

Technology

Our technology base includes a number of proprietary technologies and patents relating to brushless permanent magnet motors, generators and power electronic controllers, together with software code to intelligently manage the operation of our systems.

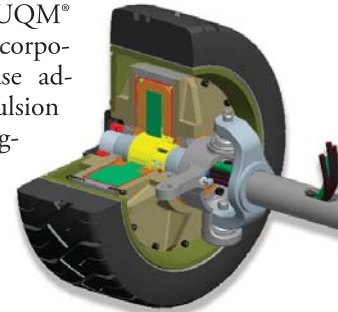
The typical architecture of a UQM[®] motor consists of a stator winding employing a high pole count configuration, which allows for high copper utilization (minimizing energy loss and cost) and a hollow rotor upon which powerful rare earth permanent magnets are mounted on the outer circumference. The stator is affixed to an aluminum housing containing a mounting ring and bearings, which allows the rotor to be suspended within the stator. Commutation of the machine is accomplished electronically by sensing the position of the rotor in relation to the stator and intelligently pulsing electrical energy into the stator such that the electric field generated by the stator interacts with the magnetic field of the rotor, producing rotational motion (motor operation). Conversely, the application of rotational motion to the rotor by an external force results in the generation of electrical power (generator operation). UQM[®] machines can be operated in either a forward or reverse direction of rotation and either in motor or generator mode and can dynamically change from one mode of operation to another in millisecond response time. The hollow design of the rotor permits the packaging of other components such as gears and electromechanical brakes in the interior of the machine. These design features contribute to lower usage of copper and iron and other materials generally (due to smaller package dimensions), reducing manufacturing cost over those for conventional machines of similar power.

In addition, we have developed and patented a method of control embodied in electronic component architecture and software code (Phase Advance Control) which allows UQM[®] motors to deliver both high output torque at low operating speeds and continuous power at high operating speeds from the same machine. Conventional permanent magnet motor designs are limited to operating at either high torque at low speeds or continuous

power at high speeds, but not both. In most vehicle propulsion applications, high torque is required to launch the vehicle from a standing stop transitioning to high

“During fiscal 2007 we began the process to initiate additional patent applications related to technology developments that have the potential to significantly increase torque density for wheel motors...”

power as the vehicle is accelerated to highway speeds. In conventional internal combustion engine powered vehicles, the transition from high torque to high power is typically accomplished through the multiple gear changes performed by a mechanical transmission. UQM[®] motors, incorporating phase advance technology, are suited as propulsion drives in electric, hybrid electric, plug-in hybrid electric and fuel cell electric vehicles due to the ability to power a vehicle from a standing stop to highway speeds without mechanical gear changes, thereby eliminating the size, weight and cost of mechanical transmissions.



Wheel motor for aircraft ground support vehicle

We have also developed a technology that allows our permanent magnet motors to achieve a 10 to 1 top speed to base speed ratio. This technology also provides both high torque and high-speed capability in the same machine, but at levels greater than that of other motor technology. Prior to this performance breakthrough, UQM[®] systems incorporating phase advance were able to achieve a top speed to base speed ratio of 4 to 1. Providing vehicle developers with electric propulsion systems capable of a top speed to base speed ratio of 10 to 1 overcomes a significant limitation and opens up potential new application opportunities for UQM[®] systems.



Silicon carbide based, electronic motor controller

Enhanced methods of electronic control for our permanent magnet motor and generator systems have allowed us to maximize the power output and efficiency of our machines, further improving their performance. These performance enhancements have increased peak power output by 33 percent, continuous power output by 50 percent and system efficiency at various operating points by 2 to 8 percent. In addition, our control enhancements have user configurable functionality and increased data transmission and processing speeds, which improve feedback, prognostics and diagnostic capabilities.

During fiscal 2007 we began the process to initiate additional patent applications related to technology developments that have the potential to significantly increase torque density for wheel motors and allow our motors to operate at higher speeds for application in advanced transmission hybrid vehicles. We also began an internally funded project to increase the functionality of the microprocessor software we use to intelligently control our motor controllers. Some of these enhancements



25 kW export power generator and controller

include torque, speed and voltage control improvements that enable more sophisticated hybrid electric operating strategies, refined generator voltage regulation to facilitate improved battery pack management and further improvements in system efficiency and power output through advances in motor control algorithms. In addition to these activities, The U.S. Air Force has contracted us to manage a research and development project in cooperation with Mississippi State University, directed toward the development of high temperature power switching devices using silicon carbide that may lead to improved power handling capability for our motor controllers.

The majority of our research and development activities are the result of projects contracted with and funded by customers, for which we typically retain intellectual property rights in the resulting technology developed.

In recent years, we have focused our research and development activities on the development of commercial products and production engineering activities to lower the cost of manufacture as well as enhance the performance and capability of our systems, as opposed to basic research in the field. We believe our future growth is dependent, in part, on the continued advancement of our technology portfolio and our ability to commercialize our technology in additional product applications and markets. Accordingly, we expect to continue to pursue additional customer funded programs and to selectively invest in internally funded development projects to accomplish these objectives.