COMMERCIALIZATION ASSISTANCE PROGRAM

Modular High-Power Bidirectional DC-DC Converter For Hybrid-Electric Vehicle Applications

ApECOR

Business Opportunity:

Modern electrified vehicles, including hybrid/electric vehicles feature large energy storage batteries used to power an electric motor drive and store energy from regenerative braking. While power must be transferred between the batteries and the motors, they operate most efficiently at two different voltages.

ApECOR has developed DC to DC converter technology that enables high power density and high efficiency energy conversion – reducing energy lost, system weight, cooling requirements and cost. ApECOR is focused on developing products for the electric and hybrid vehicle systems market. In 2008 nearly 450,000 new hybrid/electric vehicles were registered worldwide, which equates to a rapidly increasing annual DC-DC converter market of over $500 million. The company is seeking strategic partners and co-developers to collaborate in refining and developing this DC to DC converter technology into an end-use product.

Company Background:

ApECOR is an R&D company specializing in advanced power electronics technology, especially high power density, high efficiency, and digital control. ApECOR has a partnership with the Florida Power Electronics Center at the University of Central Florida, enabling the sharing of resources and equipment.

Industry Problem:

Electric vehicle designers, in order to maximize the efficiency of the drive system need to operate the drive motors with a high voltage (500V – 700V); but this is not ideal for the vehicle battery stack. The battery stack voltage is better suited around 300 volts. Since many cells must be combined in series, too many cells in series increases the difficulty in maintaining charge balance and decreases the reliability of the system. A high power bidirectional DC/DC converter is required to efficiently transfer the energy between the battery voltage (300V) and the higher motor drive voltage (700V).

The problem for industry is to reduce the size of the DC/DC converter, increase the efficiency, and increase the allowable coolant temperature. Increasing the DC/DC converter performance will reduce the overall system cost, and increase functionality.

Technology:

ApECOR's solution is a high-power density converter to enable bidirectional power flow from a hybrid/electric vehicle battery to the drive motor. The converter size was significantly reduced by advancing three concurrent technologies: 1) a proprietary control technology enabling a variable-frequency soft-switching design with multiple interleaved modules, 2) an inductor design leveraging nanocrystalline core materials for high density and efficiency, and 3) a heat extraction system combining optimized packaging and spray cooling. By reducing losses, the converter can process high amounts of power, which results in power density 50% higher than current technology. Also, the converter can use higher coolant temperature, which can significantly reduce system costs, since the DC/DC converter doesn't require a dedicated coolant loop separate from the main coolant loop.

Advantages:

ApECOR's technology outperforms the traditional DC-to-DC technology in several important ways:

- High-power density – An increase of approximately 50% power density over typical DC-DC converter designs allows reduced size and weight without reducing system capability.
- High-efficiency conversion – Greater than 97% efficiency levels versus industry standard 93%-95% means less power is wasted as heat, which then must be removed.
- Ability to operate with high coolant temperatures – DC-DC converter operation at higher temperature (100°C vs. 80°C) enables cooling without an auxiliary lower temperature cooling loop, further reducing weight/size and increasing system efficiency.

Differentiating Feature:

ApECOR's digital control technology allows the bidirectional soft-switching DC-DC converter to operate with variable frequency to optimize efficiency, while also operating up to 8 modules interleaved to optimize size and power density.

Stage of Development:

The technology is in a final prototype stage for an electric or hybrid automotive application. The design is being adjusted to improve manufacturability and performance while decreasing cost.

Competing Technologies:

The competitors of ApECOR's technology are commercial-off-the-shelf (COTS) designs (such as those from Delphi) and the internal, proprietary design of the large automobile manufacturers. These current designs utilize more basic control and DC-DC converter technology, resulting in more bulky, less efficient designs.

Applications:

- Hybrid/electric vehicles
- Industrial electric vehicles
- Military electric vehicles – Base logistics vehicles, tactical vehicles.

Benefits:

- Increased system efficiency
- Reduced overall system cost
- Reduced cooling load on the vehicle
- Removed need for auxiliary coolant loop
- Reduced vehicle size and mass
- Faster OEM integration due to digital control

Intellectual Property:

ApECOR has several technology advancements embodied in our design. Some technology ApECOR will be pursuing patent protection for, others will remain trade secrets. The University of Central Florida also has some rights to jointly developed technology, upon which UCF and ApECOR have a signed exclusivity agreement.