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More power to ground vehicle systems

By John Wemekamp

As the roles and missions of ground vehicles become more complex, the demands placed on their electrical power generation and distribution systems have increased dramatically. Even light, high-mobility vehicles, such as the ubiquitous High Mobility Multipurpose Wheeled Vehicle (HMMWV), are being mounted with sensor, weapon, and communications systems requiring much greater generating capacity than they were originally designed to provide. Most existing vehicle electrical systems are based on 28 VDC, but this does not scale well in size or weight when asked to deliver the tens of kilowatts needed to meet future expectations.

In addition to weapons, sensors, and mission electronics that are becoming part of the regular vehicle fit, dismounted soldiers are heavy consumers of electrical power. This is particularly true when they are away from base overnight, needing lighting and heating plus recharging of the many portable electronic devices they are obliged to carry. The traditional solution is to trailer-in mobile generators and fuel, but significant savings in logistics and cost could be leveraged using in-vehicle generating capacity.

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Electrical requirements

The electrical needs of a typical light utility vehicle such as an HMMWV can be met with a 28 V, 50 A alternator providing all that is needed for driving, lighting, crew comfort, and battery charging. But future needs, including support for dismounted soldiers, can already be anticipated in the order of 10 kW, requiring 400 A or more at 28 V. Unless exotic, expensive materials are used in its construction, a 400 A alternator becomes disproportionately large and heavy and will, therefore, dissipate much extra heat. The weight and cost of cabling to distribute this amount of power within the vehicle also become prohibitive; even if discrete bites are taken from the 400 A to distribute it to individual subsystems, the total, if distributed over any distance, will still add up to the same weight and cost. For these reasons, many new or upgrade vehicle programs are considering generating and distributing power at a much higher voltage, such as 600 V.

But it is still most likely that automotive systems will continue to be based on 28 VDC, hence 600 V will need to be down-converted to a number of other voltages. Power conversion units such as the example shown in Figure 1 can be positioned at as many locations as required within the vehicle and can be designed to be the most cost-effective or efficient for each intended application. For example, 28 VDC automotive components are very tolerant of regulation and electrical noise. However, power for the electronic systems and dismounted soldiers will need to be better quality and converted more efficiently to reduce overall heat dissipation. There is probably no intrinsic reason why 600 V could not be distributed directly to the vehicle's electronics architecture. But much COTS-based equipment – whether designed for rugged military or commercial use – will operate from 110 VAC, 60 Hz, making this an obvious choice for additional conversion. The 110 VAC will also be required by the dismounted soldier, offering the scope to convert within the vehicle or even remotely outside the vehicle at the point where it is required.

Future systems

Even with its inherent benefits, 600 V is still a potential safety hazard and requires extra insulation, conductor spacing, and personnel protection in addition to the extra logistics, maintenance, and training that any new technology introduction will bring. There is also the potential for unintended electromagnetic emissions at the chopping frequencies of the converters due to the size of the voltage swings. Power system architecture and physical layout will require continued refinement to avoid the creation of any unwanted electromagnetic signature.

Figure 1

Generating power at 600 V will help to resolve many SWaP issues of new vehicles, allowing the extension of their capability and mission envelopes. This will be applicable not just to light, high-mobility vehicles, but also to many other land vehicles with large power generation and distribution requirements. An advantage is the ability to share common converter, distribution, and power management technology across a range of vehicle sizes. Just as the weapon, sensor, and mission systems will become more powerful and dissipate more heat, so will power and heat management systems need to evolve with them. This will then lead to the possibility of new cooling technologies such as liquid cooling in order to make further gains in efficiency, weight, and space saving. Curtiss-Wright Controls Embedded Computing (CWCEC) is using its experience in developing armored vehicle power systems to introduce the new technologies and distribution solutions needed to apply this next generation of efficient, high-voltage, power generation systems.

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