Driving economic growth, innovation, and workforce development

CLEMSON UNIVERSITY

Laboratory Updates and Projects

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N. Charleston, SC

5th Annual Grid Simulator Workshop
November 15-16
Florida State University – Tallahassee, FL

Mission and Objective

- Objective: Accelerate the development of new technology into the wind market to reduce the cost of energy delivered.
- Mission: Provide (1) High Value, (2) High Quality and (3) Cost Competitive testing and validation services to industry.
- Establish long term partnerships with industry for work force development, research and education.

Campus Overview

Founded 1889

Top 20 NPU

20,000+ Students

- Rail Access
- Energy Innovation Center
- Warren Lasch Conservation Center
- Zucker Family Graduate Education Center (targeted 20 faculty, 200 students) – started classes Fall ‘16
- Dock Access (1,000 ton)

Clemson University Restoration Institute

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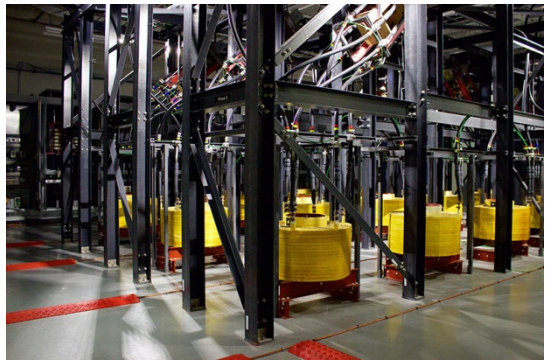
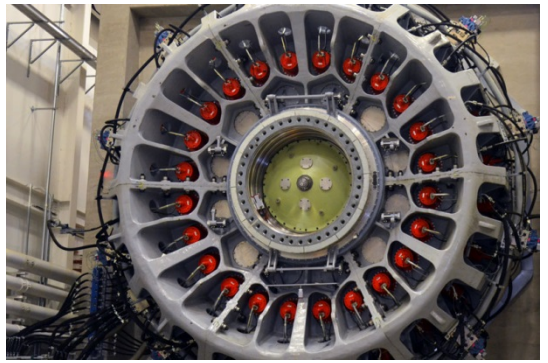
CURI Campus Organization

- Clemson University Restoration Institute
  - SCE&G Energy Innovation Center
    - Duke Energy eGRID Center
      - 15 MW HIL Grid Simulator
    - Wind Turbine Drivetrain Testing Facility
      - 7.5 MW Test Bench
      - 15 MW Test Bench





WTDTF Equipment Capabilities: 7.5 MW TB and 15 MW TB

7.5 MW Test Bench Performance Specifications	
Test Power	7,500 kW
Maximum Torque	6,500 kNm
Maximum Speed	20 rpm
Inclination	4 ° to 6 °
Static Axial Force	± 2,000 kN
Static Radial Force	± 2,000 kN
Static Bending Moment	± 10,000 kNm

15 MW Test Bench Performance Specifications	
Test Power	15,000 kW
Maximum Torque	16,000 kNm
Maximum Speed	17 rpm
Inclination	6 °
Static Axial Force	± 4,000 kN
Static Radial Force	± 8,000 kN
Static Bending Moment	± 50,000 kNm

Testing Partners

7.5 MW Test Bay

GE Renewable Energy

15 MW Test Bay

MHI VESTAS OFFSHORE WIND

eGRID Center

TECO Westinghouse

SMA

Johnson Controls

ABB

EATON

SOLECTRIA A YASKAWA COMPANY

Southern States

ComRent LOAD BANK SOLUTIONS

GE Power Conversion

GE Renewable Energy

GE Global Research

DUKE ENERGY

SCE&G A SCANA COMPANY

CYPRESS CREEK RENEWABLES

edp renewables powered by nature

Hydro Québec Institut de recherche

NREL NATIONAL RENEWABLE ENERGY LABORATORY

SRNL

EPRI ELECTRIC POWER RESEARCH INSTITUTE

IEEE

ONR Science & Technology

nyserda Energy. Innovation. Solutions.

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7.5 MW Test Rig: GE 3.X Platform

Inverter Recertification - Power Quality

» Simulated source impedance with PHIL

Problem

PV plants on low SCR circuits, noticeable flicker, site shut down

Team

Utility

Plant Developer

Plant Owner

MFR of discontinued MW scale inverter, limited software team

Consultant

NRTL

Clemson

Approach

New Firmware

Outcome

Recertification w/ UI tests & Relisting, Site back online

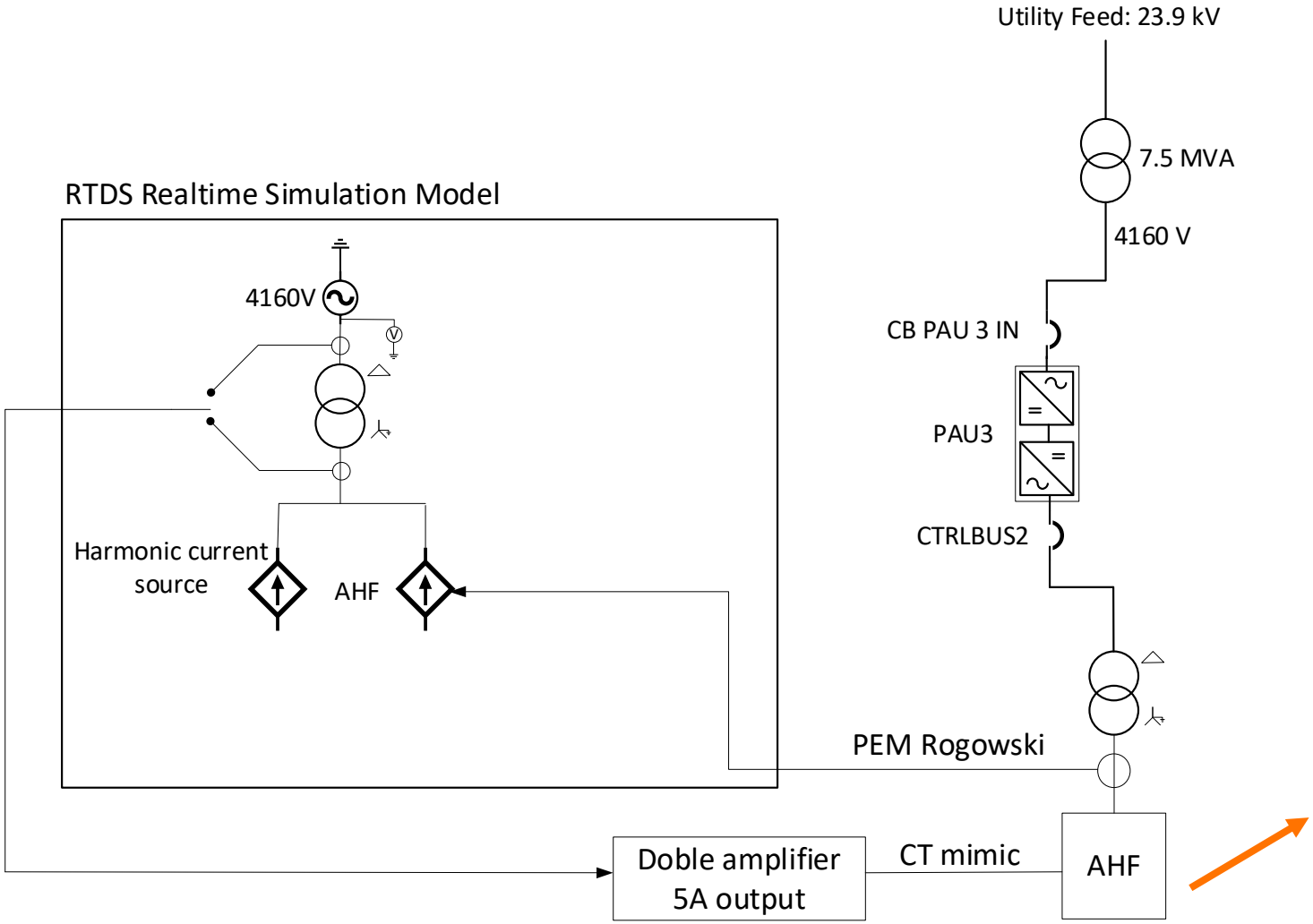
Inverter Recertification - Power Quality

Outlook:
IEEE P2800/P2800.1
for **sub-transmission** and **transmission** connected inverter based resources.

Recertification required retest of unintentional islanding with RLC.

PHIL UI methodology (1547.1 HIL):
Time & cost savings, safety

Active Harmonic Filter – Hybrid HIL

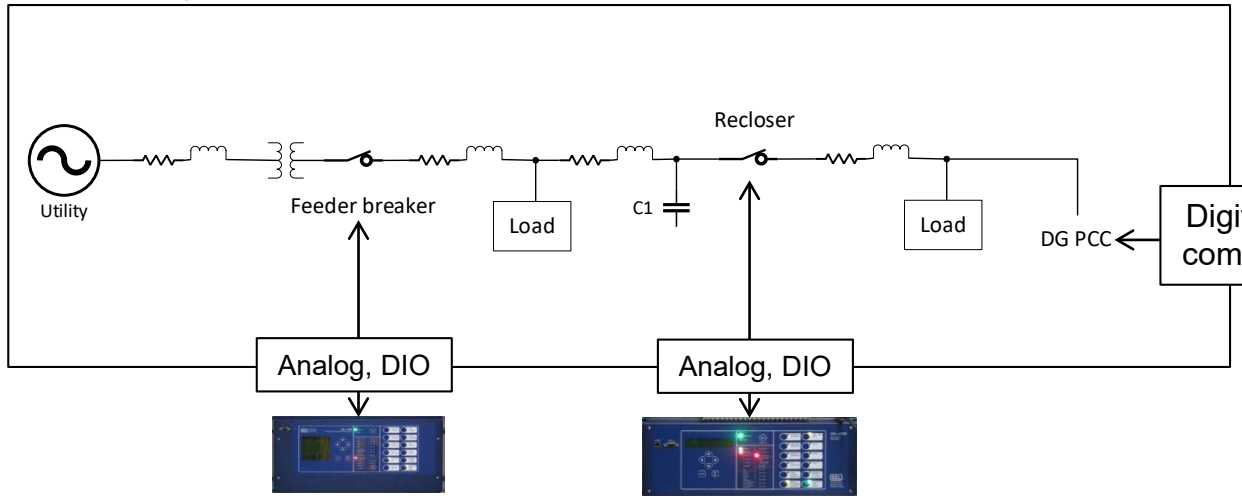


Early stage testing with HIL while remainder of equipment still in progress

Active filter compensates harmonic current of a simulated nonlinear load

EPRI – NYSERDA Risk of Islanding Study

DRTS – digital real-time simulator



PHIL interface

(4160V 3ph)

4Q AC Source

- RTDS for feeder circuit emulation
- Test with commercial available inverters
  - ABB 50 kW inverter under testing
  - SMA inverters to be tested

Test method validation: physical RLC (50 kW) vs. PHIL RLC

→

PHIL RLC

Off tune RLC, DER settings combinations

(1547.1)

→

PHIL Feeder

Feeder load P, Q

machine loads, etc.

DER location

→

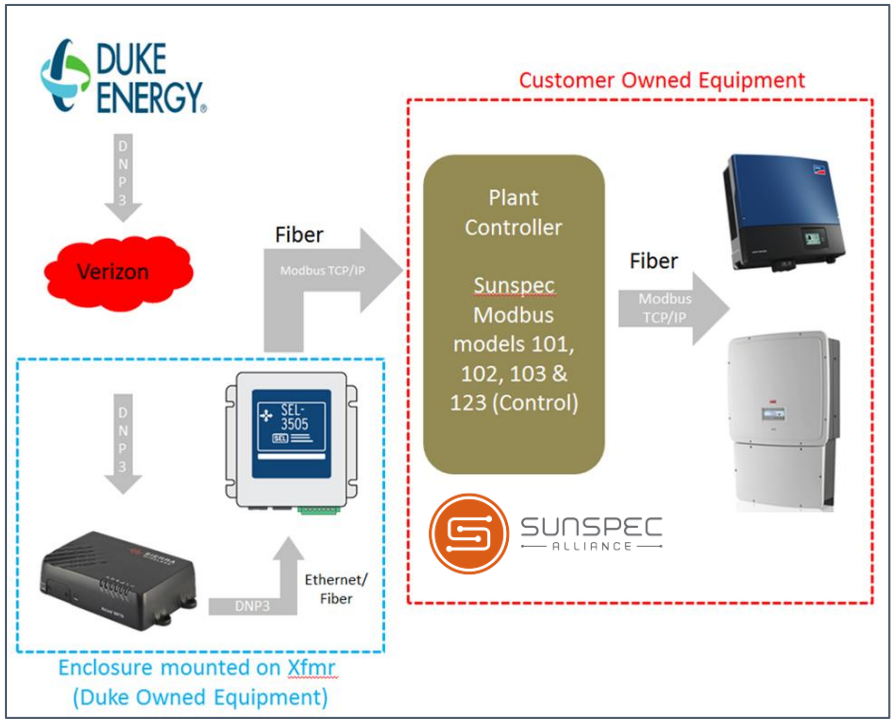
Iterating method on different inverters (higher power)

Validation

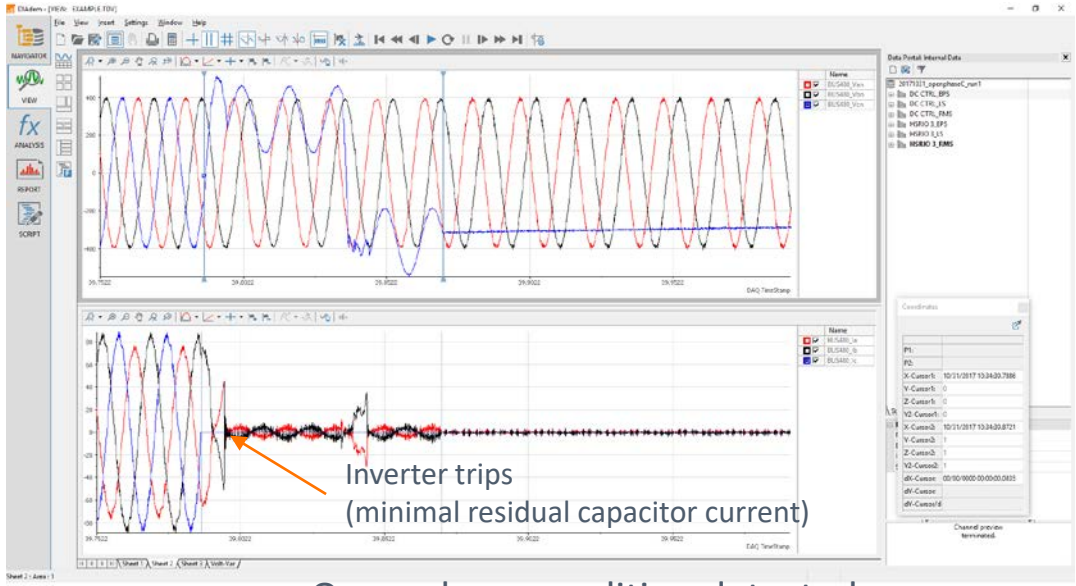
Expanded and automated design of experiments (doe) capabilities with PHIL

Duke Energy Test Projects

- Duke Energy, IEEE ICAP, ABB
  - IEEE conformity assessment program pilot for IEEE 1547
- Interconnection Communications
  - Communication of grid support function settings for DER
  - Testing cost effective solution for high penetration feeders



Pilot interconnection conformity assessment & commissioning



Open-phase condition detected

Transformer Testing

GridBridge energy router

Double-phasing failure mode testing

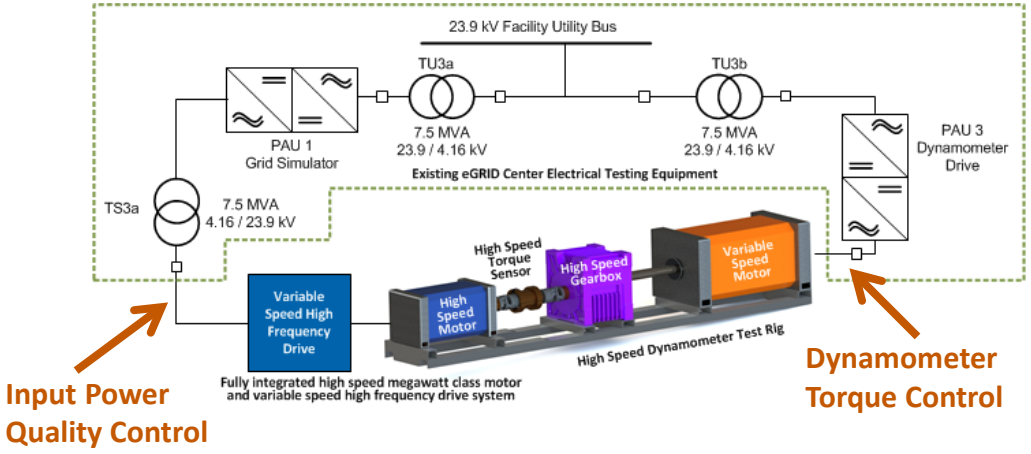
RPS SST – 12.47kV/480 500kVA

Amorphous core efficiency testing

Next Generation Electric Machines

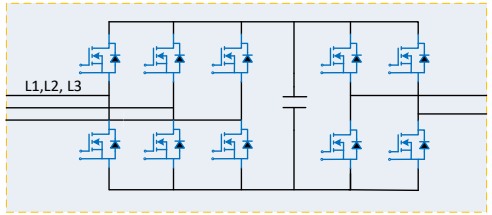
DOE EERE AMO $6.7M grant in partnership with TECO Westinghouse Motor Company

Output power	1 MW
Motor speed	15,000 rpm
Motor voltage	4.16 kV
Drive topology	Series H-bridge
Switching device	1.7 kV SiC MOSFET

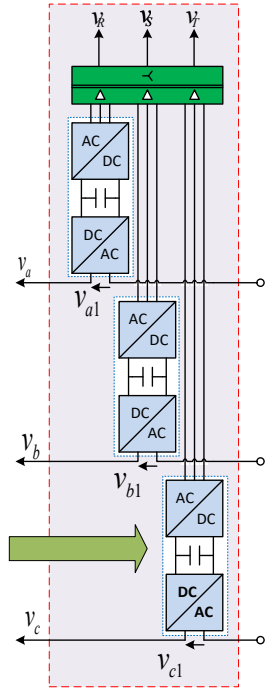


Full Scale Prototype Testing at eGRID

Power Converter Module



Power Converter Module Schematic



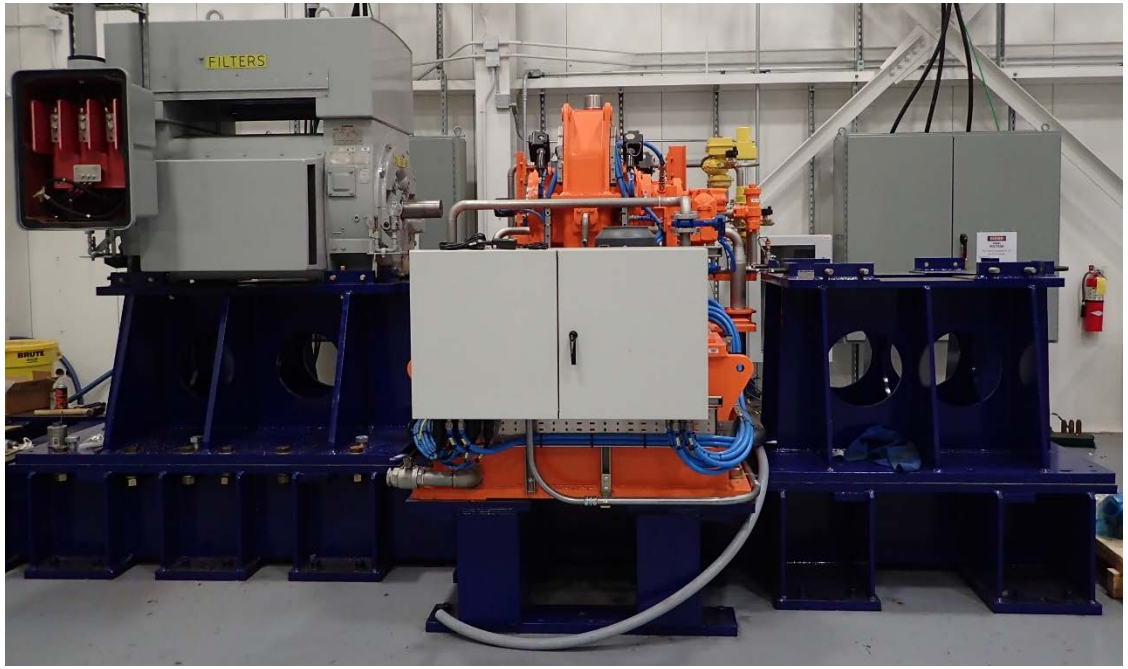
MPBB Configuration Schematic

MPBB Configuration

SiC MOSFET drive design: reduce losses, higher f_{sw}

DOE Next Generation Electric Machine

» DUT: 1 MW 4160V, 15000 rpm machine
4160V SiC SCHB drive

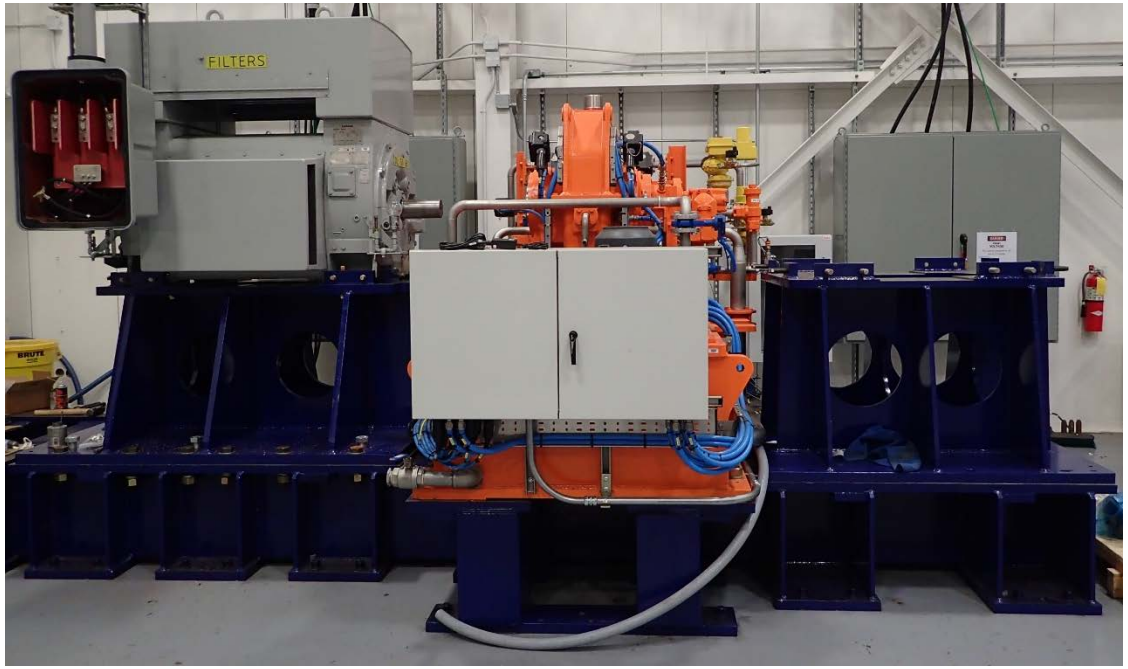


Dyno LS + GBX emulating mechanical pump load

High speed machine and drive from TWMC 2019

DOE CHP – High Speed Generators + SiC

- Eliminating reduction gears in gas turbine CHP
- SiC AC/AC converter to improve GT grid support functions



Dyno LS + GBX emulating gas turbine

High speed generator + SiC generator,
PHIL for grid support of microgrids, islands

Thank You