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Power Your Wireless Sensors For 40 Years



Battery replacement often is difficult or impossible in remote sensing systems. LiSOCl_2 batteries can extend the time between service calls to decades.

SHORT-RANGE WIRELESS SENSORS are experiencing rapid growth in a wide range of applications: RFID to GPS tracking, traditional automatic meter reading (AMR) plus advanced metering infrastructure (AMI), mesh networks, system control and data acquisition (SCADA), data loggers, measurement while drilling, oceanography, environmental systems, emergency/safety systems, military/aerospace systems, and more. Many of these applications rely on long-life lithium batteries with a potential lifespan of up to 40 years, especially in remote locations where battery replacement is difficult or impossible.

However, actual battery life is often difficult to prove because it's not particularly easy to test primary lithium batteries for lifespan in conditions that accurately simulate in-field use. Therefore, design engineers must be extremely diligent in demanding verifiable information from battery manufacturers to avoid unscheduled battery replacements, which can incur 10 times the initial cost of the original battery (see "Specifying A Primary Lithium Battery," p. 3).

LiSOCl_2 ENABLES 40-YEAR SERVICE

Bobbin-type lithium-thionyl-chloride (LiSOCl_2) chemistry is overwhelmingly preferred for remote wireless sensors because it offers the highest specific energy (energy per unit weight) and energy density (energy per unit volume) of all current battery chemistries (Fig. 1). Lithium delivers high energy density due to its large electric potential, which exceeds other metals. It produces the higher 2.7- to 3.9-V dc voltages typical of lithium batteries.



1. Bobbin-type lithium-thionyl-chloride (LiSOCl_2) chemistry is preferred for remote wireless sensors because of its high specific energy, high energy density, wide temperature range, and very low annual self-discharge rate.

Lithium cells use a non-aqueous electrolyte, enabling certain LiSOCl_2 batteries to operate in extreme temperatures typically ranging from -55°C to 125°C . Certain cells are adaptable to the cold chain, down to -80°C . For example, Tadiran tested

LiSOCl_2 cells in a cryogenic chamber and subjected them to progressively lower temperatures down to -100°C . These LiSOCl_2 cells continued to operate as necessary.

LiSOCl_2 chemistry is also renowned for long life. Formerly known as Hexagram, Aclara began using bobbin-type LiSOCl_2 batteries in 1984 to power meter transmitter units (MTUs) for automated meter reading systems used by water and gas utilities (Fig. 2).

These older devices are being replaced by more technically advanced equipment, but the original batteries are still operating after 28 years in the field. This real-life example gives AMR/AMI equipment manufacturers the confidence to offer long-term performance contracts that increase the total return on investment (ROI) of an AMR/AMI network.



2. LiSOCl_2 batteries have been utilized for decades in AMR applications, with some systems still operating on their original batteries after 28 years.

NOT ALL BATTERIES ARE EQUAL

While many battery manufacturers claim low annual self-discharge rates at ambient temperatures, such claims may be invalid depending on the construction method or specific design requirements. For example, testing on Tadiran batteries shows that these cells have an average self-discharge of approximately 0.7% per year, while other batteries using the same chemistry have 2.5% to 3% annual self-discharge.

The use of inferior raw materials or non-standard manufactur-



3. Tadiran's PulsesPlus batteries utilize a patented hybrid layer capacitor (HLC) to deliver the high current pulses required for advanced two-way communications.

ing techniques can lead to uneven battery performance. This includes batch-to-batch inconsistencies that raise the risk of anomalies in the field, even if initial performance characteristics seem identical. As a result, advanced manufacturing processes based on Six Sigma and statistical process control (SPC) methodologies are required to ensure consistent product quality.

When it comes to selecting the ideal battery, each application is unique in terms of a set of application-specific parameters:

- Overall energy consumption during sleep mode
- Energy consumption during active mode entailing the size, duration, and frequency of high current pulses, where applicable
- Battery self-discharge rate, which is sometimes higher than the actual sensor average-use rate
- Equipment cutoff voltage
- Length of storage periods
- Thermal environments

Experienced battery manufacturers know how to create a customer-specific energy-use profile along with sensitivity analyses. The end result is a mathematical model that accurately predicts battery-life expectancy.

TWO-WAY REQUIREMENTS

Wireless sensors are increasingly providing “on demand” two-way RF communications, with the device operating in two modes. One is a dormant or sleep state where daily power consumption ranges from nil to a few microamps. The other is an active interrogation and transmission mode requiring high current pulses up to hundreds of milliamps for short-range RF communications to a few amps for certain GPRS protocols.

If a wireless sensor remains dormant for extended periods at elevated temperatures and is occasionally interrupted by a high current pulse, lower transient voltage could result during initial battery discharge, especially in low temperatures. This phenomenon, which is known as transient minimum voltage (TMV), is strongly related to the quality of the battery electrolyte or cathode.

One alternative is to combine supercapacitors with lithium cells, a solution that tends to fail prematurely due to relatively high self-discharge. A supercapacitor comprising dual 2.5-V capacitors also needs a balancing circuit to ensure acceptable



4. Tadiran's TRR series batteries don't need an HLC but can deliver moderate current pulses without voltage or power delay.

service life. And, supercapacitors have a limited temperature range, disqualifying them for use in some applications.

To address the needs of advanced two-way communications, combine a standard bobbin-type LiSOCl_2 battery that works in parallel with a hybrid layer capacitor (HLC). Tadiran's PulsesPlus LiSOCl_2 battery supplies long-term, low-current power while the patented HLC delivers high-current pulses up to 15 A to eliminate the voltage delay that normally occurs when a pulsed load is initially drawn (Fig. 3). It allows users to program their devices to communicate low-battery status alerts. A 3.6-V system indicates when battery capacity is approximately 95% exhausted, while a 3.9-V system indicates when 90% capacity is gone.

The HLC is a single unit that works in the 3.6-V to 3.9-V nominal range to avoid the balancing and current leakage problems associated with supercapacitors. It has been field proven to deliver high current pulses and a high safety margin.

Tadiran's TRR series LiSOCl_2 batteries are designed for moderate current pulse applications (Fig. 4). These batteries don't require an HLC. Or, they can use a smaller HLC to deliver high capacity and high energy density without voltage or power delay. They virtually eliminate the voltage drop associated with a standard LiSOCl_2 battery when it faces an initial load, especially at cold temperatures or when the battery is nearing the end of its operating life.

APPLICATIONS

The Kohler Hybrid energy system is the first battery-powered, no-maintenance, water-saving solution designed to last 30 years (Fig. 5). This commercial faucet uses Kohler Insight Technology to continuously analyze and log feedback from its environment, automatically recalibrating the factory default settings to eliminate false actuations caused by low lighting or highly reflective lighting, two challenging conditions that commonly plague battery-powered systems.

To maintain a 30-year life, the system employs a LiSOCl_2 battery with a patented hybrid layer capacitor. When the faucet opens, the capacitor collects and discharges small electrical charges. Additionally, the faucet is mercury-free, with no harmful chemicals or additives.

Powercast Corp. uses hybrid lithium batteries to power its WSN-1101 wall-mounted sensor, which measures indoor



5. Kohler commercial faucets utilize a hybrid energy system powered by LiSOCl_2 batteries with HLCs to operate maintenance-free for 30 years.

temperature and humidity (Fig. 6). The WSN-1101 finds employment in HVAC, lighting control, energy management, industrial monitoring, and medical applications.

Designed for indoor use in temperatures ranging from -20°C to 50°C , the sensor can transmit data once per minute for more than 25 years to the Powercast WSG-101 wireless gateway, which interfaces with wired building automation systems (BAS) networks via industry-standard protocols.

The use of a long-life LiSOCl_2 battery enables Powercast to offer a highly cost-effective and reliable 25-year system that

6. Powercast WSN-1101 battery-powered wireless sensors instantly convert buildings into smart buildings with remote monitoring of HVAC, lighting, and other building automation systems.

instantly converts buildings into smart buildings. It proves to be an ideal upgrade for older structures with concrete or cinder block walls that cannot be easily retrofitted for hard-wired solutions. **3d**

SOL JACOBS is the vice president and general manager of Tadiran Batteries. He has more than 25 years of experience in developing solutions for powering remote devices. He holds a BS in engineering and an MBA.



SPECIFYING A PRIMARY LITHIUM BATTERY

OPTIMIZING A BATTERY for long-term reliability involves the choice of chemistry, the cell design, the quality of the mechanical components, the purity of the raw materials, and the specific manufacturing processes employed. Any shortcut along the way can negatively impact battery service life.

Selecting the optimal power management solution begins with a battery comparison matrix that accounts for various application-specific parameters, including desired voltage, size and weight, expected service life, required temperature range, and cost. Special requirements also need to be considered, including high current pulses, high discharge rate, and minimum equipment shut-off voltage.

Challenging environmental requirements may also be factors. For example, many automatic meter reading (AMR) and advanced metering infrastructure (AMI) meters are designed for use in underground pits, and they should be encased in acrylic to help protect them from corrosion. Available board real estate and circuits assembly criteria also need to be considered. For instance, lithium-thionylchloride (LiSOCl_2) cells come in a wide variety of sizes and configurations, with through-hole soldering leads or with wire harnesses.

From a practical standpoint, it is essential to determine whether an LiSOCl_2 battery is indeed necessary. For example, if the sensor is easily accessible and replaceable or it is located near hard-wired ac power, a relatively inexpensive alkaline or rechargeable lithium battery may suffice.

If the application requires long life, low self-discharge, and a wide temperature range,



FasTrak® electronic toll tags are subject to extreme heat, vibration, and rapid temperature cycling while demanding highly reliable, long-term maintenance-free performance. LiSOCl_2 batteries can meet these specifications.

then LiSOCl_2 chemistry is unsurpassed. A common example is the FasTrak® electronic toll tag, an RFID application that is commonly exposed to extreme heat, vibration, and rapid temperature cycling, yet demands highly reliable long-term maintenance-free performance (see the figure). For this particular application, LiSOCl_2 chemistry is the sole choice. LiSOCl_2 chemistry is also well suited for challenging applications, such as medical RFID tags that must withstand the prolonged heat autoclave sterilization, and data loggers that must operate continuously in the cold chain at -80°C .

When specifying an LiSOCl_2 battery, be mindful that competing batteries using the exact same chemistry can exhibit very different self-discharge rates, which are largely governed by the chemical composition of the electrolyte. If the electrolyte is made from inferior materi-


als with high levels of impurities, it could result in a higher self-discharge rate as well as greater impedance. An experienced battery manufacturer knows how to blend special additives into the electrolyte to reduce impedance.

Calculating expected service life based on nominal capacity can be highly misleading since the total volume of active ingredients is limited by the size of the cell. As a result, nominal capacity values typically do not vary substantially between competing brands. Instead of comparing nominal capacity, design engineers should compare the equivalent operating capacity (EOC) of competing brands to determine the estimated service life, considering the battery's self-discharge rate, its application current profile, and the environmental conditions.

Appearances can be deceiving, so it is also important to review raw material quality, manufacturing systems, and quality control procedures, as any production shortcut could severely impact battery service life.

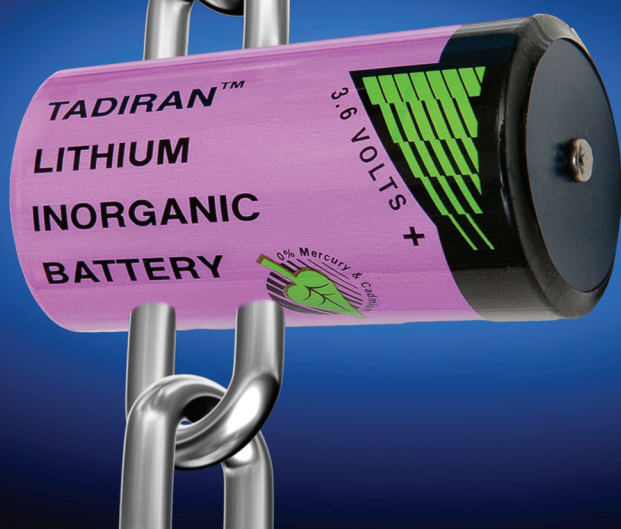
As part of the vendor evaluation process, be sure to demand customer testimonials along with fully documented and verifiable performance test data, including discharge curves, battery pulses, low-temperature pulses, and repeatability, as well as safety tests for exposure to vibration, puncture, and short circuit.

LiSOCl_2 batteries are not created equal. Proper due diligence is required during the vendor evaluation process to ensure that the right battery is powering your wireless sensor, one that can deliver the energy that is necessary for decades of maintenance-free performance. **3d**



The battery is
no longer the
weakest link
in your device's
operating life.

40
YEAR
OPERATING
LIFE*



Perfected through decades of research and development, Tadiran lithium thionyl chloride batteries feature the lowest self-discharge rate of any battery, less than 1% per year. As a result, Tadiran batteries will operate maintenance-free for over 40 years in certain applications, lasting as long as the electronics in your device. So don't just settle for anything less than Tadiran long-life batteries, your strongest link to success.



*Tadiran LiSOCL₂ batteries feature the lowest annual self-discharge rate of any competitive battery, less than 1% per year, enabling these batteries to operate over 40 years depending on device operating usage. However, this is not an expressed or implied warranty, as each application differs in terms of annual energy consumption and/or operating environment.

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