Center for High Performance Power Electronics

Director's Update

Prof. Longy Xu, Jin Wang

Jan. 26th 2021

CHPPE

THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

Center for High Performance Power Electronics

Faculty:	**9**
Research scientists/engineers:	**6**
PhD Students:	**32**
MS Students	**15**
Research Expenditures:	**>$5 Million/year**

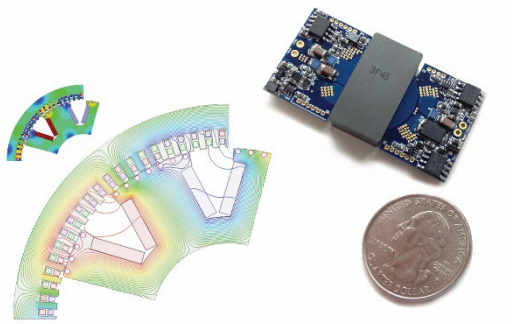
- ❑ Power Semiconductors
- ❑ Power Electronics
- ❑ Electric Machines and Drives
- ❑ High Voltage
- ❑ Power Systems and Smart Grid

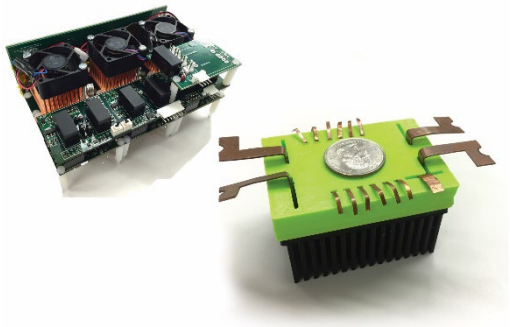
High Performance Power Electronics Lab a multi-million dollar center geared towards advanced power electronics circuits and devices;

High Voltage Laboratory a 3600 square feet facility that hosts the biggest arcs and sparks in the U.S. universities;

Distributed Real Time Simulation Platform a DoE sponsored real time simulation platform for both the electrical and communication systems within a smart grid, featured in a New York Times article.

Integrated Power Electronic Packaging Lab an integrated cleanroom lab space, with the equipment for die handling, interconnection , and module encapsulation.





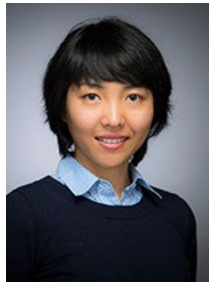
CHPPE Faculty Members

Dr. Longya Xu,
Center Director

Dr. Mahesh Illindala

Dr. Jiankang Wang

Dr. Jin Wang, Co-Director

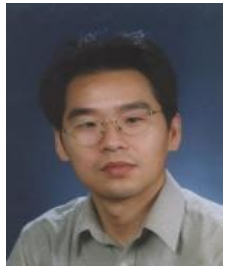


Dr. Julia Zhang

Dr. Ayman Fayed

Dr. Anant Agarwal

Dr. Siddharth Rajan



Dr. Wu Lu

Dr. Hongping Zhao

CHPPE Research Facilities/Equipment

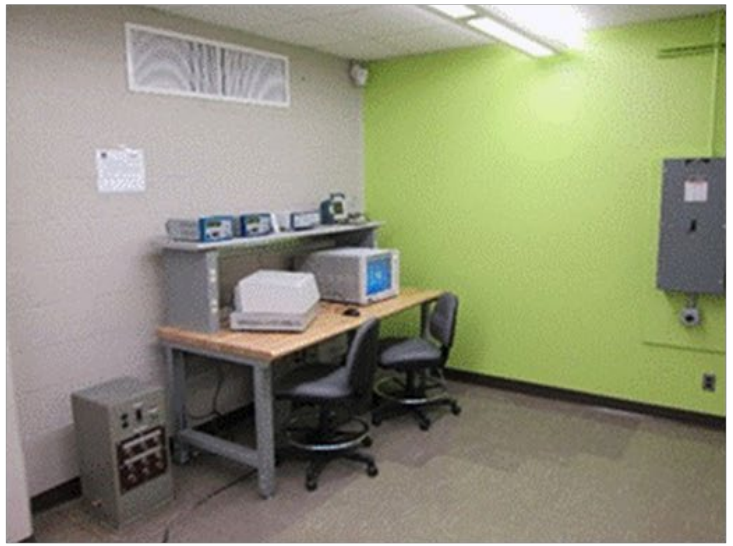
- 30,000 RPM
- 350 kVA
- Vehicle and aerospace applications

CHPPE Research Facilities/Equipment

High Power Test Area

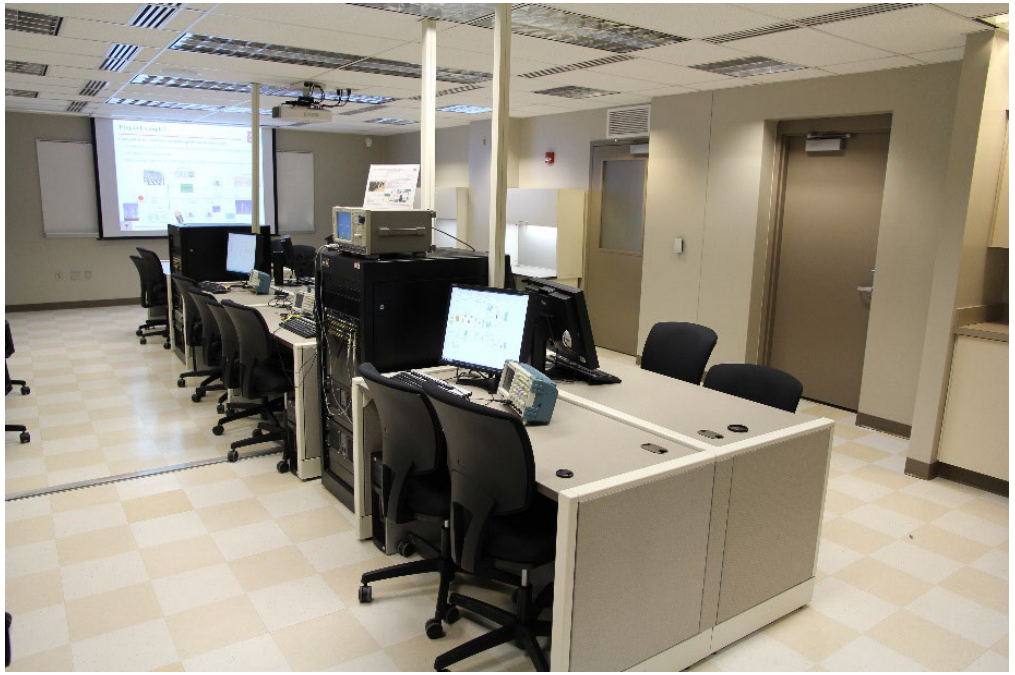
One of the Test Benches

Student Lounge



Device Evaluation Bench

CHPPE Research Facilities/Equipment



The Fully Equipped Teaching/Research Platform.

One Simulation Tower with Surrounding Benches.

The new facility hosts two real time simulation towers, eight student computers, and eight digital oscilloscopes to enable 16 students to work in the hardware in the HIL lab at a time.

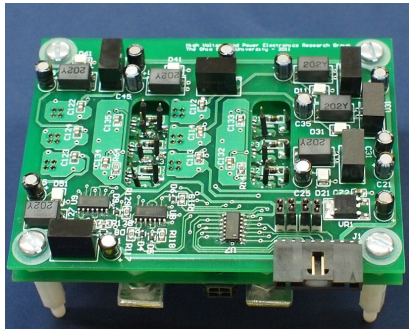
Outline

- Introduction
- 2010-2020
- Updates from 2020 and current status

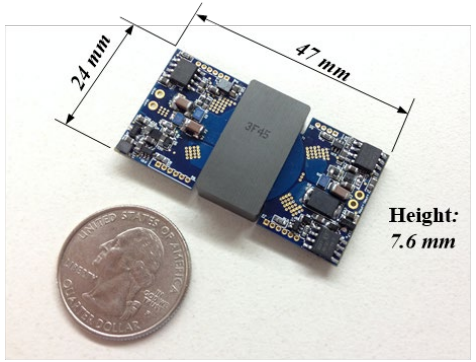
2010-2013 Building the Foundation

The Center was established in June of 2010 with the funding support from the State of Ohio, Air Force Research Laboratory, and GE Aviation.

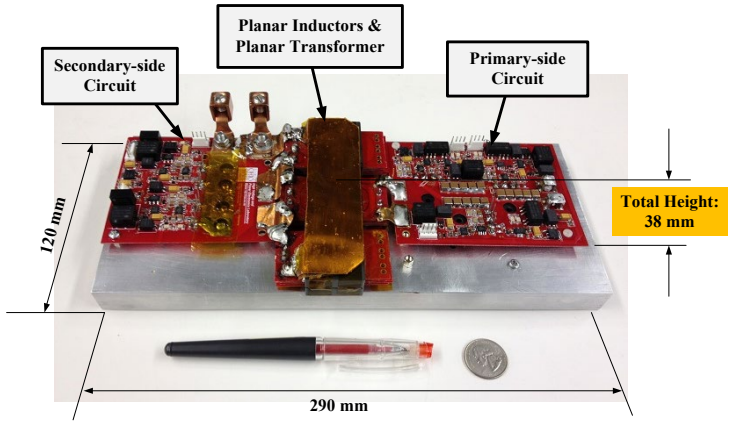
In the first few years, research at CHPPE had focused on WBG based switched capacitor circuits and FPGA based real-time simulation of WBG based motor drives.



500 W Switched Capacitor Cells with GaN devices, 893 kHz switching, 2011



90 W Isolated 85 V/19 V DC/DC stage with GaN Devices, 900 kHz switching, 2012



1 kW Isolated 400 V/12 V SiC based DC/DC for EVs, 500 kHz switching, 2013

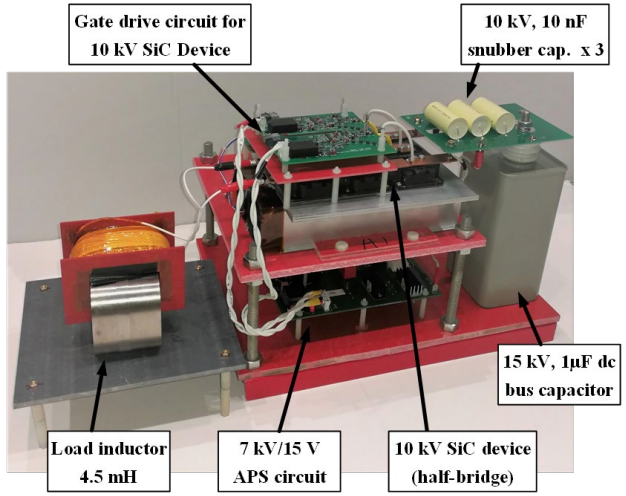
The new facility was commenced in June 2013

2014-2015 Development and Shifting towards Medium Voltage

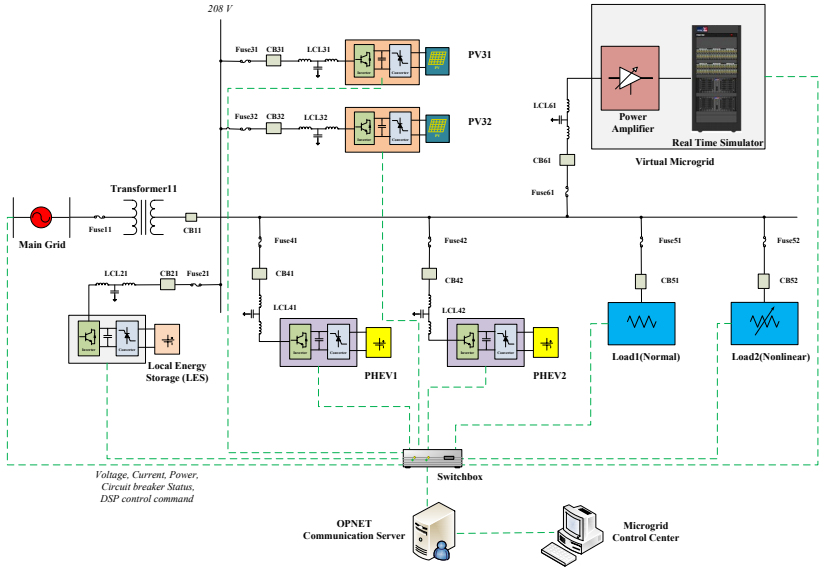
- **Started to work on medium voltage SiC device evaluation and circuit prototyping.**
- **Developed high power density GaN based motor drives.**
- **Continued work on dc network related issues: arc characterization and detection methods and control and protection strategies.**

Total box volume: 14.6 cm * 9.3 cm * 5.2 cm = 0.706 Liter

10 kVA GaN based motor drive



Self-sustained building block with 10 kV rated SiC

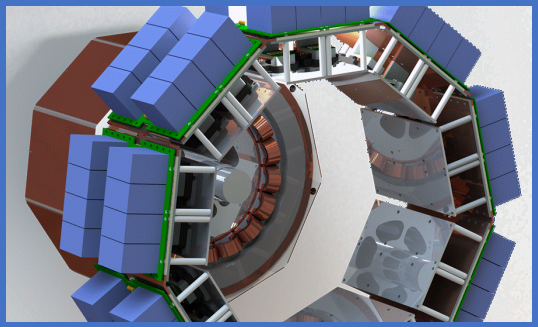


PHIL based dc microgrid test bed

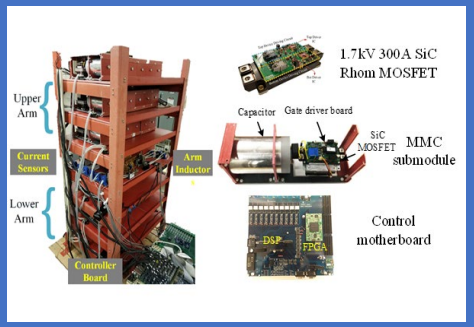
The Center won a major DoE award on SiC based MW medium voltage motor drive at the of 2015.

2016 -Now Fast Growth

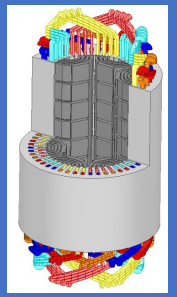
- Medium voltage motor drives for industry and aviation applications.
- Medium voltage SiC device evaluation and circuit prototyping.
- Double-fed brushless reluctance machine for distributed propulsion.
- Dc microgrids for aircraft and shipboard applications: solid state circuit breakers, control and protection.
- Partial discharge with high dv/dt PWM.
- Artificial intelligence for power electronics.

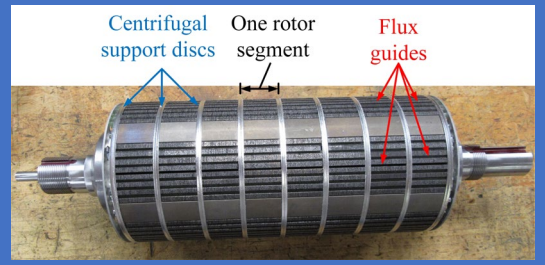


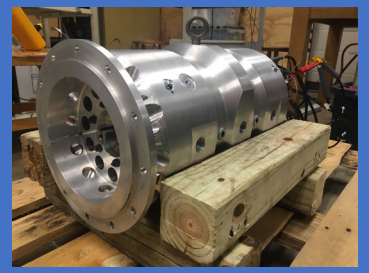
2 kV 1 MVA Integrated Drive



7 kV 1 MVA MMC







120-kW 12,000 RPM BDFM

Over $20 M Federal and State Funded Projects since 2016!

Alumni

2010-2020

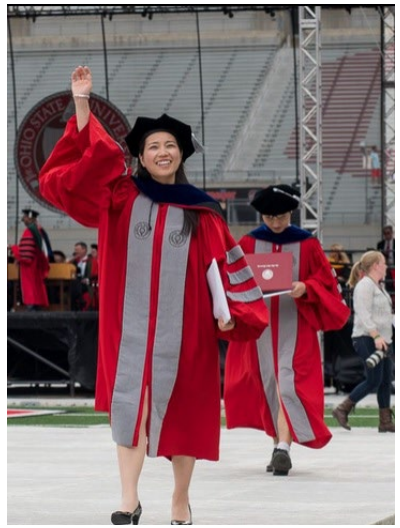
Number of graduated students:

- 35 Ph.D. Students
- 40 M.S. Students

All numbers are based on a survey of past students advised by Profs. Longya Xu, Jin Wang, Mahesh Illindala, Julia Zhang, JK Wang, and Fang Luo

Top employers of CHPPE graduates:

- Tesla: 5
- Ford: 5
- Apple: 4
- Google: 3
- Monolithic Power Systems: 3
- Texas Instruments: 3
- ABB: 2
- American Electric power: 2
- Eaton: 2
- GE: 2
- ON Semi: 2
- …



Student Awards

29 best paper and best presentation awards in leading power electronics journals and conferences, including

- 11 Best presentation awards at the Applied Power Electronics Conference (APEC)
- 2 First Prizes at the ECCE student demonstration (2015 and 2017)
- Best presentation award at the International Future Energy Challenge 2018 (by undergraduate students)
- And many other best paper awards in journals and conferences

2020 (Nov. 2019-Dec. 2020) Updates

- Lab activities at OSU halted from March 15th to July 20th.
- CHPPE labs now operate in limited access mode.
- Three months' delay are expected for most projects.
- Started 8 new federal and industry sponsored projects during the pandemic.
- The center is still looking for candidates to fill in Post-doc and Graduate Research Assistant positions.

By Jan. 23rd 2021, OSU has conducted

- 301,639 Covid tests for students with a positive rate of 2.12% (6,391 positive cases), and
- 22,572 tests for faculty and staff with a positive rate of 2.98% (673 positive cases).

OSU campus on the afternoon of Jan. 22 2021

2020 Updates

Nov. 2019-Dec. 2020

Number of Ph. D. student graduated: 10 (7 in 2019)

Number of Masters students graduated: 6 (11 in 2019)

Current number of Ph.D. students: 33

Current number of Masters students: 10

Total publications (Nov. 2019-Dec. 2020):

- 15 conference papers (41 in 2019)
- 32 journal papers (23 in 2019)

Student Awards

Jeremiah Vannest received the OSU Graduate School Inclusive Excellence Award 2020 to 2021. Advisor: Julia Zhang

Xue Hao's work on AlGaN FinFETs is highlighted by Semiconductor Today. Advisor: Wu Lu

Manmeet Singh, 1st Place in the 2020 John D. and Alice Nelson Kraus Memorial Graduate Student Poster Competition at OSU. Advisor: Ayman Fayed

Khalid Alkhalid, Outstanding Teaching Assistant Spring 2020, Department of Electrical and Computer Engineering, OSU. Advisor: Jin Wang

Faculty Awards

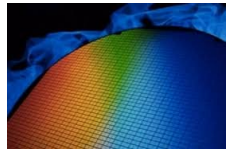
Prof. Mahesh Illindala, 2020 OSU College of Engineering Lumley Research Award, The Ohio State University

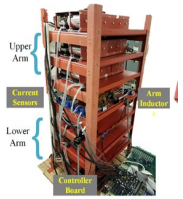
Prof. Jin Wang, Nagamori Award, Nagamori Foundation

Prof. Jin Wang, IEEE Fellow

Major Ongoing Federal Funded Projects

- GaN MOCVD growth on native substrates for high voltage (15-20 kV) vertical power devices, PI: Hongping Zhao, ARPA-E, 2019-2022
- Smart operation and fault diagnosis of next generation wide bandgap power electronics using machine learning, Army Research Laboratory, PI: Julia Zhang, 2019-2023
- DOE "Next Generation Power Electronics Manufacturing Innovation Institute (NGPEMII) - "PowerAmerica" sub-contracts, PowerAmerica Institute, PIs: Longya Xu, Julia Zhang, Jin Wang, 2019-2021





- Intelligent Power Systems, AFRL, PI: Longya Xu, 2019 - 2021
- Electrical Propulsion: Challenges and Opportunities, NASA, CHPPE lead: Jin Wang, 2017 - 2022
- T-Type Modular DC Circuit Breaker (T-Breaker) for Future DC Networks, ARPA-E, PI: Jin Wang, 2019-2022

- AMO GADTAMS: Development of a SiC based MV (13.8kV) 1MVA Inverter for a B2B AC System, Department of Energy, PI: Jin Wang, 2019 - 2022
- Intelligent Power Stage, Department of Energy/Oak Ridge National Lab, PI: Jin Wang, 2019 - 2022

- Consortium for Advanced Electric Drive Technologies (CAEDT) , Department of Energy/Vehicle Technology, PI: Anant Agarwal, 2019~2024

CHPPE Sponsors

NASA
U.S. DEPARTMENT OF ENERGY
AIR FORCE RESEARCH LABORATORY
DEPARTMENT OF THE NAVY ONR Science & Technology
arpa·e CHANGING WHAT'S POSSIBLE
NSF
NIH National Institutes of Health
ARL
PowerAmerica
Ohio Department of Development
OFMJC Federal Research Network
Ohio Federal Research Network Driving Innovation Through Strategic Partnerships
Ford
FCA FIAT CHRYSLER AUTOMOBILES
gm
TESLA
LEAR CORPORATION
CAT
BOEING
GE
SAFRAN
ANSYS
TOSHIBA Leading Innovation
ti
GeneSiC SEMICONDUCTOR
ABB
AEP AMERICAN ELECTRIC POWER
Duke Energy
FirstEnergy

Thank you for your attention!

Questions?