U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

PACE
ACCELERATING ELECTRIFICATION

Intelligent Power Stage

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Project Status: Completed **Project Term: July 2020 – April 2023** **Award Amount: $ 557,998.00** **Partners: N/A**

Project Summary

This project set off to develop an intelligent power stage (IPS) three-phase ac-to-dc power converter module with advanced power processing, monitoring, and diagnostic capabilities based on high efficiency Silicon-Carbide (SiC) power semiconductor devices, with the intent to overcome the apparent limitation of future grid-specific power electronics that remain hindered by the strong industrial reliance on custom-design power converters. On the contrary, the modular, IPS-based solutions seek to unleash the development of grid power electronics enabling their flexible, scalable integration featuring advanced power processing and control capabilities.

Technical Approach

- Exhaustive evaluation of alternative topologies and SiC MSOFET devices seeking to establish the best performer in terms of efficiency and electromagnetic interference (EMI) emissions.
- Use of multi-objective design optimization techniques to maximize the performance of the IPS.
- Use printed circuit board (PCB) technology for the construction of the dc bus and the windings of key magnetic components.
- Use of PCB-based capacitor arrays for the optimization of power density and form factor.
- Use of fiberoptic control and communication networks to maximize the electromagnetic compatibility (EMC) of the IPS.
- Construction, testing and evaluation of the IPS unit and its advanced functionality.

Accomplishments

- Topology: 2-level ac-dc converter with split dc-bus and cascaded 3-level buck-boost dc-dc converter with zero CM-EMI emissions.
- Ancillary Circuitry: fiberoptic communication network (25 Mbps) between controller, gate-drivers (GD) and sensors; auxiliary power network with high dv/dt immunity (>100 V/ns); minimized EMI susceptibility.
- Monitoring and diagnostics: GD-integrated SiC MOSFET Rdson, Tj measurement and dc-bus voltage; dc-bus capacitance measurement based on Id and off-state Vds measurements.

Impact/Commercialization

The modularity of the IPS concept combined with automated-manufacturing-oriented design of the proposed IPS will expectedly favor the development of multi-supplier IPS markets attaining economy of scale benefits.
The IPS internal digital control and communication network will demonstrate a viable alternative to operating in the harsh EMI environment generated by SiC power semiconductors, which remains the main collateral effect and adoption barrier of this technology.

Future Work

The next step in the development of the IPS is the design, construction and testing of medium-voltage IPS units, enabling the demonstration of a modular, IPS-based substation, and of all the functionalities of this innovative concept.