

Military

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Is COTS in
for a rough
landing?

Industry execs speak out
on tech, trends, future



High-power lithium batteries:

Providing more performance, life, and reliability

By Sol Jacobs

Batteries capable of delivering high-rate power to long-life single-use military applications have remained virtually unchanged for decades. Now, a new generation of high-power lithium batteries is available that offers unique performance and features, including higher capacity and energy density, reliability, instantaneous activation, and the COTS advantage.

Driven largely by advancements in embedded computers and semiconductor fabrication, long-life single-use military/aerospace systems are rapidly evolving, with new generation products offering improved functionality, miniaturization, and enhanced product reliability, as well as higher performance expectations. This applies to a wide variety of single-use military products, including mortar-guidance systems, rockets, missiles, torpedoes, mines, sonobuoys, unattended ground sensors, UAVs, and dispersed munition sensors, among others.

Realizing that limitations in battery performance could create a potential bottleneck that stifles new product development, the U.S. DoD recently identified the need for a new generation of high-

power, long-life batteries capable of providing reliable power for single-use military applications as a “critical problem” to address.

The search for solutions led to the development of new COTS high-power lithium battery technology featuring exceptionally long shelf life combined with powerful performance capabilities previously available only with reserve or thermal batteries. Design engineers are advised to perform appropriate due diligence and compare this new highly reliable COTS lithium battery against older battery technologies to ensure that optimum system performance is achieved.

Reviewing the options

The first three of the following battery chemistries have been commonly utilized

to power long-term single-use military applications; however, high-power lithium batteries are now an option to consider, too:

- Reserve and thermal batteries
- Silver-zinc batteries
- Spin-activated batteries
- High-power lithium batteries

A brief review of these competing technologies highlights the potential advantages and disadvantages of each battery chemistry.

Reserve and thermal batteries

Reserve batteries, traditionally considered the battery of choice for single-use military applications, encompass a number of different chemistries, including lithium thionyl chloride, silver-zinc, lead-acid, and thermal.

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With reserve batteries, the electrolyte is stored separately from other active ingredients, with a pyrotechnic device typically being utilized to initiate the chemical reaction. The active ingredients remain separated, so they stay inert, thus creating the potential for extremely long shelf life of 20+ years. However, there are significant trade-offs, as reserve batteries cannot be tested without being depleted and battery activation is delayed until a chemical reaction occurs.

A popular type of reserve battery is the thermal battery, which contains a metallic salt electrolyte that is inert and non-conducting in a solid state and at ambient temperatures. However, when the metallic salt electrolyte becomes molten, it quickly transforms into an excellent ionic conductor, yielding high-rate power for relatively short intervals of time (from a few watts to several kilowatts depending upon battery size and chemistry). The electrolyte is typically activated by a pyrotechnic charge delivered by a squib.

Design engineers have long preferred thermal batteries for their ruggedness, safety, reliability, and extremely long shelf life. However, due to the use of squibs and the need to keep the electrolyte continually molten at 400 °C to 700 °C to achieve optimum conductivity, thermal batteries are inherently bulky, as they must incorporate insulation layers that serve a dual purpose of retaining heat while simultaneously protecting nearby components from heat-related damage.

Silver-zinc batteries

Single-use military devices can also be powered by silver-zinc batteries, which are relatively complex to manufacture, since they require a gas generator, tubular electrolyte reservoir, manifold, battery block, vent, and heating system. As a result, silver-zinc batteries tend to be relatively expensive and require long production lead times. These batteries also have performance limitations due to relatively low energy density of just 260 Wh/L.

Spin-activated batteries

Military fuses and certain marine applications are often powered by spin-activated batteries that store the electrolyte inside an ampoule or bladder. When the projectile is fired, the bladder gets cut open, and the electrolyte is distributed throughout the cell stack by centrifugal force generated by the spinning shell. Spin-activated batteries have also been manufactured using lithium thionyl chloride chemistry to power minelets or communication jammers. These devices are propelled by artillery shells equipped with parachutes to ensure a soft landing.

A common application for spin-activated batteries is Multi-Option Fuses for Artillery (MOFA) found in 105 mm and 155 mm bursting artillery projectiles. Seeking a more standardized power management solution, the U.S. DoD considered various chemistries, selecting lithium oxhalide over lead-acid and thermal batteries. By comparison, a high-power lithium battery could deliver over six times the capacity (200 mAh versus 30 mAh), over ten times the current (3.5 A versus 325 mA), more stable voltage, and faster activation (instantaneous versus a 100 ms delay) versus an equivalent lithium oxhalide battery.

High-power lithium batteries

A high-power lithium battery has been

A systematic approach to specifying the right battery

When specifying primary batteries for long-life single-use military applications, design engineers need to stay on top of the latest technology by reviewing all available battery chemistries to ensure that the ideal power management solution is being applied. This decision-making process should incorporate:

1. Evaluating anticipated power and performance requirements
2. Developing a prioritized checklist of desired attributes such as:
 - › Voltage, capacity, and size, weight, and/or special packaging requirements
 - › Expected energy density, service life, temperature, and/or environmental issues
 - › Overall cost of ownership
 - › Considering additional requirements such as the need for instant activation as well as the ability to conduct routine testing for system readiness
3. Analyzing this checklist to ensure that the optimal technology is being employed based on overall performance criteria
4. Performing appropriate tests to confirm that the power management solution fulfills all necessary performance, quality, and safety requirements in accordance with customer specifications and applicable third-party certifications

developed that uses widely accepted COTS technology to deliver high current pulses and high rate energy, with a storage life up to 20 years and an annual self-discharge rate of less than 1 percent at room temperature. These battery cells are available in three standard cylindrical configurations (AA-size, CR-2 size, and 20 mm length). An example of this is Tadiran's AA-size TLM-1550-HP battery, which includes a 4.0 V open circuit

voltage and total energy of 2 watt-hours, able to deliver 15 A current pulses as well as 5 A maximum continuous current at 3.2 V. CR-2 sized cells deliver 1 watt-hour of total energy, while the 20 mm version offers 0.5 watt-hours of total energy. These cells can be easily configured into custom battery packs, leading to faster design and manufacturing cycles at reduced cost due to the use of COTS components.

Attributes of high-power lithium batteries include a wide temperature range (-40 °C to +85 °C) and instant activation without the need for squibs or gas generators. The ability to perform periodic testing of the battery helps ensure system readiness and reduces the number of “duds” in missile guidance systems. When activated, high-power lithium cells do not produce high internal temperatures, thus eliminating thermal insulation needs. This, in turn, reduces weight and enables a smaller form factor. Size, weight, and cost reductions are also achieved by eliminating the need for squibs, gas generators, and external heating elements.

Sample applications for high-power lithium batteries

The following examples demonstrate the potential for high-power lithium batteries to enhance performance and COTS interoperability of power management systems used in single-use military systems.

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 CR-2 sized high-power lithium batteries to power the system's laser-guided optical seekers. These batteries were chosen over CR-2 consumer type batteries because of their ability to operate in extremely cold environments (-40 °C), with up to four times longer shelf life (20 years versus 5 years).

Unmanned Aerial Vehicles: UAVs are being widely utilized by U.S. armed forces in Iraq and Afghanistan for unmanned air reconnaissance. High-power lithium batteries are also currently being utilized to create weight- and space-saving battery packs that power emergency recovery systems on a UAV. Figure 1 shows a 32 V/480 W battery pack consisting of 96 AA-size high-power lithium batteries, capable of delivering up to 120 watt-hours at -30 °C and weighing approximately 2 Kg including its metal enclosure. Since COTS technology is employed, the battery pack can be easily reconfigured for other UAV applications.

Powering missile systems: The guidance system of an air-to-ground missile

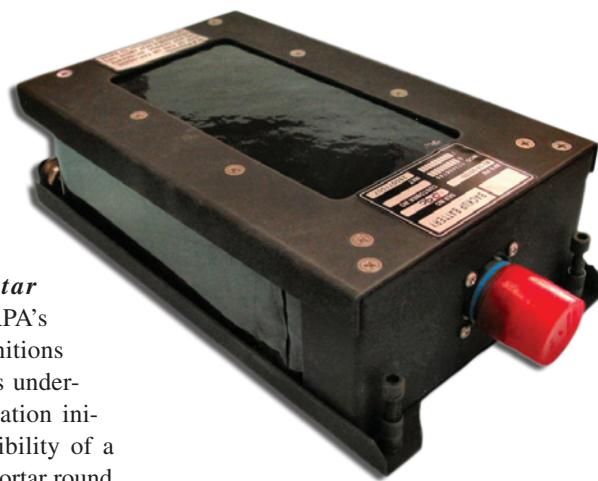


Figure 1

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 cells. The 24-battery pack results in a 30 percent reduction in size, a 75 percent reduction in weight (2.2 Kg versus 0.5 Kg), as well as approximately 3.5 times greater energy density. The high-power lithium battery pack achieves further reductions in the footprint by eliminating the need for the squib, gas generator, and heater required by the silver-zinc pack (Figure 2).

New generation of batteries to power the future

A new generation of lower-cost COTS high-power lithium batteries offers flexibility for long-life single-use military applications. This includes the potential for greater shelf life, increased performance, and enhanced COTS product reliability in challenging environmental conditions. Design engineers are advised to carefully evaluate this new technology against existing battery technologies when retrofitting existing military equipment or developing next-generation military products. +

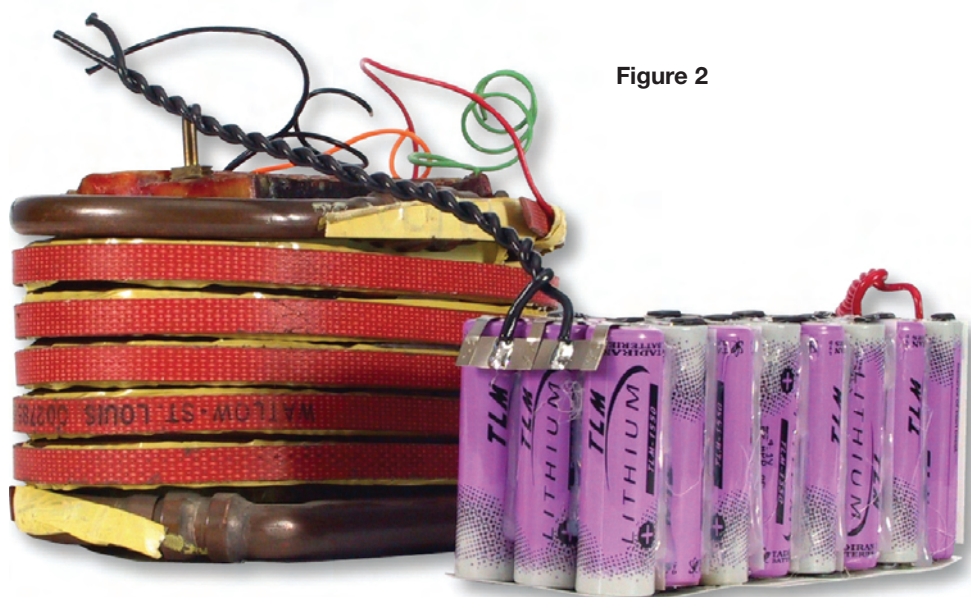


Figure 2



Sol Jacobs,
VP and general manager of Tadiran, holds BSME and MBA degrees and has been involved in the energy and military industries. He can be reached at:

sjacobs@tadiranbat.com.

Tadiran
516-621-4980
www.tadiranbat.com