Automotive 48-volt Technology
Close to reality: the series launch of the 48-volt power system

JOHNERIC LEACH
February 2016
ABOUT Automotive

Since 2002, our exclusive network of industry specialists has ensured an unrivalled resource to bring you comprehensive coverage of the automotive supplier industry. Each report gathers individual perspectives from within the industry, and formulates ABOUT Automotive’s own definitive forecasts, generally to a 5–7 year horizon.

All ABOUT Automotive authors have a proven track record, having written for leading management consultancies, financial institutions and publishers.

ABOUT Automotive reports are used by the major automotive suppliers, as well as the leading vehicle manufacturers. They are also used by banks and management consultants, as well as academic institutions.

ABOUT the Author

Johneric has over twenty-one years’ experience in the Automotive Industry and has worked in various areas including R&D, Design, Engineering, Manufacturing Planning and Program Management. His last role before establishing his own consultancy was working as a product line manager for a U.S. Automotive sensors company with specific responsibilities for vehicle dynamic (steering, chassis and braking) and transmission sensors. Johneric’s academic achievements include receipt of a B.Des in Industrial Design (Eng.) from the University of Limerick/NCAD in 1990; directly after he completed a MSc. in Work Design and Ergonomics at the University of Birmingham. In 2012 Johneric was awarded an MBA from Edinburgh School of Business, Herriot-Watt University. With a firm belief in continuous education Johneric completed his Six Sigma green belt training in January 2015. Johneric has been a regular presenter at International conferences covering both commercial and passenger vehicle steering applications. His publications have included a number of papers on transportation sensing in the fields of transmission, chassis level, steering, intelligent transportation and advanced driver assistance systems (ADAS). With a solid command of electro-mechanical assemblies and integration of electronics he has found a niche in the continued electrification of the power and drive train.
1. **A history of automotive electric power supply systems** 1
   1.1 Introduction 1
   1.2 Historical development of vehicle power supply systems 1
   1.3 The goal of the 42-volt electrical system 3
   1.4 The switch to a 48-volt standard 4

2. **A transition from 12-volt/48-volt architecture to 48-volt technology** 5
   2.1 Introduction 5
   2.2 The impact of regulations 5
   2.3 Meeting future power requirements 6
   2.4 Fuses 7
   2.5 Connectors 8
   2.6 Intensified terminal corrosion 8
   2.7 Electric arc behaviour 9
   2.8 Identification of higher voltage cabling 9
   2.9 Dual-voltage systems 10

3. **48-volt standards (LV148), regulations and geographic trends** 11
   3.1 LV148 specification 11
   3.2 Future emission legislation 13
   3.3 Europe leads the way 13
   3.4 The North American market 14
   3.5 Japan 14
   3.6 China 14
   3.7 South Korea 15

4. **48-volt electrification enabling vehicle efficiency** 16
   4.1 Introduction 16
   4.2 Vehicle cable harness 16
   4.3 Batteries 17
   4.4 Manufacturing cost implications 17

5. **48-volt mild hybrid applications and developments** 19
   5.1 Turbocharging 19
   5.2 The electric supercharger 19
   5.3 Enhanced stop-start applications 20
5.4 Energy recovery/boosting systems 21
5.5 Electrified rear axle 22
5.6 Active suspension 24
5.7 Transmission technology 26
5.8 The HVAC module 27

6. 48-volt battery and supercapacitor developments 28
6.1 Technology overview 28
6.2 Absorbent Glass Mat (AGM) battery technology 31
6.3 Ultracapacitors/Electrochemical double layer capacitors (EDLCs) 32

7. Major factors delaying 48-volt roll-out 34
7.1 Introduction 34
7.2 Challenges and concerns – an overview 34

8. 48-volt market leaders and their 48-volt projects 37
8.1 Introduction 37
8.2 JAC/Ricardo 37
8.3 Bosch 38
8.4 Audi 39
8.5 Hyundai 39
8.6 Valeo 40
8.7 Continental Corporation 40
8.8 Controlled Power Technologies (CPT) 41
8.9 Aeristech 42

List of figures

Figure 1 The Audi Prologue mild hybrid concept’s 48-volt electrical network 6
Figure 2 The 48-volt Micro Hybrid battery from Johnson Controls 10
Figure 3 Kia Optima T-Hybrid show car 15
Figure 4 Schaeffler PROtroniC Line Audi TT 48-volt concept 23
Figure 5 Advanced Lead Acid Battery Consortium (ALABC) low carbon, low consumption, low cost LC Super Hybrid technology is demonstrated in a VW Passat 29
Figure 6 Ricardo HyBoost concept 38
Figure 7 Continental’s 48-volt diesel Eco Drive technology 41
A transition from 12-volt/48-volt architecture to 48-volt technology

Automotive 48-volt Technology

Figure 1  The Audi Prologue mild hybrid concept’s 48-volt electrical network

The Audi Prologue mild hybrid concept uses a 48-volt electrical network that supplements a conventional 12-volt system: here energy flow for comfort features is shown during idle-stop.

Source: Audi

2.3 Meeting future power requirements

A single, high-voltage 48-volt architecture is the most efficient method to meet future power requirements. The move to 48-volts has an order of magnitude comparable with the change from 6-volts to 12-volts in the 1950s. Issues relating to vehicle infrastructure, the state of component development, and the requirement for all devices to be redesigned to run off 48-volts, will mean a progressive move is necessary from a dual-voltage electrical architecture to a pure 48-volt system. A dual voltage approach provides the flexibility of accommodating both high- and low-voltage loads and smooth transition to 48-volts. There are still some engineers that question the validity of moving to a dual voltage power supply rather than switching directly to 48-volts. But it is hard to escape the thought that if it were so simple, we would probably have had 42-volt technology back in 1996.

The key problem with a single-volt architecture, assuming the feasibility of the technology, is the effort required to convert all systems on the vehicle to run on 48-volts. Independent of the engineering resource required would be massive investment in prototyping, homologation and testing. With typical system fitment today, without routine fitment of energy recuperating technology by example, the
7. Major factors delaying 48-volt roll-out

7.1 Introduction

In November 2015, at the 2nd International Conference Automotive 48V Power Supply Systems, held in Düsseldorf, Germany, Controlled Power Technologies (CPT), a major sponsor of the event, together with leading vehicle manufacturers and Tier 1 suppliers, argued the need for an internationally agreed 48-volt electrical standard. To date legislative standards have not been defined creating some uncertainty in terms of direction, implementation and specification. Whilst this may be a drawback for some participants, the German OEMs who are leading the charge on 48-volt have created their own LV148 standard.

7.2 Challenges and concerns – an overview

Contact erosion is a concern on 48-volt systems due to the high-voltages and necessitates that vehicle manufacturers must upgrade switches with more expensive metals and spring-loaded contacts that jump apart faster to reduce arcing. One could argue that we use higher 120- or 220-volt household switches running 10 to 20 times the voltage in a car, but the difference is the vehicle runs DC and not AC current. The voltage in alternating current wiring swings from 120 volts positive to zero and down to 120 volts negative and back 60 times per second in a sinusoidal wave. Any arcs produced dissipate as the voltage crosses zero 120 times per second, making for a clean break. DC current, on the other hand, remains at its rated voltage. One way to resolve this problem is to run with a dual architecture keeping switches, relays and sensors on a 12-volt network and reserving 48-volt for high voltage requirements only. In time components for direct 48-volt operation will be resolved. The other factor is of course the aftermarket, where the adaption to 48-volt could be even slower; hence maintaining a 12-volt system is a necessity in the near term.

The other impact on 48-volt technology is that innovations such as wire multiplexing and lead-carbon batteries have taken some of the need out of a higher-voltage architecture. One of the key systems understood to require a higher-voltage power supply was electrical power assisted steering (EPAS),
The HyBoost collaboration between JAC and Ricardo commenced mid-2014 and has already successfully passed its mule vehicle development gateway, a major decision event in a 48-volt project. The project team is now working to put into production the HyBoost concept for a JAC vehicle intended for launch in the Chinese market. This launch vehicle replaces the 2.0L MPFI engine with a downsized gasoline 1.5L TGDI unit and couples it with the 48-volt electrical system. The collaboration is also extending to the detailed development of control strategies and software as part of the necessary powertrain systems validation.

8.3 Bosch

Bosch is developing a 48-volt entry-level hybrid system that will be production-ready by 2017. Bosch says that the low-cost system, which enables stop-start functionality and braking energy recuperation, will deliver an approximate 15% improvement in fuel consumption, not only in controlled tests, but also in everyday driving situations. An electric boost feature also enables more dynamic acceleration; the motor generator provides the combustion engine with an additional 150Nm of support during acceleration. Unlike conventional 400-volt full hybrids, the 48-volt system can utilize less expensive components. Instead of using a large electric traction motor, Bosch enhanced the generator to output four times as much power. The motor generator uses a belt to support the combustion engine with up to 10kW. The power electronics form the link between the additional low-voltage battery and the motor generator. A DC/DC converter supplies the car’s 12-volt on-board network from the 48-volt vehicle electrical system.

Bosch is now developing the second-generation of its 48-volt hybrid technology. In the prototype, the more powerful motor generator is connected directly with the powertrain rather than with the combustion engine. This allows the hybrid to provide all-electric driving even at low speeds, for example stop-start traffic,