Limitless Wireless: Hybrid Lithium Batteries Can Power Remote Wireless Sensors for over 25 Years

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Rapidly evolving technology and wireless communications have unlocked the dynamic growth potential of remote wireless sensors, resulting in growing demand for hybrid lithium batteries that combine exceptional long life with the ability to handle high current pulses.

Remote wireless sensors are now everywhere, becoming increasingly essential to everyday life. As a result, demand for dependable long-term power management solutions has intensified, with self-contained primary lithium batteries being chosen to power the latest RFID and GPS tracking systems, wireless mesh networks, automatic meter reading (AMR), system control and data acquisition (SCADA), data loggers, oceanographic, environmental measurement, emergency/safety equipment, military and aerospace systems.

As computer technology inevitably becomes more complex and miniaturized, exciting possibilities, and challenges, have emerged for battery manufacturers. Primary lithium thionyl chloride batteries (Li/SOCL2) will continue to serve as the backbone of remote wireless systems design, with energy harvesting devices being applied in specific circumstances.

Lithium vs. Energy Harvesting

For remote applications that require extremely long battery life, extended temperature range, and reduced size and weight, Lithium wins out over other battery chemistries because its intrinsic negative potential 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), making them ideal for use in extreme heat or Arctic environments.

Media attention is also focused on energy harvesting devices, which employ technologies that have been available for decades. The best known of these devices is the photovoltaic cell, which extracts energy from sunlight or other lighting sources and stores the energy in a rechargeable cell or capacitor. Photovoltaic cells can be ideal for sunny climates, but have major drawbacks involving cost, reliability and maintenance. Lack of sunlight also precludes their use underground (i.e. AMR utility metering pits), underwater, or in dimly lit areas.

Other types of energy harvesting devices include peltier elements that harvest energy created when two sides of an object have a temperature differential greater than 5° C; dynamos, which are reverse step engines that use motion to create energy; and piezo elements, which create energy from mechanical torsion. To date, these devices have gained limited market acceptance due to high cost and low reliability/durability.

Energy harvesting devices are often used in conjunction with rechargeable batteries that employ non-environmentally-friendly chemistries and are not designed for long-life use.

Complex Applications Call for Lithium Batteries

When designing a power management solution, design criteria typically involves the desired voltage, capacity, size and weight, service life, temperature range, and requirements for high current-pulses and/or high discharge rate, if applicable. Cost is always important, so trade-offs are not uncommon.

Among primary lithium chemistries, bobbin-type lithium thionyl chloride (Li/SOCL2) have been chosen for remote wireless devices such as automatic meter reading (AMR) systems, SCADA, environmental sensors and other remote devices that demand 20- to 30-year battery life. For example, in 1984, Aclara introduced a revolutionary automatic meter reading (AMR) devices for the gas and electric utility market powered by an AA-size lithium thionyl chloride battery. Millions of these devices were deployed worldwide, and virtually all continue to operate on their original batteries after 25 years. Long-term reliability is critical to the utility industry, as extended battery life leads directly to higher profits by eliminating the need for system-wide battery change outs.

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 exceptionally long-life resulting from very low self-discharge (less than 1% per year), high energy density (1,420 Wh/l), high capacity, and a wide temperature range.

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. By contrast, spirally wound Li/SOCL2 cells have a much lower energy density (800 Wh/l) and a maximum service life of approximately 10 years.

Bobbin cells (and spiral cells) can also suffer from passivation after storage at high temperature. Passivation layers that build up on the cell electrode surfaces can temporarily reduce the cell’s ability to supply current, produce a voltage delay, or temporarily reduce voltage while the passivation layer dissipates.

High Current-Pulse Applications have Unique Power Requirements

To address these issues, engineers at Tadiran developed PulsesPlus™, a patented hybrid technology that combines bobbin-type lithium thionyl chloride chemistry with a hybrid layer capacitor (HLC).

Currently employed in millions of wireless sensors, PulsesPlus batteries supply long-term, low-current power while the HLC stores current-pulses of up to 15A, eliminating the voltage drop that normally occurs when a pulsed load is initially drawn. The rate at which energy can be stored by the HLC varies from 280 A/Sec. with smaller HLCs, to 1,120 A/Sec. with larger size HLCs. PulsesPlus batteries also offer the potential for an end-of-life indication when the battery has 5 to 10% of its remaining capacity. This hybrid lithium technology is also being utilized for high rate power military and medical applications.

The HLC is a single unit that works in parallel in the 3.6V to 3.9V nominal range to avoid the balancing, impedance and current leakage problems that limit the service life of super capacitors. Alternatively, one could combine a discreet capacitor with a primary lithium cell, which would be unnecessarily bulky and result in a higher rate of charge leakage as the discreet capacitor continuously discharges the battery, albeit at a low rate.

The following example demonstrates 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. 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 pack 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.

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.

This example demonstrates how hybrid lithium thionyl chloride batteries can address the challenges of high current pulse applications by modifying standard bobbin-type Li/SOCL2 chemistry that has been proven to deliver 25+ year service life.

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