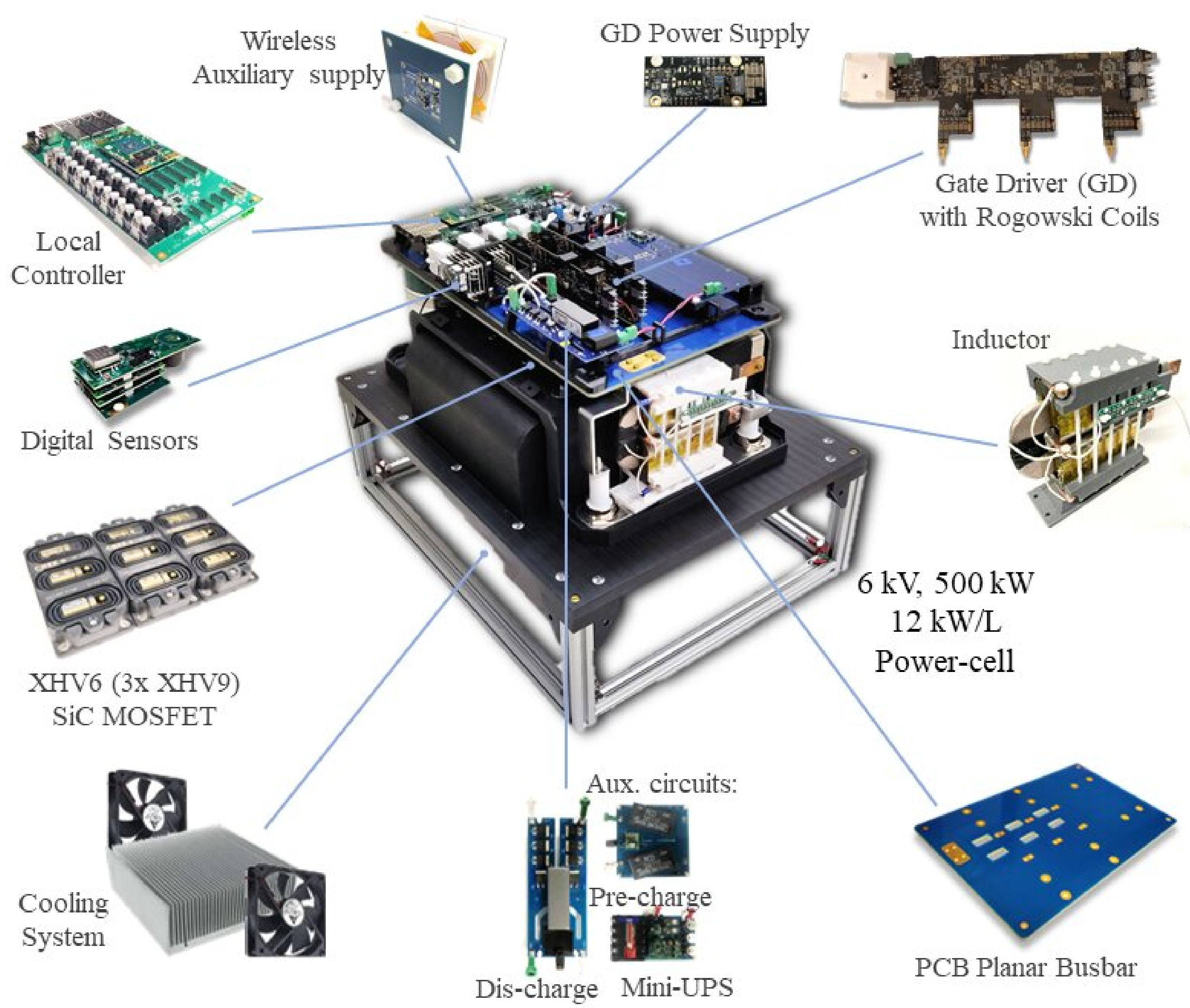
Proposed improvements to SiC MOSFET power converter technology overcome existing challenges

May 13 2022



Credit: iEnergy, Tsinghua University Press

Transistors, which are devices that control or amplify electrical signals and power, are one of the most ubiquitous components of modern electronics. The most widely used transistor is known as the MOSFET, which stands for metal–oxide–semiconductor field-effect transistor. MOSFETs have been in use since the 1960s and have typically relied on silicon to act as a semiconductor. The latest iteration of the MOSFET uses silicon carbide as a semiconductor, known as SiC MOSFET. This has many advantages, but it has not been widely adopted for medium-voltage power conversion. This is because of several challenges associated with SiC MOSFETs that researchers hope to solve by combining novel technologies.

SiC MOSFETs offer many advantages over traditional transistors. Compared to the current technology, SiC MOSFETs can meet the demands of modern electronics by improving efficiency and power density. However, if you were to just switch out the current technology for SiC MOSFETs as is, there would not be enough of a benefit to justify the transition. In order to get the most out of SiC MOSFETs and expand their use across a wide range of applications, researchers employed novel control technologies and strategies to improve how the SiC MOSFETs work in medium-voltage applications.

The techniques were described in a paper published on April 22 in *iEnergy*.

"For medium-voltage power conversion, 10 kV SiC MOSFETS have inherent superiorities, such as high breakdown voltage, fast switching, high temperature operation, and low specific on-state resistance," said paper author Slavko Mocevic, a researcher at the ABB Corporate Research Center in Raleigh, NC in the United States.

Mocevic also described the many practical applications for the technology. "In applications such as electric ships, highly populated urban areas, and, in some cases, renewable energy," Mocevic explained, "often limited and expensive land and space require high-density and high-efficiency converters. If the converter uses a 10 kV SiC MOSFET, the system benefits from higher efficiency, higher switching frequency, high-density, network simplification, and high control bandwidth can be unlocked."

Researchers identified many novel technologies that can help with the adoption of SiC MOSFETs in medium-voltage power converters. These included enhanced gate-drivers, gate-driver power supplies suppressing electromagnetic interference, and the addition of wireless power transfer converters. However, researchers identified the switching-cycle control (SCC) and the integrated capacitor-blocked transistor (ICBT) control methodologies as the most important. "The potential of developed SCC and ICBT control methodologies combined with 10 kV SiC MOSFET devices is enormous," said Mocevic. "These converters fully exploit the advantage of the fast commutation speed and high switching speed offered by SiC. They also strikingly elevate power density and efficiency and relax cooling requirements." Other benefits of this combination of technologies include the ability to utilize both alternating current (AC) and direct current (DC) power, low frequency operation, and unrestricted voltage.

By overcoming challenges like electromagnetic interference, high switching frequency, fast voltage transitions, and the need for high-voltage insulation, the SiC MOSFET technology can be more broadly applied to medium-voltage converters. Looking ahead, Mocevic said, "The immediate next step is to improve performance and fully understand the behavior of this converter to ensure stable operations in all situations for all targeted applications. The ultimate goal is to develop a family of medium-voltage circuit networks that utilize SCC and ICBT control that can fully utilize the power processing capacity of SiC devices. This will effectively tackle the lack of circuit solutions currently barring their adoption."

More information: Slavko Mocevic et al, Design of a 10 kV SiC MOSFET-based high-density, high-efficiency, modular medium-voltage power converter, *iEnergy* (2022). DOI: 10.23919/IEN.2022.0001

Provided by Tsinghua University Press