



***Grid Support and Power Quality Solutions***



**STEP Group Meeting.  
San Diego, California.  
March 08, 2004**

## **D-VAR and SuperVAR Technology Presentation**

Narend Reddy  
Network Solutions  
American Superconductor

**AMSC Introduction**

**D-VAR Technology**

**D-VAR Grid Solutions**

**SuperVAR Technology**

**Questions**



**HTS Wire**



**Power Electronic Converters**

A world leader in developing and manufacturing superconductor and power electronic products

*Revolutionary increases in power density and efficiency*

# ***AMSC's Integrated Products & Services***



***Super Machines  
HTS Rotating  
Machines***



***HTS Cable  
Project Development***



***Power Electronic Systems***

*We develop and sell products that:*

- Eliminate power grid congestion.
- Dramatically increase the reliability of power delivery networks.
- Greatly improve the quality of power delivered to industrial sites.
- Significantly reduce size, weight, cost and electrical losses of large electric motors and generators.
- Enable novel medical, industrial processing and transportation systems.

# Co-Branded DVAR Product Line



**General Electric selects D-VAR as exclusive utility product offering for Dynamic VARs in North America**

## What are **D-VAR** Devices?

- **Dynamic VARs...** Fully Integrated STATCOM with proprietary 3X overload.
- Instantaneously injects precise amounts of reactive power into a network.
- Optional real power with SMES energy storage.

*D-VAR mitigates wide variety of voltage and power quality related transmission problems*

# Just the **FACTS...** D-VAR

- High power inverters (D-STATCOM) and optional stored real energy.
- Fast Response time to sudden high and low voltages.
- No environmental permits required.
- Rated for -30 to +50°C.
- Lowest cost.
- Quickest installation.
- Easily located in distribution substations.
- No need for operator Control.
- 24 X 7 remote monitoring by AMSC.



# DVAR Basics....

*Proprietary Power Electronics  
Technology*

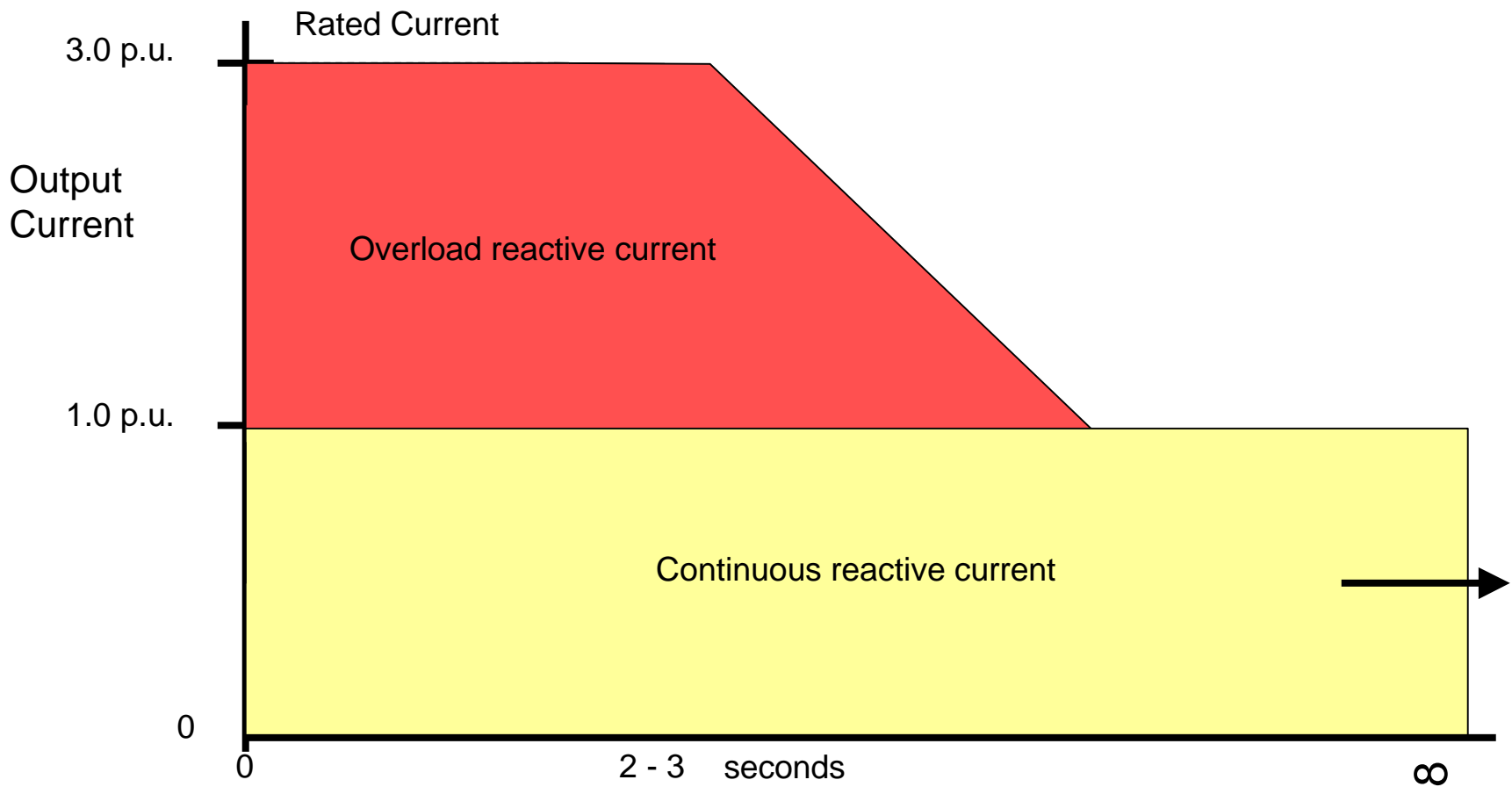


*Each D-VAR system delivers continuous reactive power... **with overload capability up to 3x cont. rating.** Each phase is individually controlled.*



*Proprietary fault-tolerant array design provides additional reliability*

# D-VAR Injection Capability



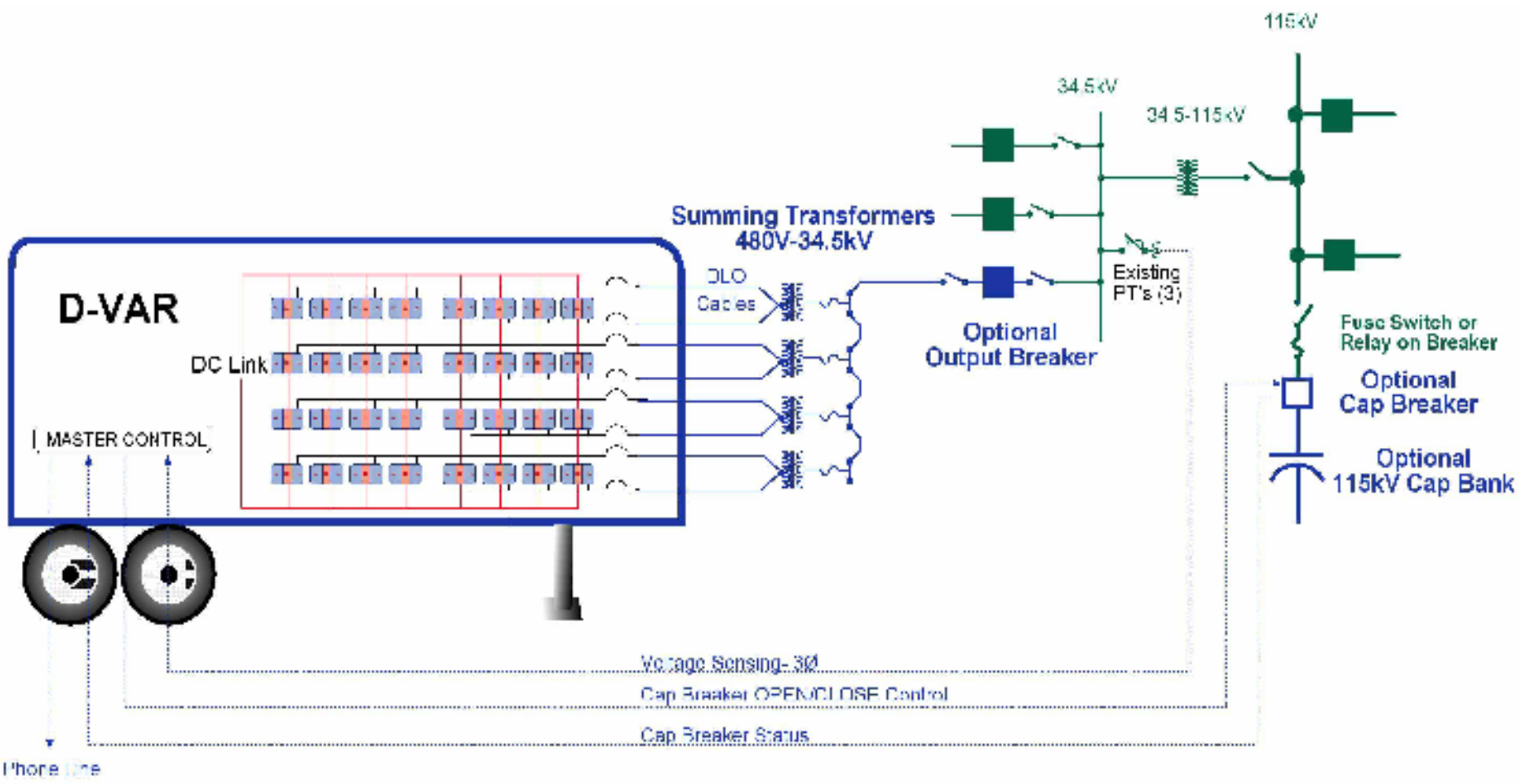
*Proprietary technology provides combination of continuous dynamic VARs with additional overload boost*

## ***Utility Problems that D-VAR systems can solve:***

- Voltage Stability / Voltage Collapse
  - Uncontrolled rapid decline in system voltage
- Steady State Voltage Regulation
  - Wind farms, radial lines, etc...
- Import / Transfer Capability Restrictions
  - Import, export, or transfer of power constrained by voltage problems
- Mitigate voltage flicker/ power quality
  - Wind farms, industrial facilities

***GE / AMSC performs full system analysis jointly with the customer to determine the least cost, best available solution***

# Typical D-VAR System Connection



## Unique Utility Problems Need Unique Solutions

Configuration of installations are dependent on

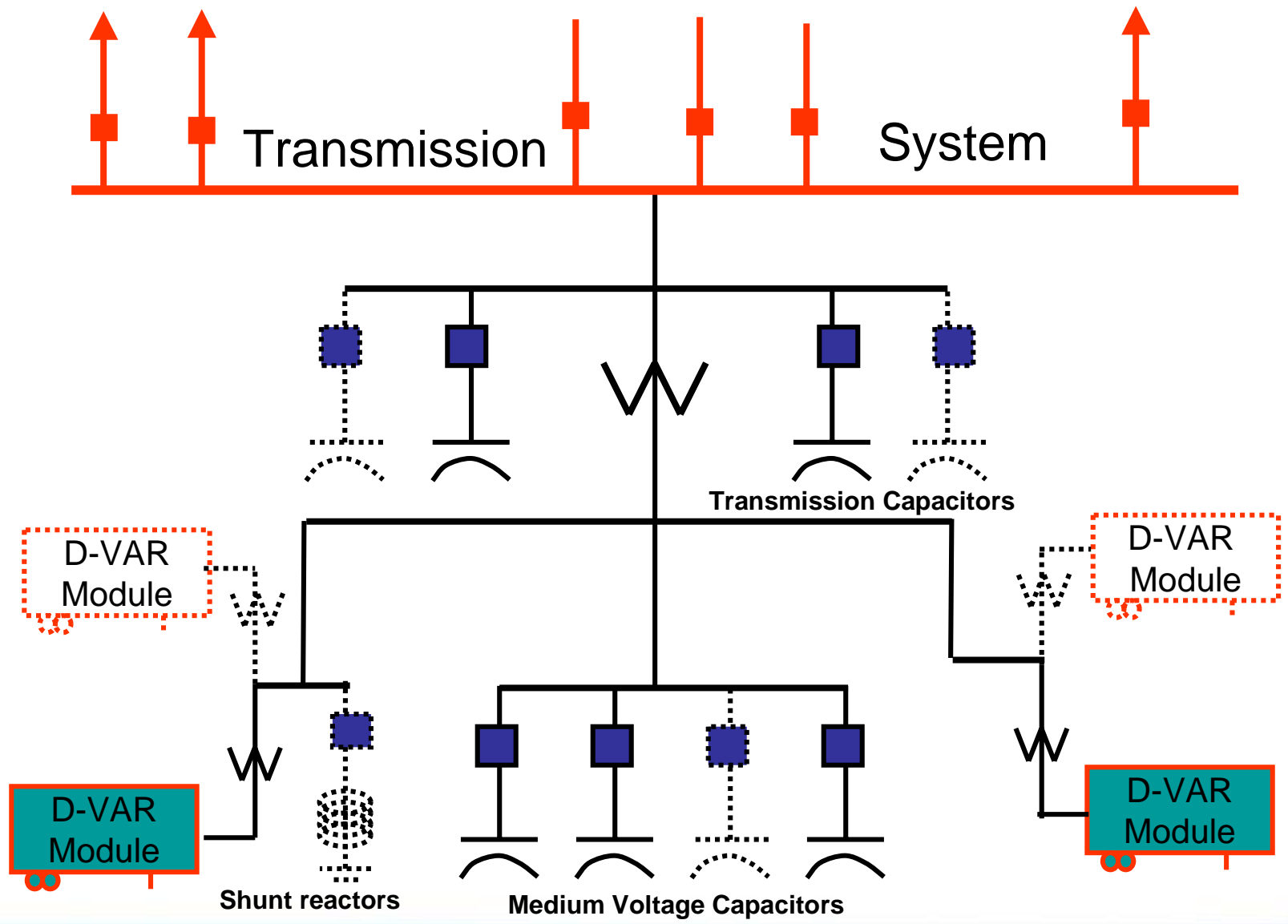
- Problems being addressed.
- Amount of Dynamic and Static reactive capability needed.
- Location of critical loads/supply areas.
- Load types and load levels.

*Solutions configured to meet customer requirements*

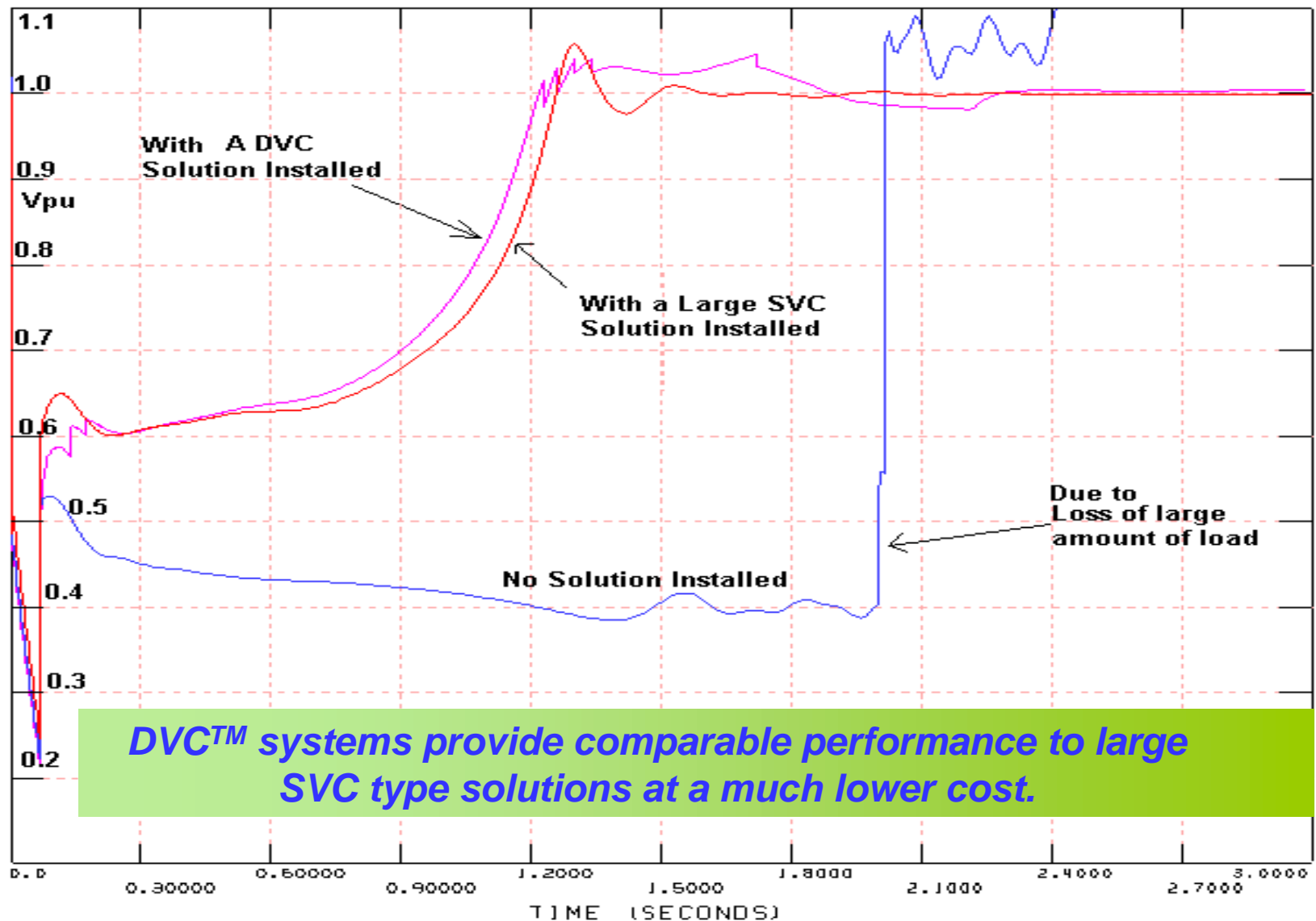
- **D-VAR modules integrated with other shunt devices.**
- **DVC™ systems provide VAR injection capability that is:**
  - **closed loop control.**
  - **fast.**
  - **right balance between dynamic and static compensation requirement of the system.**
  - **meets utility requirements**

*Solutions configured to meet customer requirements*

# Typical DVC™ System



# DVC™ System Application Studies



## AMSC Expertise

- Transmission Planning Studies
  - Analysis of transmission system to identify and define the problems accurately.
  - Identify solution options.
  - PSS/E and PSLF load flow and dynamic simulation analysis.
  - Dynamic simulation models for D-VAR simulation available.
- Provide D-VAR and DVC™ application and system integration assistance.

# Mobile D-VAR Unit



***Highly Mobile... Scalable... Easy to Install... Self Contained... Typical installation takes less than 1 week!***

# Typical D-VAR Installation



# D-VAR Installation at Wyoming



-8 to +58MVAR Continuous  
-18 to +76MVAR Transient

# D-VAR Installation at Rayburn, Texas



# Northeast Utilities, Connecticut



-24 to +108MVAR Continuous  
-55 to +139MVAR Transient

# AMSC Dynamic VAR Solutions Sample Customer Base



*Wisconsin Public Service*



*Altis Semiconductor*



≡ Scottish and Southern Energy plc

ILLINOIS POWER

Part of the DYNegy Performance Team



*Global endorsement from significant customer base*



# ***SuperVAR™ Dynamic Synchronous Condenser***

**SuperVAR is a synchronous condenser that employs HTS Superconducting field winding which allows it to be much more**

- efficient,**
- compact and**
- reliable**

**as compared to conventional rotating machines.**

- First prototype in the process of installation and testing.
- TVA has ordered first 5 commercial machines.
- Based on SuperMachines' HTS motor platform.
- Delivers large amounts of reactive power.

# SuperVAR™ - Specifications

Continuous rating	10 MVAR
Voltage rating	13.8 kV, line to line
Losses	less than 1.7% of rating
Ambient Operating temp.	-30° to +40°C
Installation	Outdoor
Remote monitoring	Mechanical and Thermal
Auxiliary power	<75 kW
Design standards	IEEE/ANSI C50.13-2002

# SuperVAR™ - Features

- Compact, Self contained system
- Minimum on-site installation
- Based on proven platform
- Remote monitoring
- Developed with TVA to solve difficult system voltage problems



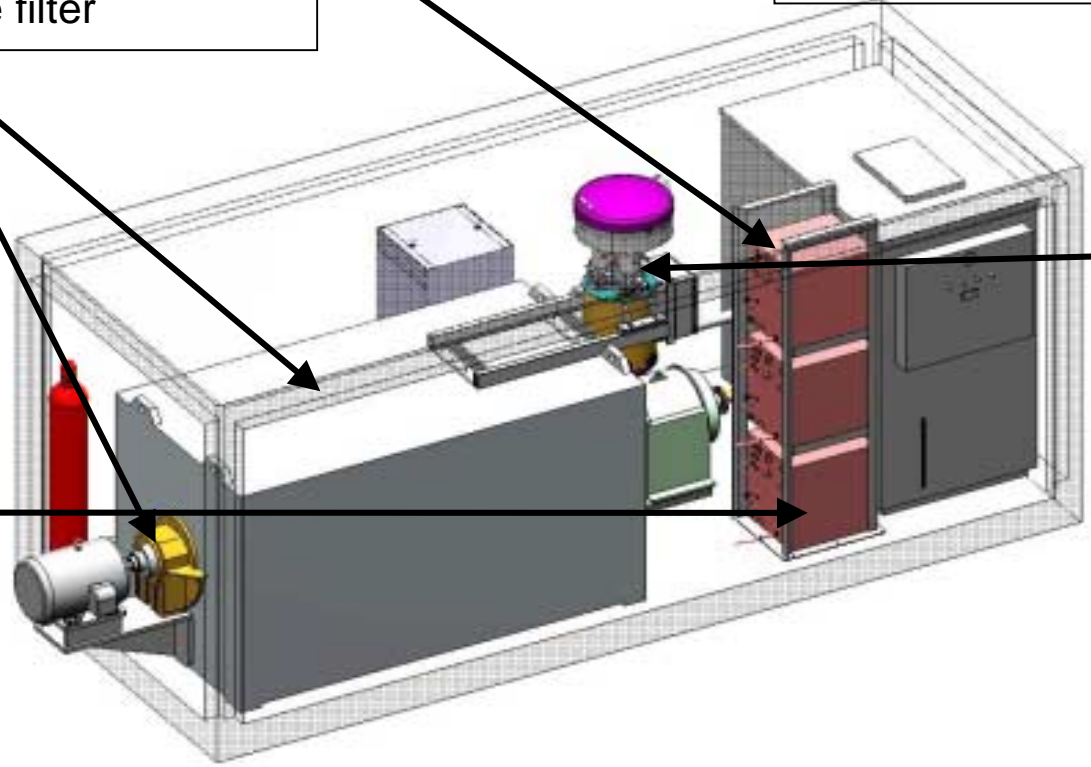
*The first 8MVA SuperVAR™ prototype machine*

# Preventive Maintenance for SuperVAR™

- Annual Maintenance
- Replace refrigeration compressor charcoal filters
  - Replace stator cooling air filter
  - Check bearing oil / Replace filter

- 3 Year Maintenance
- Refurbish refrigeration coldheads

- 10 year Maintenance
- Refurbish refrigeration compressors



**Annual system maintenance budget for a 10 MVA unit < \$10K**

## Features

- Compact, lighter and less costly to own and operate than other competing devices.
- Offers high efficiency, even under partial loads (down to 0.3 pu).
- Field windings are not affected by thermal cycling.

***First commercial power equipment utilizing HTS technology***

## Benefits

- Provides highly efficient steady state regulation and superior transient response.
- Provides inertia and increased fault level under contingency situations.
- Generates/absorbs MVARs dynamically.
- Mobile version allows quick deployment.
- No harmonic contribution to the system.

*First commercial power equipment utilizing HTS technology*

- Replacement for Reliability Must Run (RMR) generation.
- Source of dynamic reactive power in load centers
  - Fast installation
  - Compact size
  - Easily relocated
- Steady-state Voltage regulation capability
  - Interconnected transmission systems.
  - Wind farms.
  - Radial lines.

***D-VAR***



***SuperVAR***



# ***Questions***

***Narend Reddy  
Network Solutions  
American Superconductor***

***nreddy@amsuper.com  
www.amsuper.com***