freedomCAR & vehicle technologies program

U.S. Department of Energy • Office of Energy Efficiency and Renewable Energy

Oak Ridge National Laboratory

Advanced Power Electronics

Low-Cost DC-DC Converter for Multiple-Voltage Bus Systems

Background

Hybrid electric vehicles (HEVs) and fuel cell_powered vehicles (FCVs) require multiple-voltage bus systems.

The 14-volt electrical system used in automobiles has reached the limit of its electrical load capability. A 42-volt electrical system has been proposed to meet the demands of increasing electrical loads. During the transition to a 42-volt system, most automobiles are expected to employ a 14-volt/ 42-volt dual-level voltage system, in which a bi-directional dc-dc converter is required to connect the two voltage nets. Moreover, to achieve higher efficiencies, a high-voltage (200- to 450-volt) bus is preferred for traction motor drives in HEVs and FCVs. In such a configuration, a dc-dc converter is needed to interconnect the 14-volt and/or 42-volt accessory power net to the high-voltage bus. In FCVs, an energy storage device is also required for fuel cell startup and for storing energy captured by regenerative braking. With a dc-dc converter, a 14-volt battery can be used for this purpose. A triple-voltage bus (14-volt/42-volt/high-voltage) system will therefore be required in HEVs and FCVs before all vehicle auxiliary electrical components are moved to a 42-volt bus.

The Technology

To reduce component count, size, cost, and volume, a project has been undertaken to develop an integrated bi-directional dc-dc converter to interconnect the three voltage bus nets.

The dc-dc converter is based on a dual half-bridge, employing only four switching devices. Soft-switching is accomplished with the help of the device's parasitic capacitances, and enables higher efficiency and reduced electromagnetic interference.

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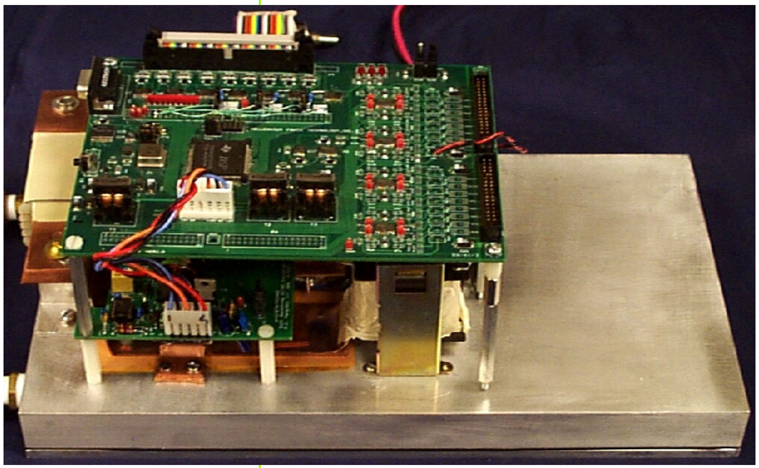

Prototype dc-dc converter: 1.6-kW continuous, 5-kW peak

Duty ratio control, without the use of additional switching devices, is employed for power flow regulation between the 14- and 42-volt nets. This is an advantageous feature, as it will be easy to adapt the converter to a 42-volt/high-voltage bus system by modifying the duty ratio control.

Recent advances in high-power-device technologies have made possible high-voltage metal-oxide-semiconductor field effect transistors (MOSFETs) with significantly reduced on-resistance and high-speed insulated gate bipolar transistors (IGBTs) capable of up to 300 kHz switching. Utilizing high switching frequencies is desirable in dc-dc converters to reduce the size of capacitors and magnetic components. These new power devices will enable reductions in losses and in the sizes of capacitors and magnetic components in dc-dc converters.

Commercialization

Due to the early nature of this work, there are not yet any specific commercial applications. Requirements and specifications for the converters will be sought from automotive manufacturers.

Benefits

- Reduced component count by over 50%
- Soft switching achieved without additional components
- Size and volume reductions due to a higher switching frequency
- Easily adapted to future vehicle power nets

Where Can I Find More Information?

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December 2003