Matrix Fault Current Limiter Project Update

Len Kovalsky, SuperPower, Inc.

HTS Solutions for a New Dimension in Power

Superconductivity for Electric Systems – 2005 Annual DOE Peer Review

HTS Fault Current Limiters - A New Technology to Address a Growing Problem

As new sources of generation are added, utilities are faced with the threat of higher levels of fault current

- High Temperature Superconducting (HTS) Fault Current Limiters (FCLs) address the market pull to cost-effectively correct fault current over-duty problems at the transmission voltage level of 138kV and higher
- The HTS FCLs will reduce the available fault current to a lower, safer level so existing switchgear can still protect the grid

Utility market needs at the transmission level:

- Accommodate increasing fault currents due to added generation
- Avoid adverse side effects imposed by existing solutions
- Prevent breaker failures and & problems (e.g., welded contacts, bus bracing, etc.)
- Reduce “through fault” stresses on aging infrastructure
- Maintain flexibility to accommodate load growth and “open access”
- Avoid need for expensive 80kA breakers

HTS FCLs will be needed for most commercial AC HTS cable systems

Discussions with 20+ utilities have consistently validated the need!

Project Description & Research Integration

Goal: Demo MFCL concept at transmission level voltage – 138kV

Cost – Original $12.2M project cost estimate, with $6.1M DOE and $600K EPRI support

Now estimating project cost at least $18M, based on complexities and lessons learned to date

Schedule – Project started 6/02, original completion 6/06 – Completion now no sooner then 6/07

Project Team:

- SuperPower, Inc.: Program Lead
- Nexans SuperConductors GmbH: BSCCO-2212 Melt Cast Processed (MCP) Materials
- American Electric Power (AEP) – Utility Host
- DOE National Labs – CRADA executed with ORNL (High voltage, thermal), CRADA pending with LANL (HTS element evaluation)
- Cryogenic partner in the wings, to be announced later

Technical Advisory Board (TAB):

- Evaluate and guide project in conjunction with DOE Readiness Review – Met 11/04 and 06/05
- Utility members: AEP, New York Power Authority, Southern California Edison, Con Edison, Entergy
- Academia: Rensselaer Polytechnic Institute (RPI)
- Funding sponsors: DOE and EPRI
- National Electrical Energy Testing, Research And Applications Center (NEETRAC)

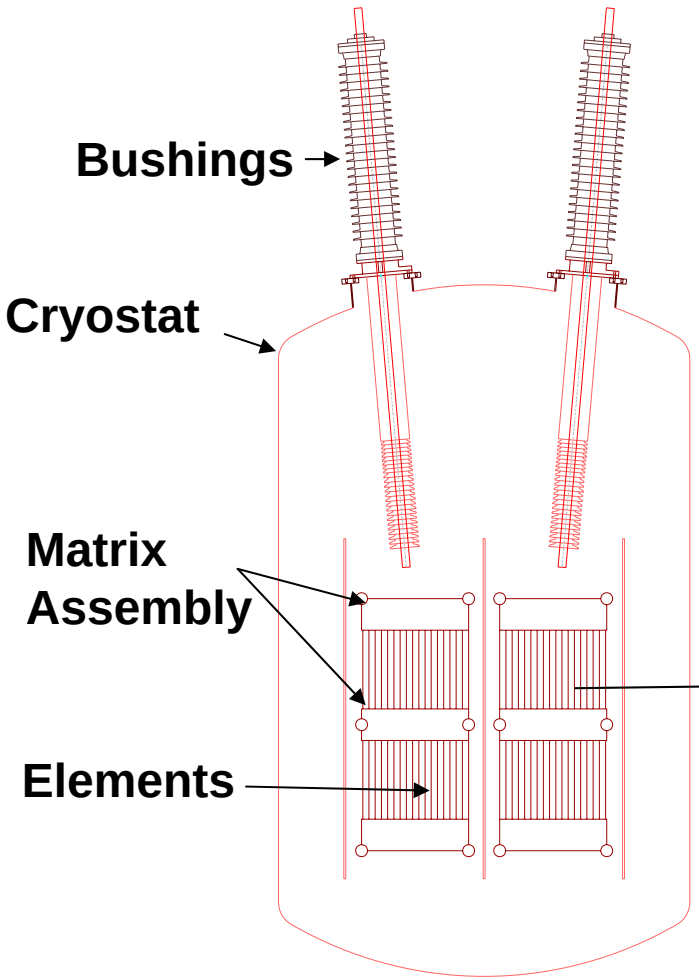
Milestone Driven Program

Major Milestone	Objectives	Completion Date
Concept Feasibility & Application Studies	• Complete Conceptual Design • Study application requirements and perform power system studies	Completed June 2003
Proof-of-Concept Demonstration	• Scaled hardware non-grid demonstration of matrix concept	Completed July 2004
Alpha Prototype	• Focus: Scale up for non-grid demonstration at high voltage • Rating: 138kV, single phase, AEP application requirements	Concept June 2005, Prototype **ON HOLD**
Beta Prototype	• Focus: In-grid demonstration for specific utility application • Rating: 138kV, three phase, AEP Sporn Application	**ON HOLD**

Fabrication of full scale prototypes on hold pending further developments in focus areas:
1. High Voltage
&
2. HTS elements

AEP has requested Beta prototype to be in service by late CY2006 or at latest early CY2007 – A stretch given current development status

Alpha Prototype Development - Main Components

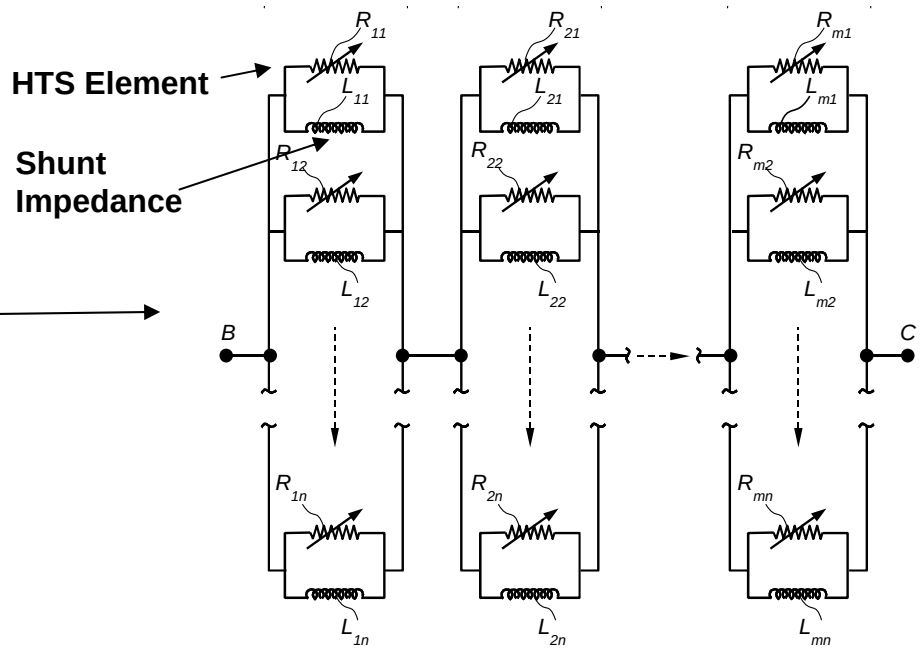


Single Phase of Alpha

High Voltage Insulation System – 1. Bushings, 2. Cryostat insulation system, 3. Matrix internal insulation

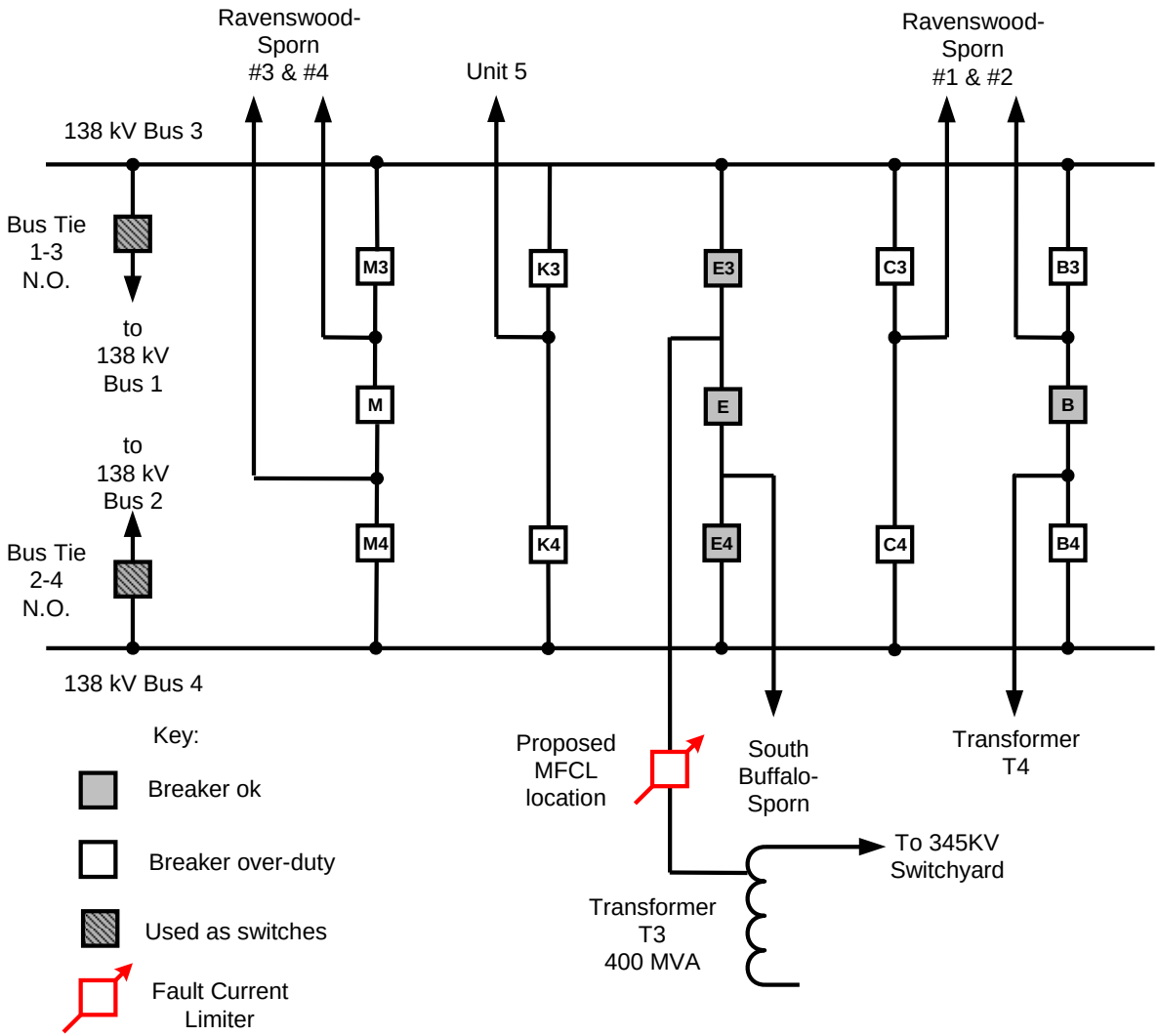
Matrix Assembly – 1. HTS Elements, 2. Connections of HTS elements and current limiting coils

Cryostat System – 1. Vessels to provide stable pressurized sub-cooled environment, 2. Cryogens and cryo-coolers



Simplified Matrix Assembly Schematic

AEP Sporn is the Location for MFCL Beta



MFCL targeted to reduce fault contribution from transformer T3 when fault occurs in 138kV system

Allows AEP to remove "sequential break scheme" – Keep E and E3 closed

MFCL reduces contribution from T3, so that 9 circuit breakers no longer in an over-duty situation

FY05 Results

Application requirements:

- With AEP partner established steady state current, prospective fault current, current limiting and high voltage test requirements

High voltage:

- Completed initial characterizations of dielectrics in cryogenic environment for 138kV transmission level application – up to 200kV AC and greater than 650kV BIL – Basic trends observed to established design guidelines
- Additional characterization tests required and need to complete designs for bushing system, cryostat insulation system and internal matrix insulation system

HTS elements:

- Demonstrated 20cm long parts up to energy levels suitable for AEP application
- Need to demonstrate high level of reliability with longer parts

Matrix design:

- Based on short circuit test results, selected basic circuit configuration for high voltage application – still need to finalize detailed component values

Cryogenic system:

- Concept design complete with input of cryogenic partner – completion of detailed design pending resolution of other issues