The Climate is Right for Wireless Environmental Sensors

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The effects of man-made climate change, once seen as a problem for future generations, is now viewed as an immediate threat, have led to significant technological investments to build a more sustainable future. From measuring the decline of snow packs in Antarctica and the North Pole, to measuring the impact of man-made dams on salmon migration patterns, to the development of systems that better predict natural disasters, remote wireless sensors are playing an increasingly critical role in advanced scientific technology.

Growing demand for wireless sensors has expanded opportunities for long-life lithium batteries capable of delivering 20+ year service life to remote location that are inaccessible to hardwired AC power. While energy harvesting devices have received much media attention, they remain largely unproven, and their use is very limited due to factors such as high cost, reduced reliability, and an inability to provide the peak power required for ZigBee, WLAN and GSM/GPRS communication protocols. Energy harvesting devices are also used in tandem with rechargeable batteries, which defeats their value proposition, as rechargeable cells offer reduced service life, high cost, and use less environmentally friendly chemistries.

Choosing Among Lithium Batteries

The ideal wireless sensor is small and lightweight, able to deliver sufficient power and battery life. Lithium chemistry the predominant choice for remote sensor applications due to its intrinsic negative potential, which exceeds that of all other metals. As the lightest non-gaseous metal, lithium offers the highest specific energy (energy per unit weight) and energy density (energy per unit volume) of all battery chemistries. Lithium cells, all of which use a non-aqueous electrolyte, have normal OCVs of between 2.7 and 3.9V. The absence of water allows certain lithium batteries to operate in extreme temperatures (-55°C to 125°C).

Under the broad category of primary lithium battery types, chemical systems currently in mainstream use include lithium poly carbon monoflouride (LiCF), lithium manganese dioxide (LiMNO2), lithium sulfur dioxide (LiSO2), and lithium thionyl chloride (LiSOCL2).

Lithium thionyl chloride batteries are often preferred for low continuous-current or moderate current-pulse applications, delivering higher capacity and energy density, lower self-discharge, and an extremely wide temperature range. Two types of lithium thionyl chloride batteries are available: spiral wound and bobbin-type cells.

Spiral wound lithium thionyl chloride cells feature 800 Wh/l energy density, a temperature range of -55°C to 85°C, and approximately 10 years of service life.

While capable of delivering high current pulses, these batteries lack the capacity and operating life of bobbin-type cells because their multiple wound layer design increases surface area, resulting in higher current draw and higher self-discharge.

Bobbin-type lithium thionyl chloride cells deliver very high energy density (1420 Wh/l), high capacity, a temperature range of -55°C to 125°C, and extremely long service life (20+ years) due to low self-discharge (less than 1% per year). These batteries also have a unique failsafe design that protects the cell against extreme temperature, pressure, puncture, shock and vibration.

Meeting the needs of high current-pulse applications

Environmental sensors increasingly require high current pulses to data. To address this need, engineers at Tadiran developed PulsesPlus®, a patented hybrid battery that combines a bobbin-type primary cell with a high rate, low impedance hybrid layer capacitor (HLC).

PulsesPlus batteries exhibit qualities of a battery and a capacitor. The battery supplies low-current power, while the HLC works in parallel to store current pulses of up to 15A, eliminating the voltage drop that normally occurs when a pulsed load is initially drawn. Smaller HLCs store energy at a rate of 280 A/Sec. While larger HLCs store energy at up to 1,120 A/Sec. These batteries also allow for an end-of-life indication when 90-95% of available capacity is depleted.

One alternative to PulsesPlus technology is to combine a discreet capacitor with a primary cell, which is bulky and results in a higher rate of charge leakage, as the discreet capacitor continuously discharges the battery, albeit at a low rate. Another alternative involves the use of super capacitors to store charges in bulk electrolytes rather than on plates. Super capacitors are small and lightweight, but they cause higher impedance, which limits the instantaneous current available to deliver high current pulses. Super capacitors made up of multiple 2.3V units working in series will also tend to have balancing and current leakage problems that reduce service life, whereas the HLC is a single unit that works in the 3.6V to 3.9V nominal range to avoid balancing and current leakage problems.

Real-life Applications

NOAA/PMEL chose PulsesPlus batteries to power experiments that measured wind, temperature, sunlight and ice thickness on icebergs at the North Pole. A battery pack formerly made with 380 alkaline D cells, and weighing 54kg, was replaced with a far smaller battery pack manufactured by Oceantronics that consisted of 32 lithium thionyl chloride D cells and four hybrid layer capacitors, weighing just 3.2kg. Use of PulsesPlus battery packs resulted in significant size weight reductions of over 90% without compromising performance or operating life. Reduced size and weight and ease of transport are critically important to scientists working in frigid Arctic waters.

Another example involves Nortek Aquadopp acoustic current meters and profilers that were utilized by the Canadian Wildlife Service in Hudson Bay to study the effects of tidal currents on eider ducks. Use of PulsesPlus battery packs enabled the Aquadopp meter to boost capacity to 3.3 times that of an alkaline battery pack of equivalent size.

Manufacturing processes can affect battery life

While the theoretical service life of a bobbin-type lithium thionyl chloride battery is over 20 years, actual service life varies based on such factors as the self-discharge rate, which is governed by the chemical composition of the electrolyte, manufacturing methods, as well as mechanical and environmental considerations. Battery performance can also be compromised by high levels of impurities in the electrolyte, as well as by high impedance caused by internal resistance between the electrolyte, the anode, and the cathode.

Since manufacturing and quality systems can significant impact battery service life, design engineers must verify that the batteries specified actually deliver as promised. To ensure product quality and authenticity, careful vendor selection requires full product traceability all the way back to the raw materials. Prospective suppliers also need to supply suitable customer references, along with independent test results for parameters such as battery pulse, low-temperature pulses, discharge and repeatability. Thorough due diligence during the vendor selection process helps ensure decades of trouble-free battery performance.