Dual Mode Inverter Controller

Advanced Power Electronics

U.S. DEPARTMENT OF ENERGY

ENERGY EFFICIENCY AND RENEWABLE ENERGY PROGRAM

OAK RIDGE NATIONAL LABORATORY

UT-BATTELLE

Transportation

FOR THE 21ST CENTURY

Background

Under the direction of the U.S. Department of Energy (DOE) Office of FreedomCAR and Vehicle Technologies, the Oak Ridge National Laboratory (ORNL) is conducting research and development in motor drives for hybrid electric vehicle (HEV) applications.

Part of the research involved assessing the candidate electric motor types and identifying any barriers to their application in HEVs. Permanent magnet (PM) motors have a very high power density and excellent efficiency relative to other motor types. Compared to an induction motor of the same ratings, a PM motor is about half the weight. While the induction machine has an efficiency in the low 90% range, the PM motor can achieve 95% efficiency. A number of concerns prevent the PM motor from being a primary contender for use in HEV traction drives. One concern is that PM motors will feed electrical faults in the inverter or dc supply system as long as the rotor is in motion. Although motor vendors have made good progress during the past year, a second concern is the difficulty in achieving a wide constant power speed ratio (CPSR) when driving a high power density PM motor. A third concern is that a controller board failure causing loss of firing signals to the inverter transistors results in heavy regenerative braking. Such a failure mode is unacceptable to electric vehicle manufacturers since the affected vehicle could pose a hazard to trailing traffic. ORNL has developed an electronic control which addresses all of these concerns.

The Technology

ORNL's investigation revealed that all concerns about using PM motors in HEVs were associated with the uncontrolled conduction of the bypass diodes in the common voltage fed inverter. To address these concerns ORNL researchers placed an ac voltage controller referred to as the Dual Mode Inverter Control (DMIC), consisting of 3 pairs of anti-parallel silicon controlled rectifiers (SCRs), between the inverter and the motor.

A diode conducts any time that circuit conditions cause a forward bias, but SCRs must be triggered into conduction. In the DMIC circuit, any motor current that flows through a bypass diode must also flow through one of the SCRs. Undesired bypass diode conduction is avoided by control of SCR firing. Control of SCR firing also assures that the traction drive system fails by losing power and coasting, a much safer failure mode than regenerative braking, which occurs with conventional technology.

ORNL, having achieved lab operation over a CPSR of 6, designed and built a DMIC and 20 kW HEV type axial-gap PM motor for performance testing. Preliminary testing at half speed has been successfully completed at a CPSR of 4. Future testing will explore the CPSR limits of this controller

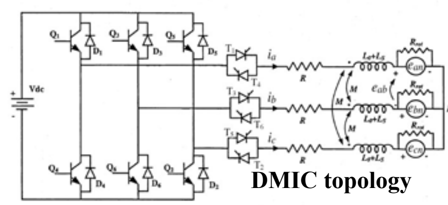
Commercialization

A major car manufacturer has expressed strong interest in exploring the use of the DMIC with low inductance permanent magnet motors for future application as the traction drive system in hybrid electric vehicles.

Benefits

The DMIC makes high power density, high efficiency PM motors viable candidates for HEVs, large trucks, and heavy vehicle applications.

- Can meet CPSR needs of both light-duty and heavy-duty vehicles
- Can be applied to motors with low inductance
- Inductance variation in motors can exceed one order of magnitude
- Provides an electrically safe system.
- Allows design of smaller PM motors



DMIC topology

Performance test of DMIC controller driving ORNL's dual stator 20 kW axial gap PM motor

For more information on how ORNL is helping America remain Competitive in the 21st century, please contact:

Don J. Adams
Director, Power Electronics and Electric Machinery Research Center
Engineering Science and Technology Division
Oak Ridge National Laboratory
(865) 946-1321
adamsdj@ornl.gov

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