News for the Ocean Industry
Ocean News & Technology
www.ocean-news.com
March 2011

Naval Oceanography
Vital to National Defense

Lithium Batteries Drive Oceanographic Technology Full Speed Ahead

Feature Story – Page 10

Feature Story

Lithium batteries drive oceanographic technology full speed ahead

By Lee Gordon, President, Doppler Ltd., lee@dopplerltd.com

Rapidly evolving technology is creating dynamic opportunities for remote oceanographic sensing equipment capable of delivering real-time information that expands the boundaries of scientific knowledge. These advances are being supported by a new generation of lithium thionyl chloride batteries that offer significant performance advantages.

As computer technology inevitably becomes more complex and miniaturized, increasingly sophisticated power management solutions are required, which enable design engineers to pack more product features into less space, with less weight, and longer service live.

Recent advancements in technology have spawned a new generation of remote sensors for marine and oceanographic applications. These applications include a wide variety of buoys (drifting, moored, ARGO), mayday and other emergency systems, GPS and ARGOS tracking devices, current meters, transponders, harbor lights, acoustic releases, seismometers and other oceanographic devices. Often, these applications require low background currents for extended periods, alternating with high current pulses for brief intervals during data acquisition and/or transmission, then returning to a low current "sleep" or "standby" state.

Adapting lithium batteries to remote oceanographic applications

Initially, many of these applications were powered by everyday Alkaline batteries. However, Alkaline batteries have drawbacks such as low energy density (causing Alkaline packs to be large and heavy), high self-discharge (making these cells unsuitable for long-term scientific experiments), and unreliable performance in extreme temperatures.

Lithium batteries are often preferred for high current pulse marine applications due to their inherent long life and high energy density. These applications typically require a battery power system that can withstand extreme temperatures and harsh marine environments. Long life and reliability are also important concerns, as battery failure will result in total system failure for standalone systems in remote locations with no back-up power source. Safety is always a major concern, as is cost. Reduced size and weight are important requirements for transportation.

Of all the different types of lithium chemistries, bobbin-type lithium thionyl chloride (Li/SOCL2) cells are best suited for remote applications due to their high energy density, high cell voltage, good low temperature performance, low self-discharge rate, and good safety characteristics. Bobbin-type Lithium cells use an outer cylinder of lithium metal and an inner electrode which is reminiscent of a bobbin of thread. The other common construction is called spiral wound, and it consists of flat sheets wound around a core. Bobbin cells have less surface area and thus cannot supply the current of spiral cells, but they can hold more lithium, which gives them a greater energy density. Because they are limited to low currents, they cannot dissipate their energy as quickly as spiral cells. Bobbin cells (and spiral cells) can also suffer passivation after storage at high temperature. Passivation layers that build up on the cell electrode surfaces temporarily reduce the cell's ability to supply current. Passivation produces a voltage delay, or temporary reduction in the battery voltage while the passivation layer dissipates.

To address limited current and passivation issues, engineers at Tadiran developed PulsesPlus™, a patented hybrid technology that combines bobbin-type lithium thionyl chloride chemistry with a hybrid layer capacitor (HLC). This combination results in a battery pack that combines high energy density with high current pulses without any voltage delay problems. The following examples demonstrate the advantages of PulsesPlus technology.

PulsesPlus battery packs reduce the size of a GPS/ice buoy pack by 90%

Oceantronics, a Hawaii-based manufacturer of scientific data collection devices, employed PulsesPlus hybrid lithium battery technology to create a smaller, more cost efficient GPS/ice buoy.

A leading supplier of commercial radars, GPS systems and peripheral equipment for the U.S. Navy and other federal agencies, Oceantronics developed GPS/ice buoys for NOAA/PMEL back in 1994. The original battery pack weighed 54 kg, and required 380 alkaline D cells to operate for a period of 1 year.

Oceantronic's GPS/ice buoy being retrieved by helicopter to the Arctic for use in experiments measuring wind, temperature sunlight and ice thickness near the North Pole. (Courtesy Sigrid Salo NOAA/PMEL.)

In 2001, Oceantronics delivered a newer generation of GPS/ice buoys to the North Pole Environmental Observatory for use in measuring the effects of global climate change on ice floating on the Arctic Ocean. The redesigned battery packs weighed just 3.2 kg, and used 32 D cell lithium thionyl chloride batteries and 4 hybrid layer capacitors.

Ease of transport is essential to technicians working in frigid Arctic waters, and switching to a hybrid lithium battery technology resulted in a size and weight reduction of over 90%. The resulting space savings also meant that a number of the smaller lithium packs could be used in place of the larger alkaline packs to extend the operational life of the system many fold.

Oceantronics' hybrid lithium pack provides same operating life with smaller size for use in GPS/ice buoys. The original battery pack (left) used 380 alkaline D cells (54 kg). The new battery pack (right) uses 32 lithium thionyl chloride D cells and four hybrid layered capacitors (3.2 kg).

The hybrid lithium battery also fulfilled critical requirements that the battery be able to operate at -40°C as well as meet UN standards for shipping hazardous goods.

Hybrid lithium technology boosts capacity and extends product life

Whereas Oceantronics utilized hybrid lithium batteries to reduce space and weight, Nortek, a manufacturer of current meters, employed this same hybrid lithium technology to provide longer life within the same physical size as the present battery.

Over a decade ago, Nortek began substituting PulsesPlus battery packs for standard alkaline battery packs of equal size to power its Aquadopp acoustic current meters and profilers. In tests conducted by Nortek, the hybrid lithium solution resulted in greatly increased battery capacity by 330% compared to standard alkaline battery packs.

Nortek's Aquadopp GPS current meter being installed by Canadian Wildlife Service as part of a field study in Hudson Bay. The Aquadopp is used to study the effects of tidal currents on eider ducks in areas near the open ocean in seas otherwise covered with ice. (Courtesy of Grant Gilchrist, Canadian Wildlife Service.)

Lithium batteries provide real-time data for subsurface oceanographic sensors

Subsurface oceanographic sensors are becoming increasingly feature-rich, and are able to record and transmit real-time data. These devices are now being deployed at high latitudes where scientists are studying global climate change and hunt for new energy reserves.

Because of the remote nature of these studies and the need for periodic measurements, advances in battery technology are required to provide high energy density, long-life, reduced weight, smaller footprints, and increased reliability to ensure the validity of data.

For example, researchers at Woods Hole Oceanographic Institute have teamed up with other researchers around the world to measure the ocean currents below the Ross Ice Shelf of Antarctica. In 2006, after drilling through several hundreds of meters of ice, the team deployed a string of multiple Nortek Aquadopp current meters to measure the ocean currents below the ice shelf. Recently, the team returned to the Ross Ice Shelf to deploy a newer generation of Nortek Aquadopp current meters configured with integrated inductive modems that allow the current velocity data to be sent through the mooring line to a data logger and telemetry system on the ice surface. Because the data is now available in real-time, the current meters can be deployed for extended periods without having to be retrieved to recover the

Nortek Aquadopp, photo was taken by Dr. Richard Limeburner, WHOI in Antarctica in 2006.

data. Two PulsesPlus battery packs (165 Wh each) were installed in each device, providing enough power to run the current meter and the inductive modem for several years.

A similar example involving oil exploration in the Northern Hemisphere, engineers sought to study sea ice formation, movement, and potential damage to coastal structures and subsea pipelines in the Beaufort Sea, Alaska. A team of engineers from Woods Hole Group, Inc (East Falmouth, MA) deployed a number of Nortek AWAC acoustic Doppler current profilers during the open-water summer season to measure the currents, waves, and ice – nearly continuously – throughout the winter and into the following summer.

Nortek AWAC acoustic Doppler current profiler, photo taken in Beaufort Sea, AK, 2008, courtesy of Dr. Bruce Magnell, Woods Hole Group, Inc.

Safely mounted on the sea floor, tens of meters below the surface, these AWACs can measure the full profile of ocean currents, waves, and ice thickness. Wave observations require collection and recording of an inordinately large amount of data, and to accomplish this, each instrument is equipped with four hybrid lithium battery packs, each containing 2,000 Wh of power.

Improved safety during installation

Golder Associates Inc. (Redmond, WA), which specializes in geotechnical engineering, environmental sciences, and marine geophysics, uses hybrid lithium battery packs to reduce the time, effort, and risk associated with measuring waves and currents in remote parts of the world.

Vessel used in Santa Marta, Colombia, to deploy a bottom-mount ADCP.

Golder Associates often conducts baseline studies for port and terminal developments in North, Central and South America. Many of the study sites are undeveloped, far from infrastructure and require continuous measurements for at least six months in severe wave and current environments.

Modular bottom frame with Teledyne RDI ADCP and Benthos Pop-Up buoy.

The wave and current measuring sensors are mounted on modular, bottom-mount frames that can be lowered to the bed or retrieved by a vessel using divers and float bags, when necessary. The bottom-mount frames are equipped with a Teledyne RDI Acoustic Doppler Current Profiler (ADCP) to measure waves and currents for an interval of at least two months between servicing. A single PulsesPlus hybrid lithium battery pack replaces three alkaline battery packs (one in the ADCP and two in an external battery pack), which substantially reduces the overall weight of the ADCP system. The reduced weight makes it much easier for divers to retrieve the system.

Golder team member servicing a Teledyne RDI ADCP on a beach in Colombia.

The modular frames are deployed in three stages: the base of the trapezoid frame is lowered first; followed by individual lead weights which are bolted to the trapezoid base, and finally an unweighted upper trapezoid with the instrumentation is lowered. Upon turn-around, the lower-weighted trapezoid is left in place and the upper trapezoid with instrumentation is floated to the surface. The hybrid lithium packs make this easier because one hybrid lithium pack weighs only 60% of an Alkaline pack and because the external battery case can be eliminated.

On most of project sites, it is cost prohibitive to return to the nearest port to service the instruments, and, therefore, the instruments are serviced in the field . Use of a single hybrid lithium battery pack instead of three Alkaline packs reduces exposure to risk by requiring only one pressure housing to be serviced rather than two. In addition, a six-month deployment would require nine Alkaline battery packs as compared to three hybrid lithium battery packs, thereby reducing shipping and disposal costs.

MBARI seismic device increases capacity by 50% at less cost

The Monterey Bay Aquarium Research Institute (MBARI), a major center for advanced ocean science and technology research and education, was conducting deep sea seismic research in Monterey Bay, one of the most biologically diverse bodies of waters in the world. The underlying canyon is important to the complex geology of the continental plate margin, and is one of the deepest underwater canyons in North America.

In developing the original seismic measuring device, MBARI had used a battery pack consisting of 128 spiral-wound lithium DD cells. To increase operating life and reduce cost, MBARI switched to a PulsesPlus battery pack consisting of 128 bobbin-type lithium DD cells plus 4 AA HLCs. At the 2°C operating temperature, PulsesPlus pack has 50% more capacity as compared with their original pack due to less de-rating at low temperatures. The hybrid bobbin-type batteries have about 30% more capacity at room temperature, and they lose relatively little capacity when the temperature falls to freezing. They are also less expensive than spirally-wound lithium cells.

Advanced oceanographic sensing applications can benefit from bobbin-type lithium thionyl chloride batteries that offer major performance advantages such as higher capacity, higher energy density, lower self-discharge, and a broader temperature range. These performance advantages are becoming increasingly important to design engineers who are looking to pack more power and performance into less space.

About the author

Lee Gordon is President of Doppler Ltd., Poway CA. Lee and his partner Kent Deines founded Doppler Ltd. in 2005, which designs and supplies PulsePlus battery packs, consults on oceanographic and electronic projects, and designs and develops electronic products.

About Tadiran

Tadiran manufactures a complete line of lithium thionyl chloride batteries, including a variety of primary cylindrical batteries, PulsesPlusTM batteries for high current pulse applications, TLM Series for high power and high energy applications, TLH Series batteries for high temperature applications up to +125° C., coin-sized cells and custom battery packs. Tadiran products are available in a variety of terminations and assemblies. For more information, contact Tadiran at 2001 Marcus Avenue, Suite 125E, Lake Success, NY 11042. Tel: 1-800-537-1368, (516) 621-4980 Fax: (516) 621-4517, Web: www.tadiranbat.com.