Commercial battery technologies have evolved to meet the military's needs. Lithium, in particular, is cost-effective, offers a long shelf-life and provides instantaneous activation without need for external equipment. Thomas Dittrich reports

High-power lithium technology for the military

The US Department of Defence recently identified the need for a reliable high-power battery for single-use military applications as a 'critical problem' demanding significant attention. Demand for high voltage/high-rate batteries is growing for applications like guidance systems for rockets and missiles, smart ammunition, torpedoes, mines, sonobuoys, unattended ground sensors, UAVs, artillery fuses, active decoy systems, trajectory correction add-on kits, proximity fuses for bombs and sensors for dispersed munitions.

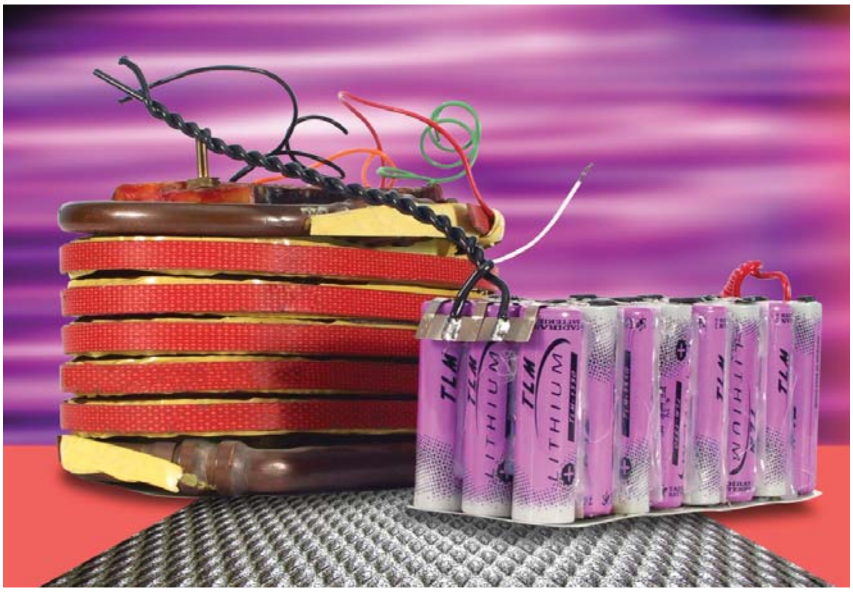
These devices require batteries that deliver high voltage and high power rates for short periods of time, ranging from fractions of a second to several hours. Design engineers must consider extremely long shelf life, rapid activation, size/volume/ weight limitations, capacity and energy density requirements, and the ability to test the battery to ensure system readiness. Certain battery technologies also require squibs (pyrotechnic charges) or gas generators for start-up; thermal insulation to protect against internal heat, and heating elements to ensure reliable operation at low temperatures.

In reserve

Traditionally, reserve batteries were preferred for single-use military applications because, in most cases, the electrolyte is either stored separately from the rest of the battery or pyrotechnic devices are used to activate it, allowing it to remain inert until use. This results in a trade-off between long shelf-life and the inability to test the battery for system readiness. Reserve batteries also require delayed activation until the chemical reaction occurs. Available reserve batteries include thermal, lead-acid, silver-zinc and lithium thionyl chloride.

Thermal batteries contain a metallic salt electrolyte that is non-conducting when solid at ambient temperatures, but which becomes an excellent ionic conductor when molten. Activated by a squib, thermal batteries provide a high burst of power - a few watts to several kilowatts - for a short period of time. Advantages include ruggedness, safety, reliability and long shelf life. However, thermal batteries have operating temperatures of between 400° and 700°C and require insulation both to conserve heat and protect surrounding components.

High-power lithium primary cell packs (right) have none of the baggage of alternative systems that require insulation and/or heating systems to ensure reliable operation



> "High-power lithium commercial battery technology can successfully compete against traditional reserve batteries, delivering benefits such as greater design flexibility, size and weight reductions and significant cost savings"

Silver-zinc batteries are complicated systems comprising a gas generator, tubular electrolyte reservoir, manifold, battery block, vent and heater system. This technology is expensive and has a relatively low energy density. Design times and costs are high, due to the extra components required. Spin-activated lead-acid batteries, commonly utilised for military fuses and marine applications, store the electrolyte (typically fluoroboric acid) in an ampoule or bladder, which is cut open when the shell is fired, and the electrolyte wets the cell stack via the centrifugal force of the spinning shell.

Spin-activated lithium thionyl chloride batteries, often found in artillery-delivered minelets or communication jammers, are slowed by parachute and must continue to operate for some time after impact. Advantages include very high rates of discharge with no voltage delay. Spin-activated batteries tend to have low energy capacity and relatively long activation times.

Lithium to the fore

Tadiran Batteries has developed a high-power lithium battery, the TLM-1550HP (pictured), based on its Hybrid Layer Capacitor (HLC) technology. This AA-size cylindrical cell features an open circuit voltage of 4.0V, 2 Watt-hours total energy and the capacity to handle 15A current pulses and 5A maximum continuous current at 3.2V. A smaller, 27mm sized version delivers 1 watt-hour total energy, and a 20mm version delivers 0.5 Watt-hour.

High-power lithium primary cells offer a wide temperature range (-40 to +80°C) and up to 20 years of storage life, with self-discharge of 1% per year at room temperature. They can be routinely tested to ensure system readiness, promoting fewer 'duds' when utilised in missile systems and other munitions. By combining the small cells into various shapes and sizes, battery packs can be made using off-the shelf products, speeding up design times and reducing costs.

High-power lithium batteries are extremely safe and can be shipped as non-hazardous goods, because the solvents are non-toxic and non-pressurised. They perform well in safety tests, including nail penetration, crush tests, high-temperature chambers, short circuit and charge tests. The cell chemistry does not generate high internal temperatures, so there is no need for thermal insulation. Likewise, their operation at low temperature, saves space and cost because external heating elements are not required.

Other advantages include faster activation with instantaneous voltage and no waiting time; moreover, no squibs or gas generators are required to start the battery, even after extended storage time. These cells remain 'on' for testing all of the time, with proven methods used to ensure that the battery power remains disconnected from the weapons systems before use.

Lithium in action

A good example of an attempt to standardise batteries for military applications is the Multi-Option Fuse for Artillery (MOFA) battery that supplies electrical energy to 105mm and 155mm bursting artillery projectiles. Among the options considered were lead-acid, thermal and lithium oxyhalide, with lithium oxyhalide selected. By comparison, a high-power lithium primary commercial battery consisting of two 20mm cells is smaller and lighter, provides up to double the operating time with instantaneous activation and more stable voltage.

Previously, in the event of a power failure, unmanned aerial vehicles (UAVs) utilised large D-sized lithium primary cell battery packs to operate the guidance system, enabling them to glide to a safe landing. Replacing the larger battery pack with a smaller pack of AA-size high-power lithium primary batteries led to substantial size and weight reductions, extended shelf life and fewer battery replacements.

Smaller AA-size high-power lithium primary batteries have led to substantial size and weight reductions in unmanned aerial vehicle applications

A silver-zinc battery pack powering guidance systems on an air-to-ground missile has been converted to a pack using 24 high-power primary lithium batteries, resulting in faster production, greater availability, reduced weight and volume, greater energy density and reduced cost. Significantly, the TLM pack does not need the squib, gas generator and heater associated with the silver-zinc pack.

In the area of guided munitions, a larger reserve battery that delivered medium power, high capacity and low current pulses was converted to a high-power lithium battery pack consisting of four to six 20mm cells. As in the previous examples, this commercial alternative reduced size, weight and cost.

High-power lithium commercial battery technology can successfully compete against traditional reserve batteries, delivering benefits such as greater design flexibility, size and weight reductions and significant cost savings.

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