48 Volt Technology: Development & Drivers

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Introduction

Back in 2011 the five premier German car manufacturers, Audi, BMW, Daimler, Porsche and Volkswagen, announced their agreement to jointly incorporate a variety of architectural components for on-board power networks into their vehicles. The five OEM's expressed their intention to implement a 48-volt power supply, and appealed to suppliers to actively engage in research and development of components for vehicles with a 48-volt electric system.

The concept of a higher voltage for E/E systems was under discussion as much as 15 years ago in regard to a 42-volt system, and although the idea was not taken further originally, the vehicle manufacturing landscape has changed significantly since then. When higher voltages were first being considered, the driving factors were predominantly comfort functions within the vehicle, but today there is a more pressing need for electric vehicles, and a much broader base of powertrain and chassis functions which could also benefit from a 48-volt supply.

Despite the potential benefits, the 42-volt system was ultimately unsuccessful due to the high cost of components and the lack of a real driving force for development. In today's market components are much cheaper, technology has improved considerably, and the need to reduce CO_2 emissions is a substantial driver for the concept. The challenge for OEM's and suppliers is to create an inexpensive alternative to hybrid vehicles, which will provide a significant reduction in CO_2.

What did happen to the 42 volt system?

In the early 1990's there was a lot of excitement around the introduction of a 42V power supply, initially intended to augment the 12V in passenger vehicles.

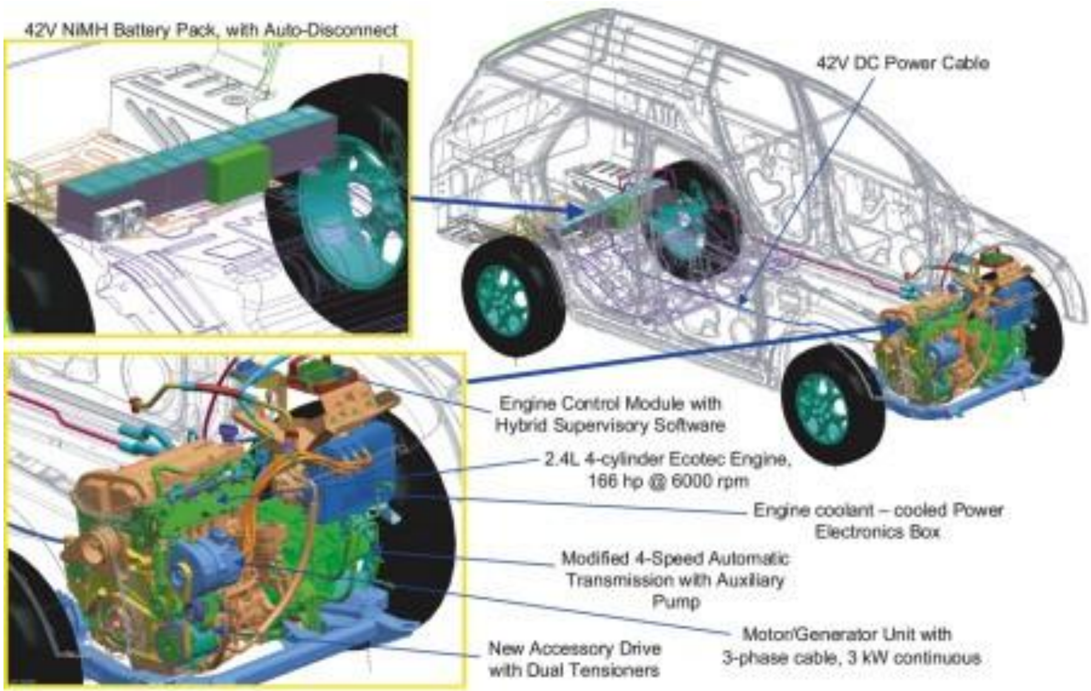

Image credit: Autobloggreen

However twenty years on and the 42V didn't materialize – even though a few vehicles did make it into production. The main reason was because engineers found ways to limit power consumption, implement intelligent power control, install buffers and increase the capacity of on board generators.

These improvements made the need of a 42V system, with the incumbent extra costs, redundant.

In light of the above developments the question has to be asked as to why a 48V system woul d be under consideration 20 years later.

The answer lies in this comment by Frank Briault, a PSA engineer: “An increase of onboard electrical needs alone won’t justify changing the voltage network…But each gram of CO2 which is saved, we accept [having] to pay for that.”

Driving the change toward 48 volts

The European regulations for CO_2 emissions require 95% of an automakers' fleet to achieve targets of 95g/km by 2020 and 100% by 2021. The introduction of real driving emissions regulations will also increase the difficulty of meeting emissions targets. With further reductions on the horizon, 48-volt technology for the powertrain is a key issue. Stop-start technology, exhaust gas energy recovery and kinetic energy recovery can produce greater CO_2 reductions with a 48-volt supply, and there are many other possibilities for improved fuel efficiency with a higher voltage supply.

Whereas there was no substantial financial penalty/ reward to offset this cost in the 1990's, the penalty for 3 g of CO_2 above the limit of 120 g now costs 45 € per vehicle, and would be an incentive to fund the additional hardware required by the tandem 48V architecture.

Start-stop systems already push 12V technology to its limits, and when used in "mild hybrids", 10 to 15 kW will be required. At these levels current draw would be 1000 A and require cables of 10 to 15 mm. This, obviously, is not feasible.

It must be remembered that both the 42V and 48V systems were/are auxiliary systems linked to the 12V supply by a DC/DC converter - meaning a duplication and vehicle on-cost.

According to Wolfgang Bernhart, an expert in electrified powertrains at Roland Berger Strategy Consultants, recovering energy during braking or deceleration with 48V is twice as efficient when compared to 12V. He says: "If you can save 5%-10% with 48V, you could only save 2.5% to 5% with 12V. And with 12V, boosting would be zero."

Challenges facing the 48V power-net

Unlike the 1990's when American manufacturers were actively involved in the architecture of the 42V system, at this time there's no concerted effort to join their European counterparts.

The risk is that cost is often driven by volumes and should America not follow the 48V route, production volumes of critical components will be curtailed. This means development, test and validation costs will be borne by a smaller production volume, resulting in higher piece prices.

At the moment, the 48 volt portfolios of most suppliers are limited which in turn limits the differentiation of products that can be offered to consumers by the car manufacturers.

Another concern to be noted is that, for voltage ranges beyond 60V, extensive measures need to be taken to ensure the safety of occupants of the vehicle. The new specification of the 48V voltage range composed by Audi, BMW, Daimler, Porsche and Volkswagen was cautiously defined to stay below 60V. The over-voltage ranges of around 52V to 54V are considered to be low enough to fulfill the limit of 60V DC with respect to all tolerances. Relay, switch, and conductor arcing are problems that must also be addressed.

Light bulb manufacturers may also face a challenge in that the filament required with a 48V supply (If the vehicle is one day standardized to 48V) will need to be extremely thin. This will result in the filaments being prone to failure when subjected to vibration. However, bulb-based technology would not realistically be used in these vehicles as a migration to LED lighting has already occurred. LED-lights will profit by a definitely higher supply voltage due to the circuit design of LED strings which have to be supplied by voltages significantly higher than 12 V.

Using 48V systems opens up numerous opportunities to improve emissions and fuel consumption while not sacrificing performance.

Opportunities in adopting the 48V architecture

Speakers at the ICE Powertrain Electrification & Energy Recovery conference in May 2013, estimate that 70% of new cars in Europe in 2020 will need electrification to meet the European Union's goal of 95 g/km of carbon-dioxide emissions. And synonymous with electrification will be the 48V power supply.

An ICE car with front wheel (conventional) drive can easily be equipped with an electric drivetrain on the rear wheels. Because electric motors have high torque at low speeds, even two motors of 15Kw would greatly enhance the performance and efficiency: A relatively easy and economical way to make a hybrid vehicle.

The introduction of 48V will also bring the industry one step closer to producing the "beltless" engine. It would be possible to power ancillaries such as HVAC, engine coolant pump, oil pump and even the recently released electrically powered super charger, with electric motors. This would significantly reduce the power losses of the ICE, while utilizing the superior efficiency of 48V electric motors.

Over and above the advantages already mentioned there are also positive spin-offs to be had in electronics – although this may be held over until the vehicle switches from tandem 12/ 48V systems to a single 48v power-net.

Many of the ECUs and transceivers designed for the 48V on-board power supply are based on CAN and FlexRay networks. While General Motors and German OEMs are the major proponents of the FlexRay architecture, CAN is more commonly used; hence 48V CAN transceivers will open the doors for a whole new set of OEMs to adopt the supplementary on-board power supply.

Real world examples

LC Super Hybrid

Source: CPT/ALABC

The energy-efficient 48-volt LC Super Hybrid has been designed by The Advanced Lead-Acid Battery Consortium (ALABC) and Controlled Power Technologies (CPT), and a demonstration vehicle is being showcased in 2013, to follow up the 12-volt demonstrator unveiled at the Geneva Motor Show in 2012. The 48-volt vehicle offers additional functionality to assist with fuel economy and CO_2 reduction, including torque assist to the petrol engine for launch and low speed transient acceleration. Other features include optimised fuelling during idle and motorway cruise conditions with electric assist 'load point moving' and a leaner fuel calibration, in-gear coast down, and the ability to harvest more kinetic energy from regenerative braking.

The vehicle, which combines ALABC's advanced lead-carbon battery with CPT's SpeedStart motor-generator system, is based on a 1.4 litre VW Passat family saloon. The new generation of advanced lead-carbon batteries incorporate capacitive negative electrodes with added carbon, which are able to absorb high current pulses of brake energy and discharge high current pulses for frequent engine cranking and torque assist.

The technology was conceived by CPT and ALABC to show that significant reductions on CO_2 can be achieved through electric hybridisation at low voltages (12-48 volts), complemented by high power density advanced lead-carbon batteries. This technology could offer manufacturers the potential to produce petrol-powered vehicles with impressive performance and fuel economy at a substantially lower cost than an equivalent diesel or high voltage (200-600 volts) hybrid.

Johnson Controls Inc.

Source: Johnson Controls 48-volt Micro Hybrid Battery

Johnson Controls Inc is a leading supplier to the automotive industry, and earlier this year showcased a 48-volt lithium-ion micro hybrid battery demonstration module at the Hannover Messe. The battery will be used in conjunction with a 12-volt starter battery and will enable greater energy and power efficiency while keeping overall system costs to a minimum.

The maximum power of the micro hybrid battery would be sufficient to power electric air-conditioning systems, active chassis control, storage and recuperation of brake energy, and to supply power to the

drive system. According to Johnson Controls, the use of the 48-volt battery can also provide a 15-20% saving in fuel.

Summary

Unlike past developments, whose pace was largely dictated by the OEM's and available technology, the timing of 48V is largely being determined by emission and fuel consumption requirements.

Although at the moment, efforts for introducing the 48V power supply rests mainly with the German OEMs, the entire value chain is trying to get ready for this paradigm shift. Component manufacturers are holding talks with OEMs from other regions to ensure that the investment reaps sufficient returns to justify the enormous fiscal outlay involved.

Sooner or later, many more OEMs are expected to join the bandwagon in implementing a supplementary 48V power supply to support the existing 12V system. Perhaps farther into the future the 48V system will replace the 12V system entirely.