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

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PROJECT PROFILE

Topic: Power Electronics| Vertical: Materials and Systems Innovation

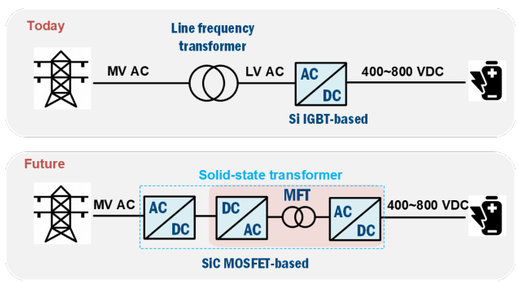
Strategic Pathway: Grow

Project start and finish: FY25-FY27

PROBLEM

► Problem & Motivation

- MVDC grid-tied battery energy storage needs compact, fast, efficient power conversion for grid resiliency and reliability (DOE priority)
- Today: Si-IGBT stages + 60 Hz transformer — bulky, slow and lossy



► Why Hard/Why Now

- Medium-voltage operation: high dv/dt, high frequency insulation, electromagnetic interference
- 3.3 kV SiC MOSFETs are maturing and 3.3 kV SiC bidirectional switches (BDS) are now prototype-ready

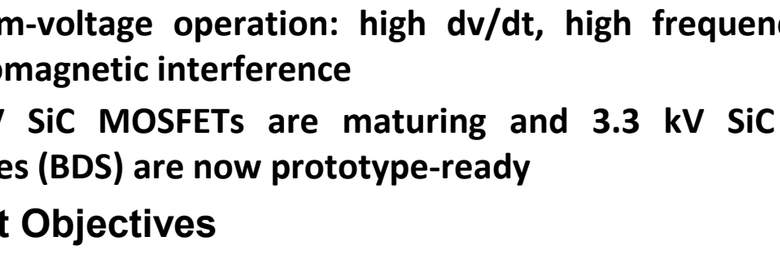
► Project Objectives

- Characterize and quantify performance tradeoffs across 3.3 kV silicon carbide bidirectional device architectures
- Develop a novel medium-voltage DC/DC converter with advanced phase-shift control

APPROACH

► System Architecture

- Circuit topology: 3.3 kV SiC BDS-enabled dual active bridge converter
- Control: normalized benchmarking and learning-based optimal control

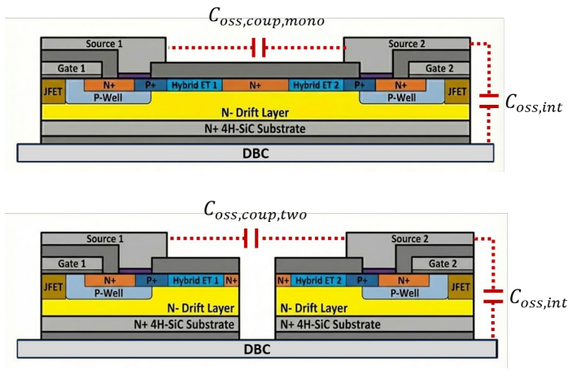


► Why This Approach / Unique Capabilities

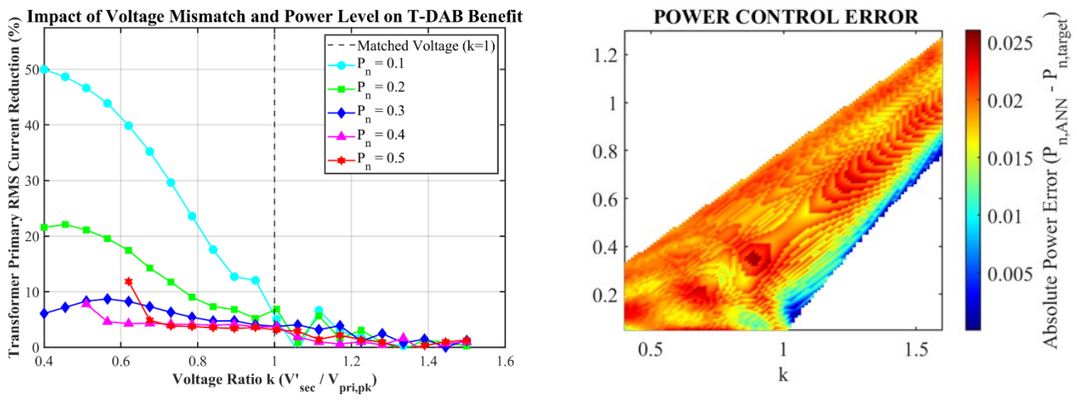
- Team member co-developed the 3.3 kV bidirectional silicon carbide device technology — direct access to pre-commercial samples
- Unique In-house medium-voltage test bed

RESULTS

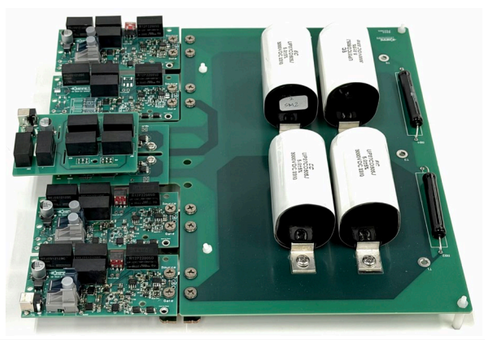
► 3.3 kV SiC bidirectional switch quantification (APEC 2026)

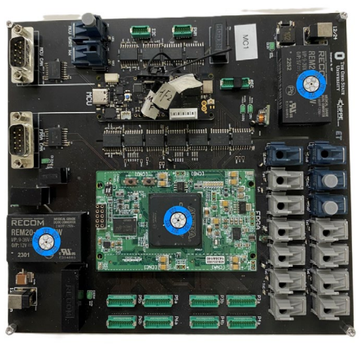


► Learning-based optimal control (ECCE 2026)



► Hardware prototyping





CONCLUSIONS & IMPACT

► Conclusions

- Device level: Established the first quantitative architecture trade-off for 3.3 kV silicon carbide bidirectional switches, showing that monolithic integration reduces chip area but incurs capacitive-coupling penalties
- Circuit level: Developed a medium-voltage T-type converter with neural-network-based optimal control, achieving up to 50% transformer current reduction versus the conventional half-bridge

► Near-term outcomes

- Peer-reviewed publications (APEC 2026, ECCE Asia 2026, ECCE 2026), journal article under review (IEEE Transactions on Power Electronics)

FUTURE DIRECTIONS

- Complete experimental validation of the hardware prototype across the operating envelope
- Explore strategies to maintain matched-voltage operation and maximize converter efficiency across wide battery ranges

This material is based upon work supported by the U.S. Department of Energy, Office of Electricity (OE), Energy Storage Division.

July 2026