Enabling Scalable, Resilient, and Modular Electric Grids with Advanced Power Electronics

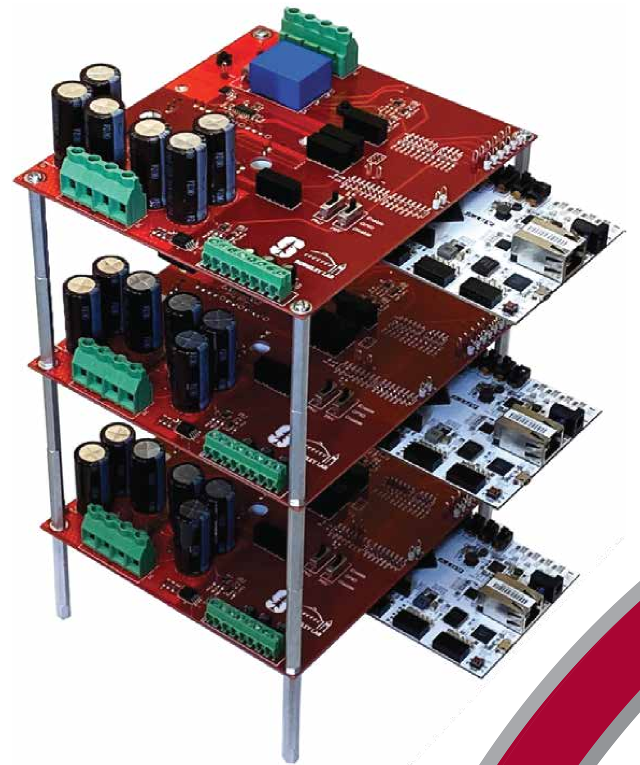
Jason Poon, Postdoctoral Scholar, Stanford University

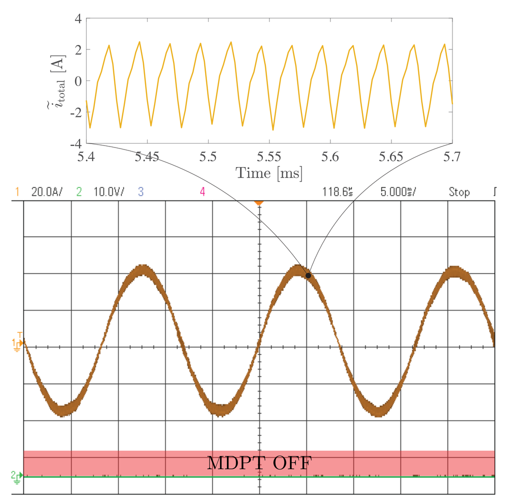
Joint work with Seth Sanders (UC Berkeley), Sairaj Dhople (University of Minnesota), Brian Johnson (UW Seattle), and Juan Rivas-Davila (Stanford University)

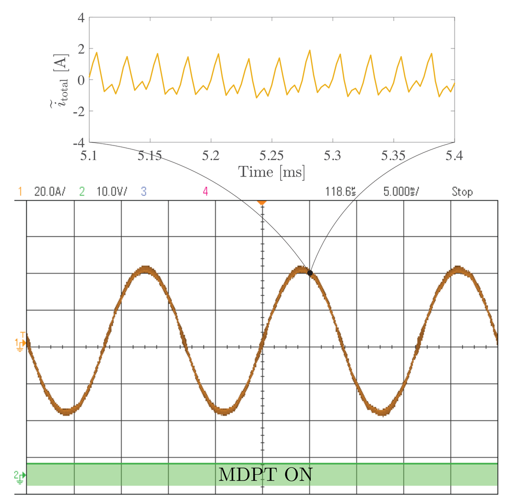
CONTROLS Decentralized Power Electronics Control for Grid Stabilization

Controlling power electronics at the **switch-level** enables greater controllability and functionality as compared to high-level *P* and *Q* commands.

Our work demonstrates that by coordinating the switch-level harmonics of interconnected power converters, the aggregate harmonics can be **reduced by as much as 100X**, enabling more stable networks and lower cost line filters.







"Minimum Distortion Point Tracking," J. Poon, B. B. Johnson, S. V. Dhople, S. R. Sanders, *IEEE Transactions on Power Electronics*, 2020.

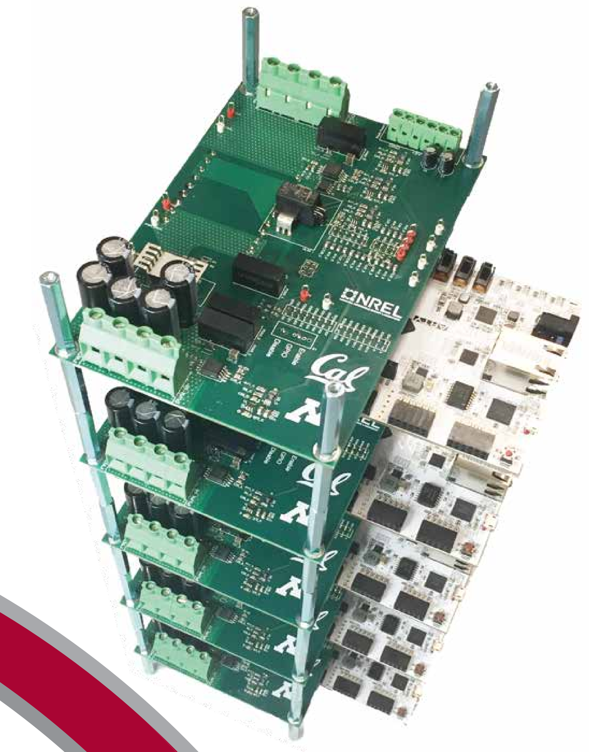
RESEARCH OVERVIEW

Power electronics are essential for enabling the large-scale integration of renewable energy, grid energy storage, and electric vehicle charging to the bulk grid. By *controlling*, *modeling*, and *designing* power electronics at the **switch-level**, we can develop **system-level techniques** that have greater functionality, performance, and impact.

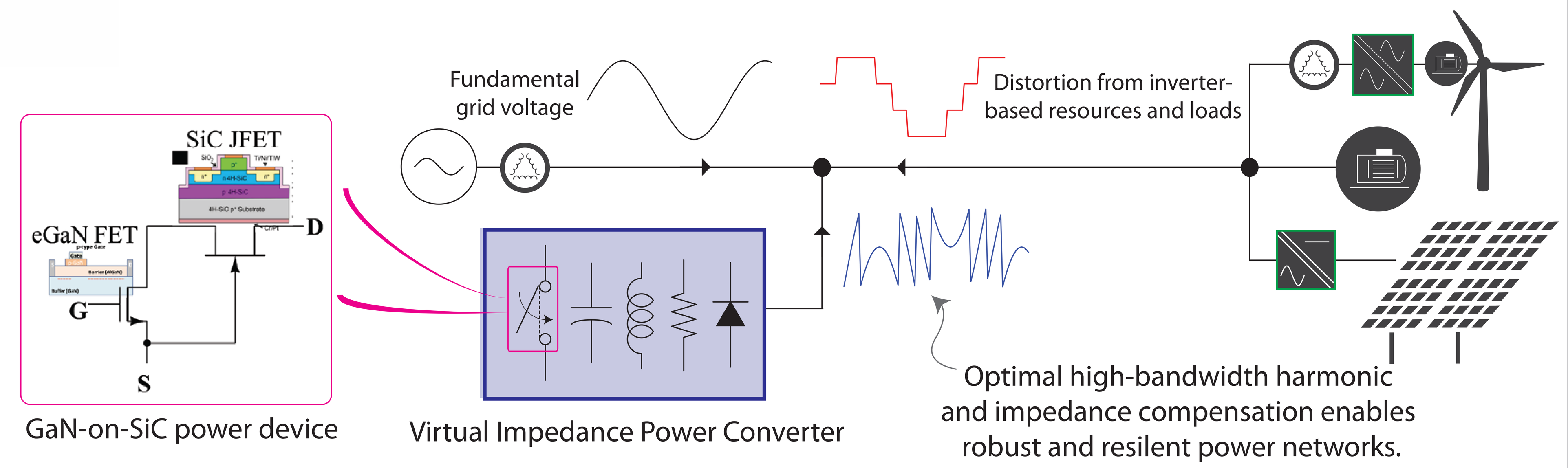
The scope of our work spans three key areas:

1. Decentralized control for networked power electronics,
2. Modular and reconfigurable power electronics circuits, and
3. Scalable power electronics models for stability analysis and control design

Modular Power Electronics Circuits CIRCUITS

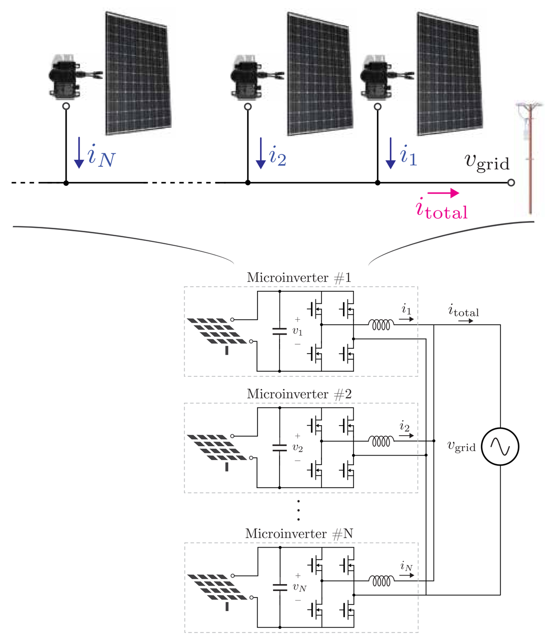


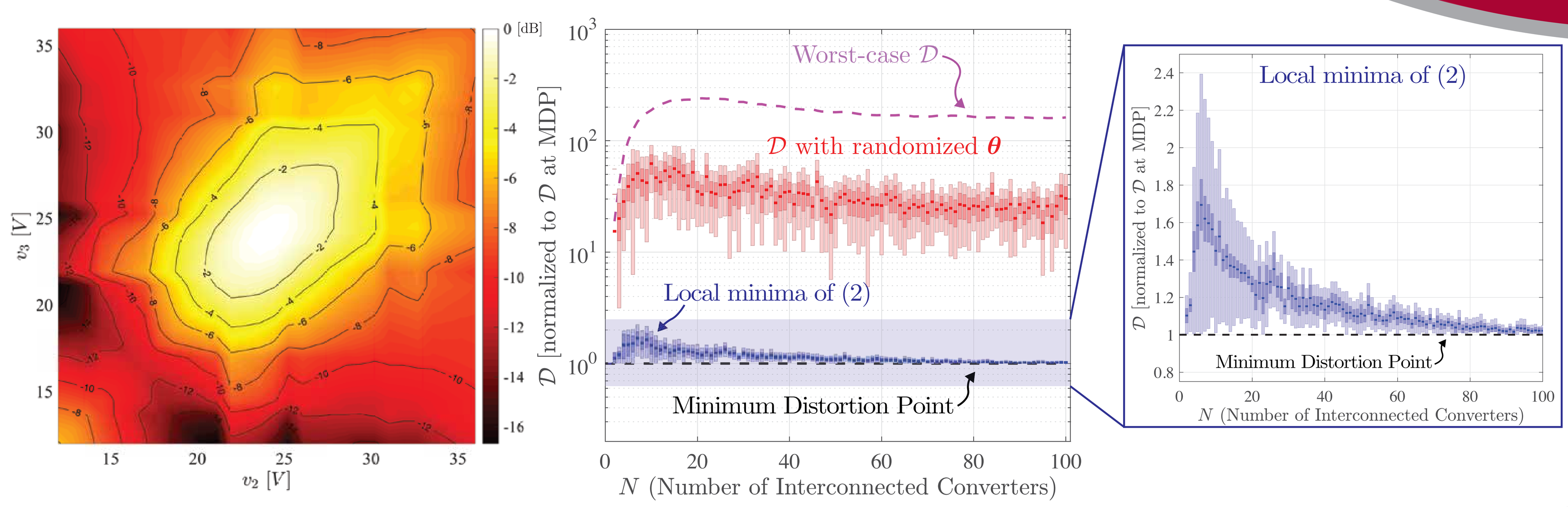
The emergence of wide-bandgap power semiconductors has enabled a new generation of power electronics that are **faster**, more **efficient**, and more **capable**. Our work seeks to leverage these new advantages to design power electronics that can dramatically stabilize the existing grid while envisioning a path towards a future grid built entirely with modular and reconfigurable power electronics.



MODELING Modeling the Power Electronics/Grid Nexus

Today, linearized averaged models of inverters are widely used for power systems stability analysis. However, in order to fully understand the limits and needs of an electric grid with high penetrations of inverter-based resources, **high-fidelity** and **scalable** models of power electronics are needed that can be used for large scale stability and reliability assessment. Towards this end, we are developing a data-driven *energy-based stability criterion* for individual inverters that can scale to networks of arbitrary size and topology.





Electric Grids and Beyond APPLICATIONS

Networks of power electronics form the basis of many important applications beyond the electric grid, including data centers, electrified transportation, and mobile electronics. Our work spans these applications and seeks to develop theory and techniques that are applicable to electric networks of all sizes and forms.

Contact Information
Web: www.jasonpoon.net
Email: jason.poon@stanford.edu
Phone: +1 (617) 599-8856

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