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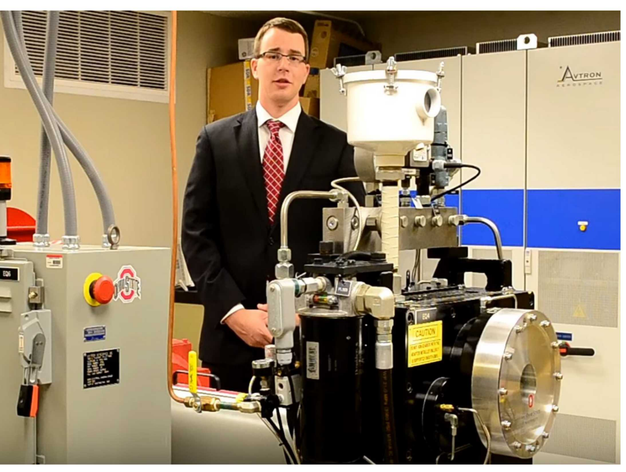
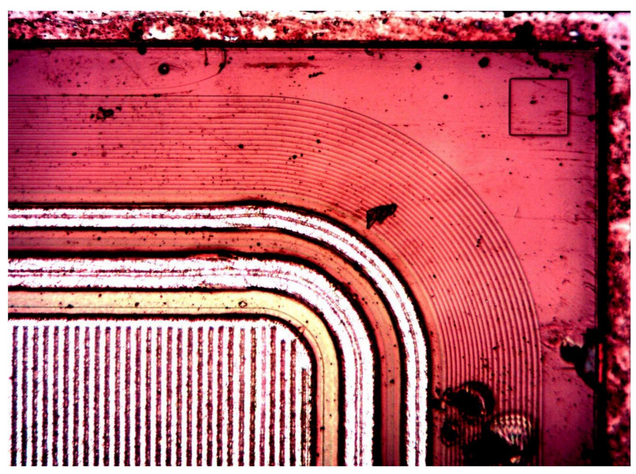




Medium-voltage Power Electronics for Grid-tied Energy Storage Applications

Diang Xing, Boxue Hu, Dr. Kristen Booth, Dr. Jin Wang, Dr. Anant Agarwal, and Dr. Stanley Atcitty

PROJECT OBJECTIVES

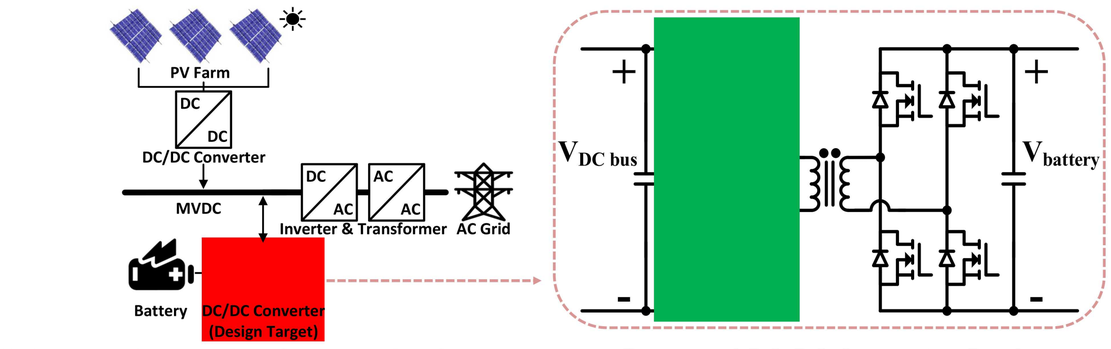
Storage integration with the grid is increasingly important due to an upward trend in use of renewable sources of energy. Compared with the traditional silicon-based power system designs, the designs based on wide bandgap (WBG) devices have shown improved performance for high-voltage, high-power density, and high-switching frequency applications due to material properties.

This project aims to build a power electronic converter with medium-voltage SiC devices for energy storage systems in a medium-voltage distribution grid.

Key Milestones:

- Year 1: Gate drive and auxiliary power supply design for medium-voltage SiC devices. [Finished]
- Year 2: Medium-voltage discrete SiC device evaluation and modeling.
- Year 3: Power module fabrication and DC/DC converter development.

PROPOSED SOLUTION

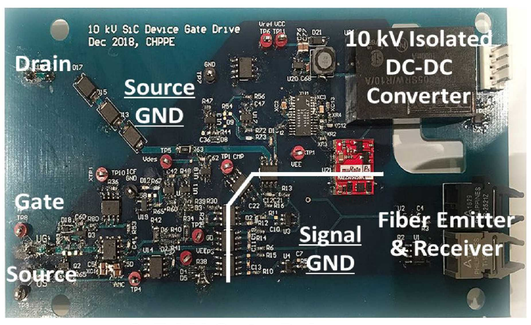


PV Energy Harvesting System with Storage — Proposed DC-DC Converter Design

- Implementation with medium-voltage DC bus simplifies the system structure and increases the efficiency of the energy storage system,
- Application of medium-voltage SiC devices increases power density and reduces power loss of the DC/DC converter, and
- High switching frequency of SiC devices leads to fast dynamic response and low current ripple which improves the stability and power quality of the power grid and increases the lifespan of the battery.

MV GATE DRIVER & AUXILARY POWER SUPPLY

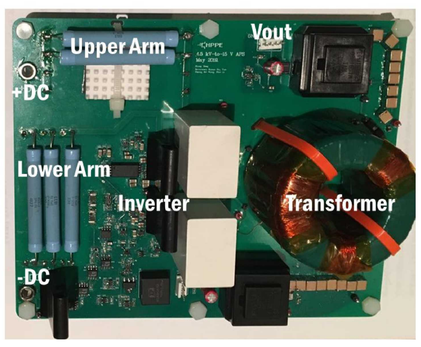
A 6.5 kV-rated gate driver with a 10 W self-sustaining auxiliary power supply was developed. This driver can provide high performance power conversion from a 4.5 kV DC bus.



6.5 kV Gate Driver

Output Voltage	+ 18 V / - 4 V
Source/Sink Currents	9 A / 9 A
Insulation Voltage	6.5 kV
CMTI	200 kV / µs
Functions	Overvoltage Protection Overcurrent Protection Soft-off During Fault Optical Diagnostics

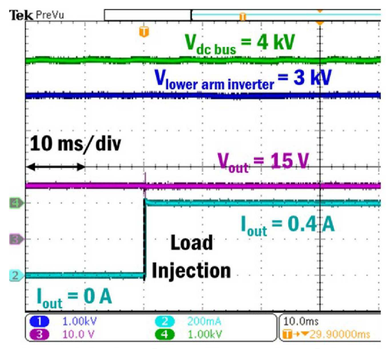
Gate Driver Profile



4.5 kV Auxiliary Power Supply

Input Voltage	3 to 4.5 kV
Output Voltage	15 V
Max Output Power	10 W
Board Size	152 x 188 (mm)

Auxiliary Power Supply Profile

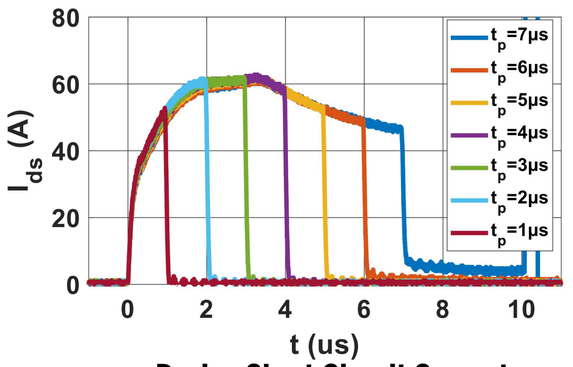


Load Injection Transient in Auxiliary Power Supply

GENESIC 3.3 KV SIC MOSFET EVALUATIONS

Short-circuit Test:

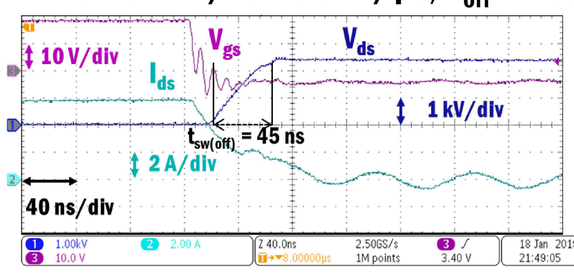
- Test condition: V_{dc} = 2.2 kV, V_{gs} = 18 V, room temperature.
- Maximum short circuit sustaining time = 7 µs.
- Gate driver desaturation protection time <= 1 µs.



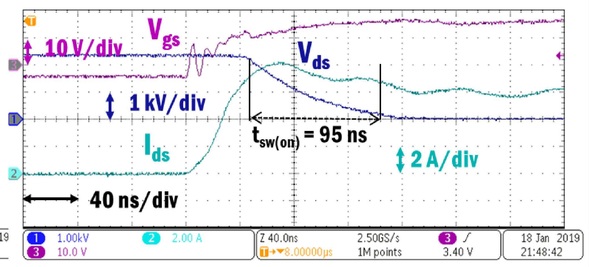
Device Short Circuit Current

Double-pulse Test:

- Test condition: V_{dc} = 2.4 kV, V_{gs} = -4 V (off) & 18 V (on), room temperature.
- SW on dV/dt = 25 kV/µs, E_{on} = 850 µJ;
  SW off dV/dt = 53 kV/µs, E_{off} = 150 µJ.



Device Switches On (2.4 kV 6 A)



Device Switches Off (2.4 kV 6 A)

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