Power is paramount

Warfighters in the field rely on novel power electronics to drive mission-critical systems.

By Courtney E. Howard

The U.S. military is reportedly the single largest consumer of energy in the world. In fact, according to the U.S. Department of Defense's (DOD's) FY2008 Annual Energy Management Report, the DOD's total primary energy consumption for the year was 1,138 trillion BTUs (British thermal units). The DOD also spent a record $20 billion for energy in FY2008. Power is an important concern for not only the DOD, but also each and every deployed soldier.

In military and aerospace environments, constant demand exists for ever-higher power density: greater performance and efficiency in a smaller size, as well as cost reduction and enhanced reliability, says Fred Lewis, director of sales and marketing at Martek Power in Torrance, Calif. As a whole, the mil-aero industry is moving into green technology, higher power densities, increased requirements, and a shift from full mil-spec to commercial off-the-shelf (COTS) or commercially available components; yet, he explains, size and weight are among the biggest drivers of power electronics designs today.

Combat vehicles

More power in a smaller package, or higher power density, is the direction in which power electronics is always moving, says Brad Dolbin, technical product manager of motion control and power electronics at Curtiss-Wright Controls Electronic Systems in Santa Clarita, Calif.

Curtiss-Wright Controls Electronic Systems servo motor controllers were tested in prototype vehicles for the FCS program, particularly the Non-Line-of-Sight Cannon (NLOS-C), shown here.

"The biggest trend is toward more electrification in vehicles, including more automation in some vehicles," Dolbin mentions. "The power requirements in older vehicles were quite minimal; today, lots of hydraulics are being replaced with electronics, driving the need for more power electronics. Existing platforms are being modernized with more electronics, and virtually all the new platforms have a much higher content of power electronics."

Many new platforms capitalize on power electronics technology developed originally for the Future Combat Systems (FCS) program. The U.S. Army's Brigade Combat Team Ground Combat Vehicle (GCV) may employ servo motor controllers (SMCs) that were developed by Curtiss-Wright Controls Electronic Systems for all the vehicles in FCS program, for example.

Servo motor controllers are used for several different functions, such as to drive the turret and turret positioning, the ammunition handling system, and fans and pumps throughout the vehicle, as well as to open doors and hatches automatically. "This motor control technology is being leveraged by many post-FCS programs for use in newer vehicles to drive virtually anything that requires a motor," Dolbin adds.

Curtiss-Wright Controls Electronic Systems servo motor controllers serve several functions in combat vehicles, such as to drive the turret and turret positioning, the ammunition handling system, and fans and pumps.

The new SMCs received testing in prototype vehicles for the FCS program, particularly the Non-Line-of-Sight Cannon (NLOS-C), the lead vehicle in terms of schedule for the FCS program. Curtiss-Wright SMCs are part of the ammunition handling system, turret drive system, fans, and pumps throughout the vehicle.

New combat vehicles increasingly are tapping high-voltage technology, requiring a slightly different power electronics approach. "Typically, the lower-voltage (28-volt) components are a metal oxide semiconductor field effect transistor (MOSFET) technology, whereas the higher-voltage (610-volt) parts are insulated gate bipolar transistors (IGBTs)," Dolbin explains. "The benefit is higher power density, greater power transfer, and better efficiency."

This trend of infusing combat vehicles with more and more vetronics will continue into the foreseeable future. "There will be more automation in a vehicle and more power requirements, so there will be substantially more power electronics in a vehicle," Dolbin predicts. "Power electronics are evolutionary: there are constant new releases in power devices and control devices associated with power electronics."

Lead-acid to lithium

Embedded in combat and light tactical vehicles are batteries used to independently power devices such as fire suppression systems or actuators to raise or lower a door. These systems traditionally have been powered by lead-acid batteries, but recent applications use lithium iron phosphate batteries, explains Jeff VanZwol, marketing director at Micro Power Electronics in Beaverton, Ore.

Micro Power designs and manufactures custom battery packs for different types of military applications; to date, the company has largely designed battery packs for handheld radios, handheld GPS receivers, and other land warrior applications. Today, however, many mobile applications that have traditionally used lead-acid or flooded lead-acid batteries now use a new type of lithium battery technology.

TDK-Lambda's LZSA series AC-DC power supplies are deployed in Tactical Mobile Shelters used by first responders.

"The specific battery technology is lithium iron phosphate," VanZwol says. What differentiates lithium iron phosphate from lithium cobalt oxide, the material in the cells powering essentially every notebook computer and cell phone, is a very high rate capability; it can deliver a lot of current and it also works at a wider temperature range. This new flavor of lithium cells enables Micro Power to build a lead-acid battery equivalent that is slightly smaller than and, more importantly, half the weight of comparable technologies. The battery pack is also safer and not susceptible to venting or leaking, which is common with lead-acid batteries.

"These days, the DOD is trying to lighten up all types of mobile applications-whether carried by the soldier or transported in a vehicle," VanZwol adds. "So, the trend for us in the power electronics space is where traditional lead-acid batteries, like car batteries, are being replaced with lithium-based batteries, which are a lot lighter."

Over the next year, VanZwol anticipates improvements in overall battery capacity and increased demand for lithium iron phosphate technology, as more original equipment manufacturers (OEMs) seek alternatives to lead acid.

Managing power

Power management systems are gaining as much DOD attention as power supplies. The U.S. Marine Corps, in fact, is scheduled to test and evaluate vehicle power management systems this summer. The goal is to improve Marine Corps mission effectiveness by increasing the electric power available to ground forces.

The BAE Systems Platform Solutions Sector in Johnson City, N.Y., won a contract to develop an onboard vehicle power management system. The contract award is part of the Marine Corps Onboard Vehicle Power program, funded by the 2009 American Recovery and Reinvestment Act.

BAE Systems engineers designed a system that will more than triple the electric power output of the High Mobility Multipurpose Wheeled Vehicle (HMMWV), and provide exportable power to support such facilities as forward-deployed command centers and field hospitals. It is also capable of providing mobile emergency power during natural disasters. Marine Corps leaders, after evaluating systems from two suppliers, plan to award a contract for five to 10 additional systems later this year.

Vicor's V·I Chip, delivering DC-DC conversion and 28-volt DC input in a rugged, miniature package, is well suited to ground vehicle and airborne applications.

"BAE Systems recognizes the need for more electricity to power the equipment of the modern military," says Marion Van Fosson, general manager of military vehicle systems for BAE Systems. "Our system supports the Marine Corps commitment to develop and field new solutions that reduce energy consumption and dependence on fossil fuels. Most importantly, the technology will help improve mission effectiveness."

BAE Systems engineers will perform vehicle integration work on a government-furnished HMMWV, expanding its power generation capability to 30 kilowatts of continuous, mobile, onboard power to support Marine Corps expeditionary units.

The integrated system generates and manages power for use on the vehicle and as an exportable power source, eliminating the need for towed generators and improving the HMMWV's mobility. The solution further manages electrified accessory systems, such as water pumps, engine fans, power steering pumps, and air conditioning.

BAE Systems' onboard power management system is employed on U.S. military Paladin Integrated Management vehicles.

First response

Other military vehicle applications are increasingly adopting power electronics based on commercial off-the-shelf components. Engineers at TDK-Lambda Americas Inc. in San Diego produce custom power supplies based on COTS power modules for military use. TDK-Lambda has launched a series of power modules that combine AC-DC and DC-DC converters into a one-module solution, enabling a size reduction of 25 percent.

The dB-3758 from dB Control synchronizes the power supply switching frequency with a radar system clock and blanks during the pulse, making it well suited for low phase noise radar transmitter applications.

The company's LZSA series of AC-DC power supplies have been deployed in Tactical Mobile Shelters used by first responders. "The LZSA, a true COTS power supply, was chosen because of its rugged shock and vibration specifications and wide operating temperature range," says David Norton, vice president of marketing and technical support at TDK-Lambda.

"We are seeing a desire for convection- or conduction-cooled power supplies," Norton adds. The company, focused on extending its range of true COTS products, will be launching a series of conduction-cooled products this summer.

Underwater and airborne

Vicor Corp. in Andover, Mass., delivers military COTS (MIL-COTS) power conversion systems for a variety of mil-aero applications. Its V-I Chip, offering DC-DC conversion and 28-volt DC input in a rugged, miniature package, is suited to various ground vehicle and airborne applications. One unique customer, however, adopted the component for an underwater active sonar system.

The dB-4118 microwave power module from dB Control is designed for manned and unmanned airborne applications, such as electronic warfare threat simulation, electronic countermeasures, and multi-mode synthetic aperture radars.

Active sonar can detect submarines that are too quiet to be located with passive sonar, and large marine mammals in high sound pressure zones such as those used for military exercises. A Vicor customer, specializing in the rapid prototyping of harsh-environment instrumentation and ocean-acoustic research for diverse commercial and government programs, used Vicor's V-I Chip to develop an enhanced active sonar system for harbor defense.

The sonar system, an underwater cylinder with attached hydrophone transducers, transmits a signal and receives a reflected signal in response. Incoming signals are interpreted to identify the object or intruder, whether a swimmer, whale, or underwater vehicle.

The sonar system's design required a solution offering high reliability, small size, low noise, 1 kilowatt of power, and low heat dissipation. Vicor's V-I Chip met these requirements, while another Vicor product met those of a military helicopter-borne laser diode countermeasure system.

The two parts of an electro-optic countermeasure system for Army helicopters - the command-and-control board and the laser diode driver board-employ Vicor's MIL-COTS VIPAC modular power systems. The one command-and-control card per system uses a VIPAC with three modules: a 15-, 5-, and 24-volt brick. The laser driver card, two in each system for redundancy, uses a VIPAC with one 24-volt brick and a VIPAC with one 15-volt brick.

UAV power needs

Delivering X- and Ku-band traveling wave tube amplifiers (TWTAs), microwave power modules (MPMs), and high-voltage power supplies (HVPSs) for manned and unmanned airborne applications is the focus of dB Control in Fremont, Calif. Its power electronics solutions power radar and communications systems integrated on platforms such as the MQ-9A Reaper, Predator B, I-GNAT, RQ-MQ-8A Fire Scout, RQ-4A/B Global Hawk, and MQ-1C Sky Warrior unmanned aerial vehicles (UAVs), in addition to the C-12/U-21 KingAir 200, and EH-60 Black Hawk manned aircraft.

Specifically, power amplifiers from dB Control are employed in Lynx SAR/GMTI radar systems, used by many unmanned aerial vehicles (UAVs) to transmit near-real-time, full-motion images of objects on the ground. The system captures images from up to 16 miles above, in total darkness, through clouds and rain.

Martek Power's MW400S 400-watt, single-output, AC-DC power module is targeted at military, industrial, and aerospace applications.

The company has introduced two microwave power modules-the dB-4118 and dB-3758-designed for manned and unmanned airborne applications, such as electronic warfare threat simulation, electronic countermeasures (ECM), and multi-mode synthetic aperture radars (SARs). The dB-3758 synchronizes the power supply switching frequency with a radar system clock and blanks during the pulse, ensuring that no signal is lost and making the MPM well suited for extremely low phase noise radar transmitter applications.

TWTAs from dB Control currently serve as transponder amplifiers in satellites requiring Ku-band and higher frequencies. According to says Joe Hajduk, chief executive officer at dB Control, efficiency and reliability are of paramount importance for such applications. "The TWTA's ratio of RF (radio-frequency) output power to prime power input (real efficiency) is now greater than 60 percent and will soon reach 70 percent. Considering that TWTs have operating lives greater than 20 years, I believe they will continue to be the best choice for providing uninterrupted service in communication and radar applications."

Military organizations, such as the U.S. Air Force, are now recommending the development of extremely high-altitude airships (HAA). "This bodes well for power electronics such as dB Control's traveling wave tube power amplifiers and microwave power modules, which can operate reliably under the extreme conditions (such as pressure, vibration, temperature) experienced at high altitudes," Hajduk says.

"Over the next decade, traveling wave tube power amplifiers will continue to be the amplification device of choice for a broad range of defense systems with RF power outputs up to 2.5-kilowatt continuous wave and 25-kilowatt pulse at frequencies up to 95 GHz," Hajduk predicts. "No single solid-state amplifier can deliver this level of peak-to-average power and bandwidth."

Martek Power's PF100 active power factor correction and harmonic attenuation module with 100-watt output power is a COTS unit designed for military and aerospace applications.

At the same time, power supplies will need to be lighter and more compact, Hajduk explains. "To meet these critical requirements, TWTAs in a power-combined configuration must be developed for each frequency band. These TWTs can then be combined with solid-state amplifiers to produce smaller, lighter MPMs."

DC to AC

Martek Power's Lewis notes a shift from DC to AC power distribution within the mil-aero industry. To meet this demand, the company developed its MW400 series 400-watt, single-output, off-the-shelf AC-DC power module. "We're seeing a desire for more power-not just in the military, but across the board," he says. "Everybody wants more for less in a smaller space."

The company's MW400 power offering and its PF series of active power factor correction and harmonic attenuation modules, originally designed for Air Force applications in conjunction with the engineering team at Martek France, are being employed in both new and old mil-aero platforms.

"We still have products that have been selling for 40 years on longtime programs," Lewis explains. Martek products also are making their way onto "new platforms and in a lot of upgrades in which they are adding equipment." The company won a contract last year with General Dynamics Canada (GD Canada) in Ottawa for work on airborne warning and control system (AWACS) aircraft for the North Atlantic Treaty Organization (NATO). GD Canada engineers upgraded monitors on the aircraft and employed a semi-custom power electronics system from Martek Power.

Rad-hard in space

Power efficiency and increased functionality in lighter and smaller solutions, as well as reliability under extreme conditions continue to be key drivers in mil-aero, observes Fred J. Farris Jr., vice president sales and marketing in the HiRel Business Unit of International Rectifier (IR) in El Segundo, Calif. "Solutions are more integrated, reducing size, weight, resistance, and inductances. The trend is toward affordable and sustainable sources of supply, high reliability, and improved performance."

In space applications, Farris notes another trend: replacing mechanical relays with solid-state relays (SSRs). IR offers radiation-hardened (rad-hard) SSRs for power bus switching, heater control circuits, and battery charging in high-reliability (hi-rel), space-qualified applications.

The company's RDHA701CD10A2N and RDHA710FR10A1N rad-hard DC single-pole, single-throw-type SSRs are designed to replace traditional electro-mechanical relays that are vulnerable to vibration and shock. IR also supplies hi-rel DC-DC converters to industry firms such as EADS Astrium in the United Kingdom.

Radiation-hardened products such as VPT's SVGA point-of-load converter are more affordable today than in years past, and available for off-the-shelf delivery.

"IR will continue to invest in research and development to provide innovative power technology-from discrete semiconductors and integrated circuits to hybrids and fully integrated power systems for high-reliability markets, including space, military, heavy-duty industrial, and medical," Farris mentions. More to the point, just last month, the company opened a new 35,000 square-foot facility-which is DSCC-certified Class H and Class K, and AS9100- and ISO9001-qualified-to design and manufacture ruggedized hybrid DC-DC converters for customers of IR's HiRel Business Unit. "IR's new San Jose facility underlines our commitment and investment in ongoing R&D, enhanced design, and world-class manufacturing to deliver high-performance solutions and to be the vendor of choice for our customers," he says.

Hi-rel avionics

"We continue to see the influence of lower-voltage processors driving our customer base, which includes a broad base of worldwide designers in the high-reliability avionics, military, and space markets, to develop power conversion designs that are extremely efficient, of a small size, and cost effective," notes Michael J. Bosmann, senior vice president of sales and marketing at VPT Inc. in Everett, Wash. To meet these challenging design demands and the high-reliability and performance needs of these markets, the company offers power electronics solutions such as its DVPL point-of-load

(POL) converter. Reportedly the only MIL-PRF-38534 Class H-qualified product of its kind, the hermetic, hi-rel converter is designed to address low-voltage, reliability, performance, and cost concerns.

VPT's power conversion devices have been employed in high-reliability applications in more than 25 countries. Its power electronics have been adopted by the GPS II Satellite program, several NASA and ESA (European Space Agency) projects, Japan's new P-1 aircraft, and the F-35 fighter jet.

VPT has added several new output voltages to existing product lines to meet the trends of specific voltages for newer military and avionics systems.

For high-reliability commercial avionics and military applications, VPT boasts a line of hermetic devices qualified to MIL-PRF-38534 Class H. Hybrid microelectronic solutions can be cost prohibitive, so the VPT series combines most of the proven topologies and design approaches used in the hybrid devices with lower cost, automated SMT (surface mount technology) assembly, and non-hermetic packaging to meet the cost goals of many projects-such as ground applications, military vehicles, and non-flight critical avionics systems. VPT has also expanded its line of radiation-tolerant and radiation -hardened products for the space market with a new 100K RAD TID point-of-load converter.

"Designers are requesting slightly different voltages to power their systems today," Bosmann continues. "In the past, 5V, 12V, and 15V were the voltages required by most systems. Today, designers are frequently requesting voltages of 6.3V, 7V, 8V, 9.5V, 18V, and others. In some cases, they are allowing for the diode drop or similar drop by utilizing slightly higher voltages. As a result, VPT is adding additional output modules to many of its most popular families of DC-DC converters.

"A company needs to remain flexible in its approach to serving the power conversion electronics needs for the mil-aero applications of the future," advises Bosmann. "Our research and development in process technology is focused on improving performance and reducing cost, whether in material, process time, or both. The one constant in this market, however, is always high reliability. Improving reliability is paramount to everything we've done in the past and will do in the future."

Saving time and money

"It may seem like a difficult goal at times," Bosmann says, "but I have always believed that shortening time to market and reducing costs while improving performance are the driving forces in all markets."

Keith Nardone, director of business development, Aerospace-Defense, Vicor, agrees. "I would say the industry trend is toward reducing development time and cost, while improving total system performance."

In the future, size, weight, and power (SwaP) will continue to be key features that end users and power electronics suppliers continually seek to optimize. Nardone says, "I expect system designers to continue to pack more electronics into smaller places, which will carry on the challenge to the power industry to develop leading-edge products to meet these difficult environments."

Systems designers and integrators will also seek out components or complete power systems with configuration flexibility, such as a wide selection of input and output voltages, power levels, and mechanical options, as well as high efficiency, low noise, ease of use, and high reliability, Nardone explains. Finally, he says, "budgets will continue to be squeezed over time and companies will be tasked to do more with less. It may force system designers to rely more on the power industry to provide complete power solutions, but without the high cost of a typical new development item (NDI)."

Whatever challenges lie ahead, providers of power electronics, systems developers and integrators, and warfighters will meet them head-on and powerfully.

More Military & Aerospace Electronics Current Issue Articles
More Military & Aerospace Electronics Archives Issue Articles

People who read this article also read the following:

- F-35 avionics: an interview with the Joint Strike Fighter's director of mission systems and software
- Pascall Electronics chosen to provide power supply electronics for in-flight entertainment systems
- FAA moves to establish research center of excellence for airport safety technology
- Future is looking brighter for electronic flight bags (EFBs)
- Curtiss-Wright moves to establish itself as embedded computing systems powerhouse with acquisition of backplane enclosure supplier Hybricon

Most Popular Articles

Future looks brighter for electronic flight bags (EFBs)
F-35 avionics: an interview with the Joint Strike Fighter's director of mission systems and software
Future is looking brighter for electronic flight bags (EFBs)
Lockheed Martin to provide airborne surveillance system to Finnish Air Force
in brief