High-Energy Lithium Batteries Power Wireless Military Devices

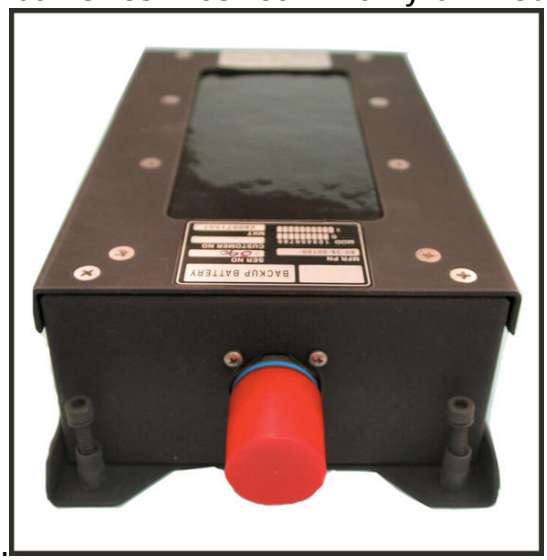
Sol Jacobs, Tadiran Batteries

Lithium metal oxide chemistry improves upon legacy battery technologies to cut costs and increase reliability of military and aerospace systems.

Demand is growing for high-rate, battery-powered solutions for avionics, navigation systems, ordinance fuses, missile systems, telemetry, electronic warfare systems, GPS tracking and emergency/safety devices, shipboard and oceanographic devices.

These applications present significant design challenges, causing the U.S. DoD to recently identify a “critical need” for a new generation of high-power, long life batteries to replace decades-old legacy battery technologies. In response, Tadiran developed TLM Series high-power lithium metal oxide batteries, which offer long shelf life, instantaneous activation, and high survivability.

Here are the primary batteries most commonly utilized for single-use, high rate mil/aero applications.



Reserve and Thermal Batteries

Reserve batteries encompass a broad range of chemistries, including lead-acid, silver-zinc, and lithium thionyl chloride.

With reserve batteries, the electrolyte is stored separately from other active ingredients, remaining inert until a pyrotechnic device initiates a chemical reaction. The most popular version is the thermal battery, which utilizes a metallic salt electrolyte that is inert and non-conducting while in a solid state and at ambient temperatures. A squib delivers a pyrotechnic charge that causes the electrolyte to become molten at 400°C - 700°C. Once activated, the battery can deliver short-term, high-rate power, from a few watts to several kilowatts of continuous current,

depending on battery size and chemistry.

Advantages of thermal batteries include ruggedness, safety, reliability, and long shelf life. Reserve/thermal batteries also have limitations. They cannot be tested without the battery being fully depleted, and battery activation is delayed until the chemical reaction occurs. Thermal batteries are also bulky, needing layers of insulation to retain heat so activated electrolyte can remain continuously molten as well as to protect surrounding components from heat-related damage.

Spin-Activated Batteries

Commonly utilized for fuses and certain single-use marine applications, spin-activated batteries store electrolyte inside an ampoule or bladder that is cut open when the projectile is fired, and centrifugal force distributes the electrolyte throughout the cell stack. Spin-activated batteries manufactured using lithium thionyl chloride chemistry are currently being used to power minelets and communication jammers propelled by artillery shells equipped with parachutes to ensure a soft landing.

Spin-activated batteries have also been deployed in Multi-Option Fuses for Artillery (MOFA) applications, including 105 mm and 155 mm bursting artillery projectiles. Seeking a standardized solution, the U.S. DoD recently chose to power the latest generation of MOFAs with lithium oxhalide batteries instead of lead-acid or thermal batteries. Had these MOFA devices been powered by high-power lithium metal oxide batteries instead of lithium oxhalide chemistry, significant performance advantages could have been realized, including seven times greater capacity (200 mAh vs. 30 mAh), over ten times greater current (3.5A vs. 325 mA), more stable voltage, and faster activation (instantaneous vs. a 100 ms delay).

High-Power Lithium Metal Oxide Batteries

Tadiran TLM Series high-power lithium metal oxide batteries deliver high current pulses and high rate energy, with up to 20 years of storage life due to an annual self-discharge rate of less than 1% per year at room temperature. These cells are currently available in four standard cylindrical configurations (AAA-size, AA-size, CR-2 size, and 20 mm length) and can be quickly and cost-effectively configured into battery packs since they use standard COTS components.

TLM batteries can deliver up to 2 Wh of energy, and feature a nominal voltage of 4V, with a discharge capacity of135 mAh to 500 mAh, capable of handling 5A continuous pulses and 15A maximum high current pulses. These batteries are constructed with a carbon-based anode, multi metal oxide cathode, organic electrolyte, and shut-down separator for enhanced safety.TLM Series batteries also feature extremely low self-discharge, a wide operating temperature range (-40°C to 85°C.), and comply with MIL-STD 810G specs for vibration, shock, temperature shock, salt fog, altitude, acceleration (50,000 gn) and spinning (30,000 rpm). These batteries also conform to UN 1642 and IEC 60086 standards for crush, impact, nail penetration, heat, over-charge and short circuit, and can be shipped as non-hazardous goods.

Unlike thermal/reserve and spin-activated batteries, TLM cells permit instantaneous activation without the need for squibs or gas generators. These batteries can also be periodically tested to ensure system readiness, thus reducing the risk of “duds” in missile guidance systems. Power can also be drawn intermittently, so they are not restricted to single-use applications.

These cells also do not generate the high internal temperatures required by thermal batteries, thus eliminating the need for thermal insulation, resulting in significant size, weight, and cost reductions. High-power lithium metal oxide batteries are being deployed in the following applications:

ODAM 60 mm mortar guidance systems: Under DARPA’s Optically Directed Attack Munitions (ODAM) project, BAE Systems undertook a development and integration initiative to demonstrate the feasibility of a laser-guided, low-cost 60 mm mortar round.

BAE Systems selected TLM-1530-HP lithium batteries to power the system’s laser-guided optical seekers. These batteries were chosen over CR-2 consumer type batteries because their ability to operate in extremely cold temperatures (-40 °C),

with up to four times longer shelf life (20 years versus 5 years).

Unmanned Aerial Vehicles: UAVs being utilized by U.S. armed forces in Iraq and Afghanistan for unmanned air reconnaissance currently employ high-power TLM lithium metal oxide batteries to create weight- and space-saving battery packs that power the aircraft's emergency recovery system. Figure 1 shows a 32 V/480 W battery pack consisting of 96 AA-size high power lithium batteries that is capable of delivering up to 120 Watts per hour at -30 ºC, and weighing approximately 2 Kg including its metal enclosure. Use of COTS technology simplifies the design and manufacturing of custom battery packs for UAV applications.

Powering missile systems: An air-to-ground missile guidance system previously powered by a battery pack consisting of 19 silver-zinc cells can be converted to a battery pack consisting of 24 high-power lithium metal oxide cells, resulting in a 30% size reduction and a 75% weight reduction (2.2 Kg vs. 0.5 Kg), with 3.5 times greater energy density. Use of lithium metal oxide chemistry further reduces size and weight by eliminating the squib, gas generator and heater required by a silver-zinc pack (Figure 2).

Design engineers need to stay abreast of the latest advancements in battery technology to address the increasingly complex power management requirements of mil/aero systems.

July 16, 2012