Discovery Across Texas: Technology Solutions for Wind Integration in ERCOT

Using Synchrophasor Technology for Wind Integration and Event Monitoring in ERCOT

Events Captured and Findings To Date

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Ft. Worth, Texas

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DOE Smart Grid Demonstration Project

- **Awarded to CCET** - Texas 501(c)6 non-profit formed in 2005
- **CCET Members and Mission**: 21 corporate members and 5 university cooperators. Mission - enhance the safety, reliability, security, and efficiency of the Texas electric transmission and distribution system through research, development and commercialization of emerging technologies (http://www.electrictechnologycenter.com)
- **Awarded Jan 4, 2010**: DE-OE-0000194; Value $27 million (DOE 50%); 17 participants; 3 Components – Synchrophasors, Smart Meter Texas Portal, and Smart Grid Community of the Future; 3 phases – Planning, Design, Demonstration
- **Title**: *Discovery Across Texas*: *Technology Solutions for Wind Integration in ERCOT*
- **Goal**: Demonstrate a synergistic approach to managing fluctuations in wind power (currently 8 GW increasing to 18 GW) in the ERCOT transmission grid through better system monitoring capabilities, enhanced operator visualization, and improved load management
- **Synchrophasor Project Participants:** ERCOT, TOs, Electric Power Group – Lead for Synchrophasor portion of the project

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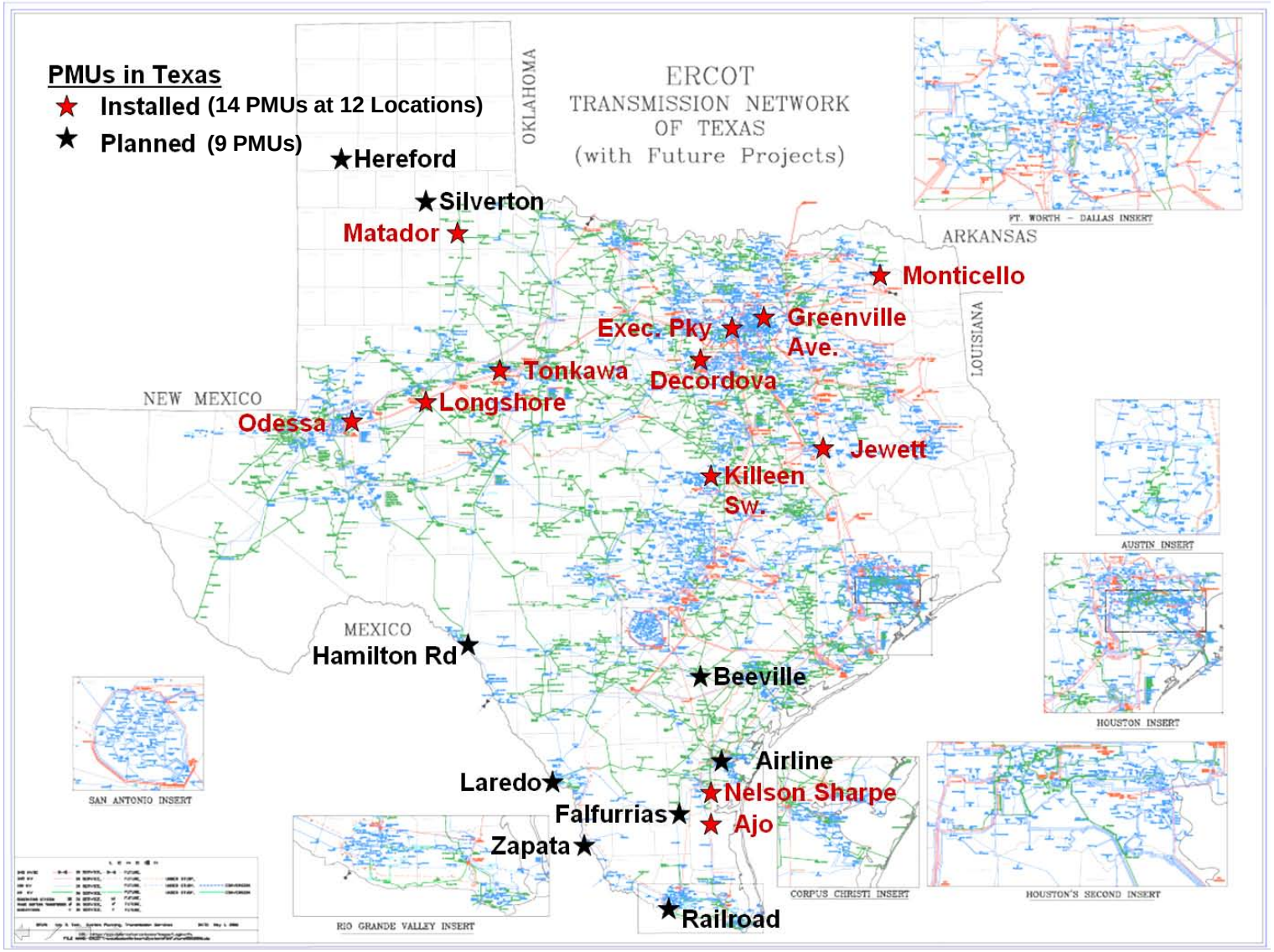
Synchrophasor Project

- Build on Current ERCOT Network started in Fall 2008 with 3 AEP PMUs
- Currently 14 PMUs installed at 12 TO locations, and at ERCOT *e*PDC™ for data synchronization, RTDMS® for visualization, and PGDA™ for off-line analysis
- Expanding to 23 PMUs, provide TOs access to RTDMS visualization applications
- Participating TOs and commitments
  - AEP TEXAS - 6 new PMUs
  - ONCOR - 4 new PMUs
  - Sharyland Utilities - 3 new PMUs, 1 PDC

Synchrophasor Project Goals

- Enable ERCOT to ***better manage*** the transmission grid to accommodate very large quantities of wind generation
- Establish and maintain a ***reliable synchrophasor network*** to provide real time dynamic information on wind resources and their impact on the transmission grid
- Use synchrophasor measurements to ***identify precursor*** conditions to undesirable grid performance and behavior
- Identify changes in operating procedures or actions to facilitate integration of intermittent resources, hence ***improving grid reliability***
- Utilize synchrophasor measurements to ***recalibrate engineering models***

ERCOT Phasor Network



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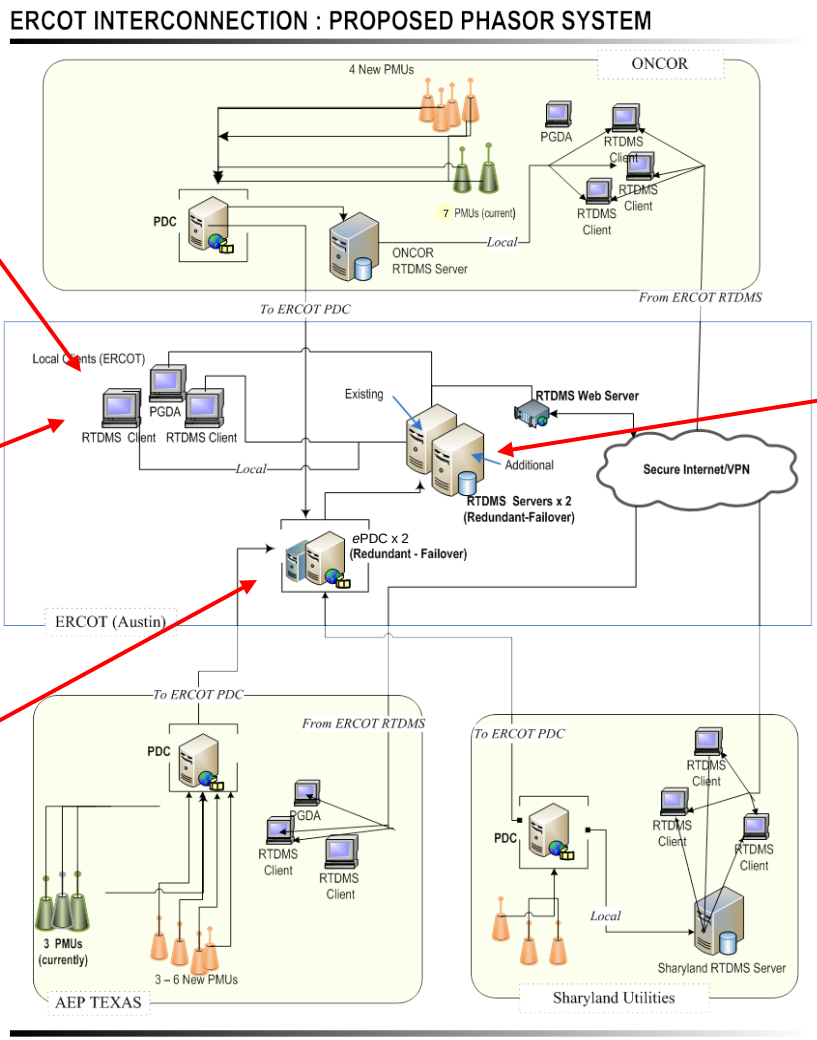
ERCOT Phasor System with RTDMS

Real Time Dynamics Monitoring System (RTDMS)

Phasor Grid Dynamics Analyzer (PGDA)

enhanced Phasor Data Concentrator (*e*PDC)



RTDMS Server & Database

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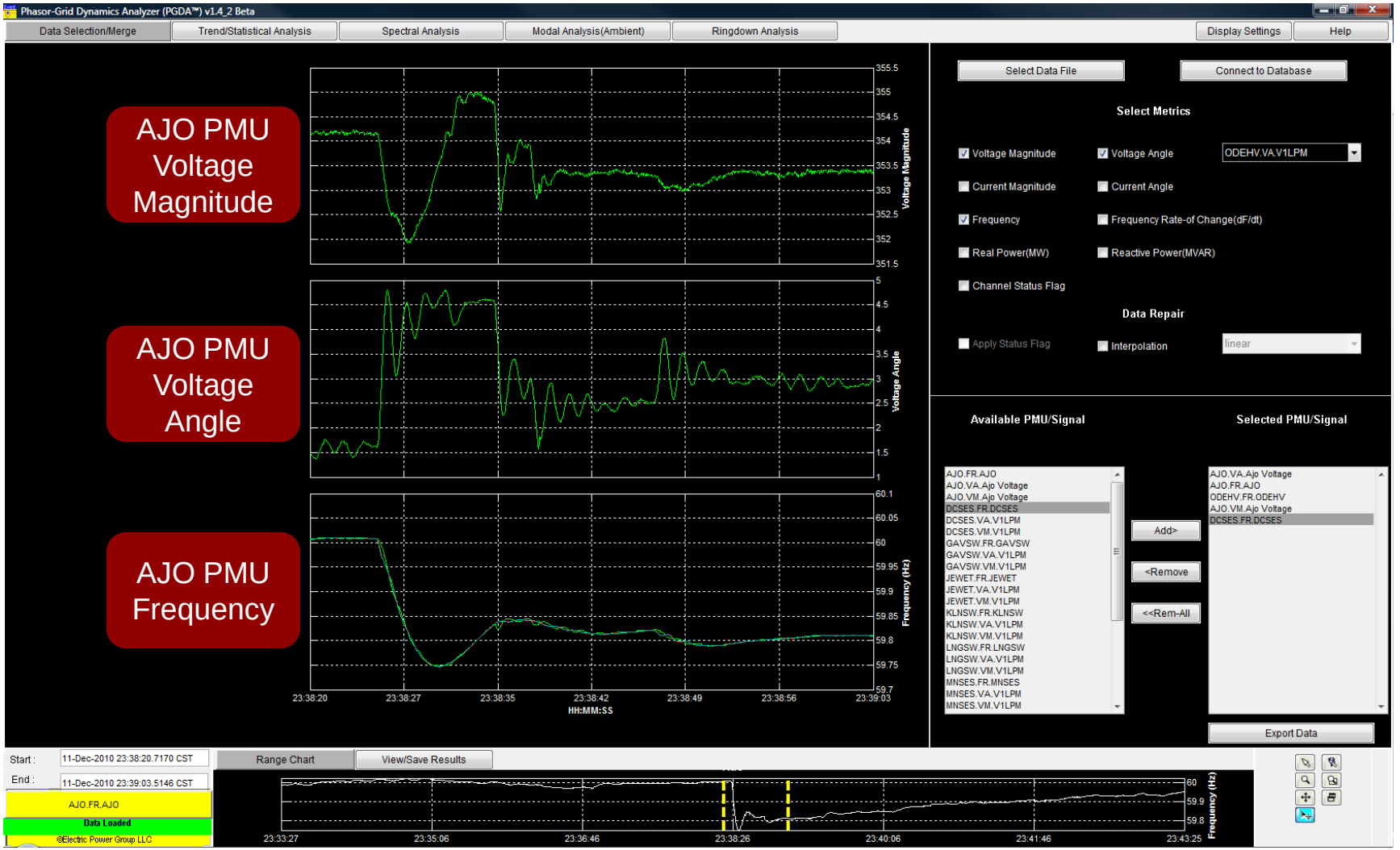
Applications of PGDA

Event and Disturbance Analysis	• Quickly determine the causes and effects of power system events like generation and line trips
Dynamic Model Validation	• Verify and refine/re-calibrate dynamic models used in power system simulations to aid in planning and engineering studies
Baselining Analysis	• Examine long-term system performance and establish reliable ranges for voltage, frequency, and other system metrics
Dynamic Stability Assessment	• Evaluate the ability of a power system to withstand and respond to disturbances by analyzing the characteristics of dangerous oscillations and calculating standard reliability metrics like frequency response

Use of PGDA for Off-Line Analysis



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Analysis of Three Recent ERCOT Events

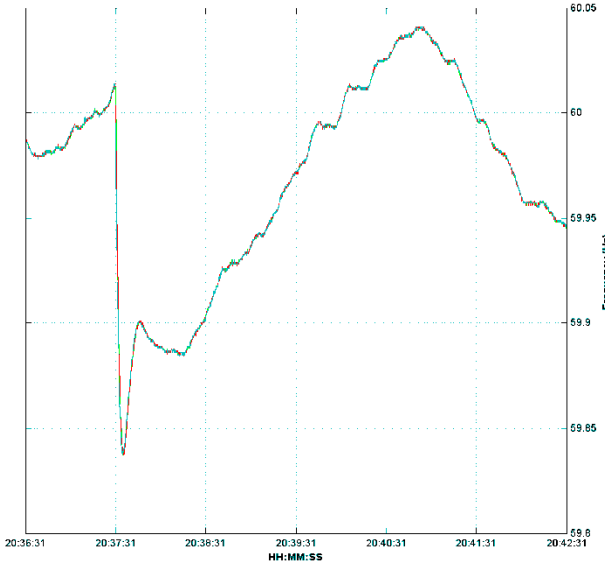
Events:

- 09/25/10 @ 20:37:30 – 545 MWs generation loss
- 11/03/10 @ 10:21:05 – 1444 MWs generation loss
- 12/11/10 @ 23:38:24 – 1085 MWs generation loss

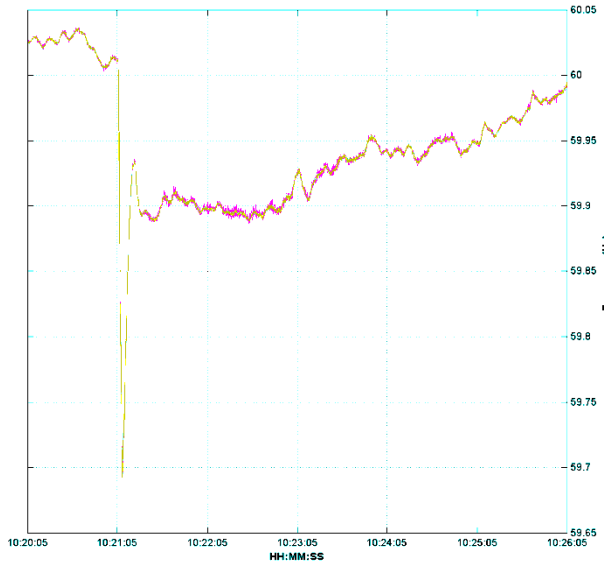
Analysis Approach:

- Capture Event Data from RTDMS Event File
- Utilize PGDA for Off-line analysis
- Select signals – frequency, voltage, power
- Analyze grid performance – frequency response, recovery time, voltages, modes

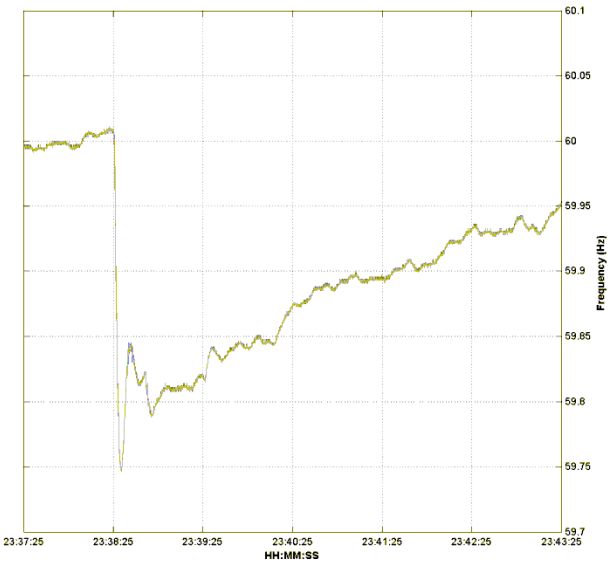
Three Events with Different Frequency Behavior



9/25/10 Event



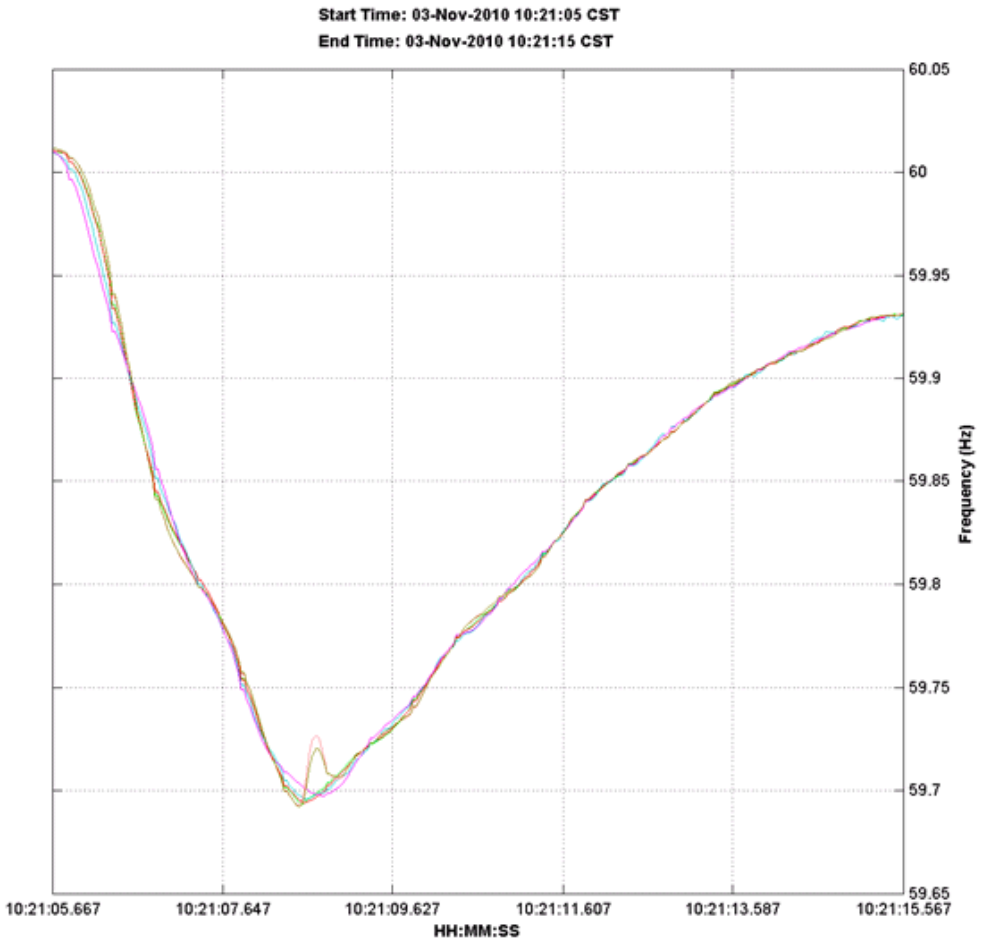
11/3/10 Event



12/11/10 Event

All three events had very different frequency behavior and characteristics

11/3/10 Event Shows Secondary Oscillation



The second event indicated secondary oscillations during the dip

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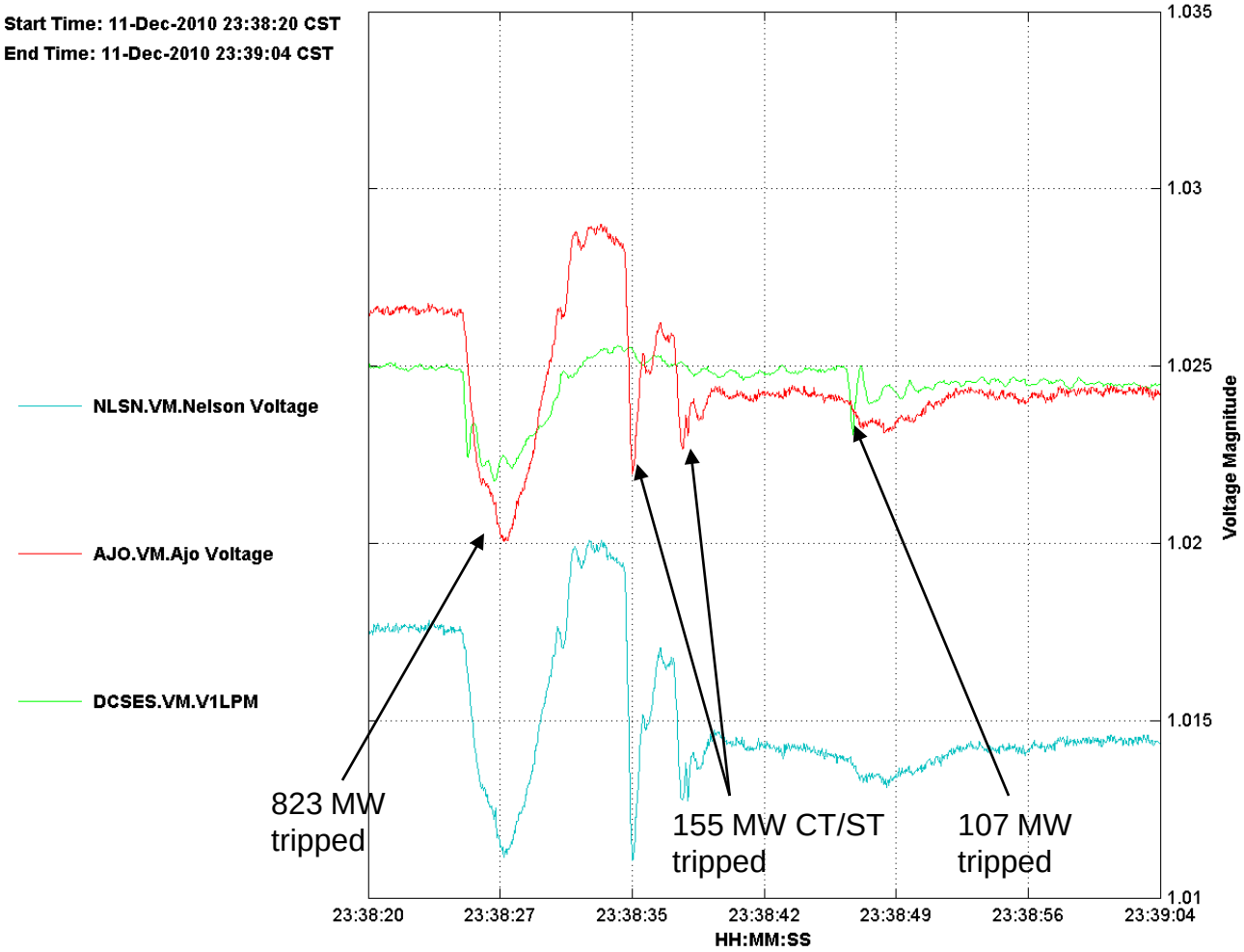
12/11/10 Event
Voltage Response

Voltage dips are moderate (0.006 pu), but voltage plots identify subsequent generation trips



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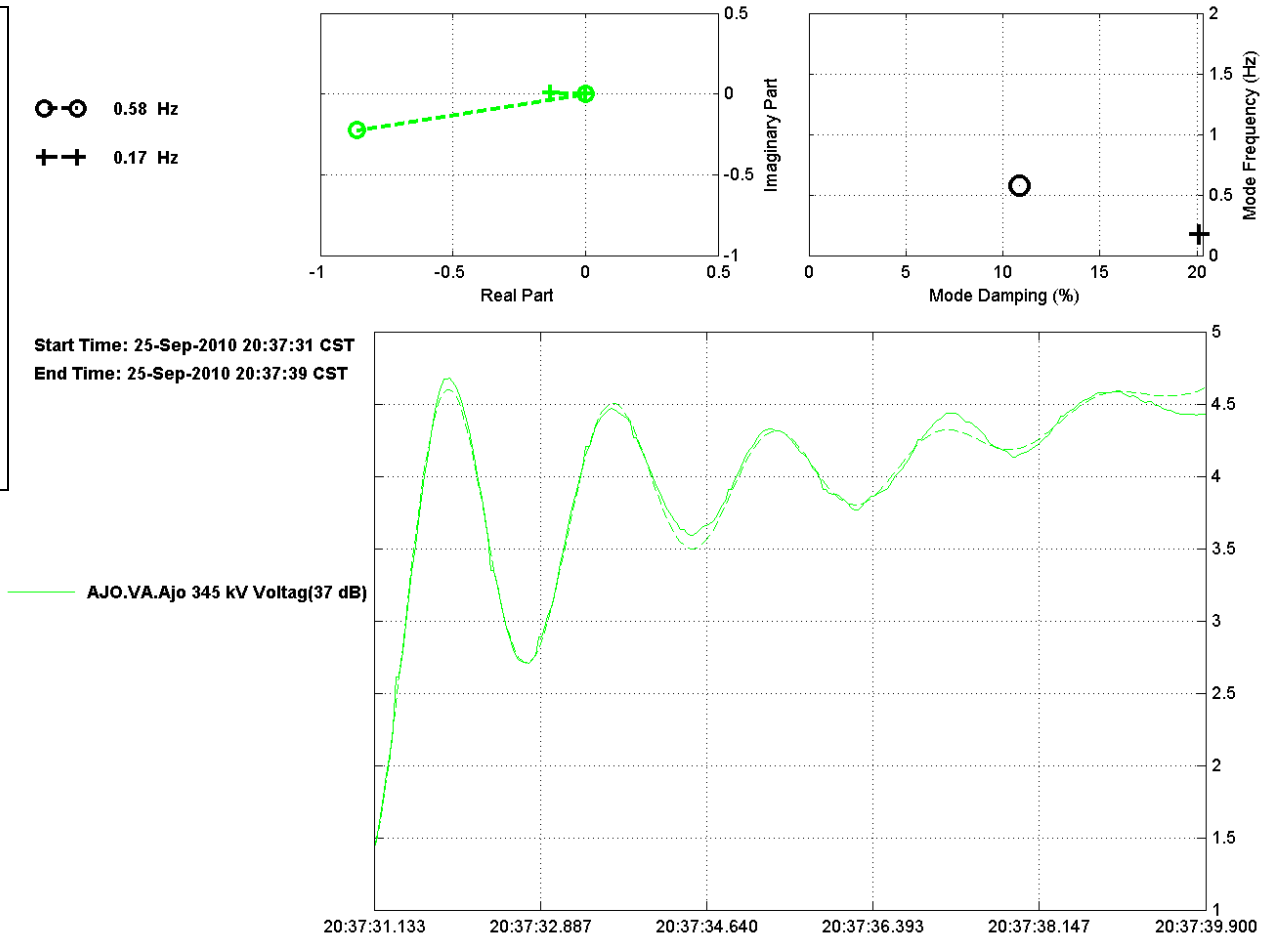
Dominant Oscillatory Mode - 9/25/10 Event

Dominant mode at 0.58 Hz shows 11% damping.

Dominant mode is west-south swing.

Mode shape modeling matches the oscillation very well.



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Analysis Summary

Descriptor	Event 1	Event 2	Event 3
• Date	9/25/10	11/3/10	12/11/10
• Time	20:37:30	10:21:05	23:38:24
• Generation Loss	545 MW	1,444 MW	1,085 MW (3 trips)
• Load MW	40,510 MW	31,688 MW	29,389 MW
• Wind	0.2%	14.8%	16.7%
• Lowest Frequency	59.9 Hz	59.69Hz	59.75Hz
• Recovery Time	2min 25sec	3min 57sec	Not in range
• Voltage Drop	Small	Moderate	Moderate
• Frequency Response	482.3 MW/.1Hz	596.7 MW/.1Hz	597.8 MW/.1Hz
• Oscillation Modes	0.58Hz	0.68Hz	0.71Hz 0.68Hz 0.69Hz
• Damping	11%	3.36%	>8.5%

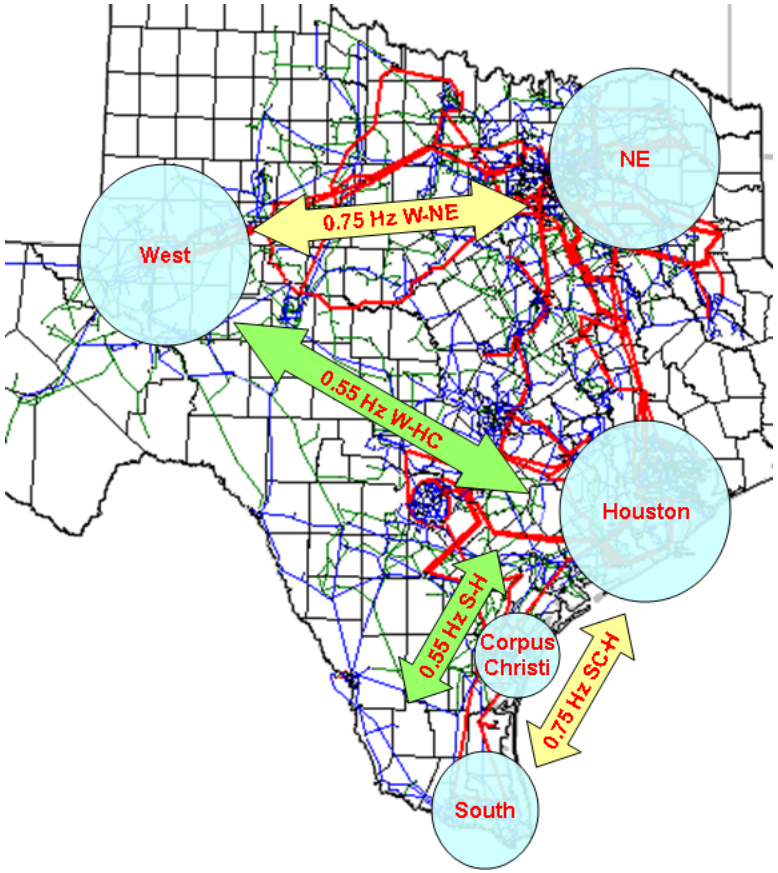
Observations and Conclusions

- Analysis of events are providing a good baseline to establish an event library
- Event analysis shows inter-area oscillations predominant in the ERCOT system
- Observed oscillation modes collaborate ERCOT's planning studies
- Need to analyze the frequency response of events in real-time to validate the frequency bias
- Grid performance after similar events is different – need to develop a better understanding of drivers of grid dynamics
- Voltage monitoring can identify secondary events (e.g. 12/11/10 event)

Back-Up

Oscillation Modes in ERCOT Annual Planning Study

Two major system oscillation modes (West-Northeast and West-Houston/Corpus Christi) were identified in ERCOT planning study.



Voltage Response - 9/25/10 Event

Voltage dips are small and voltage recovers quickly