U.S. DEPARTMENT OF ENERGY | OFFICE OF ELECTRICITY

PACE
ACCELERATING ELECTRIFICATION

Intelligent Power Stages (IPSs)

Principal Investigator: Jin Wang **Affiliation: The Ohio State University** **Team Members: Junchong Fan, Dihao Ma**

Project Status: Finished **Project Term: 07/17/2020 - 09/30/2023** **Award Amount: $449,269** **Partners: N/A**

Project Summary

The project aims to improve the reliability of grid-tied power converters with ***advanced monitoring circuits*** and ***intelligent algorithms***. Specifically, an advanced detection circuit has been built and integrated into an adaptive gate drive for power modules. Due to the inherent noisy measurement environment of power converters, the on-state device voltage drop is fused together with several other measurements to provide accurate descriptions of the stress and degradation of both the device and the converter. An 80 kVA grid-tied converter prototype with the most popular circuit topology for grid-tied converters has been built to validate the proposed advanced gate drive circuit designs and sensor fusion algorithms.

Technical Approach

- Advanced power device on-state voltage measurement with high noise immunity
- Sensor fusion algorithms to accurately report the stress and degradation of devices and power converters
- Adjustable gate drive that helps to reduce device degradation
- Robust hardware designs with comprehensive protection functions and operation margins to enable evaluation of the advanced features at a wide range of operation conditions
- High control bandwidth that enables seamless transition from grid-tied to islanding mode when it is needed
- An advanced concept of liquid metal-based cooling was proposed and validated

Accomplishments

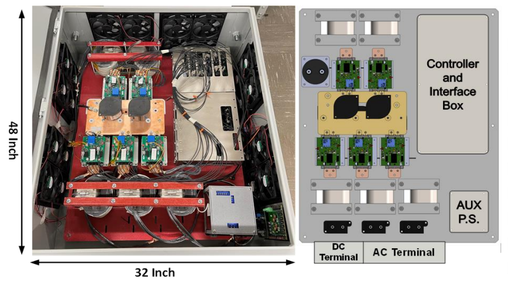
- Advanced gate drive with integrated health monitoring circuits, adjustable gate voltage, and high common mode transient immunity
- Sensor fusion-based algorithm that generates stress index and health index to enable stress based current sharing between multiple paralleled inverter units and degradation-based maintenance
- A reliable set of 80-kW IPS hardware
- Integrated liquid-metal based cooling validated with a scaled down 10-kW inverter

Impact/Commercialization

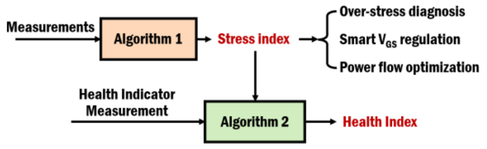
- Pushed boundary of online stress and health monitoring of grid-tied inverters with innovations in both hardware design and algorithms
- Trained a group of graduate students with advanced power electronics
- Filed one patent which already started to attract interest from multiple industry sectors
- Presented multiple papers and gave multiple talks invited by conferences and companies
- Enabled new research activities in parallel and follow-up Federal funded research projects

Future Work

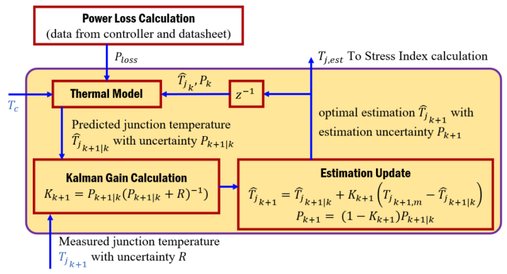
More simulation and data acquisition to improve health index generation



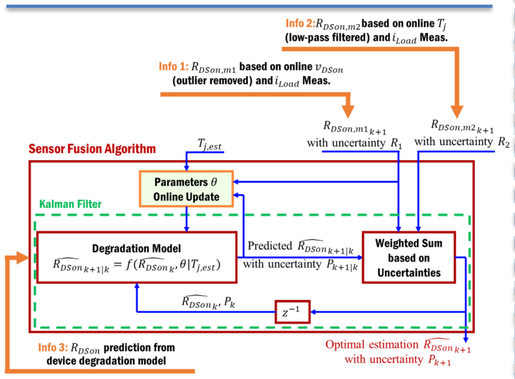
The IPS Prototype



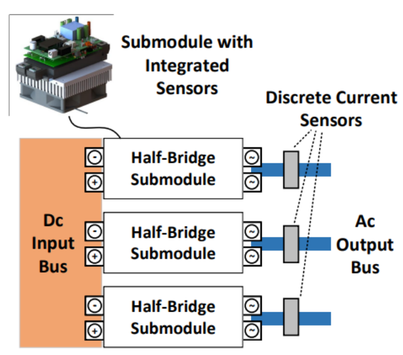
Overview of stress index and health index



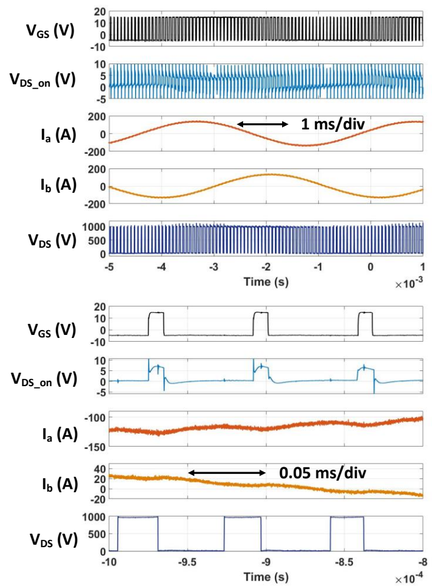
Stress index generation



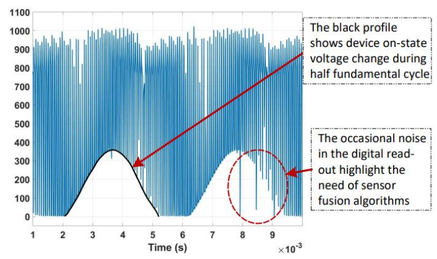
Health index generation



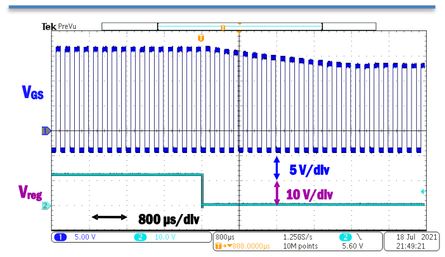
Sensor Locations for stress index and health index



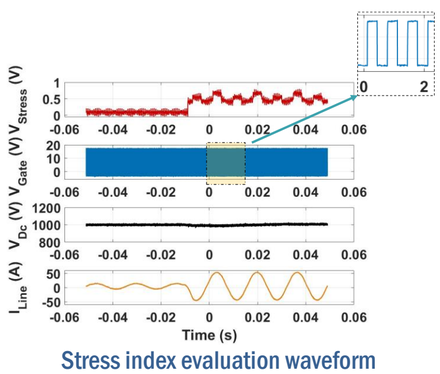
IPS full power operation waveform including the V_{DS_on}



Digital reading of V_{DS_on} measurement



Gate voltage regulation



Stress index evaluation waveform