



Synchrophasor-Based Wide Area Closed-Loop Control

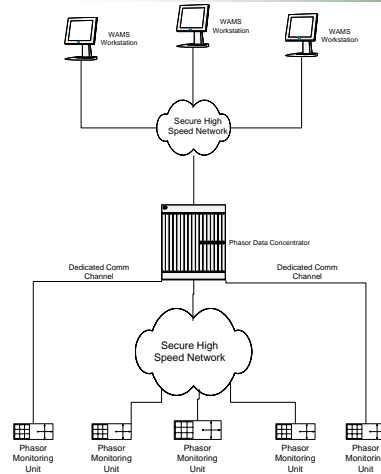
Anthony Johnson, Southern California Edison



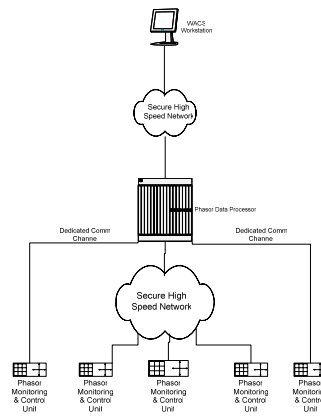
Synchrophasor Technology

- ◆ System Architecture
- ◆ Equipment Familiarization
- ◆ Historical Event Analysis
- ◆ Real Time Visualization
- ◆ “Low” Speed Closed Loop Control
- ◆ “High” Speed Closed Loop Control

Wide Area Monitoring: System Architecture



Wide Area Control: System Architecture



Equipment Familiarization

- ◆ Phasor Monitoring Unit
 - Stand Alone PMU
 - Multifunction Box (DFR or Relay)
- ◆ Phasor Data Concentrator/Controller

Phasor Monitoring Units: Stand Alone PMUs



Macrodyne PMU



Phasor Monitoring Units: Multi-Function Devices

GE – N60 Relay



> ENHANCED UR FRONT PANEL

SEL 421 - Relay

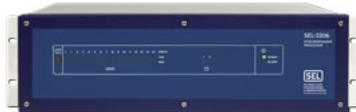


Hathaway IDM - DFR



Phasor Data Concentrators/Controllers

SEL - PDC



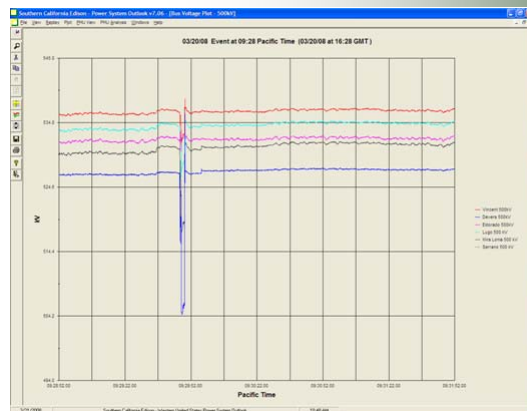
BPA - PDC



Historical Event Analysis

- ◆ Use of Synchrophasor Data to Review Power System Event
 - Time Stamped Data
 - “Wide” Area Visualization
 - High Speed Data Records

Historical Event Analysis



SCE's Power System Outlook Program

Real Time Visualization

- ◆ Tool for Grid Operations
- ◆ Provides Visualization of Events Outside of Existing Energy Management System's Visibility

Real Time Visualization

SCE's SMART System
in our Grid Control
Center



“Low” Speed Closed Loop Control

- ◆ Voltage Regulation
- ◆ Var Resource Coordination
- ◆ Enhanced State Estimation

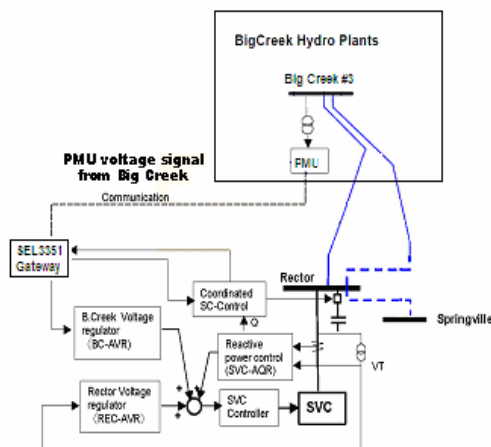
Voltage Regulation

- ◆ Use Geographically Dispersed Voltage Phasor Information to Develop an Optimal System Voltage Profile

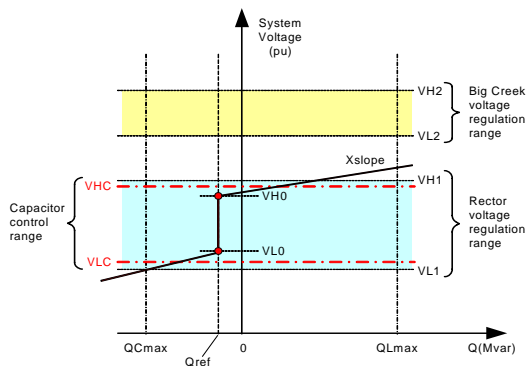
Var Resource Coordination

- ◆ Optimize Var Resource Coordination
- ◆ Maintain Optimal Voltage Regulation in Addition to Optimal Power Factor Correction.

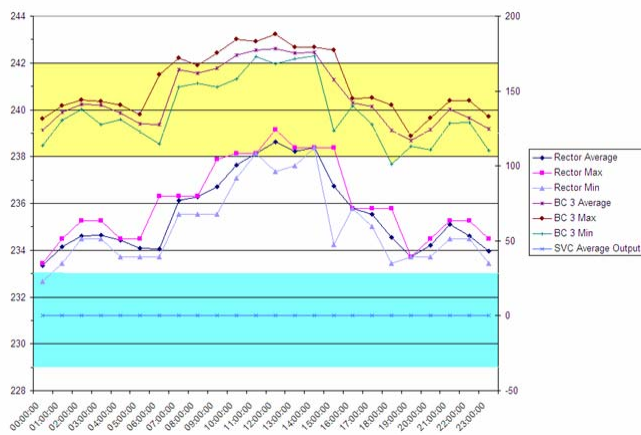
Coordinated Voltage/Var Control Scheme



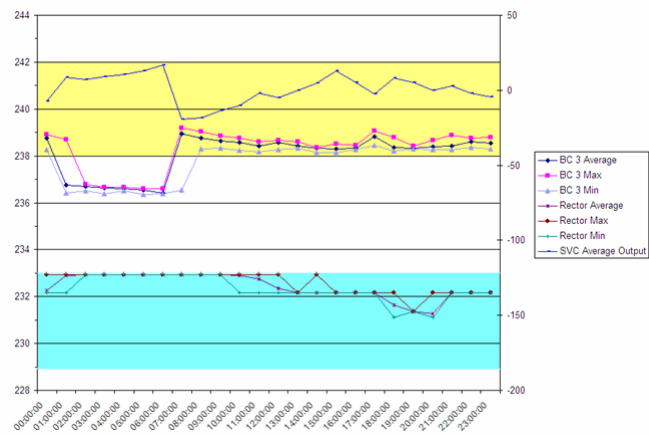
V-Q Characteristics of the Rector SVC Coordinated Control



Effect of SVC Operation on Big Creek



Effect of SVC Operation on Big Creek



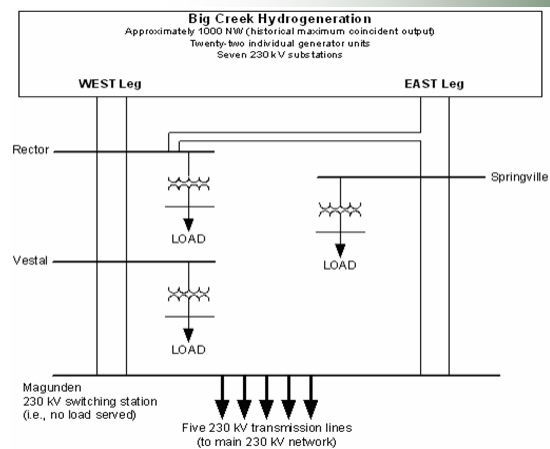
Enhanced State Estimation

- ◆ Use Synchronized Data to Refine State Vector
- ◆ Aids in Algorithm Convergence

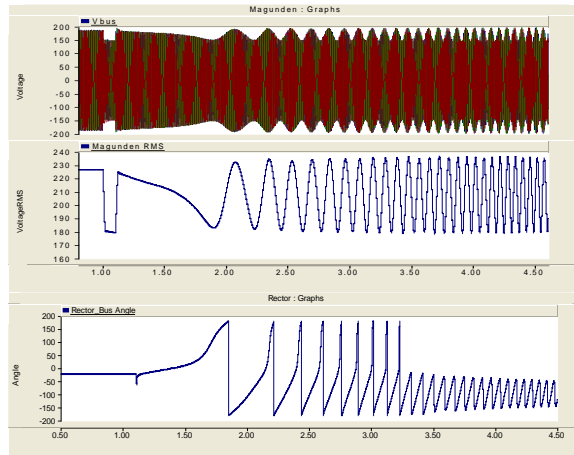
“High” Speed Closed Loop Control

- ◆ Special Protection Systems

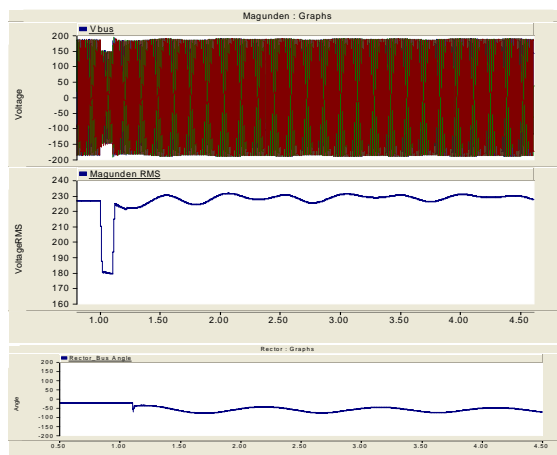
System for RAS Application



RAS: No Action Taken



RAS: Action Taken





Questions?

- ◆ **Contact Information:**
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