Sandia National Laboratories

GRID FORMING BATTERIES: DC-AC CONVERTER PROTOTYPE

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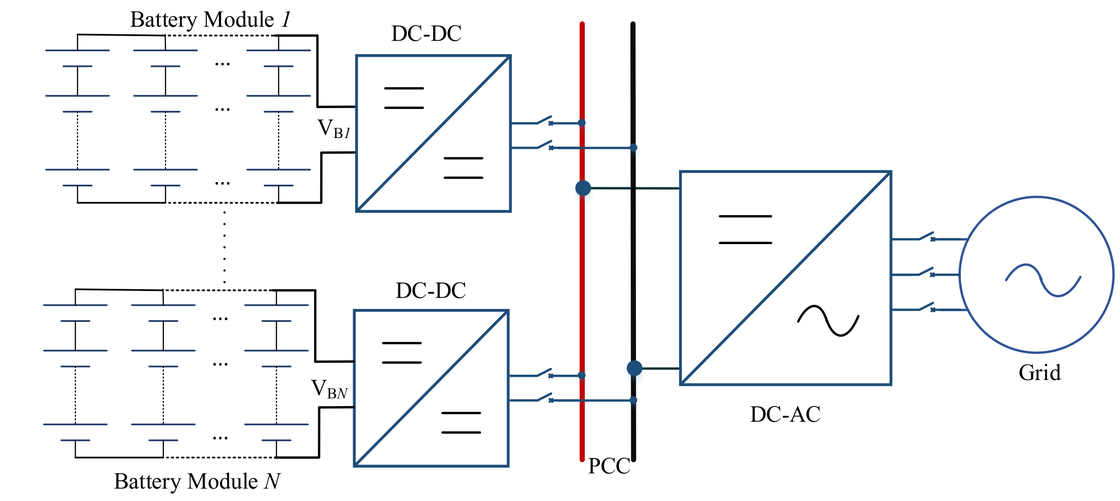
PROJECT PROFILE
Topic: Power Electronics| Vertical: Grid Integration and Field Validation
Strategic Pathway: Optimize
Project start and finish: FY25-FY27

PROBLEM

- Commercially available grid forming inverters (GFMI) are not designed to operate with modular BESS, where multiple converters interface at point-of-common-coupling (PCC).

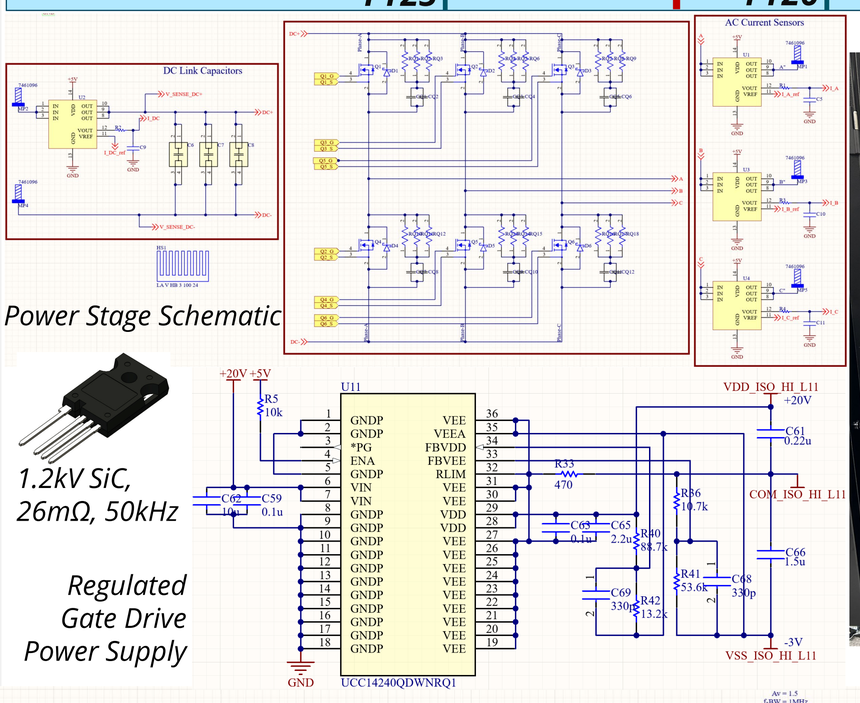


- System instabilities occur when voltage-source converters are cascaded [1]. These instabilities will exacerbate during grid forming operations.
- Modular BESS requires a hierarchical self-organizing control framework.

APPROACH

EMT Simulation	**Hardware Development**	**Control Framework**
PLECS model of 2-level GFMI (30 kW, 800V DC, 480V AC)	Analog circuit simulations in LTspice, component selection, PCB design, & testing	Mathematical modeling, large signal stability analysis, CHIL implementation

FY25 ***FY26*** ***FY27***

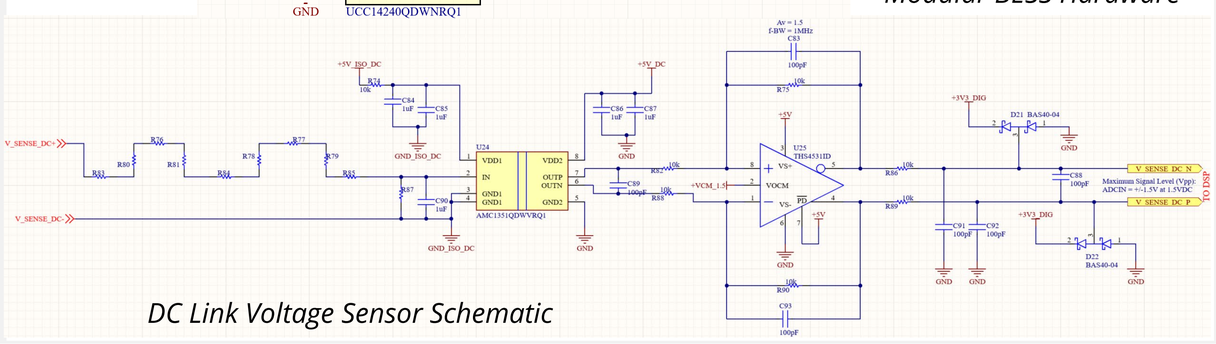


Power Stage Schematic

1.2kV SiC, 26mΩ, 50kHz

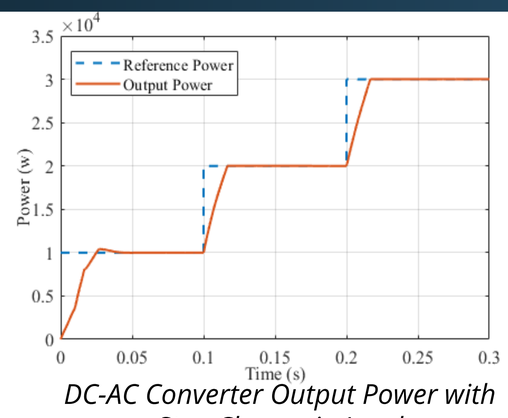
Regulated Gate Drive Power Supply

Modular BESS Hardware

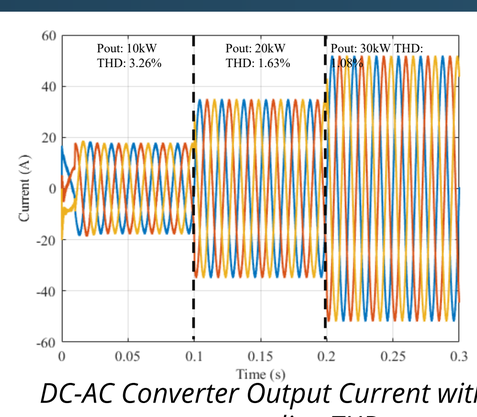


DC Link Voltage Sensor Schematic

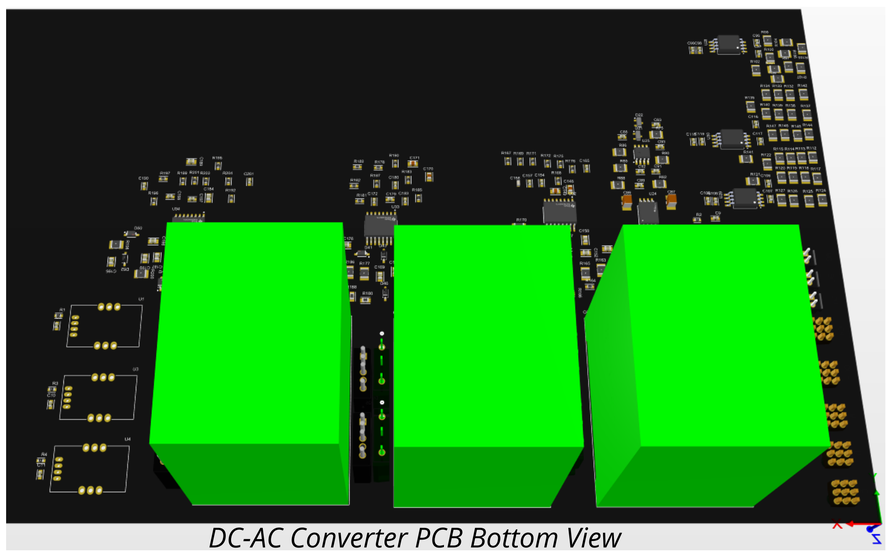
RESULTS



DC-AC Converter Output Power with Step Change in Load



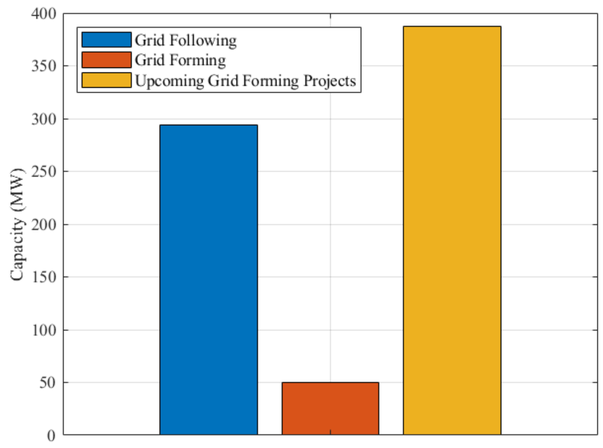
DC-AC Converter Output Current with corresponding THD



DC-AC Converter PCB Bottom View

CONCLUSIONS & IMPACT

- Existing fleet of grid following BESS can be made grid forming by retrofitting a GFMI with hierarchical control structure.

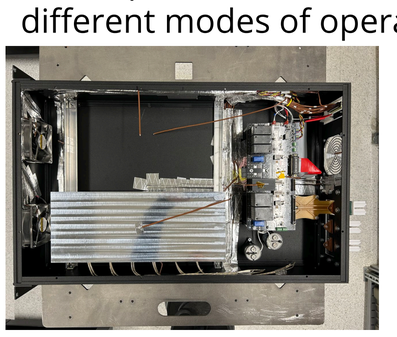


BESS Installations in the USA
*https://unifi-consortium.github.io/GFM_Map/

Grid forming BESS will **increase affordability and reliability** by supporting black start, uninterrupted supply of critical loads, stabilize a weak grid, offset costly infrastructure upgrades, absorb severe grid disturbances, etc.

FUTURE DIRECTIONS

- Develop a hierarchical self-organizing control framework for different modes of operation and test in CHIL platform.



- Implement control framework in a complete modular BESS hardware.
- A validated control framework can be **adopted by utilities to upgrade existing fleet of BESS to grid forming.**

References

[1] N. Mukherjee and D. Strickland, "Control of Cascaded DC–DC Converter-Based Hybrid Battery Energy Storage Systems—Part I: Stability Issue," in *IEEE Transactions on Industrial Electronics*, 2016

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