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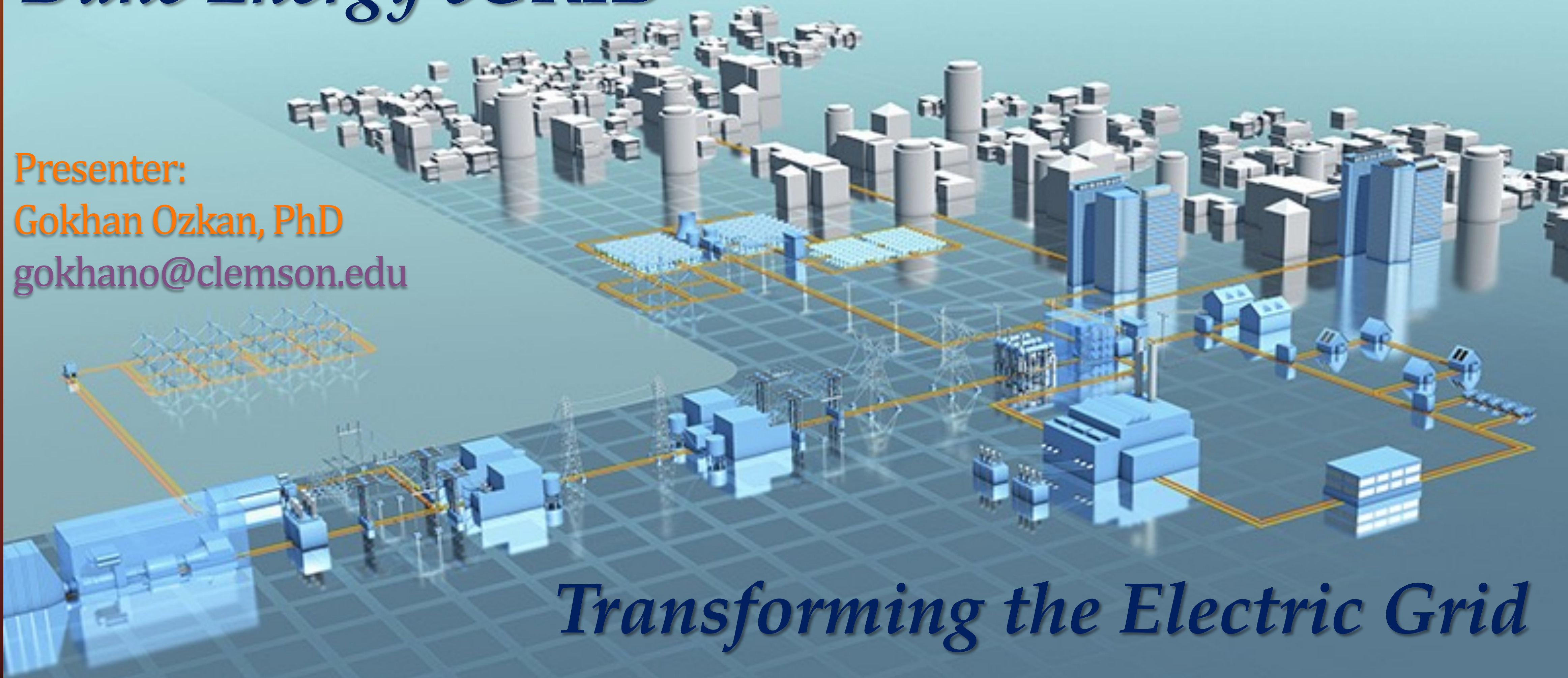
Driving economic growth, innovation, and workforce development

Duke Energy eGRID



Presenter:
Gokhan Ozkan, PhD
gokhano@clemson.edu

Transforming the Electric Grid

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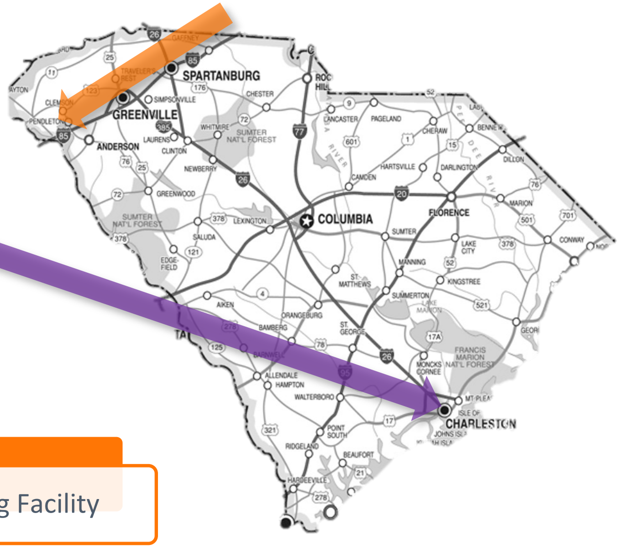
Outline

» Introduction
» High-Speed Motor
» 3.4 MW Wind Turbine
» 5 MW Transformer

Dominion Energy Innovation Center

- Clemson University Restoration Institute
  - Dominion Energy Innovation Center
    - Duke Energy eGRID Center
      - 15 MW HIL Grid
      - 30 MW HIL Grid (future)
    - Wind Turbine Drivetrain Testing Facility
      - 7.5 MW Test Bench
      - 15 MW Test Bench
      - 30 MW Test Bench (future)



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The eGRID Center Team Members

Meredyth Crichton	Executive Director of the Energy Innovation Center
Gokhan Ozkan, PhD	eGRID Research Faculty
Moazzam Nazir, PhD	eGRID Lab Leader
Russell M. Moore	Research Engineer
Jeremy Jones	Data Systems Engineer
Jonathan Dobson-Lewis	Data Systems Engineer
Travion Simmons	Data Systems Technician

Graduate Students:

3 PhD Students

Dominion Energy Innovation Center

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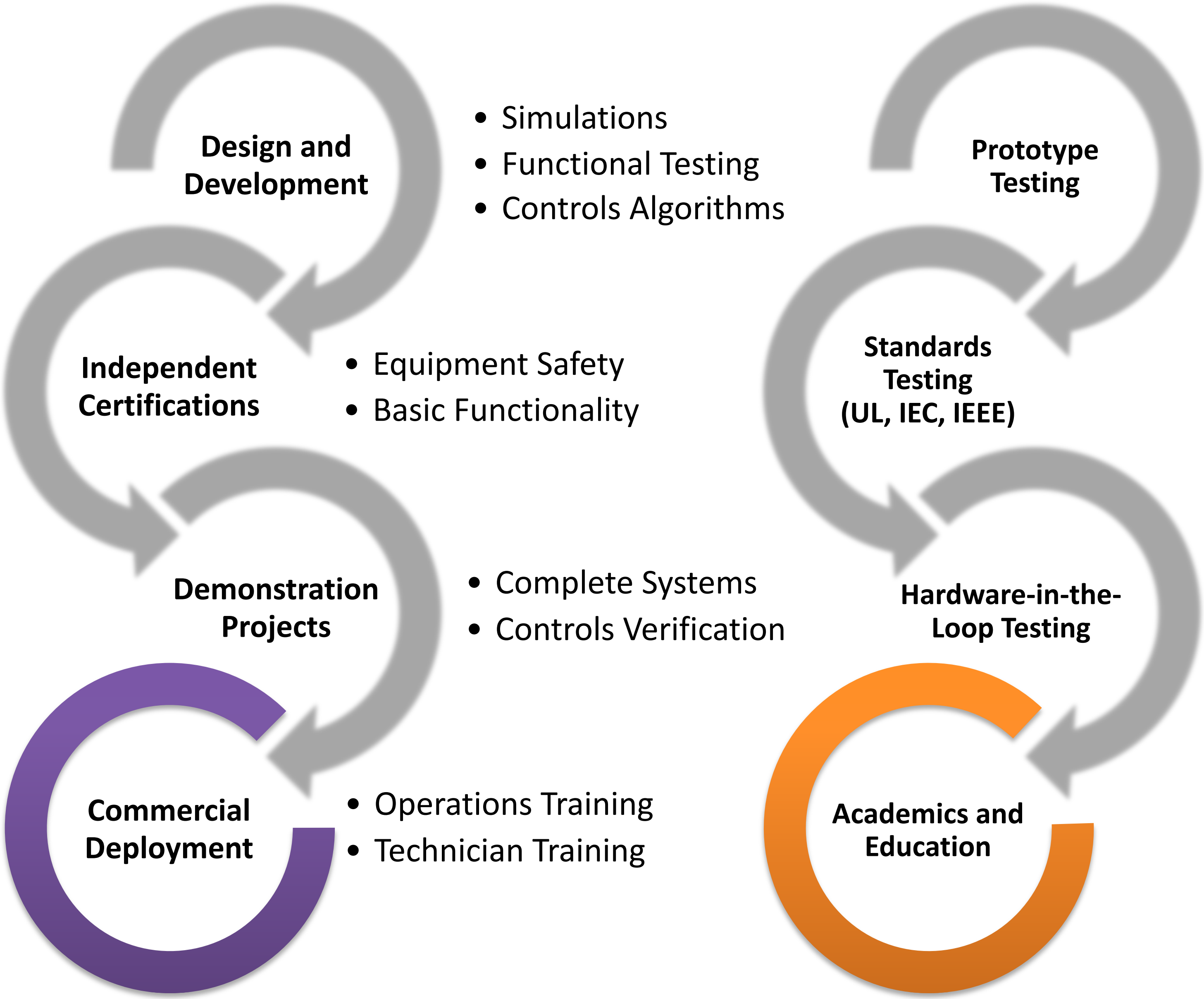
Where We are in Technology Development Cycle



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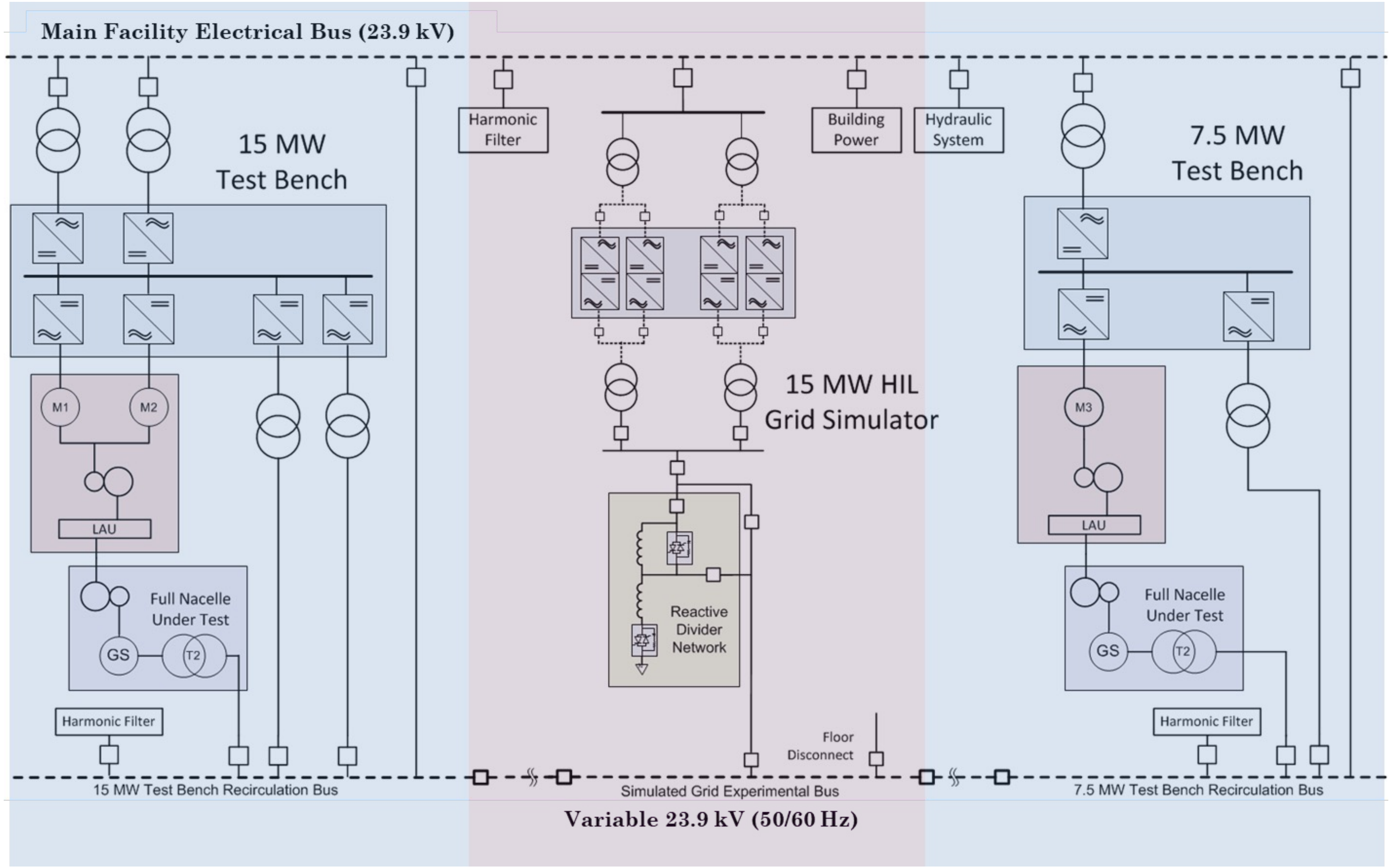
Dominion Energy Innovation Center



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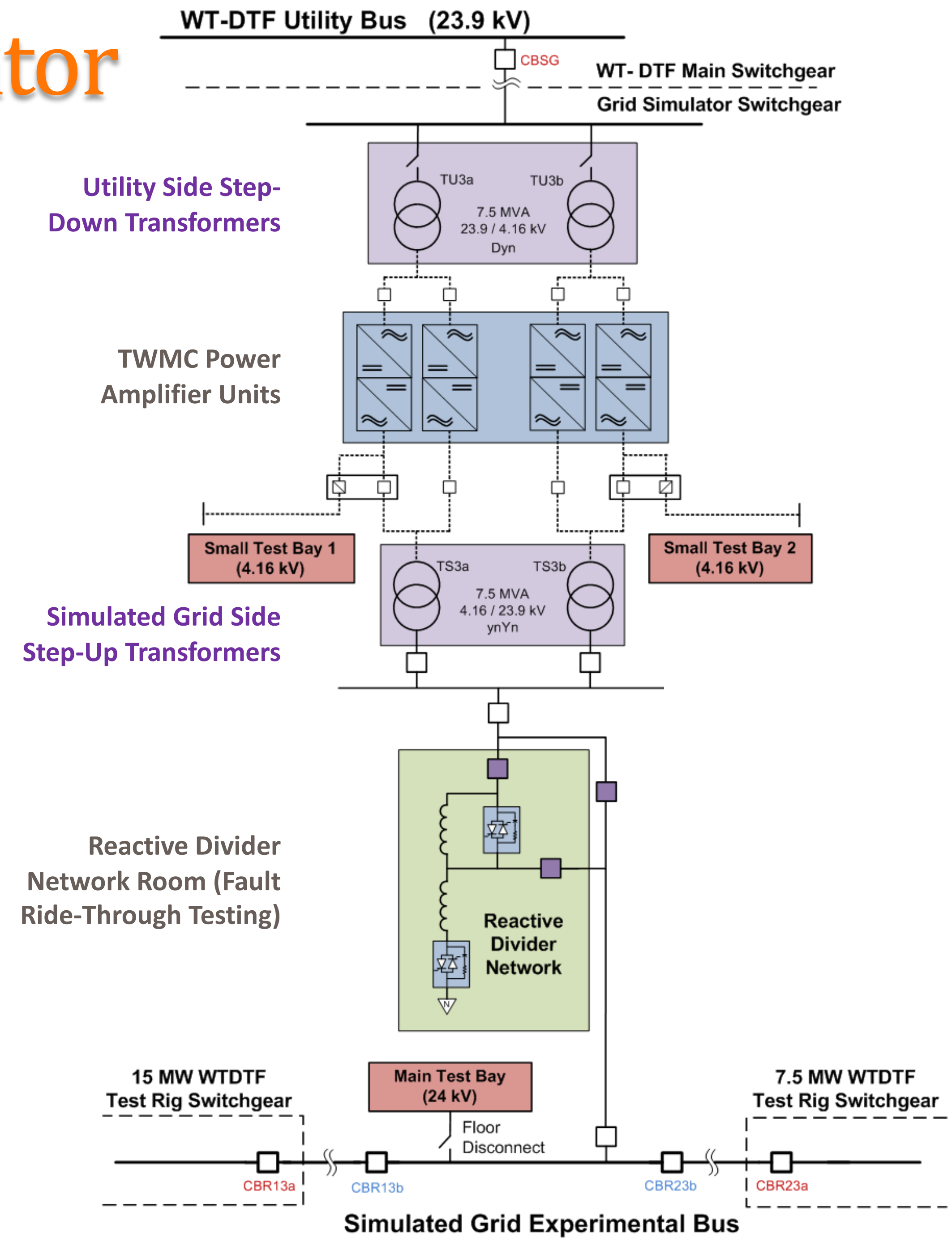
The 20 MVA HIL Grid Simulator

Three Independent Test Bays

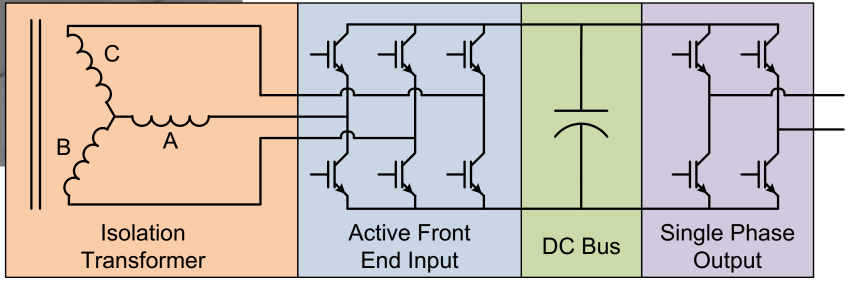
Overall Electrical Capabilities	
Main Test Bay	
Nominal Voltage	24 kV (50/60 Hz)
Nominal Power	20 MVA
Frequency Range	45 to 65 Hz
Sequence Capabilities	3 and 4 wire operation
Overvoltage capabilities	133% Continuous Overvoltage
Fault Simulation	Yes (includes Reactive Divider)
Hardware In the Loop	Yes
Small Test Bay 1	
Nominal Voltage	4160 V (50/60 Hz)
Nominal Power	5 MVA (4 MW @ 0.8 PF)
Frequency Range	0 to 800 Hz
Sequence Capabilities	3 and 4 wire operation
Overvoltage capabilities	133% Continuous Overvoltage
Fault Simulation	Limited to Converter Only
Hardware In the Loop	Yes
Small Test Bay 2	
Nominal Voltage	4160 V (50/60 Hz)
Nominal Power	5 MVA (4 MW @ 0.8 PF)
Frequency Range	0 to 800 Hz
Sequence Capabilities	3 and 4 wire operation
Overvoltage capabilities	133% Continuous Overvoltage
Fault Simulation	Limited to Converter Only
Hardware In the Loop	Yes



The 20 MVA Power Amplifier Units

4 Power Amplifier Units (PAUs)

8 Slices Per PAU



3 Cubes Per Slice

2.5 MW Controlled DC Supply

- Modify a single PAU cabinet set to create a DC supply without changes to the control scheme
- Aimed at solar testing with Maximum Power Point Tracking and 2D PV field simulation
- Limited bi-directional power flow (dynamic braking resistors) allows for tight regulation

DC Supply Module Specifications		
	1 Module	6 Modules
Voltage Range	200 – 1000 V	
Current Rating	420 A (1000 V)	2500 A (1000 V)
Short Circuit Current	835 A	5000 A
Ripple Frequency	2400 – 4800 Hz	
Reverse Power Flow	67 kW (1000 V)	400 kW (1000 V)

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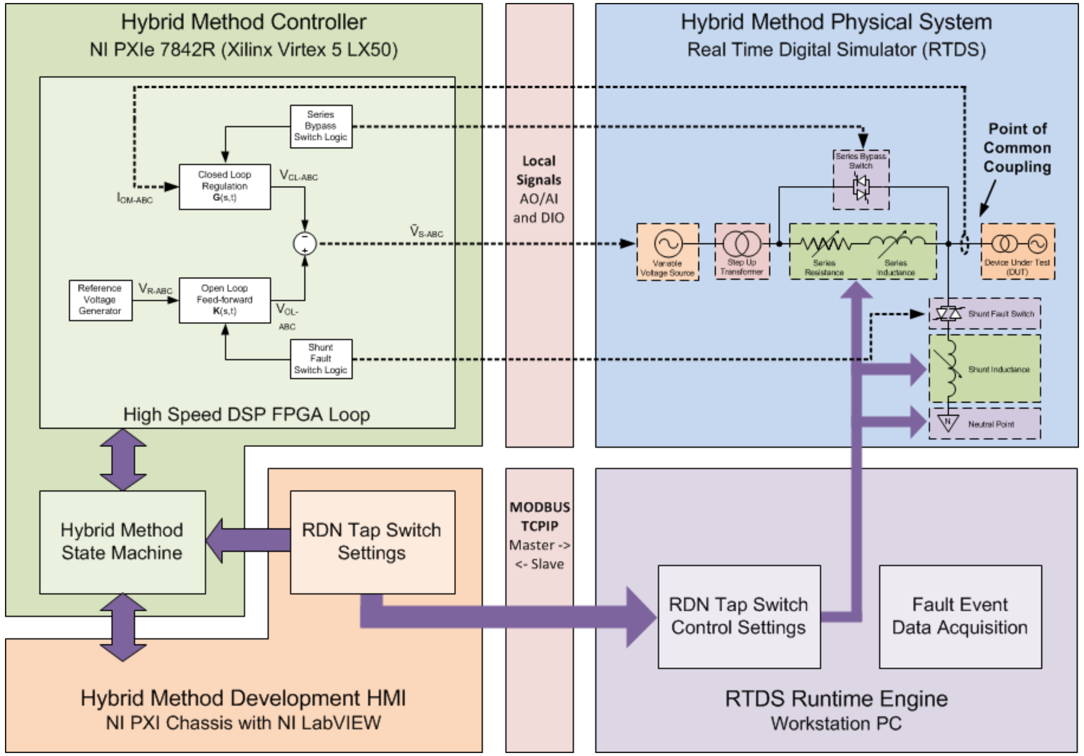
Controller Design Validation with Controller Hardware-In-the-Loop Experiments

- Controller Hardware-In-the-Loop (CHIL) experiments are designed to evaluate the controllability and stability of performing fault ride-through evaluations with the Hybrid Method
- The RTDS system simulates the Grid Simulator physical system model and the DUT models
- A scale version of the Interface Controller is used to validate the control algorithms

National Instruments Interface Controller



Block Diagram of the CHIL experiments for the Hybrid Method

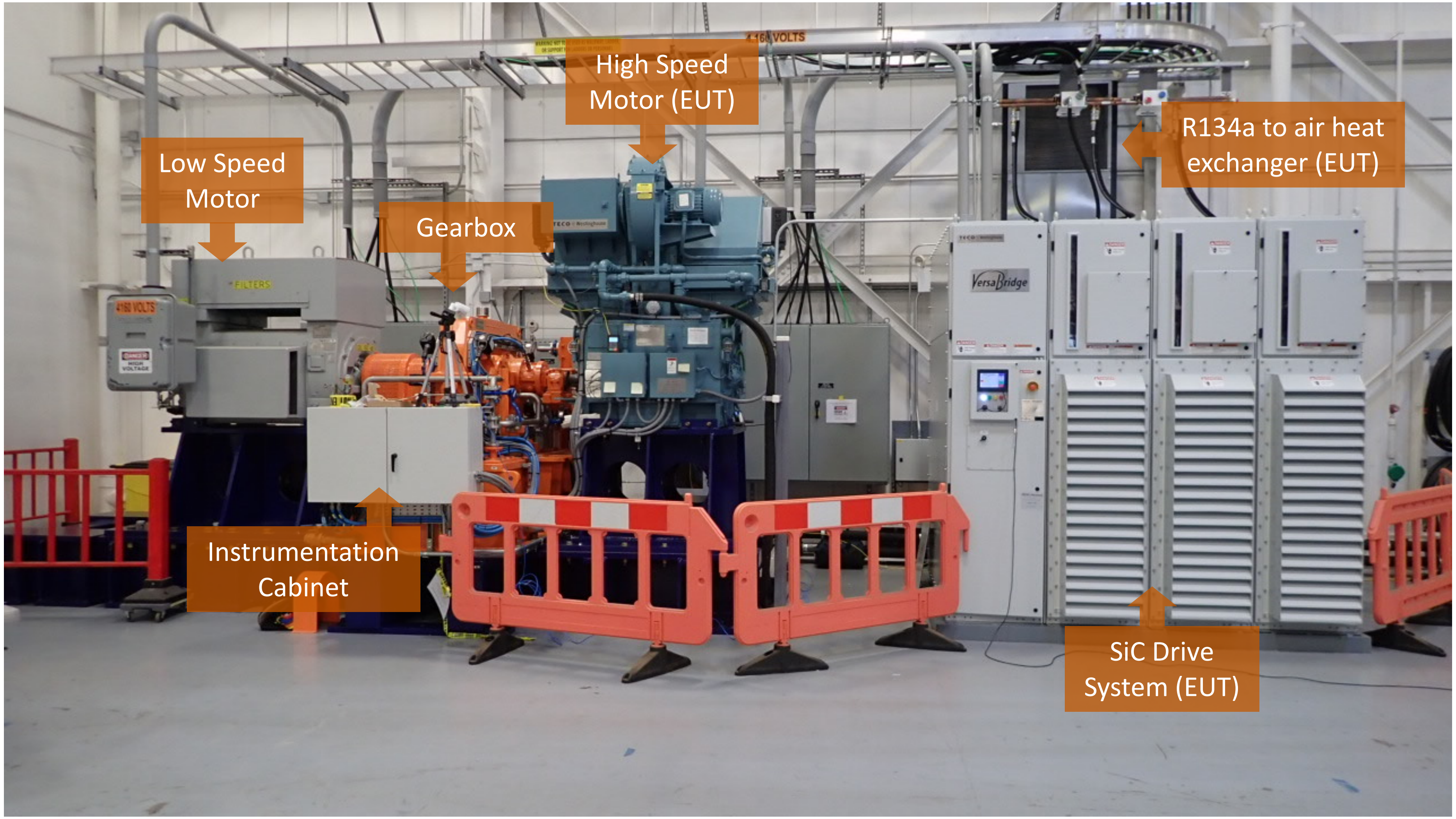
Real-Time Power System Simulator RTDS®

Digital Real-Time Simulator SpeedGoat®

High Speed Dynamometer

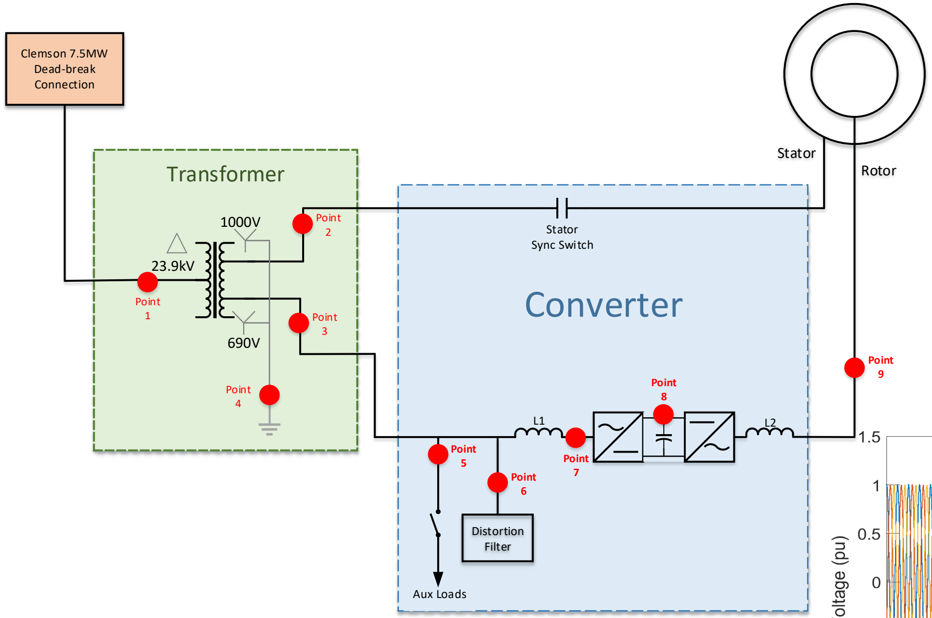
» Dyno testbed developed as part of DOE AMO Next Generation Electric Machines program

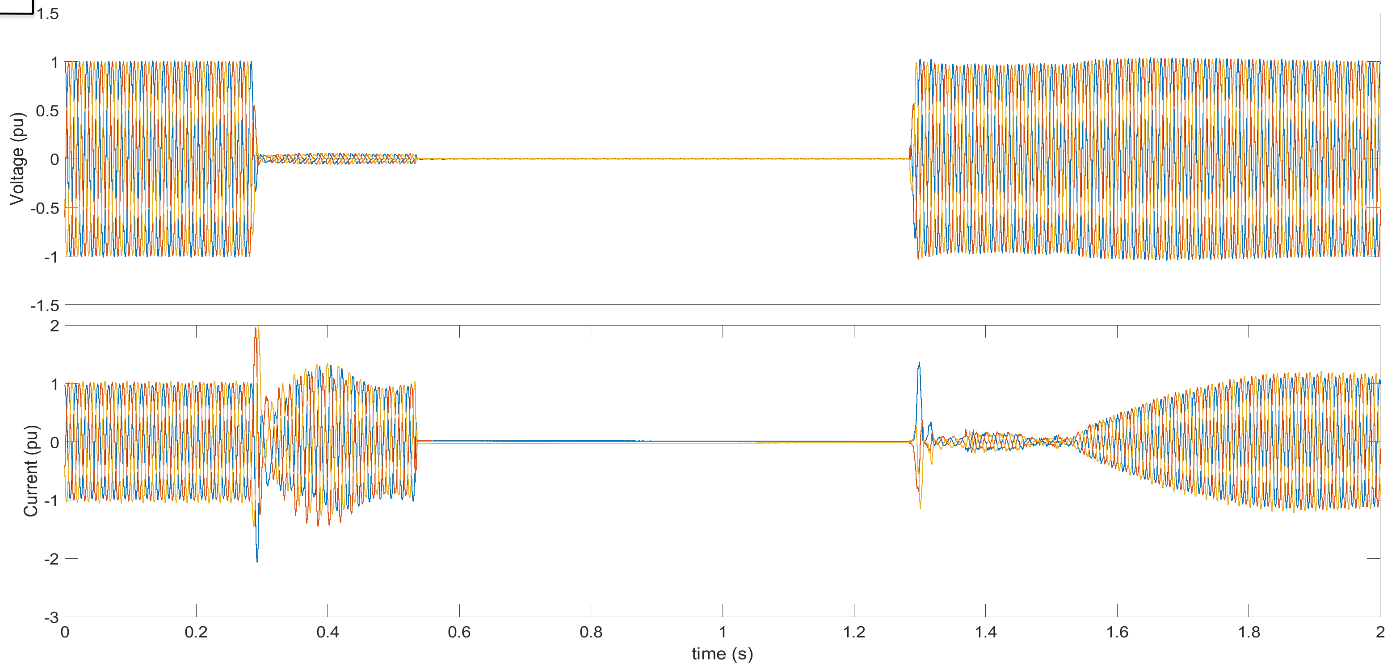
» Partner: TECO Westinghouse Motor Company (TWMC) designed HS motor and SiC drive



3.4 MW Wind Turbine

- Zero voltage ride through testing for type 3 wind turbine

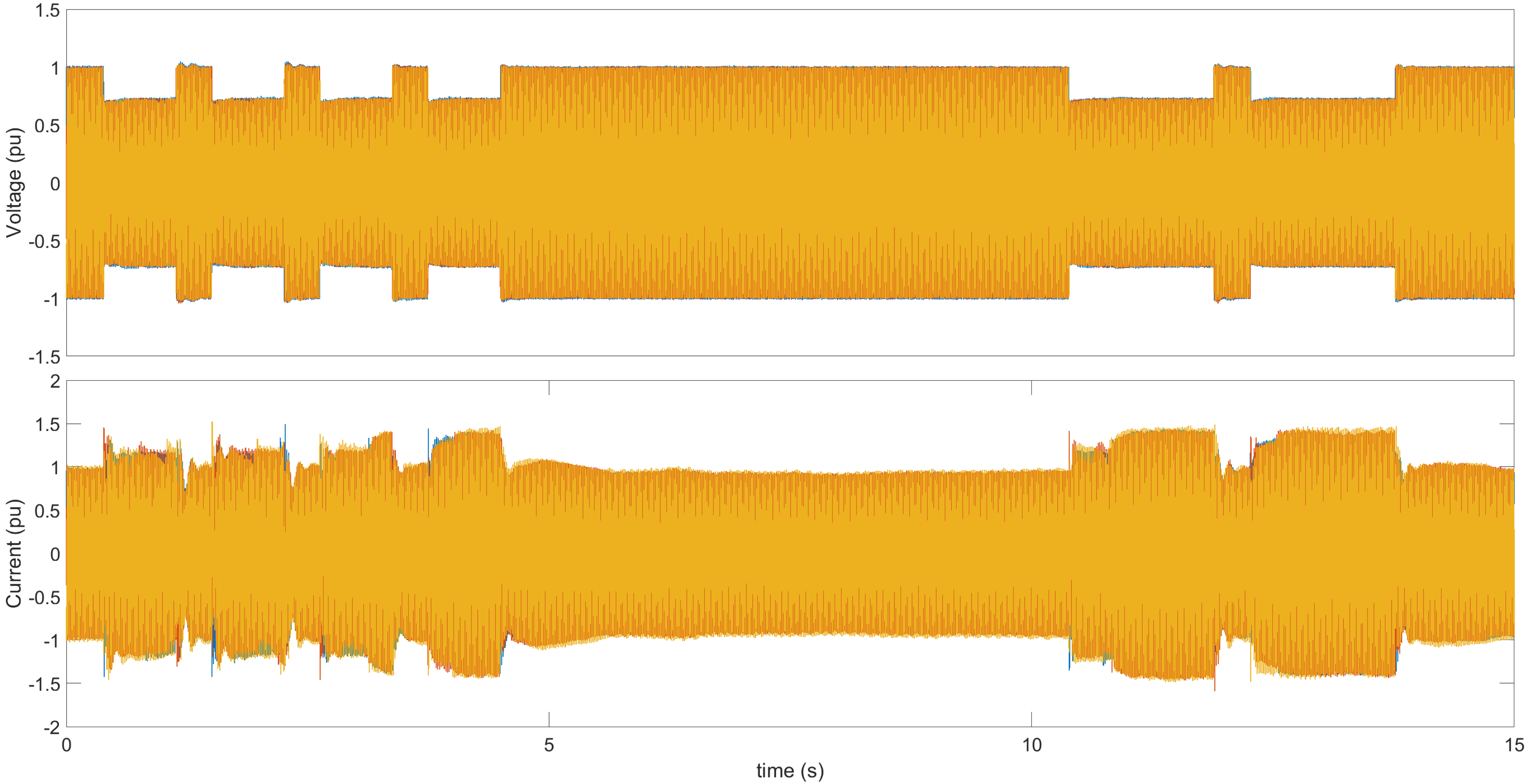




Zero Voltage Ride Through for 1 sec (point 1)

3.4 MW Wind Turbine

- IEEE 2800-2022 Consecutive voltage deviations ride-through capability
- 4x0.8 seconds and 2x1.6 seconds with %70pu voltage ride-through



Multi-Voltage Ride Through

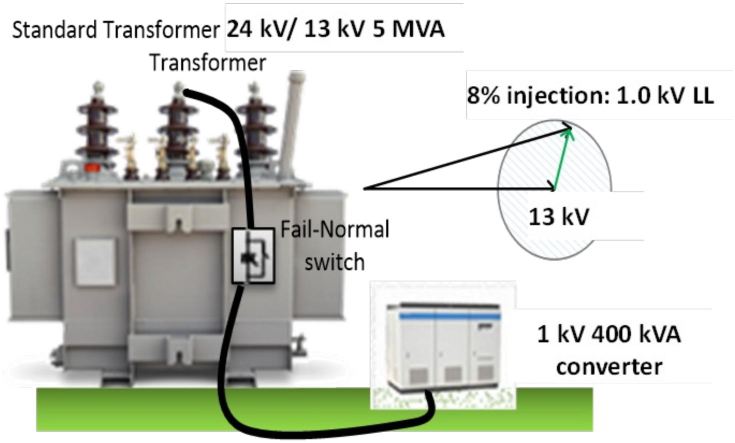
5 MVA Transformer Test

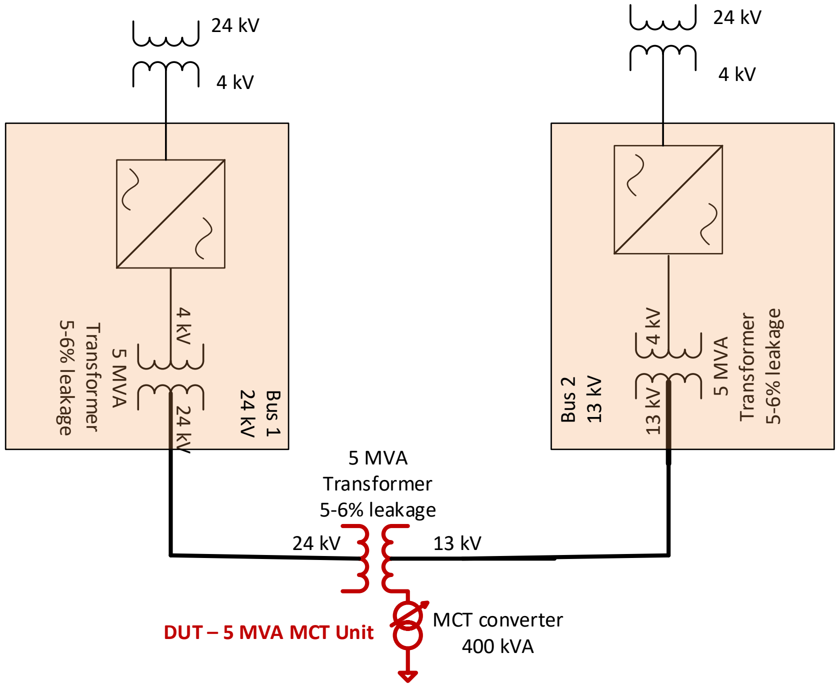
5 MVA Transformer test IEEE 1547

Low voltage ride through, voltage regulation, power quality

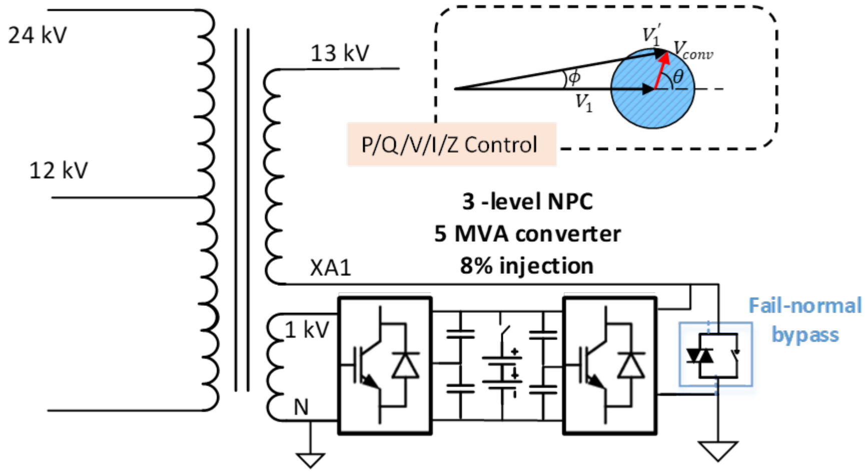
MCT Implementation

Power electronics provide dynamic load balancing caused by mismatched impedances





Single-line diagram of test ring



Single-line diagram of DUT

eGRID Founding Partners

Duke Energy
SRNL
U.S. Department of Energy Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable
SCANA Power For Living
Santee Cooper
Underwriters Laboratories
TECO Westinghouse
Dominion Energy

eGRID Market Applications

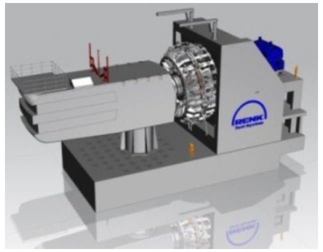
Large Solar PV Converters

Micro-Grid Applications

EV Charging Stations

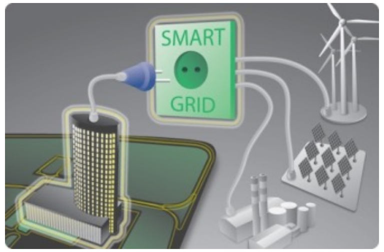
Utility Scale Energy Storage

Wind Energy

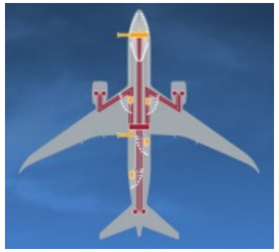


Traditional Distributed Generation (Diesel, NG. etc.)

Smart Grid Technologies



Aerospace



Thank You

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