Advanced Power Electronics

High Constant Power Speed Range Operation of Switched Reluctance Motors

Background

Off-road electric vehicles, which are required to produce high torque at low speeds, are often also required to deliver constant power as they move between work sites at highway speeds. Traditionally, this has been accomplished with an oversized motor and an inverter. Recent research at Oak Ridge National Laboratory (ORNL) has shown how this can be accomplished with lower cost and smaller size by using a high constant power speed range (CPSR) motor—that is, a motor that can deliver constant power over a range of speeds far above its maximum work site torque speed.

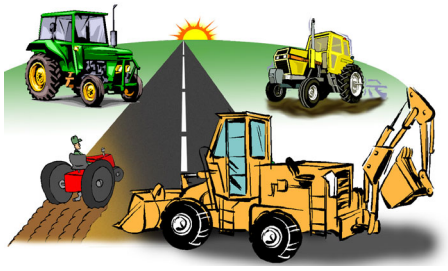
ORNL has identified two high-CPSR motors. One is the brushless dc permanent magnet motor, which uses ORNL's dual mode inverter control. The other is the switched reluctance motor (SRM), which becomes a high-CPSR motor when it is operated in continuous conduction mode.

The Technology

ORNL has been evaluating the conventionally operated SRM for use as a traction drive in hybrid electric vehicles. Current SRM technologies yield high torque ripple and generate more noise than competing technologies. These issues are being investigated to reduce their magnitudes and significance in automotive applications.

The SRM rotor is similar physically, electronically, and electromagnetically to a stepper motor. The use of a stator with a few more salient poles than the rotor ensures that there is always a pair of stator poles to pull the rotor into alignment. Only the stator has windings, and the rotor is just a simple piece of ferromagnetic material with no magnets. In conventional operation the current returns to zero at the end of each electrical work cycle, requiring that the flux linkages be built from zero every cycle. ORNL discovered that by allowing a modest current to continue flowing

Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle



The SRM traction drive for off-road vehicles delivers worksite capacity and, when driven in continuous conduction mode, is expected to move the vehicle at highway speeds between sites.

at the end of each cycle, the buildup time saved could be used to deliver more torque and thus more power.

In FY 2003 a linear magnetics model was developed. This model showed that when the SRM is operated in continuous current mode, it has an infinite CPSR if resistance losses are ignored. This was also demonstrated by a detailed model of the SRM.

ORNL then demonstrated, using one phase of a four-phase typical SRM, that the SRM can be controlled to allow continuous conduction and to deliver a power peak predictably sensitive to advance and dwell angles.

Commercialization

ORNL is entering into collaboration with industrial partners to determine if the increase in specific power achieved by operating an SRM in continuous conduction mode is sufficient for commercialization.

Benefits

- Delivers high torque at low speed and constant power over a wide range of speeds
- Simple rotor has no wires and no magnets, for low-cost manufacturing
- Only stator has windings, for high efficiency
- Environmentally and electrically robust

Where Can I Find More Information?

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