The Sandia Advanced Power Electronic Conversion Systems (APEX) Laboratory

PRESENTED BY
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The Advanced Power Electronic Conversion Systems (APEX) laboratory is:

- A new facility at Sandia dedicated to the development of next-generation power conversion systems for energy storage applications
- A rapid prototyping environment for ground-up design and integration of new hardware topologies, advanced component technologies, and intelligent control systems
- The center point of a comprehensive power electronics R&D strategy
1. Identify the challenges in power electronics R&D for next-generation energy storage
   ◦ U.S. DOE Office of Electricity Power Electronics Strategy Report (still in progress)

2. Design and implement a lab space (and research framework) to address these challenges
Energy Storage

Topologies
Modularization
Thermal Management

Packaging Techniques
Semiconductor Devices (IGBT, MOSFET, IGCT, etc.)
Capacitors, Inductors, Transformers

Advanced Magnetics and Dielectrics
Advanced Conductors and Insulators
Wide Bandgap Semiconductor Materials

POWER ELECTRONICS R&D
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The APEX lab allows us to take on a more active role in our external collaborations

We will leverage this capability to:

• Identify opportunities for synergistic research activity
• Increase collective alignment with OE mission
ENERGY STORAGE R&D

Energy Storage Technology
- Cell characterization
- Safety and reliability
- Power/energy density
- Battery management
- Degradation

Power Conversion Systems
- Efficiency
- Affordability
- Power/voltage capabilities
- System reliability
- Modularization

Power System Applications
- Peak shaving
- Ancillary grid services
- Optimal sizing and placement
- Transmission investment deferral
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ENERGY STORAGE R&D
APEX CAPABILITIES

**Simulate**
Real-time simulation of components, converters, and systems
*Ansys Maxwell, Matlab/Simulink, PLECS, PSIM, Opal-RT FPGAsim*

**Design**
Electrical and mechanical CAD tools for PCB design and converter assembly
*Autodesk Eagle, Solidworks, Solidworks PCB, ORCAD*

**Construct**
Automated assembly equipment for in-house production of converter prototypes
*Manncorp MC400 Pick and Place Machine, MC301 Reflow Oven*

**Control**
Reconfigurable digital control platforms for development of new control strategies
*Code Composer Studio, TI C2000 DSPs, Vivado, Xilinx FPGAs and SoCs*

**Analyze**
Fully bidirectional hardware-in-the-loop testbed for assessment of converter performance in practical application scenarios
*30kW Grid Simulator, DC Sources up to 950V/±40A, Comemso 144-Ch Cell Simulator*

**Stress**
Fault-tolerant source equipment and protective enclosure for destructive testing
*Custom polycarbonate enclosure, Opal-RT master system controller*
PROJECT OUTCOMES
Target Research Areas

1. Power conversion systems for scalable energy storage deployments
   - Modular topologies for direct MV grid connection
   - Integration of storage in existing and emerging power electronic energy infrastructure

2. Uninterruptible converter topologies for critical storage assets
   - Fault-tolerant and reconfigurable hardware architectures
   - Hot-swap capable converters and storage systems

3. Applications of power electronics in storage system safety
   - Stranded energy extraction
   - Active response to thermal runaway

Expanding Lab Capabilities

- Performance analysis under extreme environmental conditions
- Additional grid simulator inputs for exploration of integrated storage in solid-state transformers
Thanks For Your Attention

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Slides with supplementary information may be found beyond this point.
Utility Grid Emulation
Chroma 61830 Grid Simulator (30kW, 480V)

System-Level Storage Emulation
Keysight RP7952A (500V, ±40A)
Keysight RP7953A (950V, ±20A)

Module-Level Storage Emulation
12x Kepco BOP 1kW (±50V, ±20A)

Cell-Level Storage Emulation
Comemso Battery Cell Simulator
144 Cell Emulator Channels (8V, ±5A)