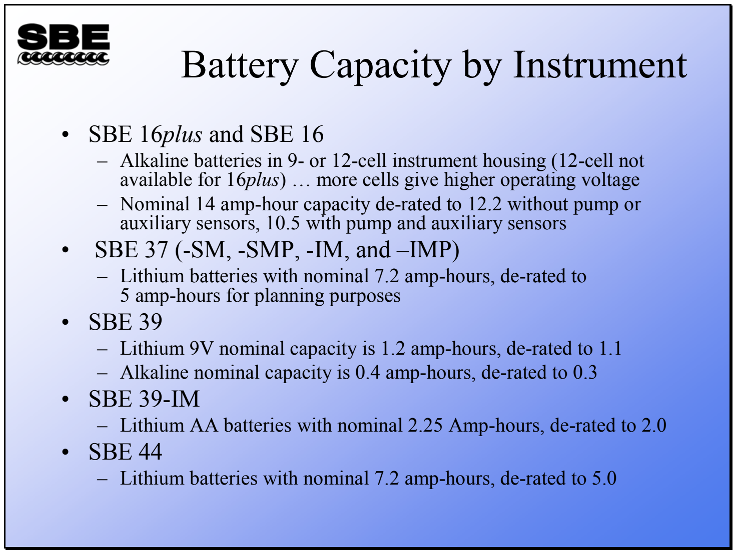


Battery endurance is a topic of great interest to those who work with moored instruments. However, estimating battery endurance is a very difficult to do accurately. Battery manufacturers specify the amount of energy contained in a battery in terms of ampere hours. This is the amount of current that the battery can supply for a given length of time. If a small amount of current, 100 milliamps for example, is drawn from the battery, it will last many hours (years). Conversely if a large current is drawn, 1 amp for example, the battery will last for few hours.

Calculating battery endurance requires summing the amount of current drawn by the instrument and its auxiliary sensors for the length of time they are operating. In addition, the quiescent current of the main instrument must be included. The quiescent current is that drawn by the instrument while it is sleeping, and is required for operation of the clock and the circuits that monitor the communications lines, so that when you attempt to communicate with the instrument it awakens and responds.

For instruments that use alkaline batteries, Sea-Bird uses Duracell brand alkaline batteries exclusively; all our examples for alkaline batteries will be based on these.

Battery Capacity by Instrument

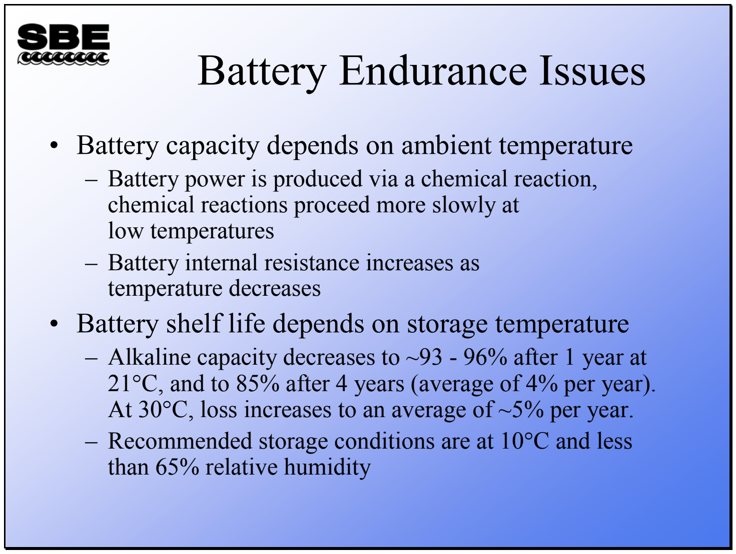


Sea-Bird offers different types of batteries depending on the type of instrument.

- The SBE 16*plus* is normally supplied with alkaline batteries; however a lithium battery pack *kit* may be supplied at the user's request (these lithium batteries are not supplied by Sea-Bird).
- The SBE 37 and 44 come with lithium batteries only.
- The end user may choose lithium or alkaline batteries for the SBE 39.
- The SBE 39-IM comes with AA lithium batteries only.

  Note: A few early versions of the 39-IM used the same batteries as the SBE 39.

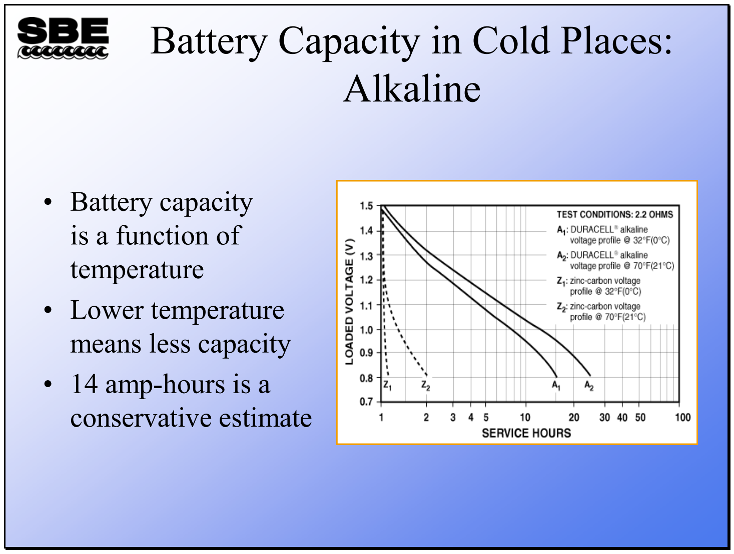
Battery Endurance Issues



As mentioned in a previous page, battery endurance is very difficult to estimate. Battery capacity depends on the temperature of their use for the reasons outlined in the slide above. In addition, batteries exhibit shelf life degradation. A battery in storage will slowly discharge at a rate that leaves about 85% capacity after 4 years in good storage conditions. Batteries stored at high temperatures will lose capacity more rapidly. Obviously, a fresh battery has the most capacity.

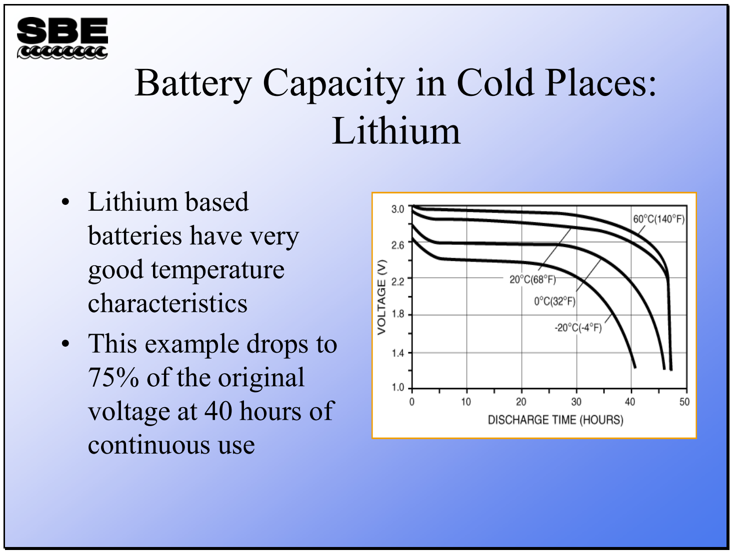
- A battery operated at high temperature will gain capacity due to a faster chemical reaction and lower internal resistance, but will lose capacity due to more rapid shelf life degradation.
- Conversely, a battery operated at low temperature will gain from better shelf life but lose due to less efficient chemical reaction and higher internal resistance.

Battery Endurance: Alkaline Battery Capacity



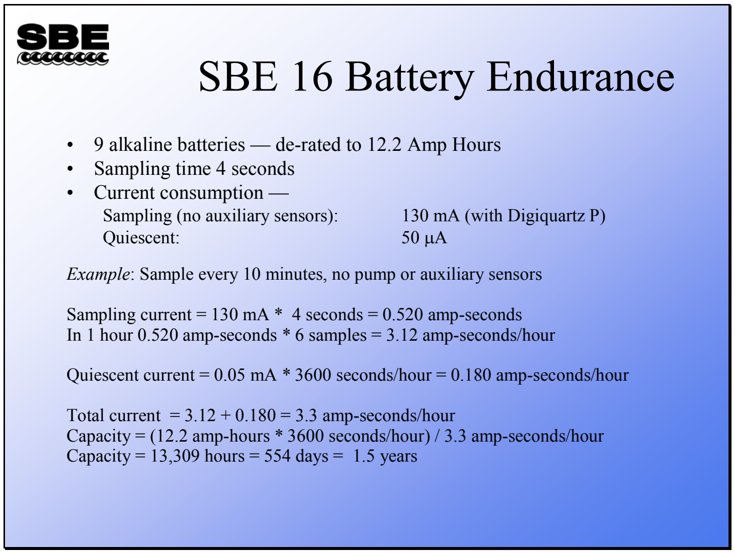
Considering the time and money involved in making a mooring, fresh batteries are a small expense. We estimate the battery life in an SBE 16 or 16*plus* assuming that it begins with 14 amp-hours of power. As you see from the plot, 14 amp-hours is a conservative estimate. At 0 °C an alkaline battery is expected to supply 0.8 volts after 15 hours of service. A standard, 9-cell battery pack starts at 13.5 volts and drops to 7.2 volts after 15 hours. Sea-Bird instruments measure the battery voltage and will not sample if the voltage is below a cut-off threshold. The value of 7.2 volts is above the cut-off for an SBE 16 and just below it for a 16*plus*.

Battery Endurance: Lithium Battery Capacity



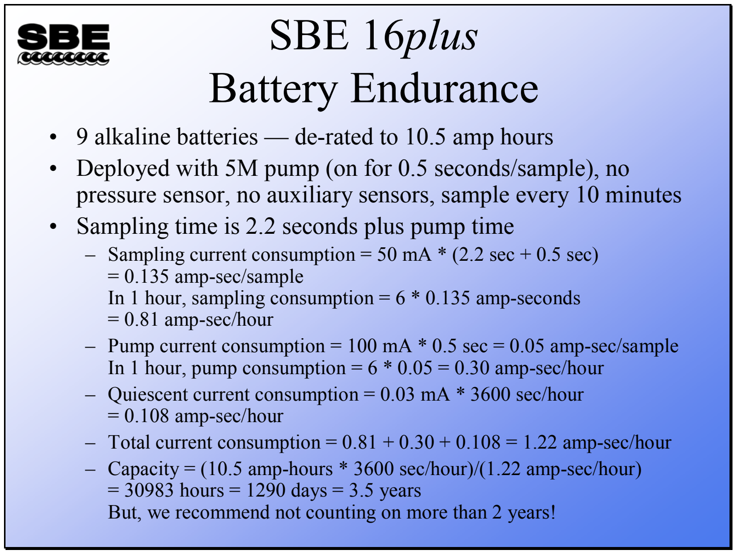
Lithium batteries offer better performance. The main drawback to using them is international shipping restrictions on lithium. For example, the battery pack used by the SBE 37 is made of 6 batteries. It is legal to ship them separately; however, once assembled into the battery pack they become illegal to ship, as they are too large a mass.

Battery Endurance: SBE 16



Recall the slide on memory endurance for the SBE 16. We can calculate that we have memory for 115,918 samples if measuring temperature, conductivity, and Digiquartz pressure, with no auxiliary sensors (115,918 = [1,048,576 – 5308] / [4 + 5]). This is enough memory for 19,319 hours of operation if sampling every 10 minutes. We will run out of battery power before we run out of memory.

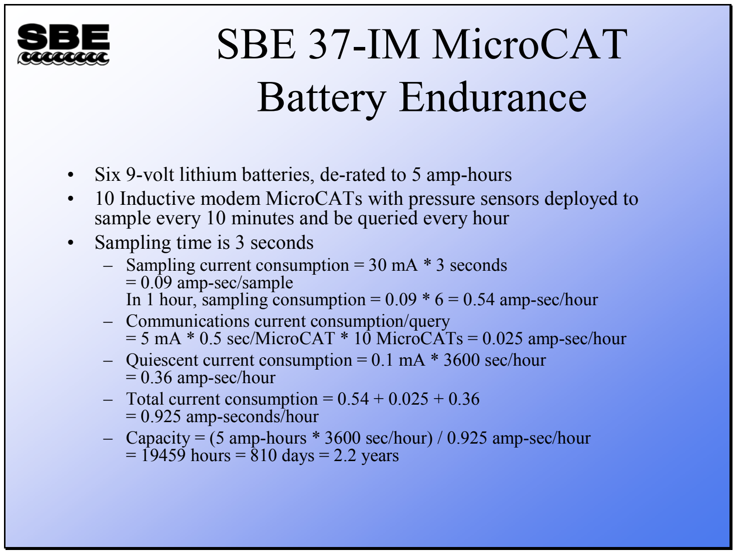
Battery Endurance: SBE 16*plus*



Recall the slide on memory endurance for the SBE 16*plus*. We can calculate that we have memory for 800,000 samples if measuring and storing only temperature, conductivity, date and time (800,000 = 8,000,000 / [6 + 4]). However, we have battery power for only 185,000 samples (≈ 30983 hours * 6 samples/hour). As with the SBE 16, we are battery-limited.

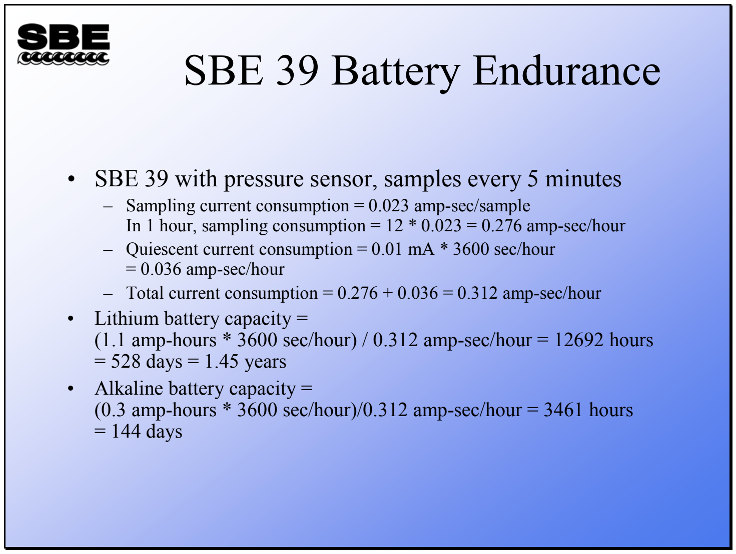
Note that battery capacity depends on operating temperature; capacity is reduced as battery temperature goes down. With profiling applications, an instrument may spend part of its time in cold water. In moored applications it is not unusual for an instrument to spend its entire deployment in cold water.

Battery Endurance: SBE 37 MicroCAT



As we have come to expect, the MicroCAT has more memory than batteries.

Battery Endurance: SBE 39



Sea-Bird provides a battery endurance calculator, SBE Battery Budget Calculator, which can perform these calculations for our moored instruments. The calculator, an Excel spreadsheet, is available on the training CD as well as on our website.

Activity

Activity:
Calculate Battery Endurance

- 37- SM MicroCAT with pressure sensor samples every 10 minutes
  - 2.7 seconds sample time
  - 20 mA sampling current
  - 0.01 mA quiescent current