

Oceanographic Instrumentation, 2.693 (13.998) – Lab 4 – Batteries and Power

I. Batteries:

- A. Primary and Secondary
 - a. Primary – use once and throw away, such as flashlight batteries
 - b. Secondary – rechargeable. They generally have less energy than the same size primary and cost more, but then can be charged and reused over many cycles (i.e. 500). Recent chemistries have much greater energy densities. A rechargeable battery generally has more power than stated at the start of its life, and less than the rating toward the end of its life.
- B. Alkaline primary (e.g. standard “D” cells) – Used most in oceanographic applications – safe (no toxic compounds such as Lithium, mercury, or lead), cheap (less than \$1.00 in bulk), reliable (work good over wide range of temperatures and current drains). (see attached handout on discharge tests).
- C. Lithium – high energy density, low weight, long shelf life (> 10 yrs), costly
 - a. Primary:
 - i. SO₂ – delivers power, but outgases – dangerous. Dumping in seawater discharges at an optimum rate (but not safe chemistry).
 - ii. Thionyl chloride and other recent chemistries – controlled current – safer. Chemistry “used up” when discharged and safe to dispose.
 - b. Ion (rechargeable) - used in notebook computers. High energy density, light weight, high capacity. However, require microcontroller for charging (not sold as cells, but to special assemblers who add controller. Example of ABE (Al Bradley) for successful use of.
- D. NiCd – old type of rechargeable – Have to be careful that charge right (memory) – discharge fully to reset memory, don’t overcharge, don’t charge too fast, must discharge fully or can’t recharge and get full life. Can survive surprising hard service – electric model racing boats (charge on car battery, discharge in a few minutes).
- E. NiMH (Nickel-Metal Hydride) – used in digital cameras, computers- a great improvement. Rapid recharge, high discharge rate, but high self discharge (a few months to half power). Doesn’t have memory of NiCd and double the capacity of NiCd. Has the same voltage (~1.2 volts so can be used in most all NiCd applications. Life of 500 charge/discharge cycles.
- F. Lead Acid:
 - a. Standard “flooded” car battery – can work at high pressure, low temperature – oil protected (in an oil filled case, or with chlorofin - paraffin oil whose density is midway between battery acid and seawater), low in cost, high in weight. Sometimes used as part of anchor.
 - b. Gel cell – as used in computer UPS, operates in any orientation, but can outgas when overcharged – the rate that power than can be drawn limited by the silica gel and the chemistry (lower charge and discharge rates than flooded battery). Has been used in solar charged buoys, until glass mat batteries were developed.

- c. Glass Mat – the electrolyte (acid) is held in fiberglass mat and won't spill, higher rate of power output and charge – currently used in most buoy applications (NDBC, WHOI, GoMOOS, etc.)

Most batteries have some rate of self discharge - lead acid as well. A contaminant (such as arsenic) is added to the lead to make it simpler to pour the plates. A pure lead plate battery has a low self discharge (and a high price). Lead acid batteries have a problem with disuse of sulphate buildup on the plates that cuts down the ability to charge and discharge, and greatly reduces the power. Lead acid batteries in exit signs and UPS are trickle charged to prevent this. A lead acid battery must be charged (1.2 x capacity) each 6 months to prevent sulphate buildup. Some electronics are available that send a sudden pulse and short through the battery to “knock off” sulphates.

- G. Seawater battery – Magnesium and Iron – single cell, need large area to get much current. Not a big success yet.
- H. Fuel Cell – discussed for buoy applications, but again not a proven technology that is better than what we have.

II. Solar Power:

A. Advantages.

- a. Provide power for long deployments – not dependent on number of batteries in instrument.
- b. As power is intermittent (daily cycle, and cloudy weather), power must be stored in batteries (unlike satellites where get continuous power from sun). Batteries then power during night and cloudy times.
- c. Generally used in buoys and in surface instrumentation, but have been used on AUVs which can surface to recharge batteries. If you have something on the surface, solar power is a good option.

B. Solar Panels

- a. Come in different shapes and sizes – 10 Watts to 64 Watts used on buoys
- b. Silicone photovoltaics are current sources – that is they provide a more or less constant current rather than a voltage.
- c. Panels are generally fully enclosed in glass, so that there is no problem surviving in marine applications where washed with waves. However, panels can be damaged by hitting the front or back.
- d. Regulation is required so that a battery is not overcharged. Simplest way is a shunt regulator which shorts out the solar panel. It may still output 4 amps of current, but now the voltage is 0.001 v, so that the power is now milliwatts that can be dissipated in a resistor without overheating.
- e. Panels are often supplied in two 6 volt sections that can be tied together to provide 12 volt charging, or several 12 volt panels can be connected in series for 24 or 48 volt systems.
- f. Panels have long life as 10 Watt panels first put in use in 1985 are still outputting nearly full power. Manufacturer warranty generally says 10 years the solar panel will output >90% original and after 20 years > 80% original.
- g. Although land applications say best orientation is south with angle of latitude plus 10 degrees, at sea on a buoy, the whole buoy turns with the tides, so use

four solar panels on the sides of the tower to have one cell pointing at sun. Orientation on buoys has been vertical, at latitude plus 10° and horizontal. All seem to work well. Vertical probably gets some reflection from sea surface to boost power, horizontal has potential problem of birds fouling – mount low to water so waves will keep clean.

- h. Multiple solar panels can be connected to one regulator to charge one battery. Generally desire one regulator per battery.
 - i. Blocking diode required preventing the solar panel from draining the battery at night. Most solar regulators include this diode.
- C. Uses: (from my experience).
- a. UNH-OOA monitoring buoy. 4 ten watt solar panels mounted vertically charging two 17 ah gel cell batteries (from UPS) through regulator.
 - b. GLOBEC science buoys – 4 twenty watt solar panels mounted at about 55° (latitude plus 10°) charging 3 forty ampere hour batteries through shunt regulators.
 - c. GLOBEC guard buoys – 2 ten Watt solar panels charging a 40 ah battery through a shunt regulator.
 - d. GoMOOS buoys – 4 fortt Watt solar panels mounted at about 55°
 - e. STTR buoy – four 64 Watt solar panels mounted at about 60° angle charging four 40 ampere hour batteries through shunt regulators.
 - f. Coast Guard navigation buoys – one 20 Watt solar panel
- D. Rule of Thumb:
- a. Split system so that you have twice the required power. e.g. with four solar panels, have two batteries with two regulators. Have two adjacent solar panels charge one battery. Then connect the two batteries to the power bus through diodes. Then if something damages one part of the solar system, you have a second part to continue working e.g. NH wave buoy.
 - b. I generally plan on getting 1/10 of the solar panel power rating out of the batteries. This takes into account the orientation of the solar panels, temperature, cloudy periods, short days, battery and charger inefficiencies, etc. Then when summer rolls around, you have fully charged the batteries by mid-morning and are dumping extra power. A smart data system could change sampling depending on power available.

III. Wind Power:

A. Small wind generators built for pleasure boats have been used on buoys along with solar panels to charge batteries. The wind is generally stronger in the winter when the sunlight is weaker, and the sun is generally stronger in the summer when the winds are weaker. Worked well off NH on an open ocean aquaculture feed buoy. Little use on buoys since wind isn't as predictable as sun radiation.

IV. Measurement of Power requirement and estimation of Battery Needs:

- A. As part of experiment planning and past of selecting a sampling plan is consideration of power requirements, data storage and instrument power capabilities.

- B. If we want rapid sampling that exceeds the capacity of the batteries in the instrument, then we need to add an external battery pack.
- C. There is no need to deploy an instrument that won't use up its batteries and data storage during the planned deployment (plus a safety factor).
- D. Detailed measurements of the system power requirements may also indicate potential problems that haven't yet caused instrument failure, but cause higher power drain.
- E. A checkout sheet with sampling plan, deployment length, and battery use estimate are valuable. A history of these sheets will aid in determining if an instrument is working properly.

In LAB, Discuss and Use:

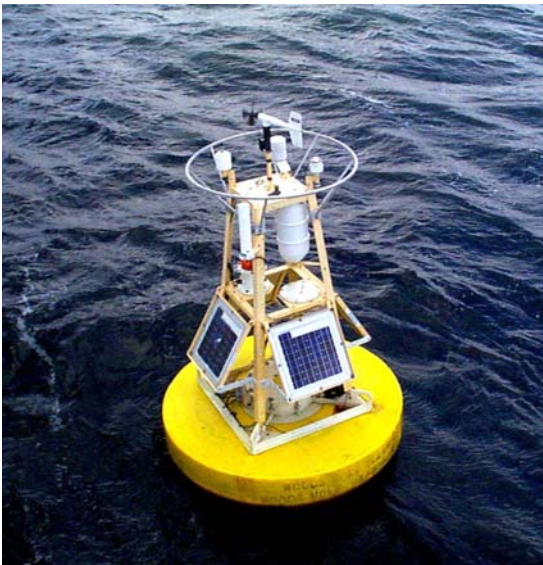
- A. DVM for measuring voltage.
- B. DVM for measuring current.
- C. Measure the power (current and voltage) for the OIS CTD for a moored deployment as specified below. How long would it run in a continuous sampling mode?
- D. Measure the current/power required by a Sea Bird Seacat.
- E. Estimation of current needs for sampling program
- F. Estimation of Battery requirements.
- G. LAB Writeup: discuss the above, and a sampling plan for an experiment that is:
 - a. to run for three months with as rapid sampling as possible with the power available, and
 - b. How long would it run with a 5-minute sample interval?



UNH – Open Ocean aquaculture demonstration project. Quarter ton feed buoy with solar and wind charged banks of 120 ah batteries 24 volt batteries.



AIRMAP ozone buoy deployed in the Gulf of Maine has four 64 Watt solar panels charging four 40 ah glass mat batteries.



GLOBEC Southern Flank buoy with four 20 Watt solar panels on the four sides of the tower with shunt regulators charging three 40 ah glass matt batteries.



GoMOOS buoy (next version of GLOBEC buoy) has four 40 Watt solar panels and four 40 ah glass mat batteries.