Laboratory Updates and Projects

Jesse Leonard
Clemson University
Duke Energy eGRID Center
N. Charleston, SC

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

SCE&G Energy Innovation Center

Duke Energy eGRID Center

Wind Turbine Drivetrain Testing Facility

15 MW HIL Grid Simulator

7.5 MW Test Bench

15 MW Test Bench
### 7.5 MW Test Bench Performance Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Power</td>
<td>7,500 kW</td>
</tr>
<tr>
<td>Maximum Torque</td>
<td>6,500 kNm</td>
</tr>
<tr>
<td>Maximum Speed</td>
<td>20 rpm</td>
</tr>
<tr>
<td>Inclination</td>
<td>4° to 6°</td>
</tr>
<tr>
<td>Static Axial Force</td>
<td>± 2,000 kN</td>
</tr>
<tr>
<td>Static Radial Force</td>
<td>± 2,000 kN</td>
</tr>
<tr>
<td>Static Bending Moment</td>
<td>± 10,000 kNm</td>
</tr>
</tbody>
</table>

### 15 MW Test Bench Performance Specifications

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<thead>
<tr>
<th>Specification</th>
<th>Value</th>
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<tbody>
<tr>
<td>Test Power</td>
<td>15,000 kW</td>
</tr>
<tr>
<td>Maximum Torque</td>
<td>16,000 kNm</td>
</tr>
<tr>
<td>Maximum Speed</td>
<td>17 rpm</td>
</tr>
<tr>
<td>Inclination</td>
<td>6°</td>
</tr>
<tr>
<td>Static Axial Force</td>
<td>± 4,000 kN</td>
</tr>
<tr>
<td>Static Radial Force</td>
<td>± 8,000 kN</td>
</tr>
<tr>
<td>Static Bending Moment</td>
<td>± 50,000 kNm</td>
</tr>
</tbody>
</table>
Testing Partners

7.5 MW Test Bay
GE Renewable Energy

15 MW Test Bay
MHI VESTAS OFFSHORE WIND

eGRID Center

Logos of various partners including TECO Westinghouse, SMA, Johnson Controls, ABB, Eaton, SCE&G, Hydro Québec, NREL, SRNL, Southern States, Cypress Creek Renewables, EPR, IEEE, and others.
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

Consultant

MFR of discontinued MW scale inverter, limited software team

Approach

New Firmware

Outcome

Recertification w/ UI tests & Relisting, Site back online

NRTL

Clemson
Inverter Recertification - Power Quality

Recertification required retest of unintentional islanding with RLC.

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

Outlook:
IEEE P2800/P2800.1 for sub-transmission and transmission connected inverter based resources.
Early stage testing with HIL while remainder of equipment still in progress
Active filter compensates harmonic current of a simulated nonlinear load
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)
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
Transformer Testing

12.47kV/480 YgYg
Double-phasing failure mode testing

12.47kV-120/240
Amorphous core efficiency testing

GridBridge energy router

12.47kV-120/240

12.47kV/480 with DC ports

RPS SST – 12.47kV/480 500kVA
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

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

Full Scale Prototype Testing at eGRID

MPBB Configuration

Power Converter Module Schematic

Dynamometer

Torque Control

Input Power

Quality Control
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

Grid simulator interconnection
Thank You