POWERING PROGRESS

Lithium batteries enable long-term, remote, and wireless deployments

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> PRIMARY LITHIUM BATTERIES FEATURE THE HIGHEST SPECIFIC ENERGY (ENERGY PER UNIT WEIGHT) AND HIGHEST ENERGY DENSITY (ENERGY PER UNIT VOLUME), WHICH AIDS IN PRODUCT MINIATURIZATION.

Lithium batteries power remote wireless devices worldwide that are utilized throughout oceanographic and geophysical sciences, including buoys (drifting, moored, ARGO), mayday, GPS and ARGOS tracking devices, current meters, transponders, harbor lights, acoustic releases, and seismometers, to name a few.

Most remote wireless devices utilize primary (non-rechargeable) lithium batteries. However, certain niche applications draw enough average energy to prematurely exhaust a primary battery, thus requiring the use of rechargeable Lithium-ion (Li-ion) cells in combination with energy harvesting devices. For these specialized applications, industrial grade TLI Series Li-ion batteries were developed that can operate for up to 20 years and 5,000 full recharge cycles while delivering high pulses and surviving extreme temperatures.

Bobbin-type $LiSOCl_2$ batteries combined with a patented hybrid layer capacitor (HLC) last up to 40 years and deliver high pulses to power two-way wireless communications.

Primary lithium batteries feature the highest specific energy (energy per unit weight) and highest energy density (energy per unit volume), which aids in product miniaturization. As the lightest non-gaseous metal, lithium offers the highest electrical potential, which enables higher voltage (2.7-3.9 VDC) to potentially enable the use of fewer or smaller cells. Because lithium chemistries are non-aqueous, they are less prone to freezing than alkaline.

Numerous primary (non-rechargeable) lithium chemistries are available, with bobbin-type lithium thionyl chloride ($LiSOCl_2$) cells being widely preferred for low-power devices that draw average current measurable in micro-Amps with pulses in the multi-Amp range. Bobbin-type $LiSOCl_2$ cells feature the widest temperature range (-80°C to +125°C) with an annual self-discharge rate as low as 0.7% per year, enabling certain devices to operate for up to 40 years without battery replacement.

Due to their low-rate design, bobbin-type $LiSOCl_2$ must be combined with patented Hybrid Layer Capacitors (HLCs) to generate high pulses. This hybrid approach uses the bobbin-type cells to deliver low-level base current during 'standby' mode while the HLCs deliver high pulses to power wireless communications. As an added benefit, HLCs feature an end-of-life voltage plateau that can be interpreted to deliver 'low battery' status alerts for scheduled battery replacement. These two technologies are easily configurable into battery packs.

CONDENSED POWER

Oceantronics' GPS/ice buoys were deployed by NOAA/PMEL to monitor the status and position of icebergs in the North Atlantic. Originally powered by bulky (54 kg) battery packs consisting of 380 alkaline D-size cells that provided one year of shelf life, the buoys were redesigned using 32 D-size bobbin-type $LiSOCl_2$ cells and 4 HLCs, which reduced size and weight by over 90% while increasing operating life manyfold and enabling the devices to operate reliably at -55°C, modifiable to below -80°C.

Similarly, remotely piloted aircraft dropping asset-tracking tags onto icebergs floating off the coast of Antarctica required a lightweight solution (under 500 g) capable of surviving a 100 m drop. A lightweight pack was created by combining one AA-size $LiSOCl_2$ bobbin-type cell and two HLCs, weighing just 70 g while delivering 20 uA of current at 2.4 Ah in 'standby' mode with 1A pulses during 'active' mode.

MONITORING DEEP-WATER CHANNELS

Researchers studying the impact of rising sea levels in deep-water channels beneath glaciers in Greenland and Antarctica deployed Cryoegg, which was developed at Cardiff University, to monitor changes in temperature, pressure, and electrical connectivity.

Utilizing the same 169 MHz Wireless M-Bus radio technology found in AMR/AMI utility meter transmitter units (MTUs) to transmit signals underwater, Cryoegg eliminated the need for bulky and expensive cables susceptible to damage by glacial movement, using high pulses to transmit data twice per day for up to two years.

FISH TELEMETRY DATA

VEMCO VR4-UWM underwater modem receivers track the migratory activity of aquatic fish and wildlife, including shark warning systems. For example, schools of fish are randomly tagged with transmitters that operate at depths of up to 500 m. The VR4-UWM periodically activates the transmitters to communicate through the OTN (Ocean Tracking Network) or AATAMS (Australian Acoustic Telemetry and Monitoring System) while storing up to 800,000 detections.

These underwater modems are powered by 24 D-sized bobbin-type $LiSOCl_2$ cells and 12 HLCs that deliver 1600 Wh of energy, enabling 9.5 years of single channel listening or 5.5 years of dual channel listening.

SUB-SEAFLOOR FLUID PRESSURES

Scientists collaborated with the Ocean Drilling Program (ODP) to install Circulation Obviation Retrofit Kits (CORKs) that measure temperature and pressure on the seafloor and within sub-seafloor boreholes. CORKs incorporate a wellhead data logger powered by a $LiSOCl_2$ battery pack that draws 4 mW of continuous current during 'standby' mode and 100 mW pulses while sampling data at a rate of one second per minute.

The power supply consisted of 6 DD-size bobbin-type $LiSOCl_2$ cells that delivered 750 Wh of capacity (7.2V, 105 Ah) with a lifespan of up to 7 years. Since data is typically retrieved once per year by deep submersibles, HLCs were not required.

Seismic station near WAIS Divide camp, a location similar to Thwaites. (Credit: EarthScope)

SUBSEA BROADBAND SEISMOMETER

The Monterey Bay Aquarium Research Institute (MBARI) deployed Monterey Ocean-Bottom Broadband (MOBB) seismometers to detect low-frequency seismic activity at depths up to 1,000 m and up to 50 km from seashore for four-month intervals, requiring 2.2 W of continuous with 7 W pulses. The required battery pack delivered 10 kW/hr supplied by 96 D-size bobbin-type $LiSOCl_2$ cells and 12 HLCs.

SEISMIC MONITORING IN ANTARCTICA

The EarthScope Consortium, formed through the recent merger of IRIS and UNAVCO, assists the research community in procuring, deploying, and maintaining scientific instruments used in geophysics and other Earth sciences, along with related data archiving and distribution services.

In collaboration with Tadiran, EarthScope developed the TLP-93101E battery pack that was specifically designed to survive artic temperatures using Schottky diodes, positive temperature coefficient (PTC-200 thermistors), 18-guage wire, a weather pack shroud style (WPS) connector, PVC jacketing, and shrink enclosure.

TLP-93101E battery packs combine 50 D-size bobbin-type $LiSOCl_2$ cells and 5 HLCs to deliver 190Ah of energy at 18.57V along with up to 15A pulses. With an operating life of 1-2 years, these packs remain stable down to -55°C, modifiable to below -80°C. This power management solution features a 93% smaller footprint than an equivalent pack using cold-rated lithium iron phosphate ($LiFePO_4$) batteries (13.62" x 2.59" x 6" vs. 28" x 14" x 7.4"), along with an 85% weight reduction (11 vs. 70 lbs.): a space-saving solution that reduced shipping costs and permitted greater numbers of packs to fit into small plane cargo holds and helicopter slings.

These battery packs were deployed in seismometers surrounding Mt. Erebus, an active volcano located 20 miles from the McMurdo Station, supplying real-time data to monitor seismic activity and study the volcano's dynamics while enduring high altitude and katabatic winds. TLP-93101E packs were also deployed throughout a network of seismometers installed at Twaites Glacier that recorded seismic signals produced by cracking or lurching movement of the ice as well as for mapping and characterizing the bedrock beneath the ice.

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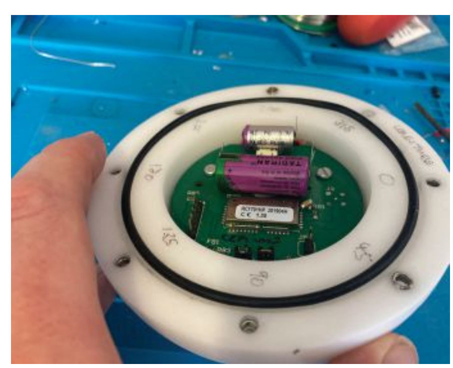

Cryoegg monitors temperature, pressure, and electrical connectivity by transmitting data underwater via radio waves, powered by bobbin-type $LiSOCl_2$ cells. (Credit: Cardiff University)