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Ask the Expert: 48−Volt Automotive Electrical Systems Emerging

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Introduction

Ever since the auto manufacturers switched from a 6−volt battery to a 12−volt battery in the mid 1950's, they have continued to add more electrical and electronic equipment. All of these new accessories have stretched most 12−volt vehicle electrical systems to their limit. The industry is responding by developing a new, improved electrical system using a 48−volt battery. The more powerful 48−volt systems are first showing up on new vehicles called "mild hybrids." Mild hybrid electrical vehicles (MHEVs) use a small internal combustion engine (ICE) and an AC synchronous induction motor to power the vehicle. The discussion here relates to those mild hybrid vehicles.

Figure 1. Jay Nagle
Senior Engineer for the Power Solutions Group Division, onsemi

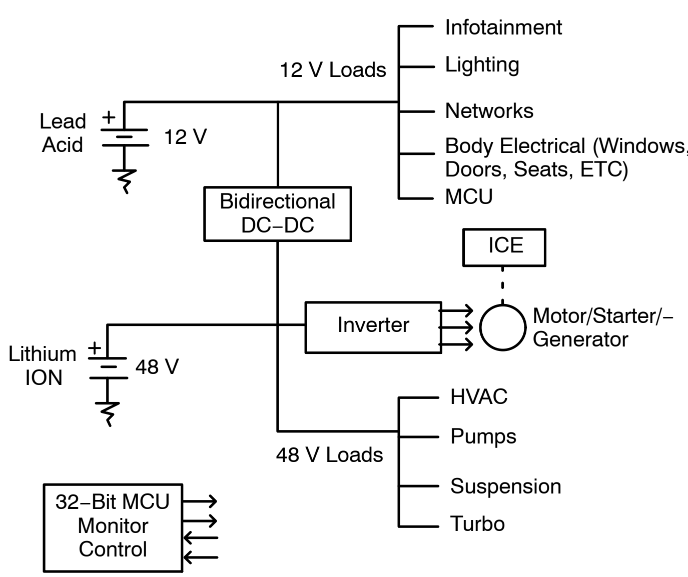
Q. What factors are actually driving the development and adoption of these mild hybrids?

A. The primary driving force is the increasingly stringent government regulations that dictate the reduction of CO2 emissions, improvement in gas mileage, and making the vehicle more environmentally friendly. The Americas, Asia, and Europe are all working toward new rules and regulations. The European region has the most aggressive reduction target compared to the Americas and Asia regions. One solution has been the development of the mild hybrid vehicle with its small ICE and a strong electric motor.

Q. Can a 48−volt battery really deliver enough power to run a MHEV?

A. No, the 48−volt battery cannot propel the car on its own. Its main function is to power the electric motor, or electric machine as it is also called, and give the ICE a boost when starting off. The extra torque makes the vehicle feel like it's a larger, more powerful vehicle. To clarify, there are several different MHEV topologies that are based upon the physical location and connection of the electric machine to the vehicle drive train. These are designated P0 through P4. The P0 configuration has the electric machine connected to the ICE by belt.

The P1 architecture puts the electric machine directly on the crankshaft of the ICE. The P2 through P4 arrangements involve more complex gearing connections. The P0 and P1 arrangements are the most common but do not provide full driving capability with the 48 V battery alone. Then the S/G automatically restarts the ICE when the accelerator is pressed. While some gas mileage savings will accrue, the primary objective of the mild hybrid vehicle is to provide an additional 4%−10% reduction in CO2 emissions compared to traditional ICE vehicles.



This simplified diagram shows the dual 12/48−volt electrical system in mild hybrid vehicles.

Figure 2. 12/48−Volt Electrical System

Q. What does the electrical system of a mild hybrid with its 48−volt battery look like?

A. A simplified diagram of that electrical system is shown in Figure 2. It consists of two power buses, a 12−volt battery and bus to power most of the traditional auto loads, and a 48−volt battery and bus to power the electric drive motor and other higher power accessories. The 12−volt system operates all the usual equipment including the infotainment system, lighting, and body electrical accessories such as windows, doors, seats, etc. The 48−volt system operates the electrical drive motor and any heavy−duty loads such as HVAC, selected pumps, steering, and suspensions systems — and an electric turbocharger if the ICE uses one.

The two major electrical systems are connected to a bidirectional buck−boost DC−DC converter that serves both the 12− and 48−volt buses and an inverter to operate the 3 phase PM synchronous induction drive motor. Some S/Gs are belt driven, while other manufacturers are placing the S/G between the engine and transmission.

Q. When will we begin seeing the mild hybrids with their 48−volt systems?

A. Some vehicles with 48−volt systems are already available. For example, Mercedes and Audi offer cars, and Fiat Chrysler offers the 1500 RAM pickup with a mild hybrid system. Volkswagen will have vehicles soon. Between now and 2025, the number of mild hybrids is expected to grow at least 30% per year and eventually becoming about 10% of the total vehicle market. Industry has determined that the mild hybrid is a good balance between complying with the new tougher emission standards and providing reasonable cost and performance.

Q. How are the batteries usually charged?

A. In the mild hybrid, the 48−volt battery is charged by a belt−driven S/G driven by the ICE or the integrated starter generator. Some charging also occurs during deceleration, regenerative braking, and coasting. The 12−volt battery gets charged by the 48−volt battery via a DC−DC converter. The 12−volt battery can also recharge the 48−volt battery, if required. A mild hybrid is not like a plug−in hybrid vehicle (PHEV) that contains an onboard charger (OBC) and connects directly to the AC line source at home or some convenient charging station to recharge.

Q. What are some of the main electronic components and circuits in this new system?

A. The primary electronic units in the 48−volt system are a three−phase inverter to operate the motor/ starter/generator and the DC−DC converter that ties the 12− and 48−volt systems together. A major control center with 32−bit MCU oversees the whole system. It takes inputs from various sensors around the vehicle and provides the outputs that enable the system.

Q. What are some of the products that onsemi offers to address this new system?

A. onsemi has a broad automotive portfolio that can provide complete system solutions for 48−volt MHEV systems. The central component is the fast discrete silicon power MOSFET. The **onsemi** MOSFET portfolio offers low resistance, low inductance devices in small, cost−efficient packages that help to minimize switching and conduction losses.

This translates into high−efficiency operation of both the inverter and the 48− to 12−volt bi−directional converter in the 48−volt system with lower system costs. These best−in−class devices are complemented with matching gate drivers.

onsemi’s Automotive Power Modules (APMs) are complete pre−wired one−half or three−phase bridge circuits that make it easy to build an inverter for the S/G or any 48−volt motor in the system. The primary benefits of using an **onsemi** APM module in a 48−volt system is that these integrated modules with their compact footprint and high−power density have the ability to deliver high power when needed. This translates to cost and weight savings essential for CO2 emissions reduction.

Additional solutions offered in **onsemi**’s portfolio to provide the “one stop shopping” are:

- A new product line of operational amplifiers optimized for current sensing in the main drive motor and other critical circuits
- High−speed digital isolators
- Gate Drivers
- High−efficiency DC/DC converters
- Transceivers for CAN, LIN, and Flex Ray communications
- ESD/EMI protection components
- eFuse, a protective device that connects between the 48−volt battery and the inverter

Why 48 Volts?

Many have wondered why 48 volts was selected as the new vehicle power source. First, it provides a significant boost in power over a 12−volt system. While a standard 12−volt system can put out a maximum of 2 to 4 kW, the 48−volt system can deliver up to 10 − 20 kW. The higher voltage does a better job of operating heavy−duty devices like pumps, compressors, turbos, and suspension components.

A good source of 48 volts is a lithium ion battery. Higher voltages reduce current levels for a given amount of power consumption. Less current means that smaller wiring can be used to reduce the size and weight of the vehicle wiring harnesses.

Finally, that level of voltage falls right below the threshold of human shock. Most individuals do not feel electrical shock from voltages below 50 to 60 volts. That makes the 48−volt systems generally safe for humans to operate, service, or troubleshoot.

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