Silicon Carbide Power MOSFETs Replace Silicon Devices in High Voltage Power Electronics

In a move that heralds a performance revolution in energy-efficient power electronics, Cree, a market leader in silicon carbide (SiC) power devices, has introduced the industry's first fully-qualified commercial silicon carbide power MOSFET. This establishes a new benchmark for energy efficient power switches and can enable design engineers to develop high voltage circuits with extremely fast switching speeds and ultralow switching losses.

The SiC MOSFET can be used today for solar inverters, high-voltage power supplies and power conditioning in many industrial power applications. Over the next several years, SiC power switches and diodes could also expand into motor drive control, electric vehicles and wind energy applications. The market for power semiconductors in these applications is estimated at approximately $4 billion today, reaching nearly $6 billion by 2015.

The addition of the SiC power MOSFET to Cree's world-class silicon carbide Schottky diode family enables power electronics design engineers to develop "all-SiC" implementations of critical high power switching circuits and systems with levels of energy efficiency, size and weight reduction that are not achievable with any commercially available silicon power devices of comparable ratings.

"This introduction of our SiC power MOSFET represents many years of materials research, process development and device design," said John Palmour, Cree co-founder and chief technology officer, Power and RF. "But the end result is that the industry's first 'ideal' high voltage switching device is no longer a future technology – it is commercially available and ready for design-in today. Together with our 600V, 650V, 1200V and 1700V SiC Schottky diodes, Cree Power has established a new class of SiC power components that are destined to lead the power semiconductor industry in the years to come, and eventually replace silicon devices in the majority of critical power electronics applications with breakdown voltage requirements of 1200V or higher."

"Cree's release of the SiC MOSFET represents a major step forward in power technology and enables a new standard in performance and reliability to be reached," said Per Ranstad, Product Manager at Alstom Power - Thermal Services in Sweden. "At Alstom, we have been working with Cree to demonstrate the capabilities of this new device, in particular seeing its impact on energy efficiency in power systems, and we are definitely excited by the results we have achieved to date."

Cree's SiC MOSFET, the CMF20120D , provides blocking voltages up to 1200V with an on-state resistance (RDSon) of just 80m? at 25°C. Setting Cree's SiC MOSFET

apart from comparable silicon devices, the RDSon remains below 100m? across its entire operating temperature range. This consistency of performance characteristics across operating conditions, along with a true MOSFET device architecture (normally-off), makes it ideal for power electronics switching circuits. Compared to commercially available silicon MOSFET or IGBT devices of similar ratings, in tests conducted by Cree the CMF20120D had the lowest gate drive energy (QG <100nC) across the recommended input voltage range. Conduction losses were minimized with forward drop (VF) of <2V at a current of 20A.

The CMF20120D SiC MOSFET provides significant advantages over silicon devices, enabling unprecedented system efficiency and/or reduced system size, weight and cost through its higher frequency operation. It can meet or beat silicon MOSFET switching speeds and reduce switching losses in many applications by up to 50 percent.

Compared to the best silicon IGBTs, the Cree device improves system efficiency up to 2 percent and operates at 2-3 times the switching frequencies. Higher component efficiency also results in lower operating temperatures. Combining these lower operating temperatures with the CMF20120D's ultra-low leakage current (<1?A) adds significantly to system reliability.

Cree's CMF20120D is ideal for high voltage applications where energy efficiency is critical. Solar inverters are an example where SiC MOSFETs can be used in both the boost and inverter sections of the DC-to-AC converters. Switching losses are decreased by more than 30 percent using SiC MOSFETs; and when combined with Cree's SiC Junction Barrier Schottky diodes, overall system efficiency has been demonstrated at >99%.

Similar efficiency benefits can be achieved in other applications that require high blocking voltages in combination with fast, efficient switching, such as industrial motor drives, high power DC data center power architectures, PFC (power factor correction), boost and high frequency DC/DC conversion circuits in industrial, and computing and communications power systems. In addition to potential efficiency gains, the low switching losses of Cree's SiC MOSFETs and diodes can enable design optimization at switching frequencies up to three times those built with commercially available silicon devices.

"Silicon carbide technology is critical to developing the next generation of advanced, energy-efficient power electronic system designs," explained Cengiz Balkas, Cree vice-president and general manager, Power and RF. "We believe that the addition of the industry's first commercial SiC MOSFET will speed the development of smaller, faster, lighter and more efficient power devices in certain critical power device applications, with the potential to reduce global electric power consumption. This MOSFET is the first SiC MOSFET product that Cree plans to release, drawing on our technology and patent base."

Cree has been a recognized leader in SiC MOSFET process and design development for more than 20 years, demonstrating the first vertical SiC MOSFET devices; the first SiC MOSFETs at >600V; the highest voltage MOSFETs ever fabricated (10kV);

and numerous processing developments to enhance SiC MOS interface quality and reliability. Cree has been awarded more than 50 patents on SiC MOSFET technologies, with numerous patents pending.

The CMF20120D power devices are fully qualified and released for production. Samples are available now from Digi-Key (www.digi-key.com [1]). For samples and more information about Cree's 1200V devices or any of Cree's 600V, 1200V and 1700V SiC Schottky diodes, visit www.cree.com/power [2].

For additional product and company information, please refer to www.cree.com [3]

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