PACE

ACCELERATING ELECTRIFICATION

MERIT: Reliable Medium-Voltage Power (MVP) Building Block

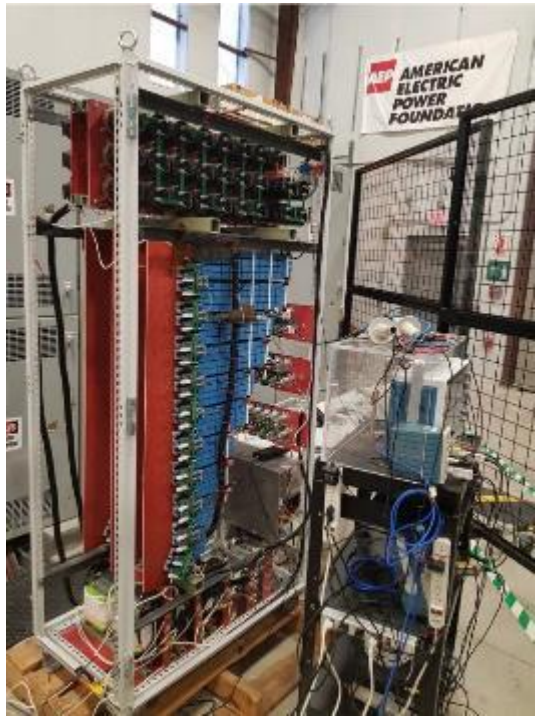
Principal Investigator: Yue Zhao

Affiliation: University of Arkansas / NSF I/UCRC GRAPES

NSF I/UCRC: GRid-connected Advanced Power Electronic Systems (GRAPES)

Mission of GRAPES is to accelerate the adoption and insertion of power electronics into the electric grid to improve system stability, flexibility, robustness, and economy.

MV Storage Converter



MV Phase-Current Compensator

National Center for Reliable Electric Power Transmission (NCREPT)

- 12,000 ft2 lab space
- Up to 6MVA 15 kVac

Industry Members

- Utility Companies
- Equipment Manufacturers
- Components Manufacturers

SPP Southwest Power Pool
EATON Powering Business Worldwide
ITRI Industrial Technology Research Institute
KOONTZ Electric Company, Inc. OUR POWER IS IN OUR PEOPLE
Typhoon HIL
We Energies Energy You Can Depend On
DRS Technologies
MISO
Electric Cooperatives of Arkansas Your Local Energy Partners
G&W
SEMIKRON innovation+service
WattEV
Entergy
Electronic Concepts
KOHLER
DYNAMIC RATINGS

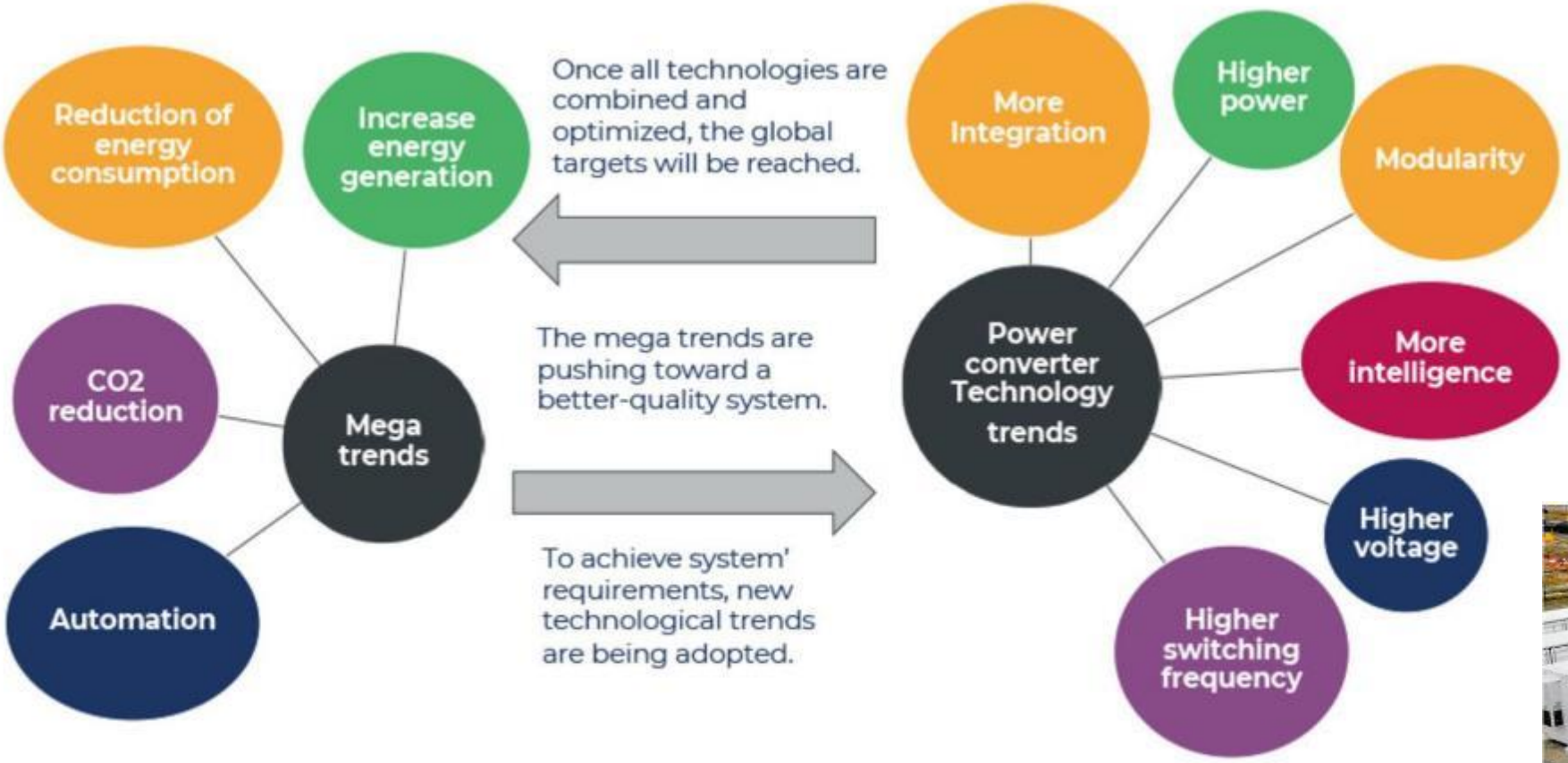
GRAPES
GRid-connected Advanced Power Electronic Systems

Need for MV Power Electronics

1500V 352 kW PV String Inverter
Source: Infineon/Sungrow

Electric Aircraft Charger
Source: Green Motion Air by Eaton

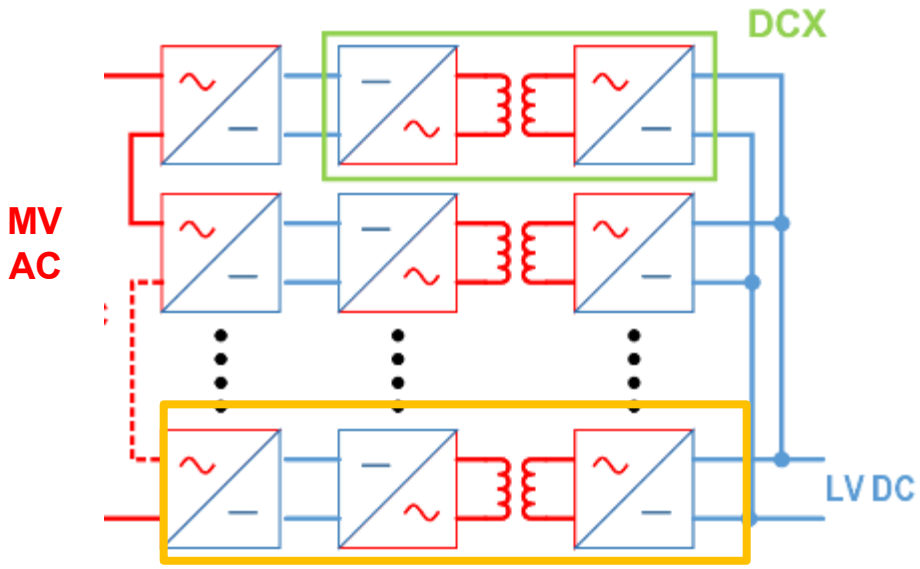
Battery Energy Storage Systems
Source: Mitsubishi Electric Power Products, Inc.



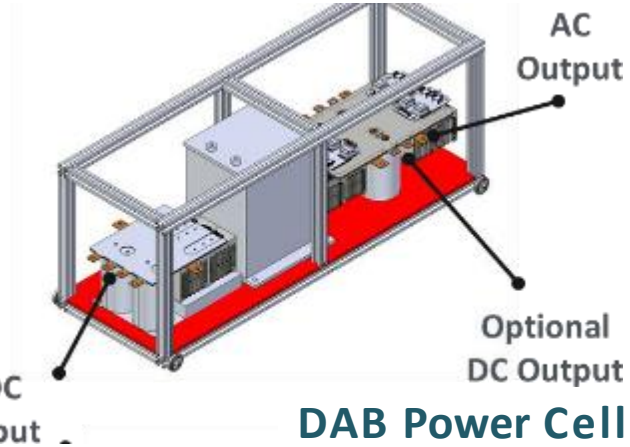
Source: Yole Intelligence: Status of the Power Converter Industry, July 2023

Prior Research & Challenges

SOLAR ENERGY TECHNOLOGIES OFFICE
U.S. Department Of Energy

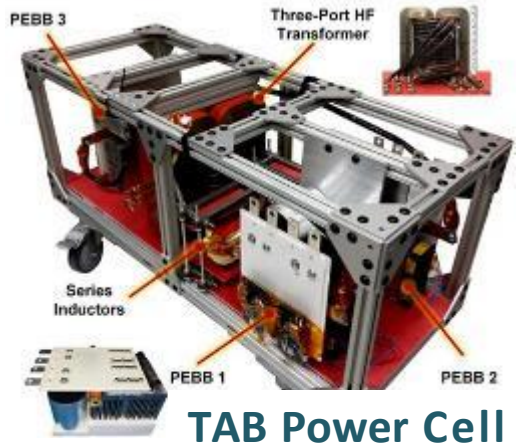


Power Cell



DAB Power Cell

Power Stack



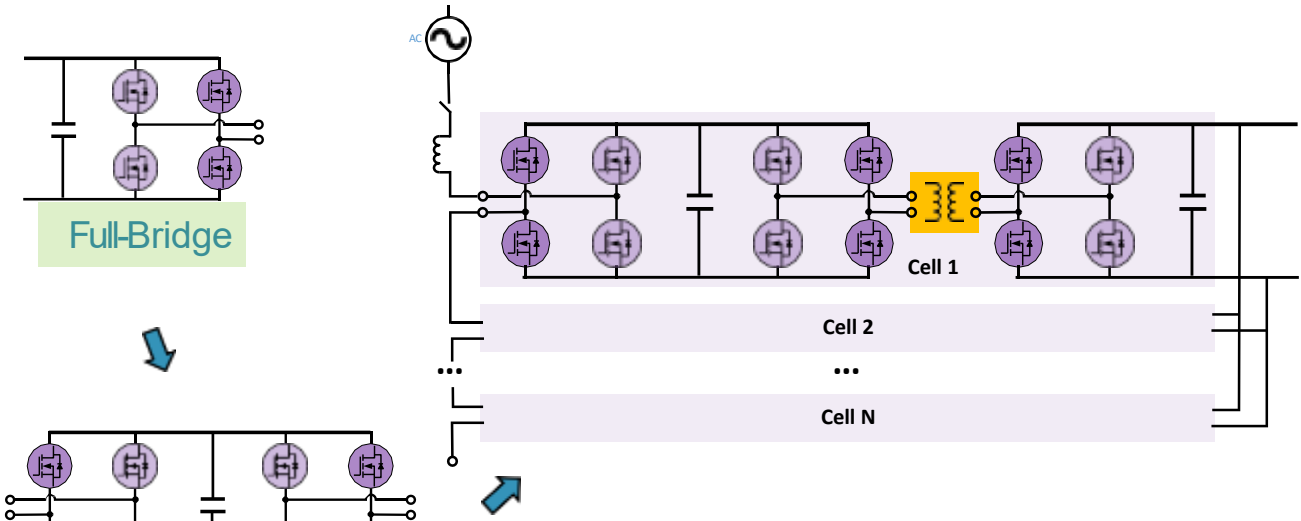
TAB Power Cell

Complexity due to the use of LV power modules

Project Summary

- **Reliable MVP** – Reliable Standardized MV Power Building Block
- **Standard** 100 mm x 140 mm module package to enable **wider adoption**

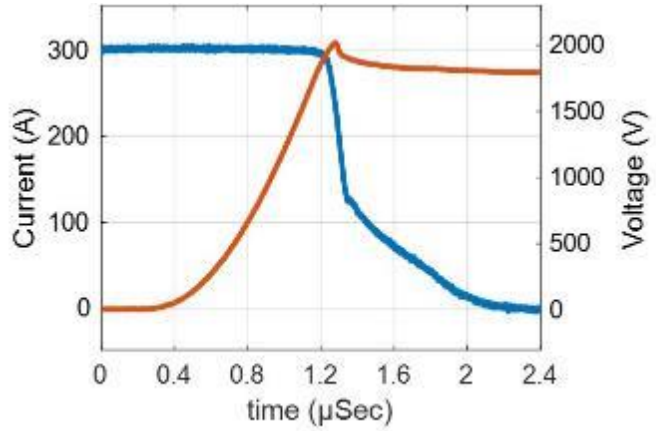
- **Standard** full-bridge topology – the most widely used building block topology for grid-tied MV power electronic systems

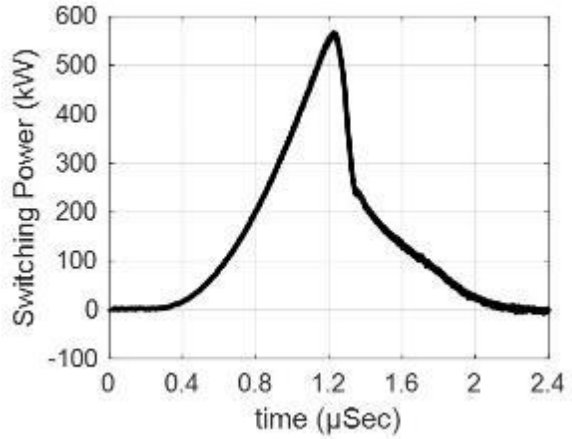


Project Summary

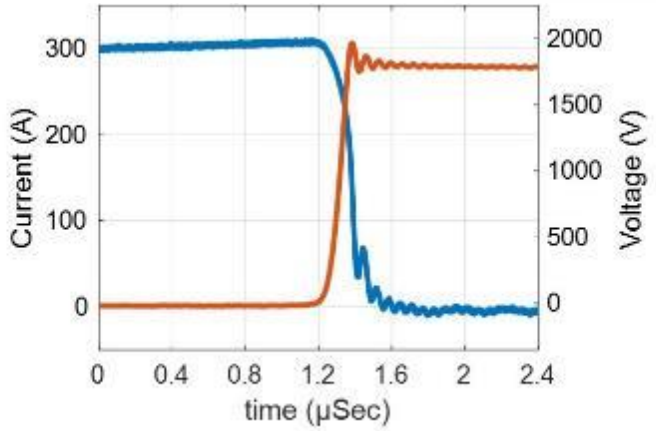
Performance ⟷ **Reliability**

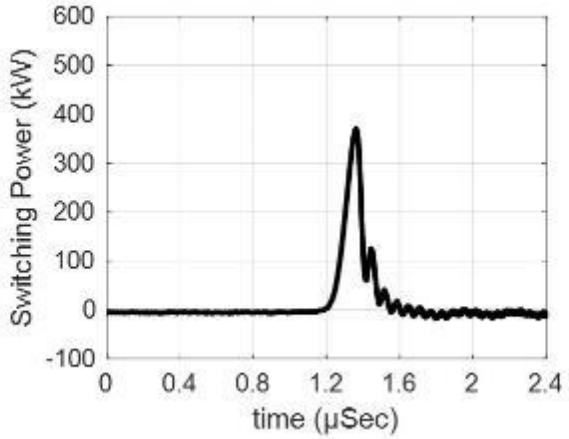
3.3 kV IGBT Module from Vendor A



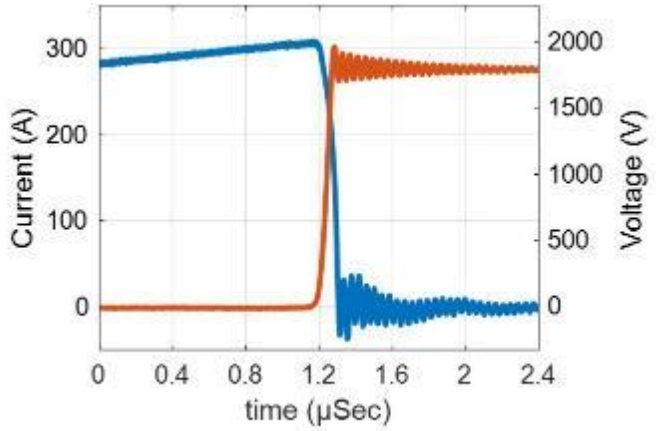


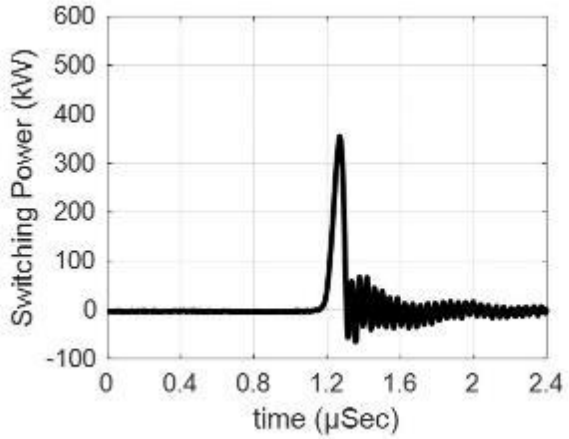
3.3 kV SiC MOSFET Module from Vendor B





3.3 kV SiC MOSFET Module from Vendor C

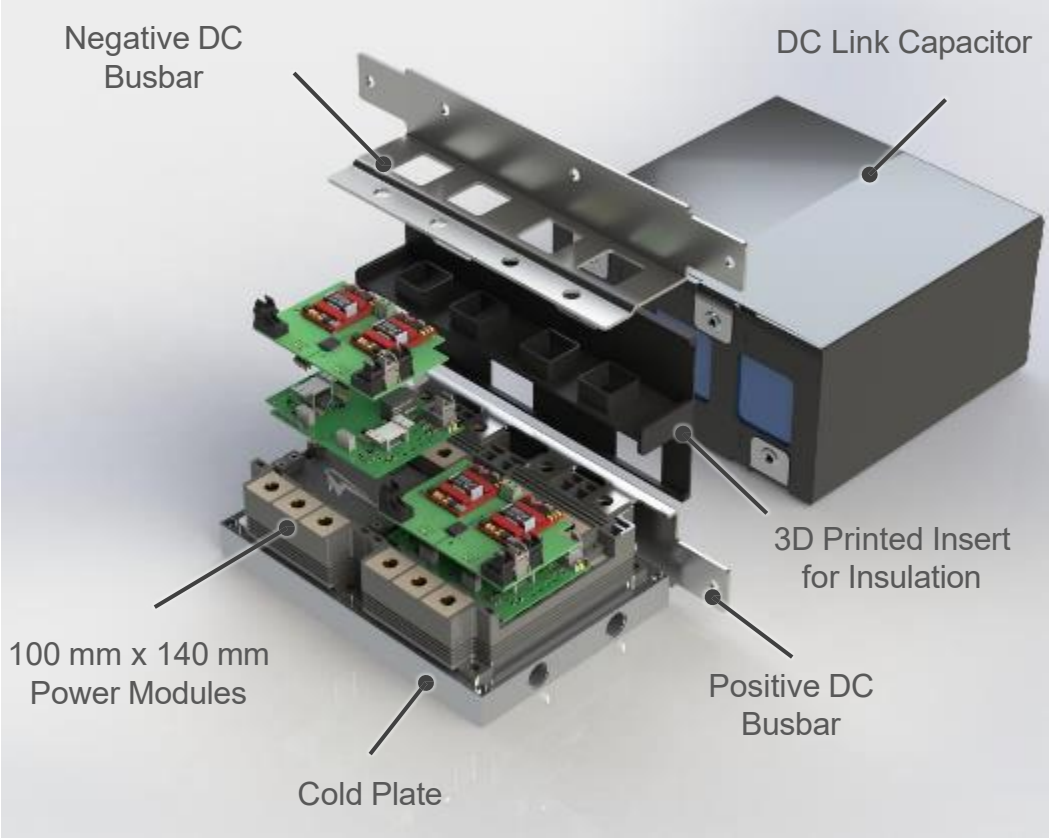


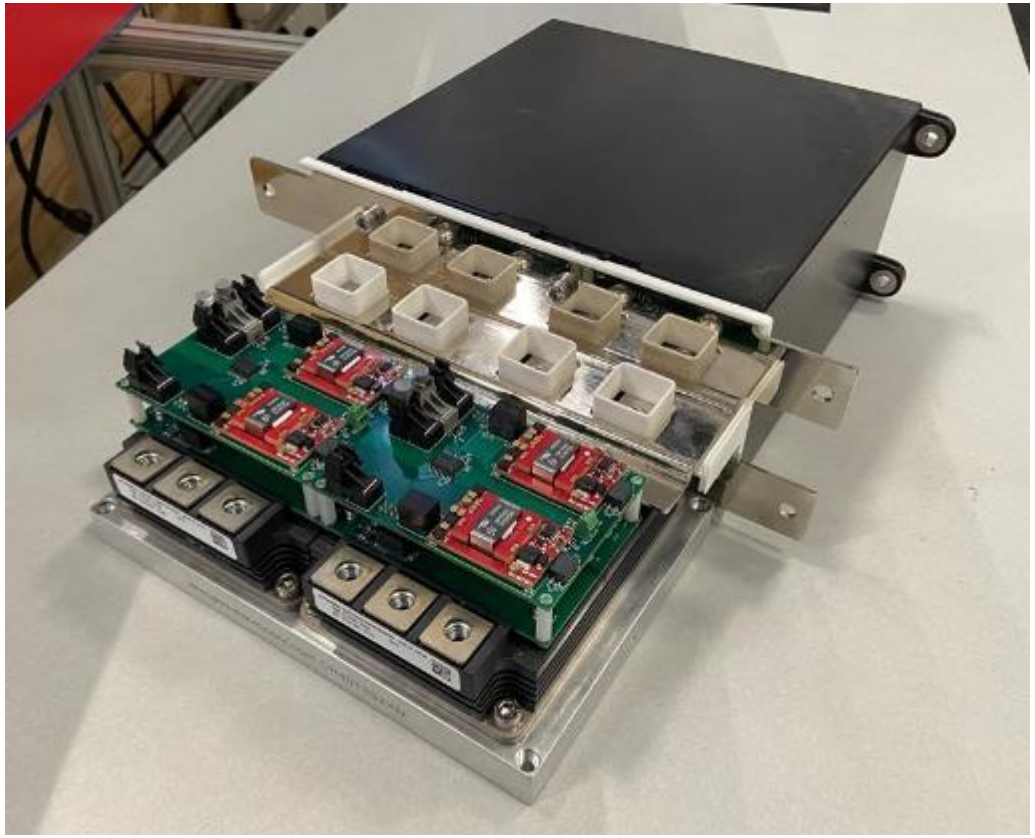


Testing Conditions: 1800Vdc, 300A, 25C

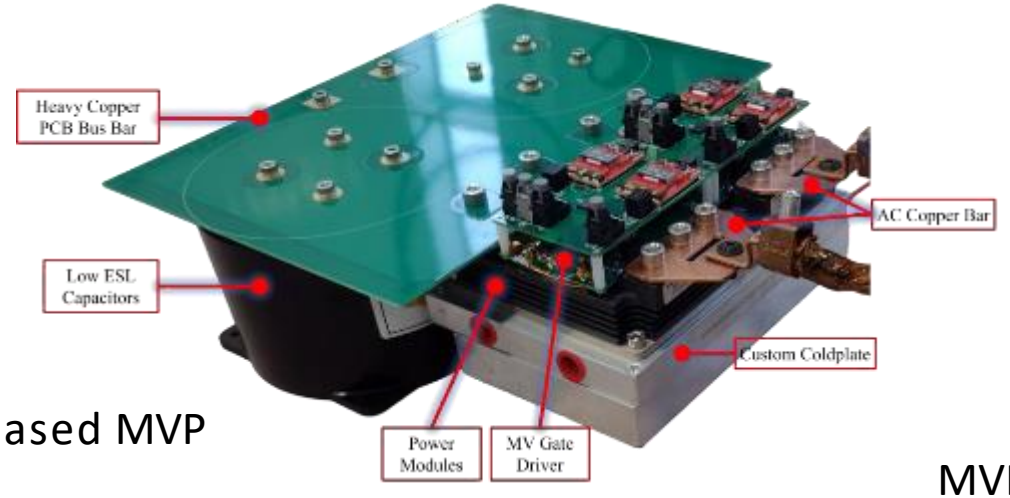
Project Summary

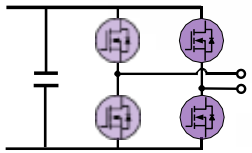
- Task 1: Design and fabricate an MVP building block using 3.3kV power modules
- Task 2: Performance validation of the prototyped MVP building block
- Task 3: Reliability assessment and data collection





MVP Building Block(s)



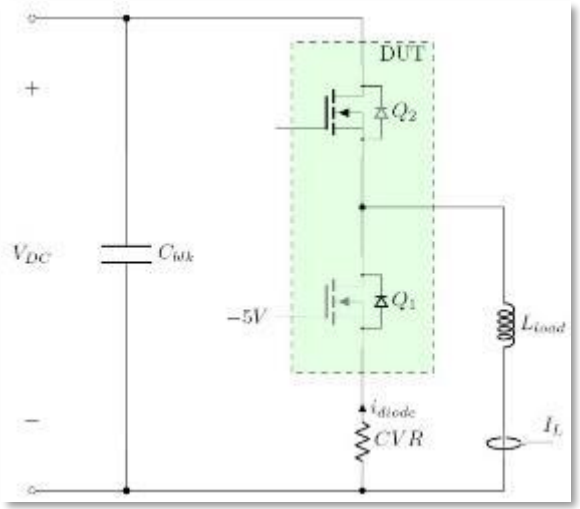


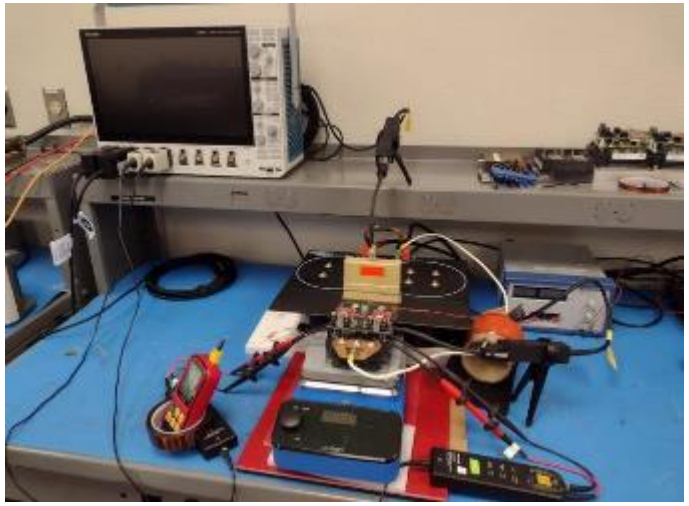
PCB Based MVP

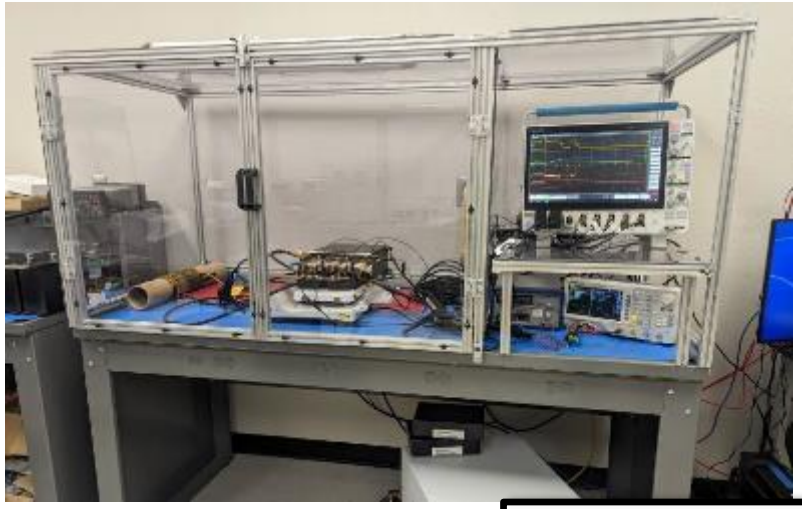
MVP in this Project

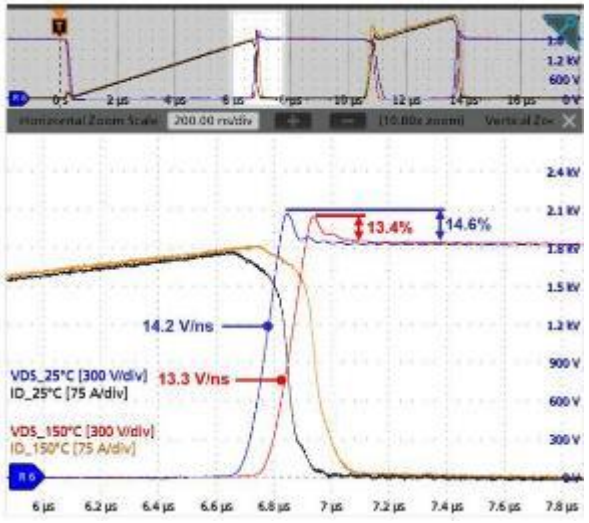
4x Modules version MVP+

Module Level Switching Characterizations

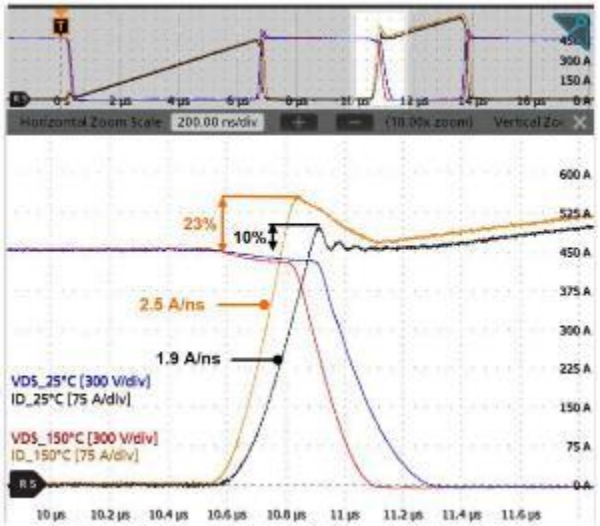




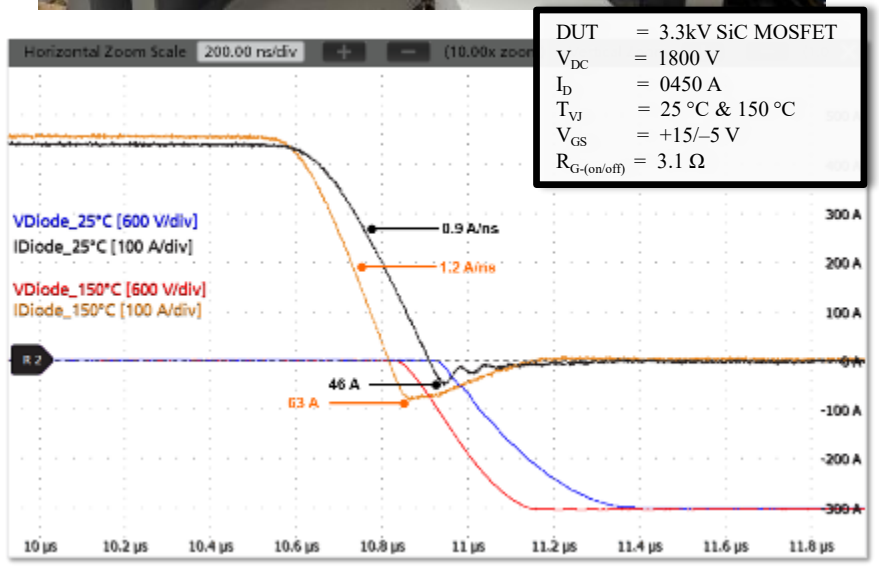




Turn-off switching transient



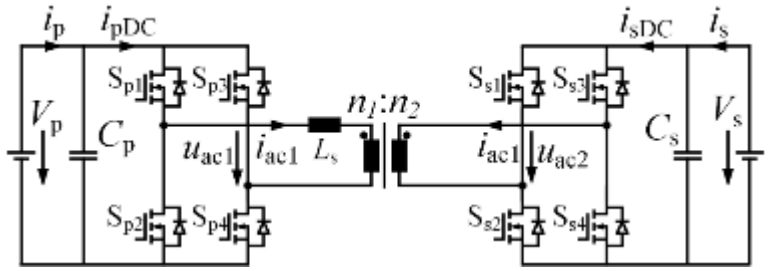
Turn-on switching transient

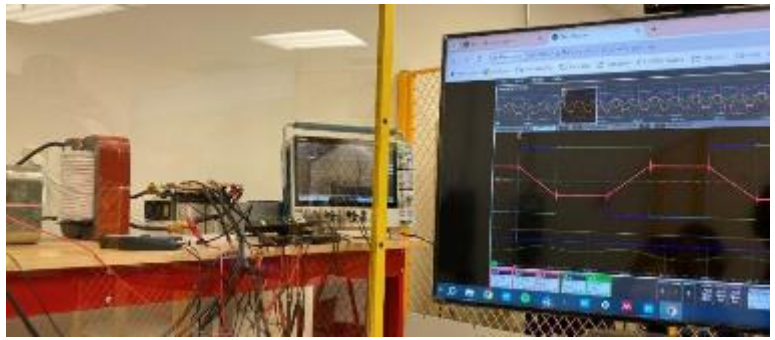


Diode Reverse Recovery

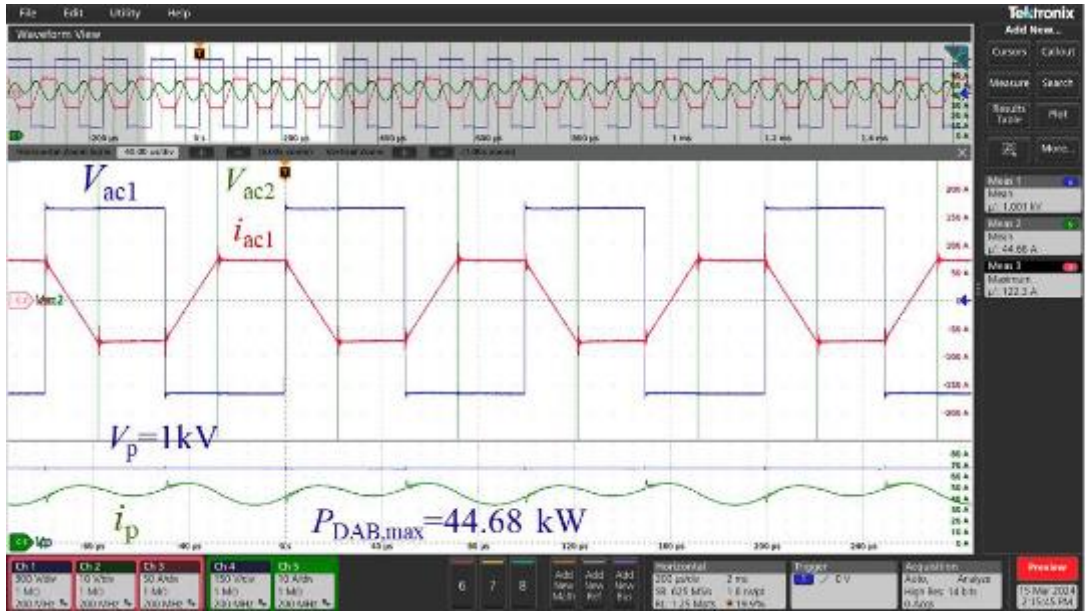
MVP Building Block Testing and Validation

Dual Active Bridge (DAB) Configuration



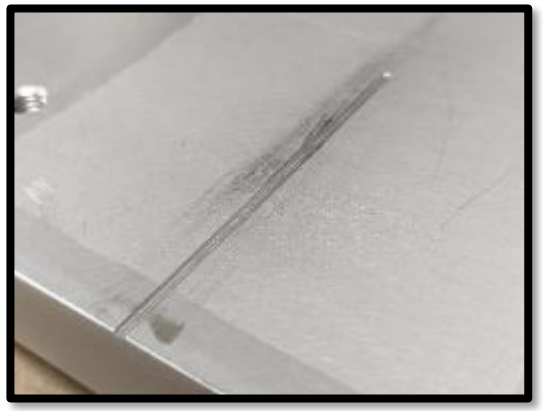


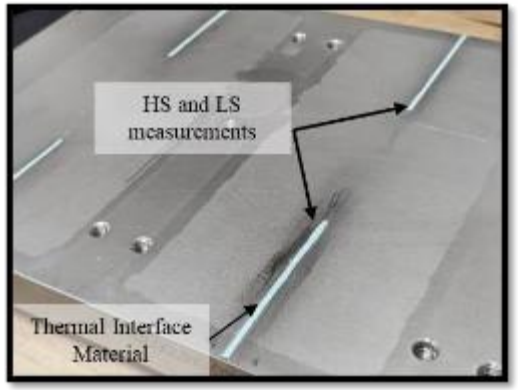
DAB Design Specification: 1.8 kV DC-Link (@ 100 kW)	
Prim./Sec. Voltage (±10%)	**±1.8 kV** [1620V 1980V]
Transformer Turns Ratio *Ntr*	**1:1**
Nominal Power (Expected Eff. 0.95)	100 kW
Max. Power of DAB in Theory (Nominal Volt., Power Transfer Margin)	130 kW (30 kW)
Transformer Rated Power (Design)	100 kW
Switching Freq. *fsw*	10 kHz
Series induct. $L_{s,max}$	**311 µH**
Prim./Sec. Side Device	1.8 kV HB

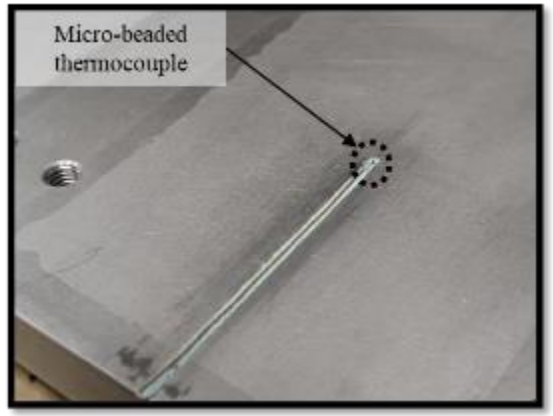


MVP Building Block Testing and Validation

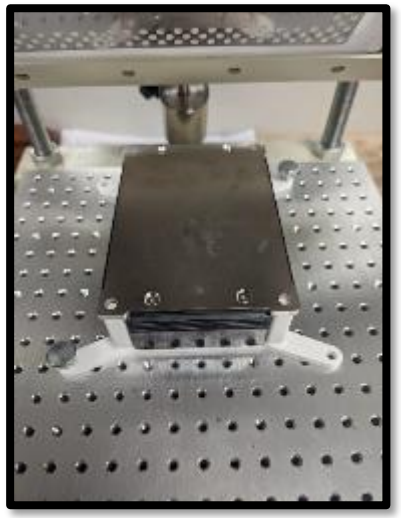
Thermal Management and Online Monitoring

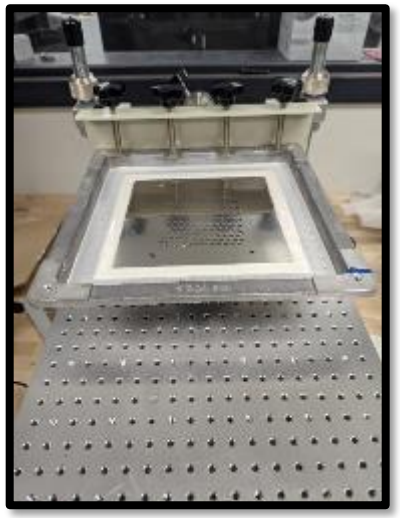






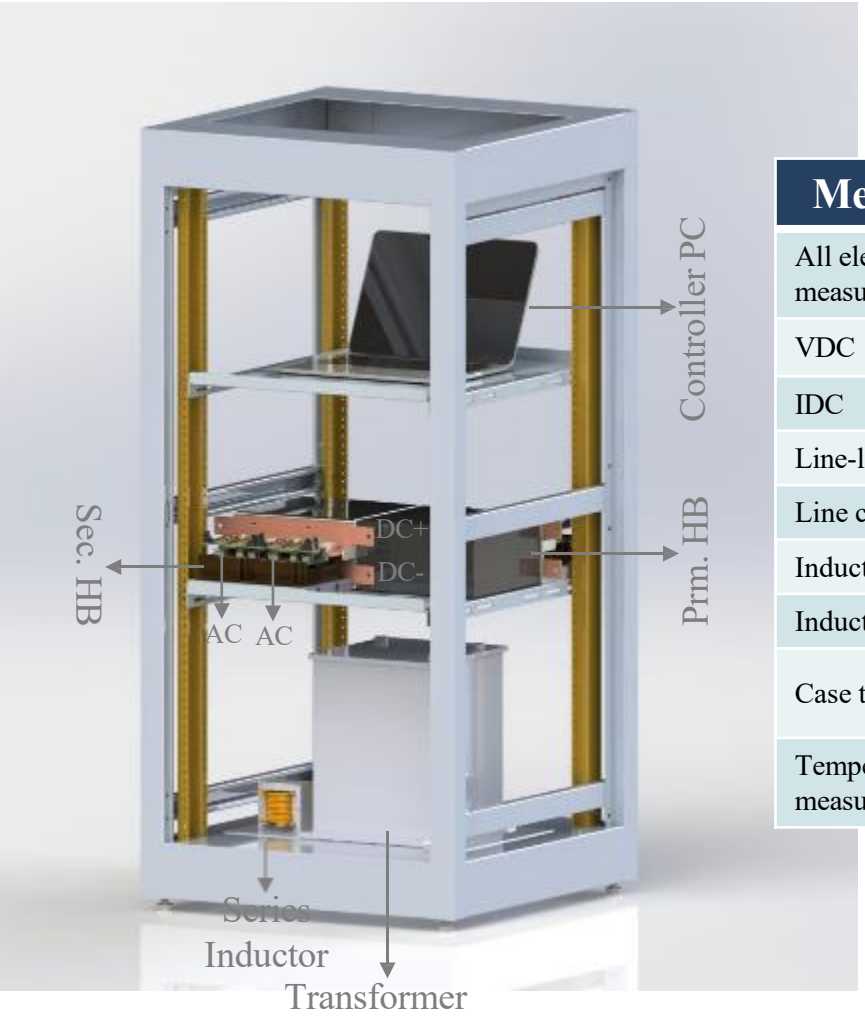
Case temperature monitoring method





Apply TIM to power module

MVP Building Block Testing and Validation



Measurement	Probe	Specs
All electrical measurements	MSO58/MSO58B	500 MHz Scope
VDC	THD0100	6 kV, 100 MHz differential probe
IDC	701933	Yokogawa 30 A/50 MHz
Line-line voltage	THD0100	6 kV, 100 MHz differential probe
Line current	701931	Yokogawa 500 A/2 MHz
Inductor phase voltage	THD0200	1.5 kV, 200 MHz differential probe
Inductor current	TCP404XL	Tektronix 500 A/2 MHz
Case thermocouples	K1X-WBWX-40G-EX-0.25-PFXX-80-S	Micro Beaded Thermocouple Type K
Temperature measurements	NI 9213 cDAQ	16-Channel, 75 S/s Aggregate, ±78 mV

Size H x W x D	49.31 in x 23 in x 23.63 in (1,252 mm x 584 mm x 600 mm)

THANK YOU

This project was supported by the Department of Energy (DOE) - Office of Electricity's (OE), Transformer Resilience and Advanced Components (TRAC) program led by the program manager Andre Pereira (OE), Eric Miller (Office of Energy Efficiency & Renewable Energy), and the Grid Modernization Initiative.

Backup Slides

Acronyms

Insert any acronyms used and the associated definitions here.