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SiC MOSFETs for Offshore Wind Applications

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Summary-

This paper investigates the switching performance of half-bridge SiC MOSFET and Si IGBT modules. Both the modules have same packaging and voltage rating.

Turn-on and turn-off switching energy losses are measured using a standard double pulse methodology. The conduction losses from the datasheet and the switching energy losses obtained from the laboratory measurements are used as a look up table input when simulating the detailed inverter losses in a three-phase grid-side inverter in an offshore wind application.

Simulated inverter loss is verified analytically. The total inverter loss is plotted for different switching frequencies in order to illustrate the performance improvement that SiC MOSFETs can bring over Si IGBTs for a grid-side inverter from the efficiency point of view.

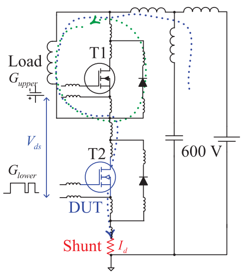
The overall analysis gives an insight into how SiC MOSFET outperforms Si IGBT over all switching frequency ranges with the advantages becoming more pronounced at higher frequencies.

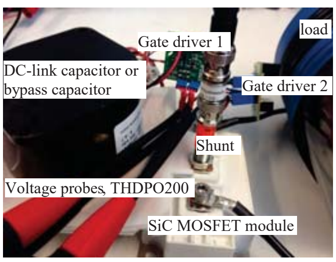
Introduction-

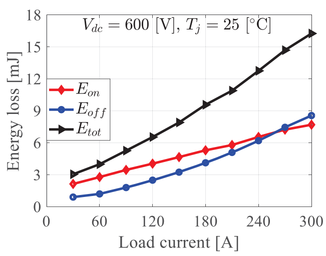
The superior material properties of silicon carbide (SiC) can be translated to switching devices with higher operating temperatures, higher breakdown voltages, lower conduction and switching losses, and higher power density, and thereby fulfil the demand of converters for offshore wind applications. In particular, these converters will be compact, efficient, and thermally stable, and thus can be easily mounted in the nacelle of wind turbine.

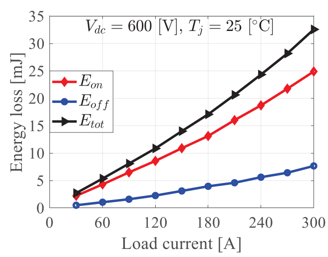
Material properties	Si	SiC	Results
Bandgap (eV)	1.1	3.2 (=2.9 × Si)	Higher operating temperature
Breakdown electric field (MV/cm)	0.25	3 (=12 × Si)	Higher blocking voltage and lower losses
Thermal conductivity (W/(cm.K)	1.5	4.9 (=3.2 × Si)	Increased power density

Laboratory setup and measurement results-







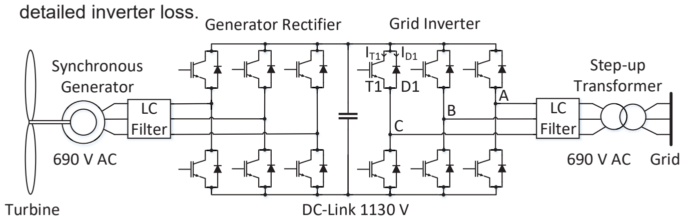


- **Key electrical parameters of SiC MOSFET versus Si IGBT module**

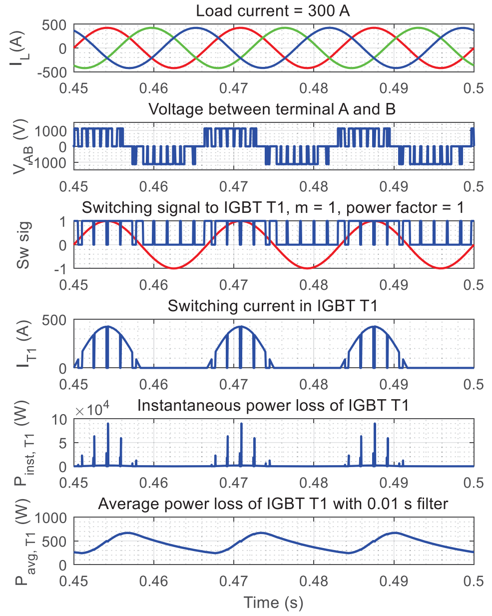
Parameters	CAS300M12BM2 (Wolfspeed) 25 (°C)	125 (°C)	difference (%)	SKM400GB125D (Semikron) 25 (°C)	125 (°C)	difference (%)
R_{ds}/R_{ce} (mΩ)	5	7.8	+ 36	6.3	7.6	+ 17
V_{CEO} (V)	Absent	Absent	Absent	1.4	1.7	+ 17
R_d (mΩ), diode	2.25	4.35	+ 48	2.7	3	+ 10
V_{F0} (V), diode	0.925	0.83	- 11	1.4	1.1	- 27

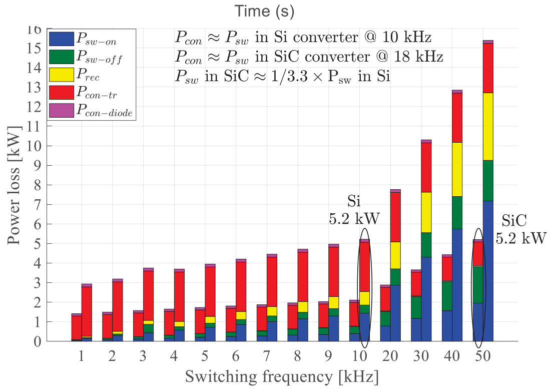
Simulation of inverter loss-

- Conduction loss from datasheet and switching loss obtained from the laboratory measurements are used as a look up table input for simulating detailed inverter loss.

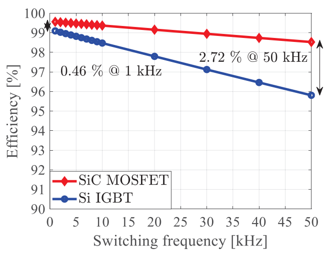


Simulation results-





- $P_{rec}+P_{sw\text{-}on}$ is about 69 % of total inverter loss at 25 °C for inverter with Si IGBTs at 50 kHz. Thus, Si IGBT is not a viable solution at high switching frequency.
- For the same output power, the inverter switching frequency with SiC MOSFETs can be increased by 5 times and still have the same total power loss.



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