



Design, Development, Testing and Demonstration of a 10-MVA, ETO-based StatCom

Phase 1

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Founder and CEO

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November 4, 2010

ETO-Based StatCom

BACKGROUND

Evolution of Project

- Department of Energy (DOE) Energy Storage Program
- BPA
- North Carolina State University (NCSU) developed the Emitter Turn-Off Thyristor (ETO) and design for a Laboratory ready 10-MVA StatCom
- Silicon Power Corporation (SPCO) in FY2009 started to take Government supplied Designs and Equipment obtained from NCSU to work toward a practical and cost effective ETO-Based StatCom

OBJECTIVE

Purpose of Project

- Develop a 1.67MVA Full ETO-Based Bridge for Incorporation in a 10-MVA ETO-Based StatCom
- Field Test at BPA (Bonneville Power Administration) Lab



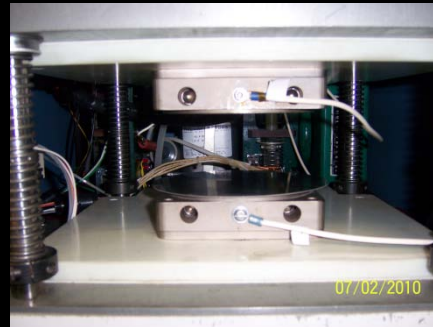
TECHNICAL APPROACH

- ELECTRICAL
- MECHANICAL
- THERMAL
- PACKAGING

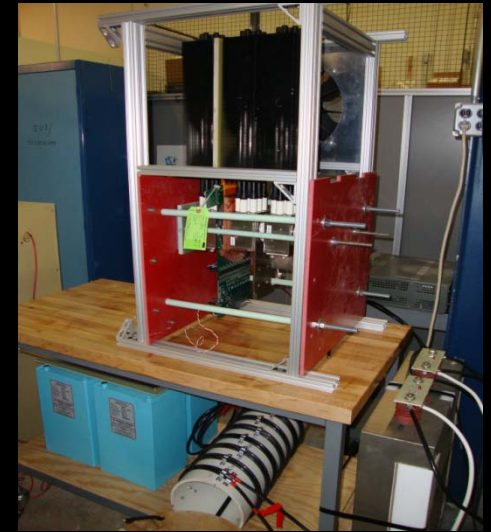


ELECTRICAL STATUS

- Electrical Simulation
 - Boost Converter
 - H-Bridge
- Static Test
- Boost Test
- Low Power H-Bridge Test
- High Power H-Bridge Test (Limited)



Static Test Fixture



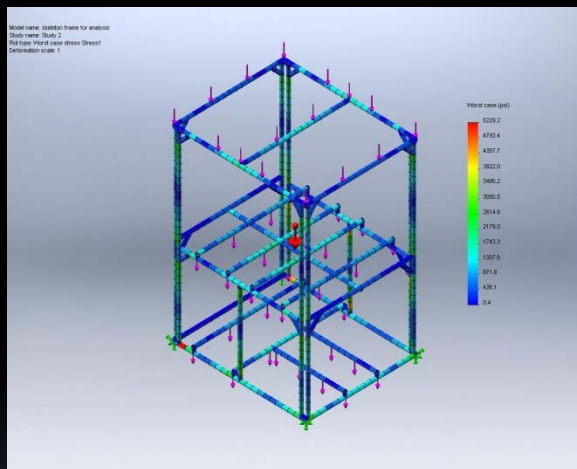
Boost Test Fixture



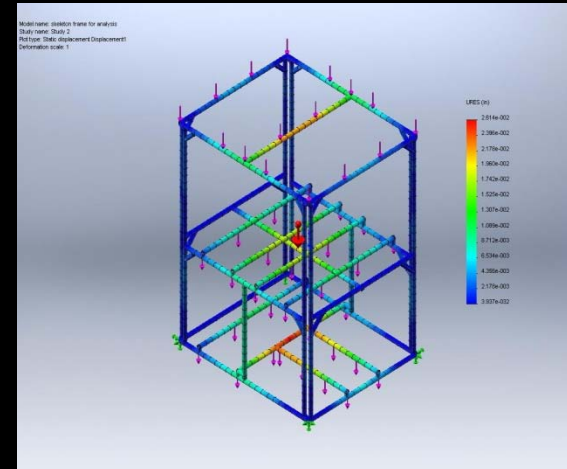
H-Bridge Test Fixture

MECHANICAL STATUS

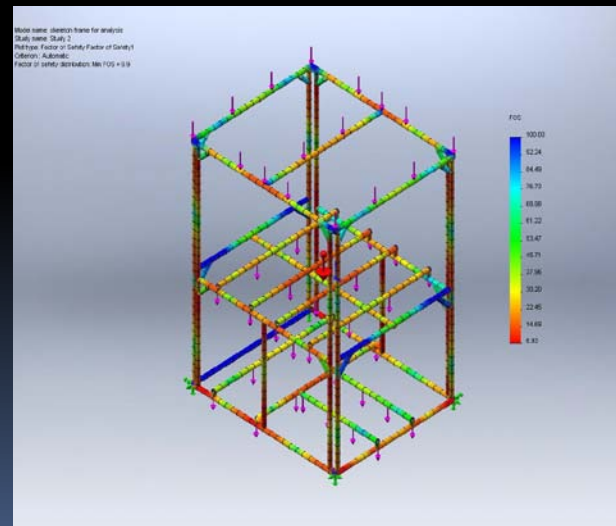
- Enclosure Stress Analysis Complete



Stress distribution across the framework



Resultant Displacement in the structural frame corresponding to loads

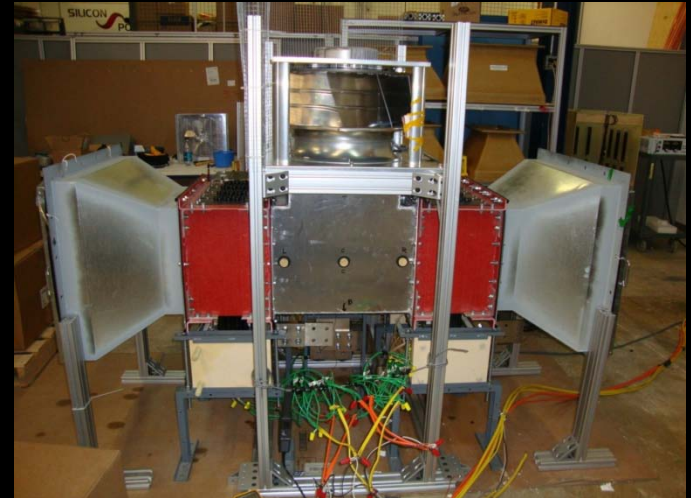
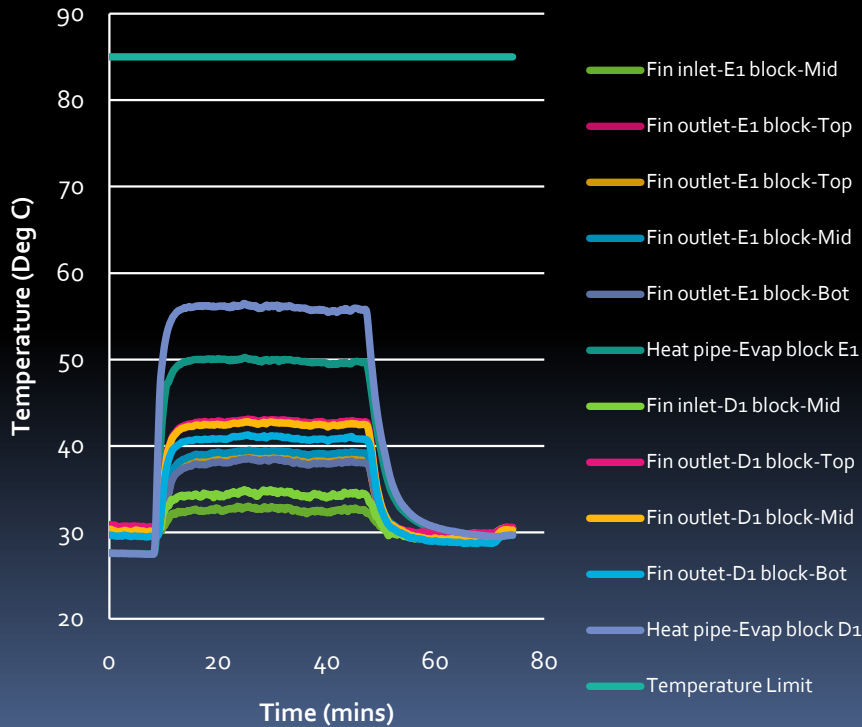


Factor of Safety for the frame

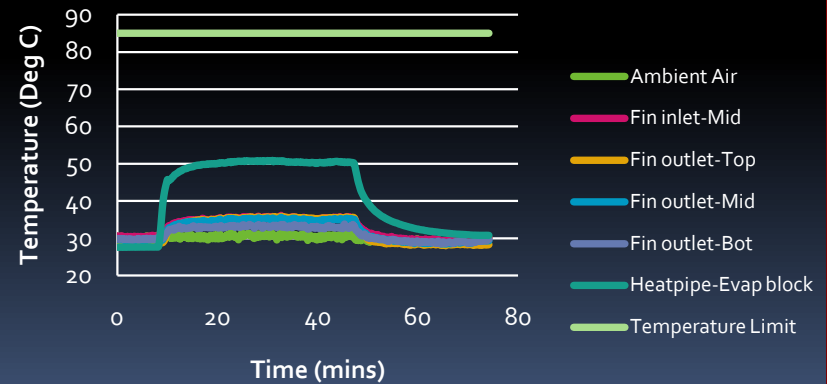
THERMAL STATUS

- ETO-Based Half-Bridge
- Clamp /Snubber

Thermal Response at High power (10.97 KW)
Plot for Half-bridge section

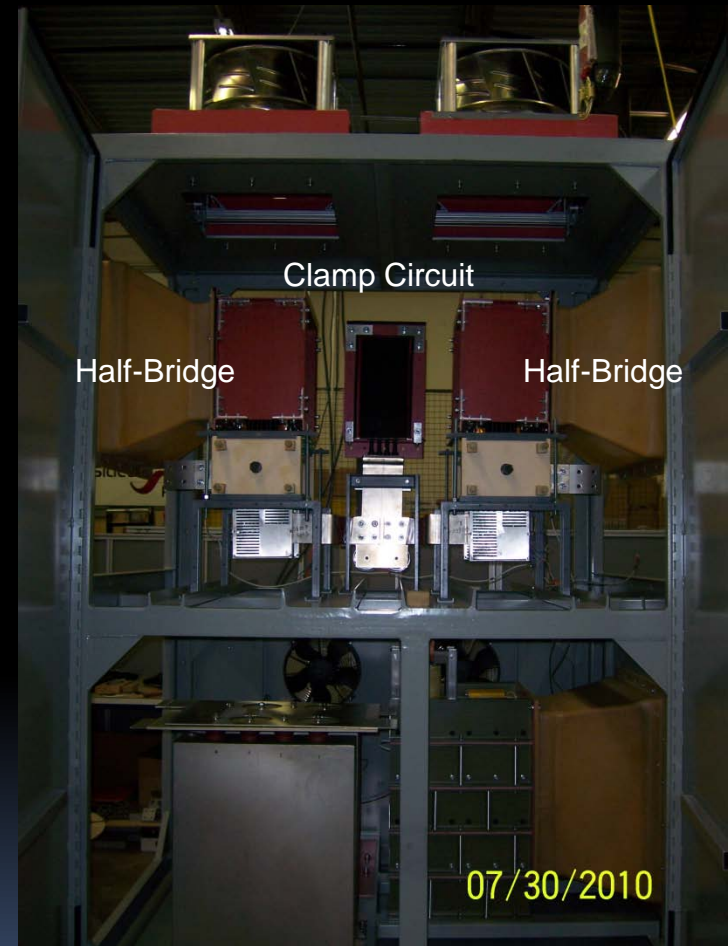


Thermal Response at High power (10.97 KW)
Plot for Clamp-circuit section



PACKAGING STATUS

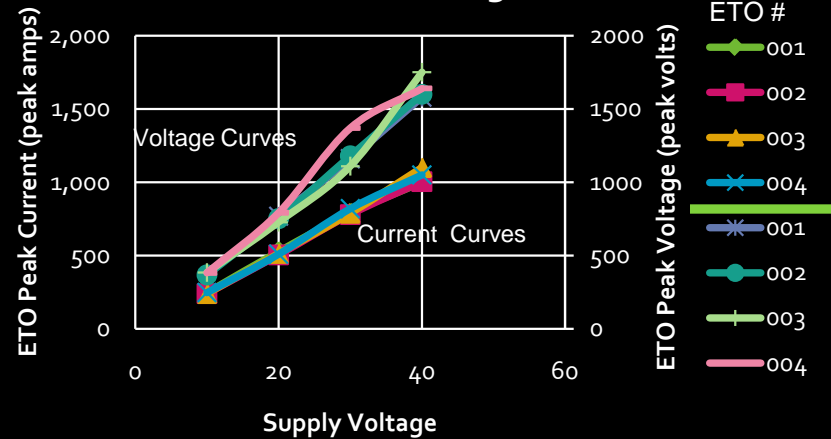
- Component Placement
- ETO-Based Half-Bridge
- Clamp Circuit



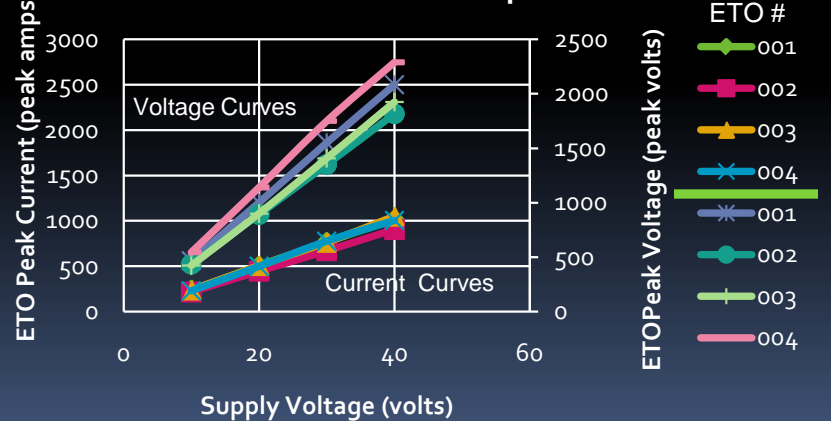
TEST RESULTS

- Static
 - 4 ETO Modules Passed
 - 3 ETO Modules Failed
- Boost
 - 4 ETO Modules Passed (see graphs)
 - 3 ETO Modules Failed

Boost Converter ETO Single Pulse

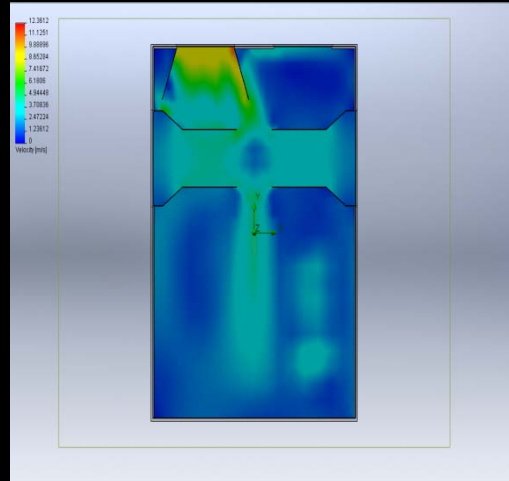


Boost Converter ETO Multiple Pulses

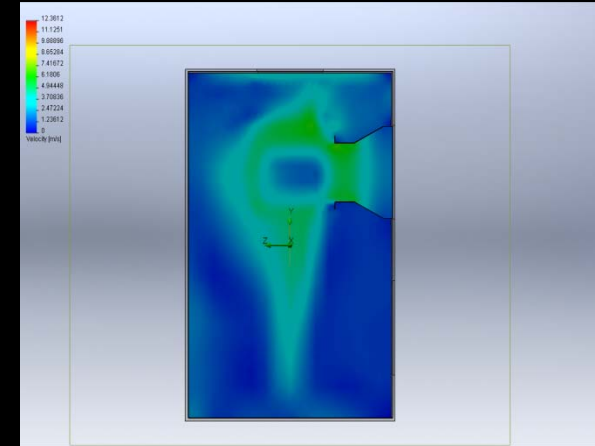


TEST RESULTS (cont.)

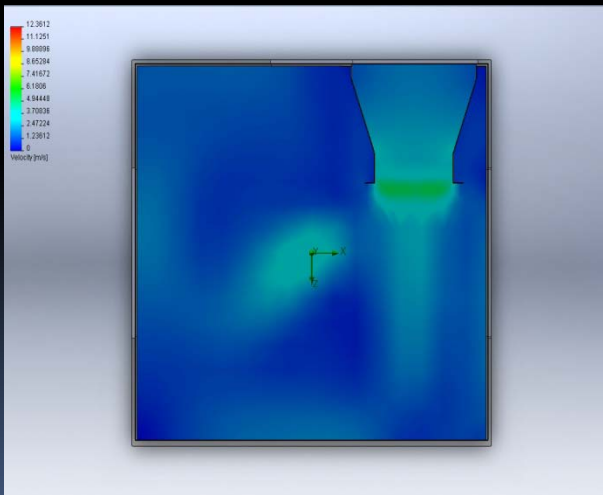
- Thermal
 - Velocity Views



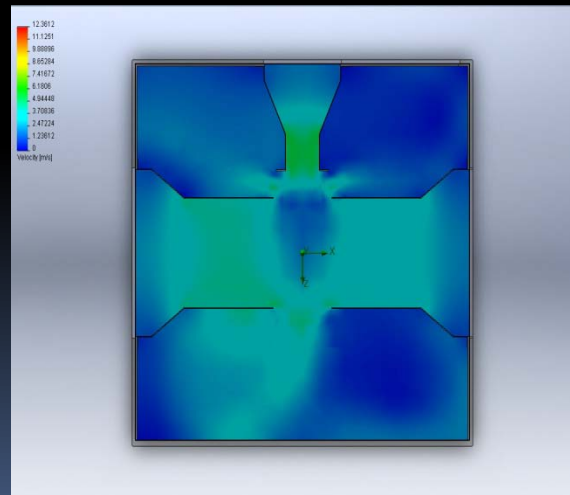
Front view (2KW Heat pipe ducts)



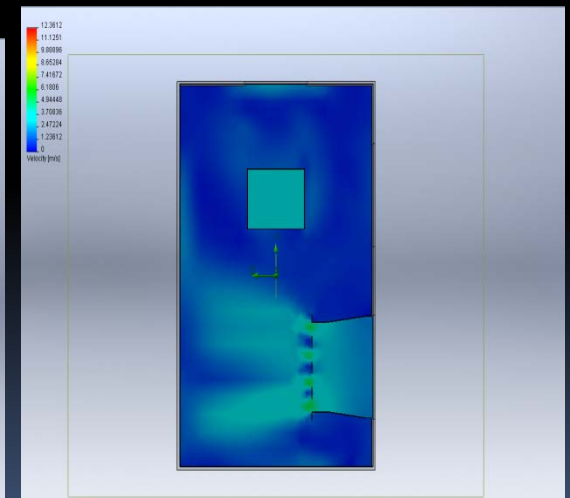
Right-side view (1Kw Heat pipe duct)



Top view (Resistor section)



Top view

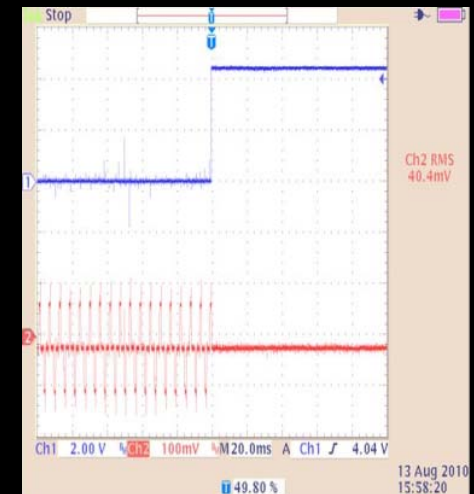


Right-side view (Resistor section)

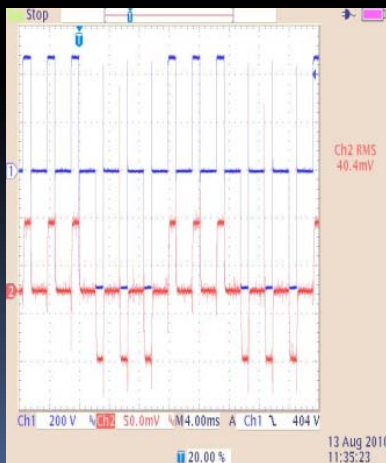
TEST RESULTS (cont.)

- ETO-Based H-Bridge Low Power
 - 2 ETO Modules Needed Repair
 - All 4 ETO Modules Demonstrated Soft-Switching
 - Success in Driving ETO's in Various Modes:

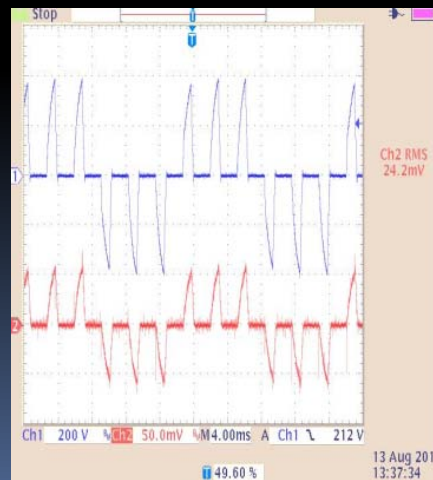
Over-Current



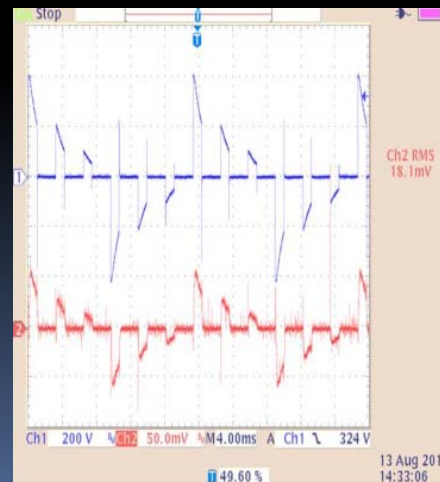
Resistive Load



R-L Load



R-C Load



•Blue Traces
Voltage Across
Inductor

•Red Traces
Current Across
Inductor

ACCOMPLISHED

Mechanical Analysis and Simulation

Electrical and Control Simulation

Thermal Analysis and Simulation

Electrical Fabrication

Mechanical / Thermal Fabrication

Completed

Static Testing

Thermal Testing

Boost Testing

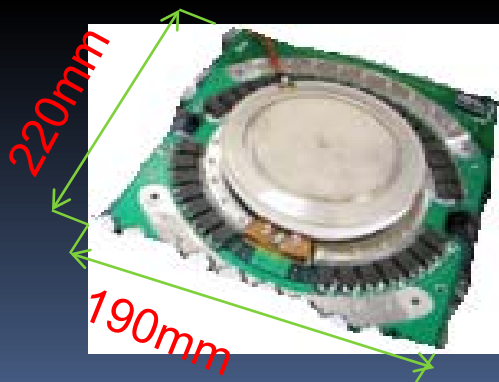
ETO-Based H-
Bridge Low Power
Testing

Final Report Published
and Cost Proposal for
Phase 2 & 3 Submitted

NEXT STEPS

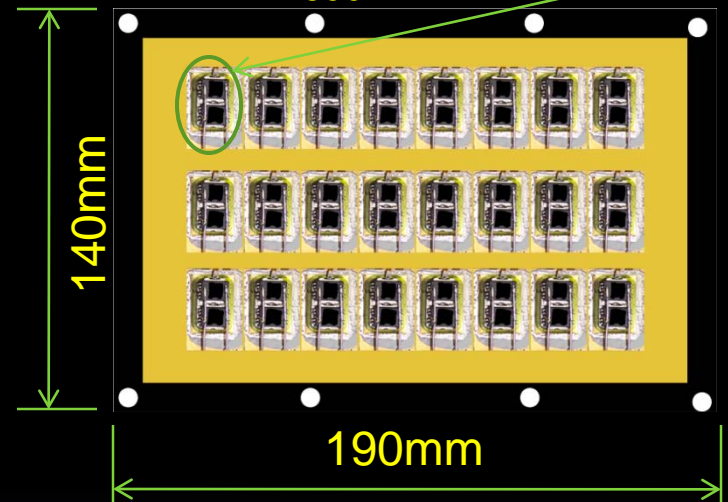
Hybrid Architecture

- Wafers Fabricated on a Standard IC Line
- Standard SPCO Die Size (12mm)
- Voltage and Current Sharing
- Thermal Management
 - Air Cooled (No Liquids)
- Individual Control at Die Level
- Hybrid SGTO-ETO Function at Die Level



Std. ETO
Power
Section
41800mm²

SPCO-ETO Power
Section
22600 mm²

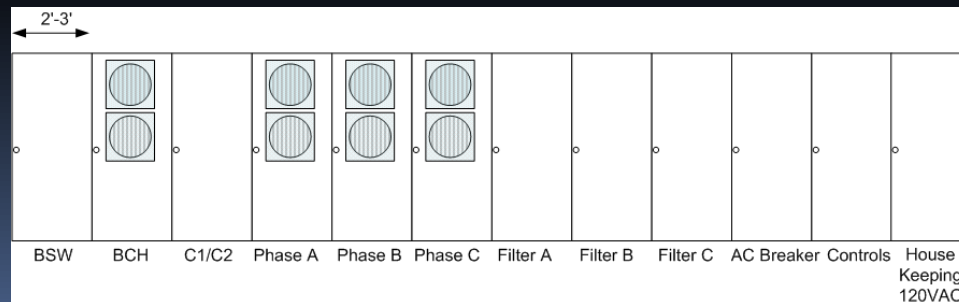
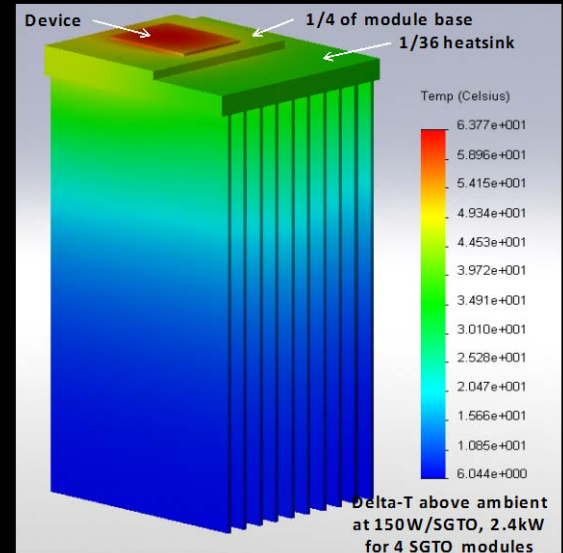
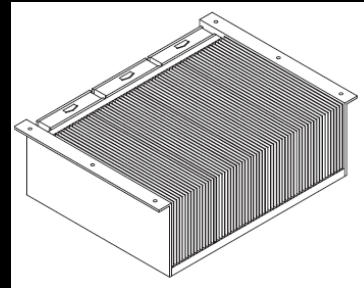


SPCO-ETO is
54% Area of Std.
ETO and 30% Less
Weight!

NEXT STEPS (cont.)

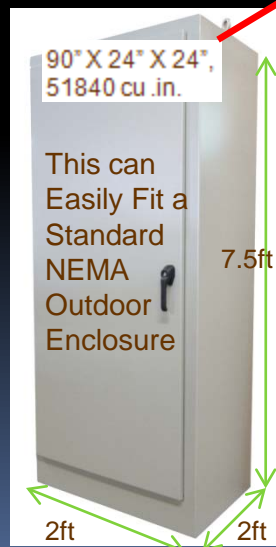
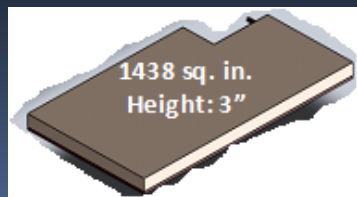
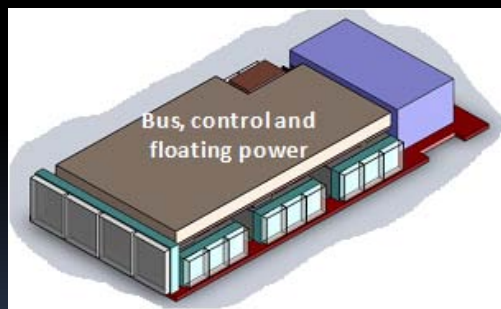
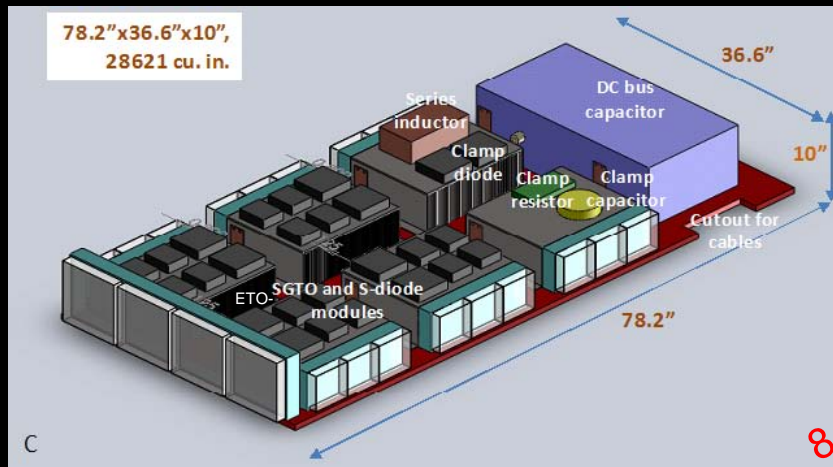
System Architecture

- Standard Cabinet Size
- Modular Air Cooled
- Sectionalized by Function
- Serviceability
- Optional Redundancy
- Scalable
- Portable

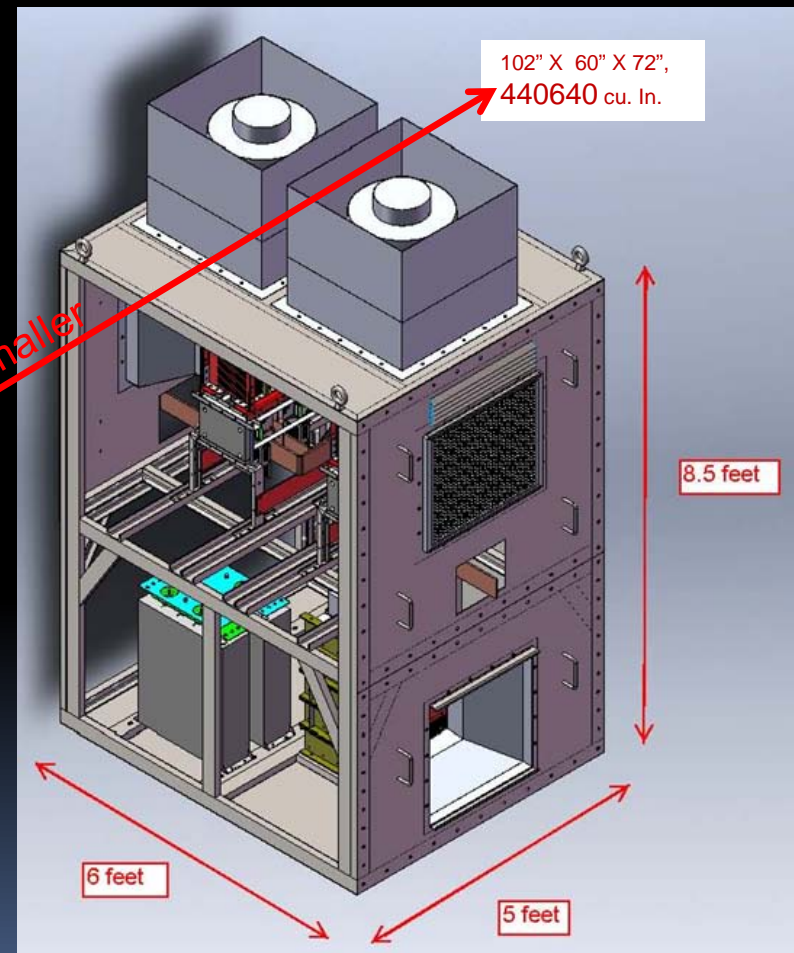


COMPARISON

SPCO-ETO-Based H-Bridge



NCSU-ETO-Based H-Bridge



8.5 X Smaller

CONCLUSIONS/RECOMMENDATIONS

- Phase 1 Objectives Accomplished
- High Power Testing Limited by Devices
- Phase 2 Proposal Submitted to Develop a Commercially Feasible Product
- Vision : **M** (Manufacturable), **U** (Usable), **S** (Sellable), **T** (Technology)

ACKNOWLEDGEMENTS



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S.N.L. for TECHNICAL DIRECTION



B.P.A. for the SYSTEM REQUIREMENTS

NC STATE UNIVERSITY

N.C.S.U. ETO REQUIREMENTS