

## **Chemistry, application requirements help determine long-life battery selection**

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***Specifying the right battery is critically important for long-life applications that require maintenance-free performance for up to 25 years or more.***

Lithium chemistry is preferred for long-life applications because its intrinsic negative potential exceeds that of all other metals. Lithium is the lightest non-gaseous metal, offering the highest specific energy (energy per unit weight) and energy density (energy per unit volume) of all available battery chemistries.

Lithium cells, all of which use a non-aqueous electrolyte, have normal open-circuit voltages (OCVs) of between 2.7 and 3.6 V. The absence of water also allows certain lithium batteries to operate in extreme temperatures (-55°C to 125°C), with certain models adaptable to cold-chain temperatures down to -80°C.

Within the lithium family, only bobbin-type lithium thionyl chloride (LiSOCl<sub>2</sub>) chemistry can deliver 25+ year service life due to its high energy density, high capacity, extremely low self-discharge, and extended temperature range.



In 1984, Aclara, formerly Hexagram, began using bobbin-type LiSOCl<sub>2</sub> batteries to power meter transmitter units (MTUs) for automated meter reading systems used by water and gas utilities. Many of these early devices are now reaching the end of their operational lives but the older units were still operational after 27 years, using their original batteries.

Aclara's example clearly demonstrates that 25+-years of battery life is achievable. However, this milestone is often difficult to prove, as bobbin-type LiSOCl<sub>2</sub> batteries cannot be easily tested in conditions that accurately simulate actual in-field use.

The cost of battery replacement can be as high as ten times the initial cost of the original battery, so due diligence required during the vendor evaluation process.

Superior grade batteries use high-quality materials and advanced manufacturing techniques that reduce the potential for electrolyte leakage or short circuits. Many battery manufacturers claim to offer low annual self-discharge rates at ambient temperatures. However, these claims may be invalid depending on the size of the battery, its method of construction, or the application-specific temperature requirements. A difference of just a few microamps in self-discharge rate can significantly impact battery life expectancy.

Use of inferior raw materials or non-standardized battery manufacturing techniques can lead to batch-to-batch inconsistency, which severely impacts long-term battery performance, even if initial performance seems identical.

## Understanding application-specific parameters

Remote sensors increasingly offer advanced features such as two-way RF communications or remote shut-off capabilities that tend to drain battery power and reduce battery life expectancy.

Advanced two-way communications is being utilized in utility meter reading (AMR/AMI), wireless mesh networks, system control and DA (SCADA), data loggers, measurement while drilling, oceanographic measurements, emergency/safety equipment, and other remote sensors. These devices typically remain in a dormant or 'sleep' mode, where average daily power consumption ranges from zero to a few microamps to conserve energy. The device periodically powers up to gather and transmit data, then returns to dormant mode, a sequence that can require current pulses ranging from hundreds of milliamps for short-range RF communications up to a few amps for certain GPRS protocols.

Every application is unique, so design engineers must be aware of various application-specific requirements, including:

- Energy consumed in dormant mode (the base current)
- Energy consumption during active mode (including the size, duration, and frequency of high-current pulses)
- Storage time (as normal self-discharge during storage diminishes capacity)
- Thermal environments (including storage and in-field operation)
- Equipment cut-off voltage (as battery capacity is exhausted, or in extreme temperatures, voltage can drop to a point too low for the sensor to operate)
- Battery self-discharge rate (which can be higher than the current draw from average sensor use)

If the application involves dormant periods at elevated temperatures, alternating with periodic high current pulses, then lower transient voltage readings can result during initial battery discharge. This phenomenon, known as minimum transient voltage (MTV), is common to bobbin-type LiSOCl<sub>2</sub> batteries because of their low-rate design and is strongly linked to the choice of battery electrolyte or cathode.

One possible solution is to use supercapacitors in conjunction with lithium batteries,

but the supercapacitors' relatively high self-discharge rate can cause the battery to fail early. A supercapacitor made up of two 2.5 V capacitors also needs a balancing circuit to extend service life, and suffers from limited temperature range, which prohibits its use in extreme environments.

As alternatives, one new line of batteries has been developed for high current pulses; and another series batteries suits moderate current pulses. Both technologies solve the TMV problem inherent to bobbin-type LiSoCl<sub>2</sub> cells while providing long life and low self-discharge.

The high-current pulse solution combines a standard bobbin-type LiSOCl<sub>2</sub> battery with a patented Hybrid Layer Capacitor (HLC). The battery and HLC work in parallel, with the battery supplying long-term low-current power while the HLC supplies current pulses up to 15 A, thus eliminating the voltage drop that normally occurs when a pulsed load is initially drawn. The batteries can also enable low battery status alerts; a 3.6 V system indicates when approximately 95 percent of battery capacity has been exhausted and a 3.9 V system indicates when 90 percent of available capacity has been used up. The single-unit HLC works in the 3.6 V to 3.9 V nominal range to deliver high current pulses and a high safety margin while avoiding the balancing and current leakage problems associated with supercapacitors.

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