Inverter Proof-Of-Concept Improves Efficiency Of 80-kW Electric Motor

Hillcrest Energy Technologies has completed initial internal testing of its high-efficiency inverter with an electric motor and has released the results in whitepaper available on the company's website. These results demonstrate the ability of the Hillcrest's inverter to improve the efficiency of an electric motor used in EV traction applications. This builds on the results of previously announced tests, which confirmed the ability of the Hillcrest inverter technology to achieve efficiencies exceeding 99% at switching frequencies up to 60 kHz (Figs. 1 and 2).

More recently, new tests were performed using the 10-kW Hillcrest high-efficiency inverter proof-of-concept on an 80-kW electric motor currently used in EV powertrain applications. After running efficiency tests on the motor to establish a performance baseline at the 10-kHz switching frequency, the same tests were run at 20 kHz, 40 kHz and 60 kHz. Results showed motor efficiency improvements at each increased switching frequency level, confirming the ability of the Hillcrest technology to leverage higher switching frequencies without generating additional losses/heat, thereby enabling the electric motor to operate at higher efficiency levels (Fig. 3).

"Currently, electric motors used in electric vehicle powertrains operate within a switching frequency range of 8 kHz to 16 kHz due to the historic tradeoff between the best possible switching behavior and acceptable thermal losses," said Harald Hengstenberger, managing director and founder of Systematec GmbH, a strategic partner to Hillcrest and current power electronics design house to the German automotive industry.

"The ability of the Hillcrest high-efficiency inverter to operate at much higher switching frequencies without generating additional losses will now allow motor manufacturers to take advantage of new motor concepts not previously available to them," added Hengstenberger.

To achieve high efficiency with high switching frequencies, Hillcrest's inverter applies zero-voltage switching (ZVS) implemented with a proprietary control software running on standard microcontrollers. In developing its algorithms, the company says it has overcome problems such as temperature- and load dependent performance, sensitivity to circuit parameters and narrow operating range, which have hampered previous attempts to apply ZVS in inverters. According to the company, their algorithms overcome these problems, enabling a wide operating range while maintaining the required safe operating area.

Leveraging the Hillcrest traction inverter to improve motor efficiency in an electric vehicle powertrain has the potential to reduce motor size and cooling requirements and increase power density. In an electric vehicle, this can result in more power, more payload capability and increased range.

"We are thrilled to see these initial tests not only validate but exceed our expectations in demonstrating the ability of the Hillcrest traction inverter to increase the efficiency in electric vehicle and motor applications," said Hillcrest Energy Technologies CTO Ari Berger. "Combined with our existing test results confirming inverter efficiency exceeding 99% at switching frequencies up to 60 kHz, we are one step closer to demonstrating the ability of our technology to anchor the next generation of highly efficient, high-performance powertrain systems."

The successful tests completed thus far with the Hillcrest proof-of-concept are the first steps in the commercialization testing protocol. Testing of the Hillcrest 250-kW 800-V commercial prototype inverter will commence in the coming months with delivery of a working prototype expected this fall.

While this specific testing demonstrates Hillcrest's efficiency targets in the EV powertrain application, the results indicate similar potential for other target applications, such as grid-tied renewables, charging and storage systems, and other high-voltage/high-power applications. As the world moves towards clean energy and electrification in a variety of sectors, these systems must be as efficient as possible. Future testing will be tailored to these additional applications.

To download a copy of the white paper, "Evaluation Of The Hillcrest High Efficiency Inverter And Implications Of Its Use In A Drive System", see the website.

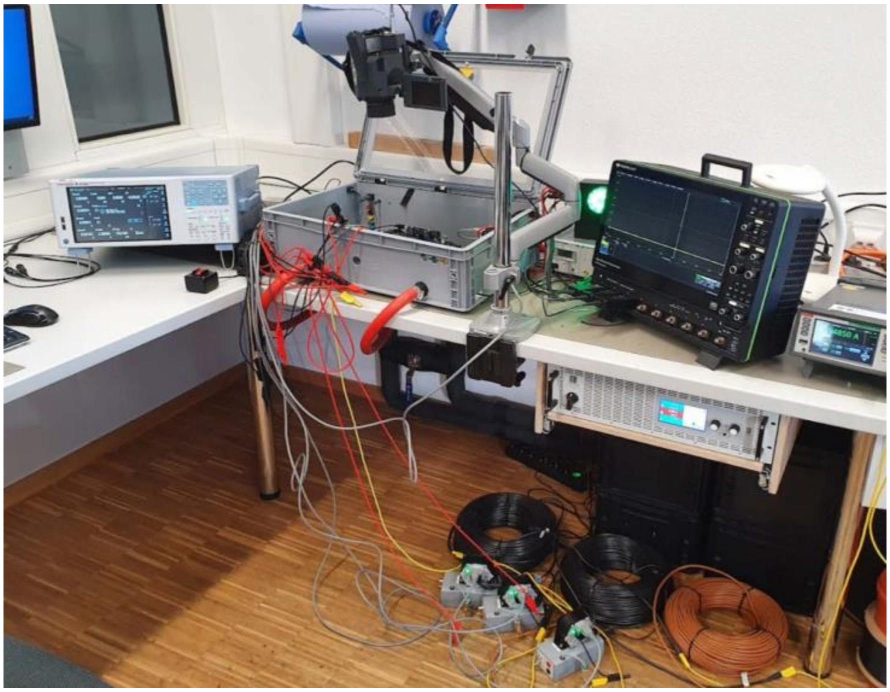

Fig. 1. The Hillcrest inverter proof-of-concept implements the company's proprietary ZVS control algorithm on a TI C2000 microcontroller and uses SCT3160KW 160-mΩ 1200-V SiC MOSFETs from Rohm in the power stage. This inverter achieved significant reductions in losses at higher switching frequencies versus a comparable hard-switched inverter as documented in the white paper.

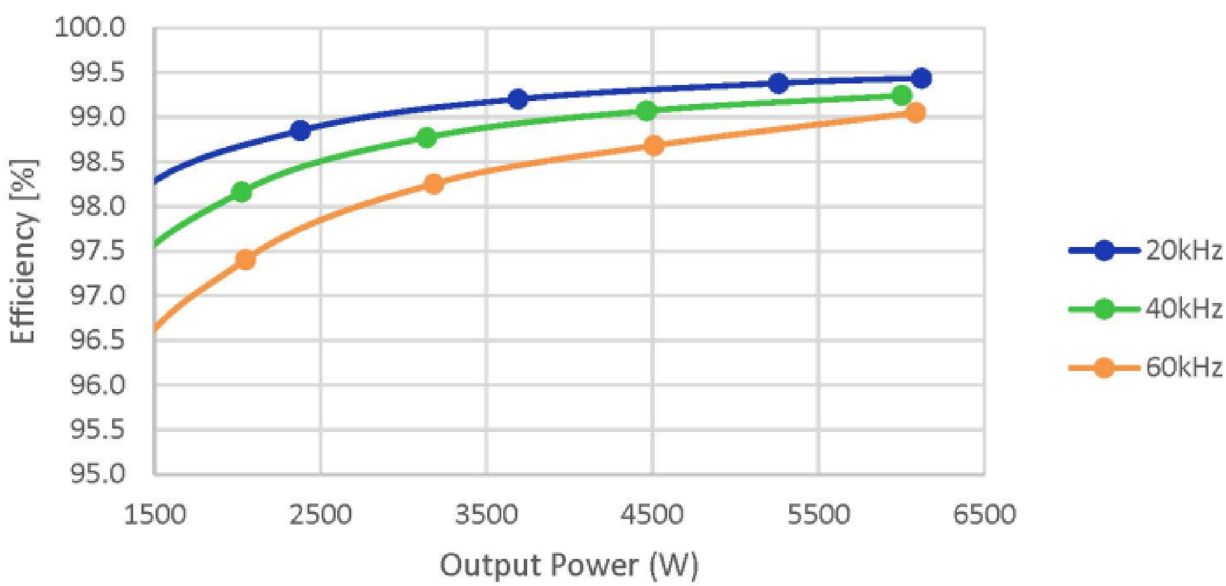

Fig. 2. Efficiency of Hillcrest inverter over various loads and operating frequencies.

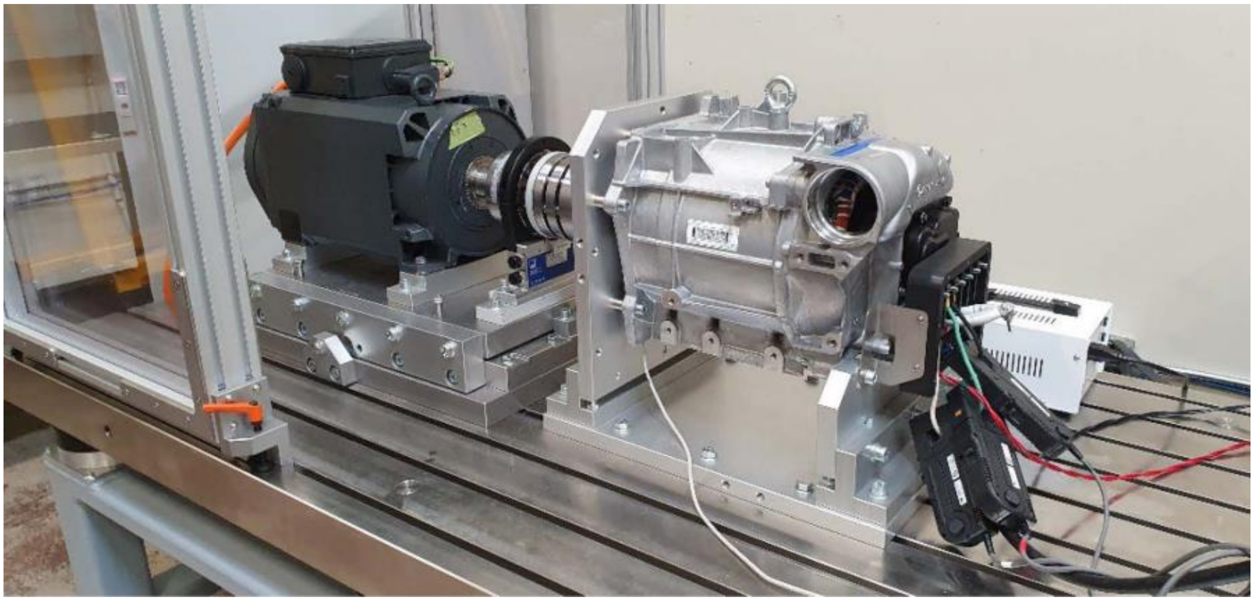

Fig. 3. Raising the switching frequency of the inverter reduces iron losses in the electric motor, improving motor efficiency. It also reduces pulsating torque for better motor performance. The setup shown here consisting of two mechanically coupled machines and a Hillcrest inverter was used to demonstrate these benefits. In this setup, one machines acts as a motor while the other acts as a generator. The Hillcrest inverter controls the 80-kW motor, which is made by Renault. As reported in the white paper, the efficiency of the motor was tested at 7 kW, which is a partial load corresponding to an EV cruising at low speed which represents a condition of low operating efficiency for the motor. The motor was tested with the inverter running at 10 kHz, 20 kHz, 40 kHz and 60 kHz. When compared with the baseline performance at 10 kHz, drive system efficiency was 7% higher at 20 KHz and 14% higher at 60 kHz.