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48V Vehicle Systems Becoming Significant
IDTechEx
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By Dr Peter Harrop

Analysts IDTechEx Research almost completely rewrote their report "Power Electronics for Electric Vehicles 2015-2025" (www.idtechex.com/power) this year and frequent updates take place, such is the pace of change. Part of the new scenario is the rapid electrification of conventional cars without them becoming strictly electric vehicles because they do not have an electric motor exclusively propelling them along some or all of the time. That brought us to the hot debate about 48V systems replacing 12V and 24V ones as much larger batteries are needed and compatible 48V components are arriving from multiple sources.

Conventional vehicles at 48V

Conventional vehicles with an internal combustion engine as the sole traction power have become more electric over the years for many years. That includes mild hybrids which, despite the name, are not electric vehicles because the wheels are never driven electrically.

Firstly, customers demand more and more electrical and electronic devices. Consider the increase in number of electric servo motors and actuators for seat adjustment remote opening of the trunk and so on. Add the increase in electronics such as new telematics. This trend continues with 2015 models sometimes having an inductive charging system for your mobile phone and stop-start systems are becoming the norm.

Already, the battery can have a drain of 500W. The increase in electrification will continue. For example, the Torque Assist Reversing Alternator (TARA) systems near to market introduction need to store the harvested energy and deliver it rapidly on demand. Other new energy harvesting modes are coming in such as energy harvesting shock absorbers and variants providing active suspension and photovoltaics will cover more of the vehicle. It all adds up to a need for more power to be stored on a conventional vehicle, even including some conventional small ships and aircraft, as they become more electric and electronic.

There are three favourite ways of increasing the amount of energy storage. Enlarge the 12V battery, add a lithium-ion 48V battery and distribution system and thirdly have that lithium-ion battery alone. In each case a supercapacitor may be added to give better power density in and out and sometimes protect the battery. The reasons for 48V include increasing the voltage to reduce losses in the distribution system in the vehicle and yet staying under the 60V or so where regulations become onerous.

Tier One suppliers and OEMs in the automotive industry are keen to get into 48V conventional vehicle systems. Some say affordable 48V components will soon appear from reputable large suppliers and 48V conventional vehicles will be commonplace within five years. The global thrust towards 48V was seen at EVS28 in Korea this year. For instance, one poster display concerned "Development of High Efficiency, Bi-directional DC/DC Converter for 48V-12V Dual Voltage System in Vehicle". 48V lets it be more efficient.

Audi will introduce 48V electrical architectures to its vehicles to improve efficiency. It will use a dual 12V/48V system, which will allow engineers to integrate systems such as electrical booster technology – which has been showcased on Audi's RS5 diesel concept vehicle. The vehicle is fitted with an electrically powered compressor that operates independently of the engine load, and helps improve acceleration performance.

Audi's member of the board for technical development, Dr Ulrich Hackenberg, said: "We are using the full bandwidth of electrification in our drive principles strategy. Running part of the vehicle electrical

system at 48 volts plays a central role in this. It enables us to make more energy available. That paves the way for new technologies with which we can make our cars more sporty, more efficient and more convenient to use."

Current 12V electrical systems are reaching their limits and, at low temperatures, static-load components can account for the entire power generated by the alternator – up to 3kW.

Audi's solution is a secondary subsidiary electrical system running at 48V, to complement the traditional power supply. The higher voltage means smaller cable cross-sections make architectures lighter. The 48V system features a new lithium-ion storage battery and a DC/DC converter integrates the 12V electrical system.

Audi said: "The lithium-ion battery operates in conjunction with a new alternator. Within this concept there are diverse ways of starting, controlling and deactivating the combustion engine as needed. The powerful alternator achieves an energy recovery output of 10kW. That adds up to a saving of up to 10g/km CO_2, equivalent to around 0.4 litres/100km."

In 2015, the Advanced Diesel-Electric Powertrain project, known as ADEPT, is a ground-breaking 48V mild hybrid under development by some of the UK's leading automotive technology companies and academia, led by Ricardo and Ford joined by CPT, EALABC, Faurecia and the University of Nottingham. On another front, CPT SpeedStart is a new advanced motor-generator system, validated for two million stop-starts, offering significant additional functionality for 48V mild hybrid applications including torque assist for launch and low speed transient acceleration, optimised motorway cruise conditions with electric assist 'load point moving' and a leaner fuel calibration, in-gear coast-down and the ability to harvest significantly more kinetic energy from regenerative braking compared with 12V stop-start systems.

Many argue that 48V confers the advantages of hybridization without the complexity. Such systems more effectively capture a vehicle's braking energy, provide more power for a growing list of electrical loads, and boosts fuel efficiency -- possibly 15%.

"We believe that, by the end of this decade, 48V will become a significant part of the market," Craig Rigby, vice president of product management strategy for Johnson Controls Inc., which has developed a 48V product, said in 2014. "It's probably the next technology after start-stop that will make sense for the mass market consumer."

Employing a dual-voltage architecture, Johnson Controls' Micro Hybrid battery system would use a low-voltage lead-acid battery and a 48V lithium-ion unit. One 48V configuration, supported by a number of automotive suppliers, takes a 12V network using a conventional lead-acid battery and adds a 48V lithium-ion battery with a separate 48V network. The 12V network handles traditional loads: lighting, ignition, entertainment, audio systems, and electronic modules. The 48V system supports active chassis systems, air conditioning compressors, and regenerative braking.

"There's a size and weight advantage to using a lithium-ion battery," Rigby said. "Back in the '90s, we were looking at stringing three lead-acid batteries together to get that voltage."

More importantly, the 48V lithium-ion battery has more charging capability, making it a better candidate for capturing regenerative braking energy. "It really comes down to the notion of regenerative braking -- harvesting the kinetic energy from the vehicle during deceleration and storing it in the battery."

Most recent interviews

Ongoing interviews by IDTechEx across the world reveal that new power electronic systems are being designed on the assumption that 48V systems will be adopted for conventional cars in the next five years. For example, Levant Power, an MIT spinoff, is developing energy harvesting active suspension that needs no separate electricity input because the energy harvesting shock absorbers in the vehicle both create the electricity and use it, the shocks acting as active suspension. Founder and CEO Shakeel Avadhany told us that he believes that 48V is coming in soon for safety reasons. His systems

will be compatible.

Honda says that all major motor manufacturers are working hard on 48V. IDTechEx visited a senior executive in another of the top automotive companies recently. On a non-attributable basis, he said that 48V is definitely coming in within the next five years and it will go to entirely 48V, the 12V PbA with 48V Li-ion dual systems being only an interim stage.

Advanced lead acid battery company Energy Power Systems in Michigan advises IDTechEx that 42V and 48V systems are definitely coming in soon for reasons of cost, since motors and inverters can be smaller. Its lead acid batteries have exceptional cycle life so stop-start on conventional vehicles is a good application. This and other needs for extra storage are leading to advanced lead acid batteries or supercapacitors being used for stop start and then one large battery for everything. EPS claims to be the only lead acid battery company making a single cavity 48V battery for this new need. The interim stage of a 12V and a 48V system will not endure and will often be bypassed, the company said.

Electric vehicles at 48V

IDTechEx has been tracking how the voltage trends for electric vehicles have been moving inexorably upwards in order to capture the efficiency now that high voltage motors are viable. The slowest to move have been saturated old markets like golf cars often staying at 24V. Next come maxi-scooters typically at 74V and hybrid and pure electric cars at 100 up to the 375V of the Tesla models with some of the most advanced technology in volume production. Then we have Hummer, Frazer Nash and the 2014 hybrid Ferrari "LaFerrari" top performance car at 500-550V then record-breaking motorcycles and cars, experimental agricultural vehicles, road vehicles such as buses, military and others at 650-700V. Energy Power Systems said that 400V is good today and 700V systems are becoming good.

Nonetheless, a contrarian approach is coming in with the European Community FP7 SAFEDRIVE program seeking low voltage such as 48V to make it easier for small OEMs to make small volume industrial and other EVs. A common platform is sought for small cars, heavy goods and utility vehicles. IDTechEx is less optimistic about 48V EV systems in EVs beyond those using lead acid batteries such as golf cars and some car-like microEVs such as the new Toyota lead acid pure electric microcars that have potential for 300,000 just for postal services in ten countries of Europe, says the company. In addition, pure electric golf cars are variously on 24V, 36V and 48V systems. In larger vehicles, 48V may find some place however. For more see the IDTechEx Research report, "Power Electronics for Electric Vehicles 2015-2025" and attend the parallel IDTechEx conferences Energy Harvesting and Storage and Electric Vehicles: Everything is Changing in Santa Clara, California, November 18-19.

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