Fred Wang Personal Info

- **UTK Professor in power electronics, CURENT Technical Director, ORNL joint faculty**
- **Research Interests: Wideband gap power electronics, power electronics for grid and transportation applications**
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2020-2021 Research Projects

1. A Smart and Flexible Microgrid with a Low-cost Scalable Open-source Controller (ARPA-E)
2. Medium Voltage SiC based asynchronous microgrid power conditioning system module (PowerAmerica)
3. SIC based transformer-less MW-scale power conditioning system and control for flexible CHP (DOE)
4. SiC based modular transformer-less MW-scale power conditioning system and control for flexible manufacturing plants (DOE)
5. Operation and control of large-scale power electronics based power grids (ORNL)
6. Ultra-Light Tightly-Integrated Modular Aviation-Transportation Enabling Solid-State Circuit Breaker (ARPA-E, Boeing)
7. Power electronics based MW universal tester (UTK internal)
8. A combinational Rogowski coil (Keysight, with Helen Cui)

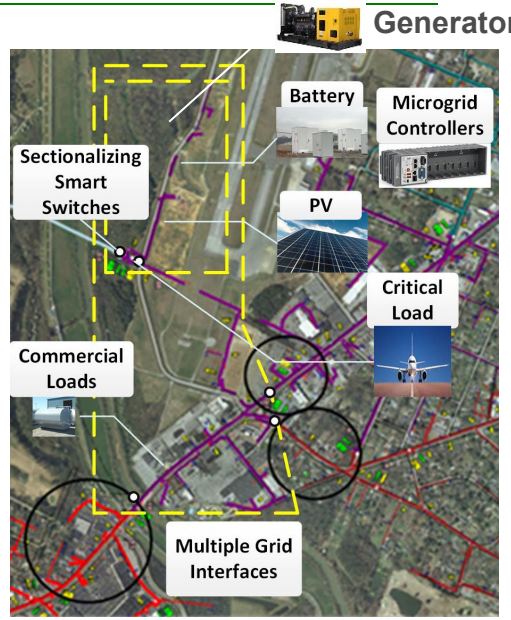
A Smart and Flexible Microgrid with Low-cost Open Source Controller

Project goals and previous accomplishments

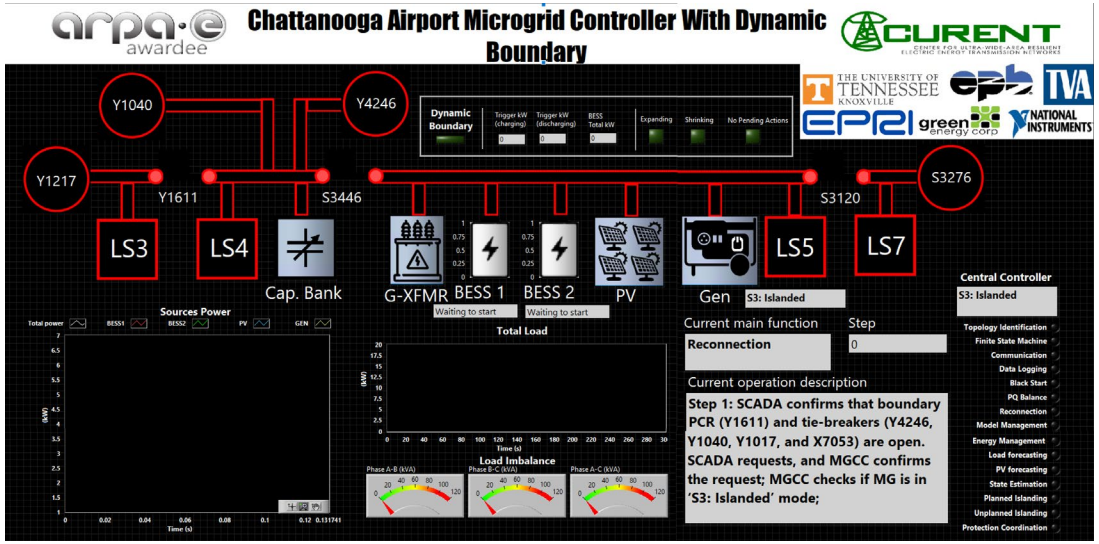
- Designed/implemented a community-based microgrid at EPB with 99% improvement on reliability and 34.5% improvement on energy use efficiency
- Developed a design guideline for flexible microgrid with dynamic boundary
- Developed a microgrid controller capable of realizing dynamic boundary
- Tested controller in Opal-RT Hardware-In-the-Loop (HIL) setup and CURENT HTB.

Recent activities

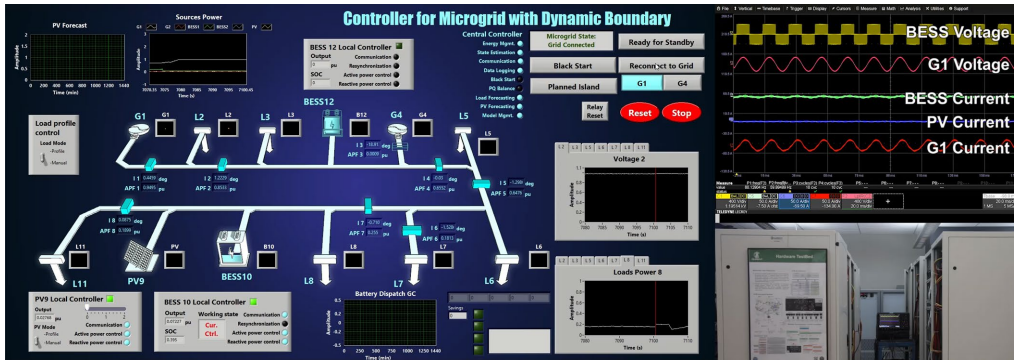
- Installed a backup gas generator and customized the controller
- Completed the field tests and ready for final demo



EPB microgrid with dynamic boundary



Visualization interface of MGCC for the field test



Visualization for controller test on CURENT HTB

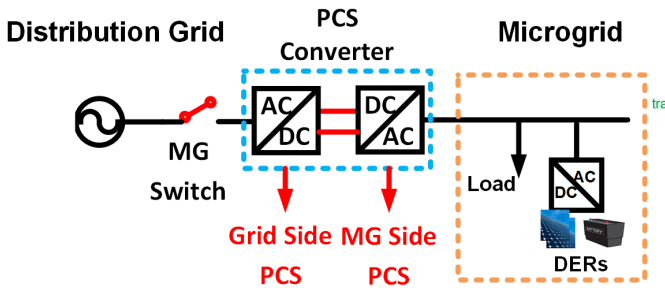
Multi-functional Medium Voltage SiC based Asynchronous Microgrid Power Conditioning System Module

Project Objectives

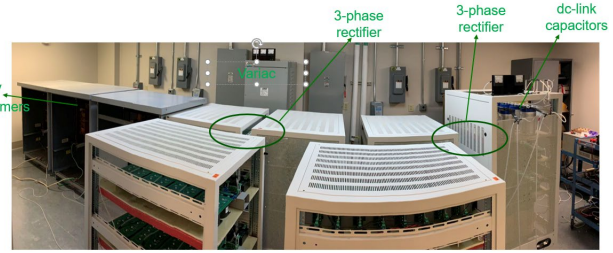
- Develop an asynchronous microgrid PCS module employing 10 kV SiC MOSFETs with >10 kHz equivalent switching frequency to deliver at least 100 kVA power at a required ac voltage level of 13.8 kV, achieving:
  - ✓ (1) overall efficiency target of 98% and 95% with low/partial load (<30% loading);
  - ✓ (2) volumetric density of 4 m^3/MW, footprint of 3 m^2/MW, and specific power of 1 kW/kg;
  - ✓ (3) sufficient bandwidth (voltage control bandwidth > 300 Hz and current control bandwidth > 1 kHz) for both the grid-facing and microgrid-facing functions.

Recent Achievements

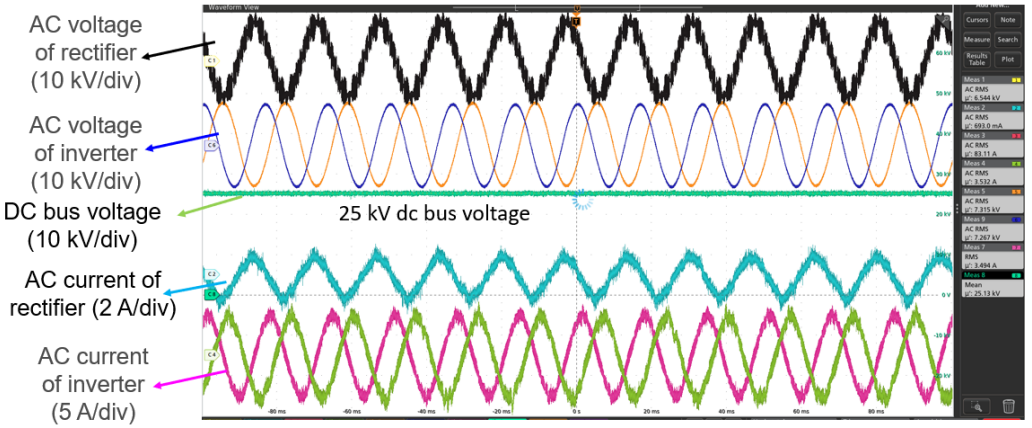
- The back-to-back PCS module is successfully tested with both balanced and unbalanced load at 25 kV dc bus voltage.
- Two PCS inverters parallel operation has been successfully tested at 25 kV dc bus voltage.
- PCS grid supporting functions including unbalanced load support in islanded mode, active power filter, and STATCOM have also been successfully tested with the developed PCS converters.



Asynchronous microgrid with PCS converter



Hardware setup of the 100 kVA back-to-back PCS module

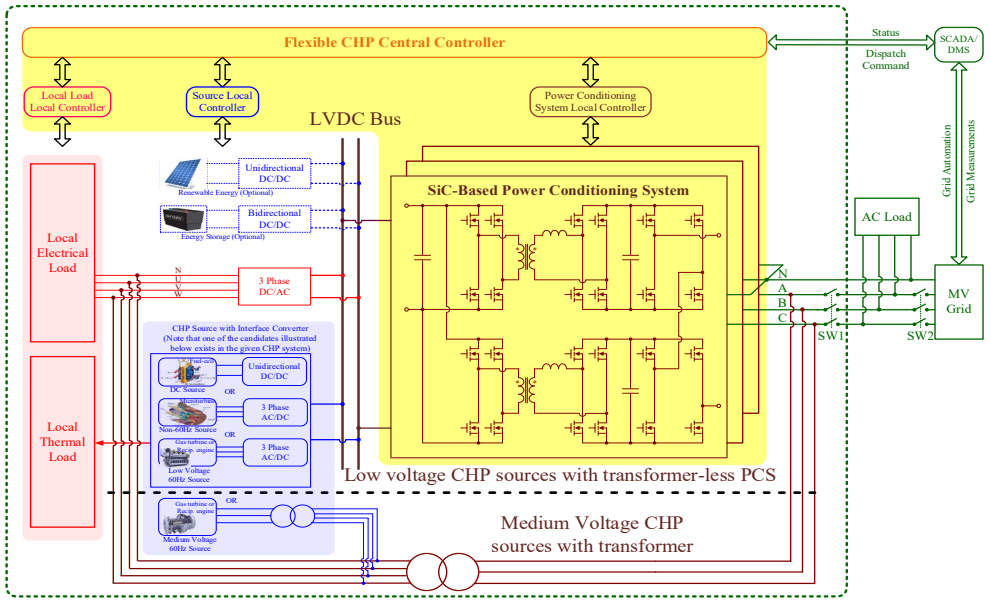


Waveforms of the back-to-back PCS module at 25 kV dc bus voltage and 100 kVA power

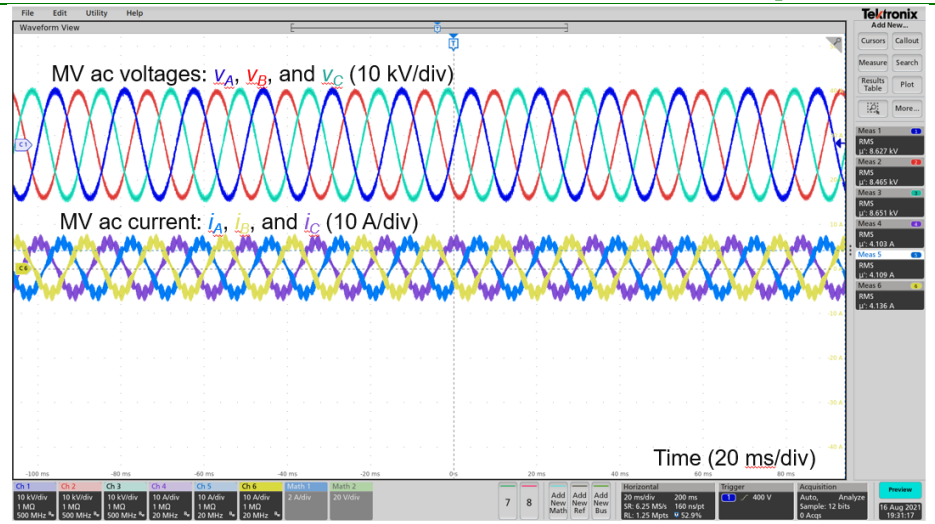
SiC Based Modular Transformer-less MW-Scale Power Conditioning System & Control for Flexible CHP (F-CHP) System

❑ Project Objectives

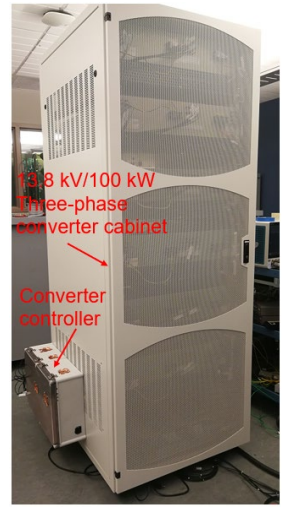
- Develop a SiC-based, modular, transformer-less, MW-scale, four-wire dc/ac power conditioning system (PCS) converter and a corresponding control system for the F-CHP system, providing cost effective dispatchable energy generation and grid support services



The F-CHP system configuration



The PCS converter waveforms @ 13.8 kV/100 kVA



The PCS converter prototype

❑ Recent Achievements

- The F-CHP system controller is tested in the hardware-in-the-loop (HIL), considering controller functions, and in the hardware testbed (HTB), considering grid transients and mode transitions
- The 13.8 kV / 100 kW PCS converter prototype is designed, built, and tested in different operation modes and grid conditions, such as voltage support, high/low voltage/frequency ride-through
- The built PCS converter has 300 Hz ac voltage control bandwidth, 1.1 kHz ac current control bandwidth, 96.4% efficiency at the rated operation condition, and partial discharge (PD) inception voltage 50% higher than the rated operation voltage

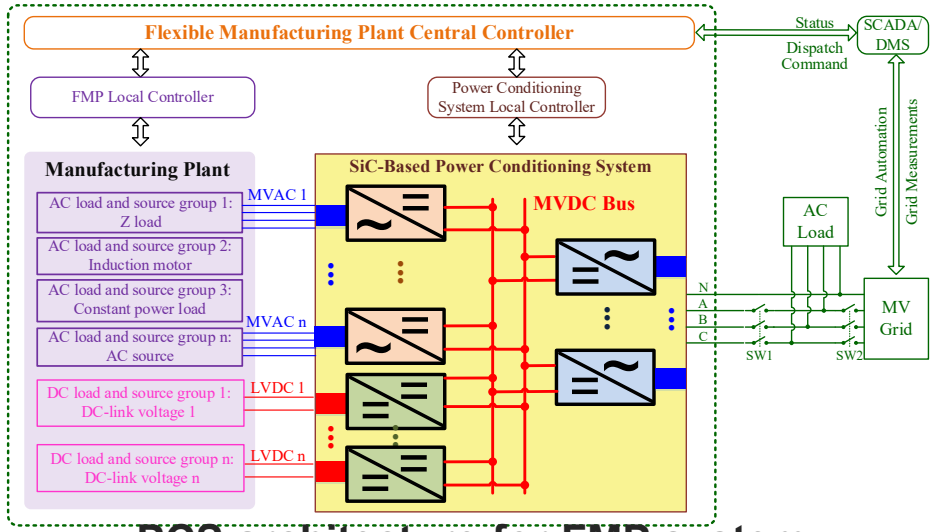
SiC based Modular Transformer-less MW-scale Power Conditioning System & Control for Flexible Manufacturing Plants

Project Objectives

- Develop a 10 kV SiC MOSFET-based 1 MW bi-directional power conditioning system (PCS) for manufacturing plants, consisting of back-to-back 13.8 kV AC/DC converters and a 200 kW isolated DC/DC converter connected to the PCS MV DC bus.
- The proposed PCS converter will meet performance targets including >99.4% power efficiency, <0.3 m^3/MW volumetric density, >10% dispatchability, <$30/kW cost (excluding SiC die cost), > 10 years lifetimes, 300 Hz voltage control bandwidth and >1 kHz current control bandwidth, and grid support functions.
- The PCS converter can also be scaled to form at needed power (> 10 MW) and support multi-port operation.

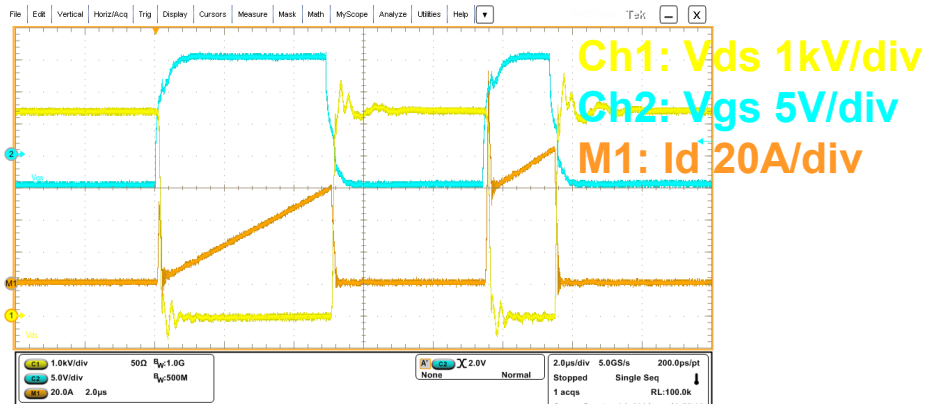
Recent Achievements (preferably last year)

- PCS specifications and grid requirements are determined.
- Medium voltage submodule (a key component of PCS) has been designed and tested.
- Design of the 1 MW DC/AC converter and 200 kW DC/DC converter conducted.
- FMP controller functions are determined. FMP simulation model and control algorithm validation are completed.



PCS architecture for FMP system

10kV SiC MOSFET power module

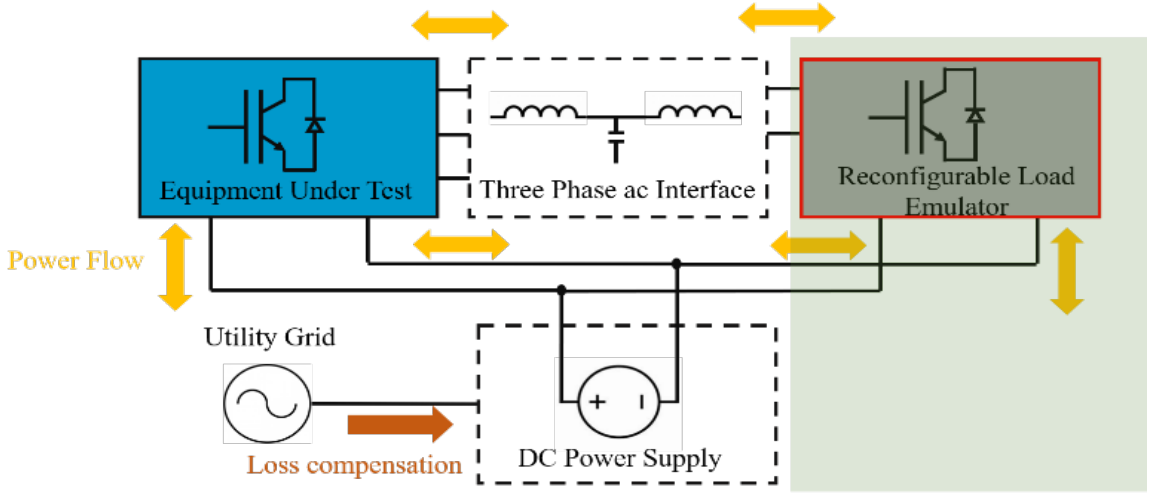


Double pulse test waveform of the 10kV SiC module at 6.5 kV/60A

Mega-Watt Power Electronics Based Universal Power Tester

Project Objectives

- Develop a versatile testing platform for mega-watt, medium voltage level voltage source converters
- Design and implement the power tester based on modular approach to enable flexible reconfiguration for covering extremely wide operation range of voltage, current and frequency
- Develop fast and reliable control system with accurate load characteristics models of different kinds for emulating real testing conditions



Test set up with universal power tester

Recent Achievements (preferably last year)

- All modules assembled, tested and installed in power cabinets
- Control system designed, implemented and preliminary testing program developed
- High-pot, partial discharge and safety sensor conducted for high voltage operation

Fully assembled modules under testing