ERCOT STF UPDATE

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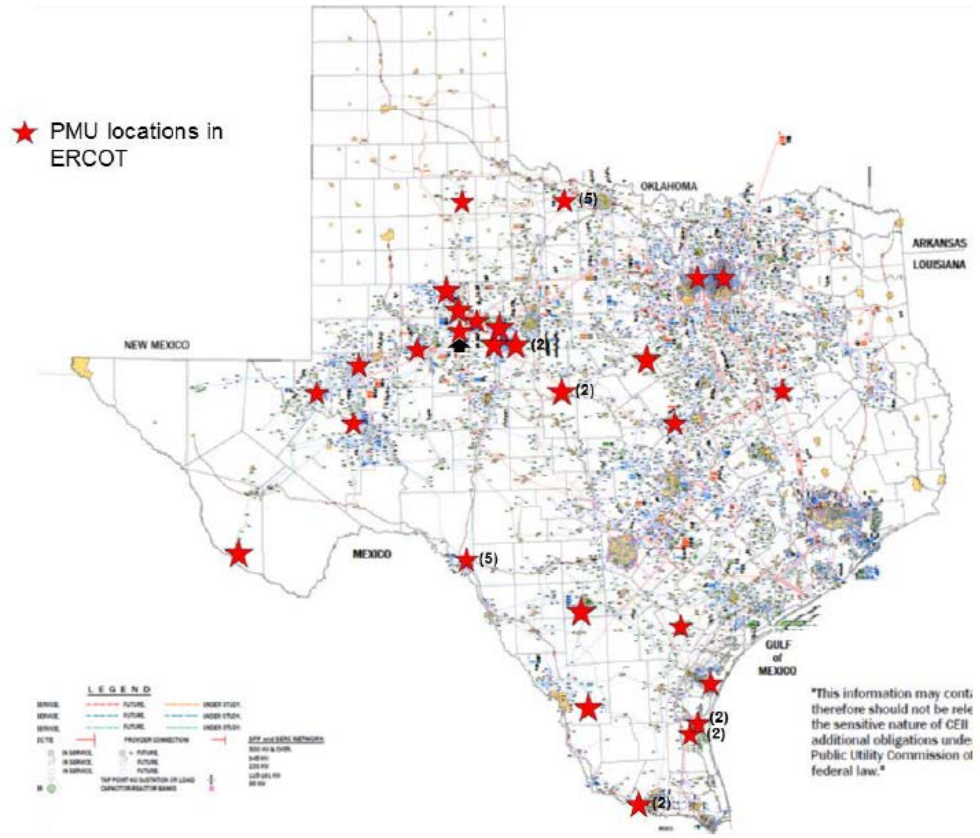
Manager, Operations Support

Synchrophasor Taskforce Meeting
November 12, 2013

PMU Deployment Status – all

- **New release of RTDMS installed (Sept 2013)**
- **Helps to handle data dropouts and other issues**
- **Total 41 PMUs**
  - AEP: 22 (+14 new* ?)
  - ONCOR: 17
  - Sharyland: 2

* Note: Need to finalize on AEP new PMUs



LCRA PMU ADDITIONAL PMU OUTSIDE OF CCET PROJECT

- At the following six substations install synchrophasor measurement equipment including satellite-synchronized clocks and telecom hardware necessary to enable Phasor Measurement Unit (PMU) functionality:

Substation	# of PMUs
Austrop	4
Clear Springs	3
Fayetteville	1
Kendall	2
Marion	2
Zorn	5
Total	

Locations were chosen based primarily on: SEL-421 relay availability, telecom bandwidth, 345kV system coverage, proximity to generation, and line pairs

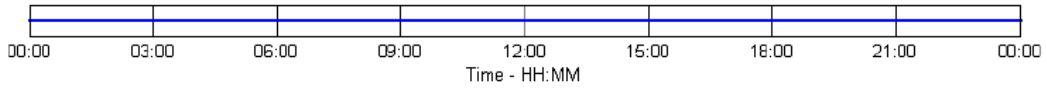
TYPICAL PMU DAILY PERFORMANCE REPORT

9th October, 2013 Report (Contd)

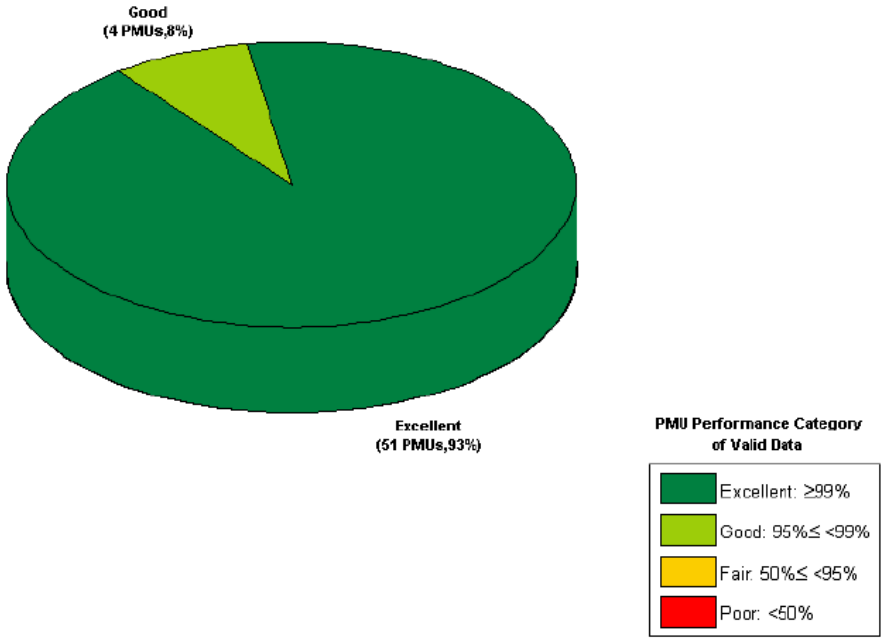
DATA QUALITY

Wednesday, October 09, 2013 (Central Daylight Time)

Data Availability (23.98 hours)



PMU Performance*



*PMU Performance is based on Archived Data only. (PMU Performance(%) = Valid Data / Total Archived Data * 100%)

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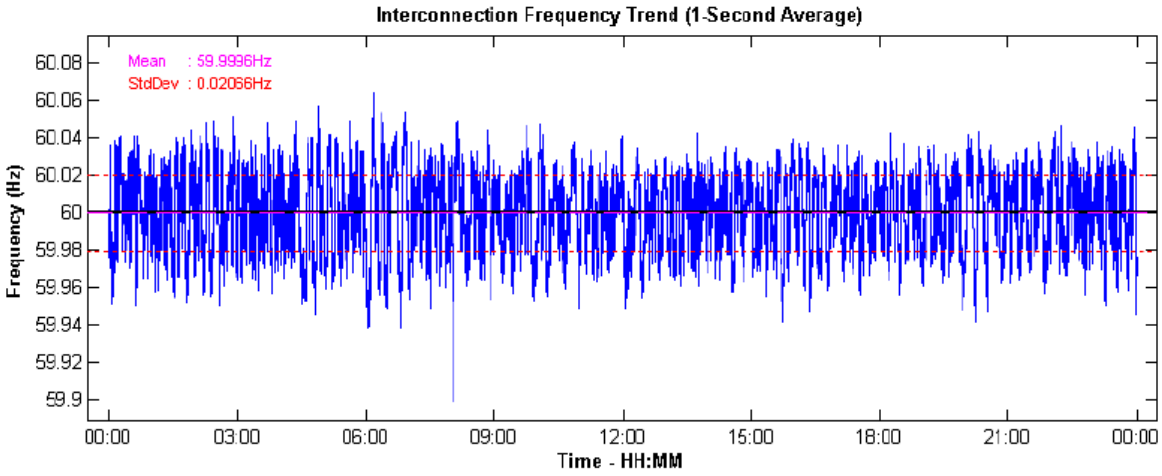
PMU Frequency Performance Report

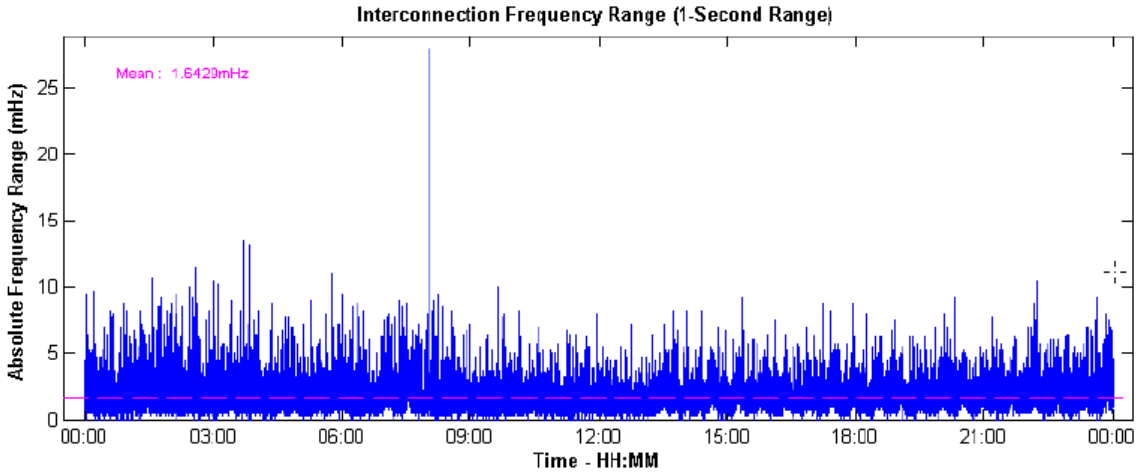
9th October, 2013 Report (Contd)

TRENDS & STATISTICS

Wednesday, October 09, 2013 (Central Daylight Time)

Interconnection Frequency Trends & Statistics





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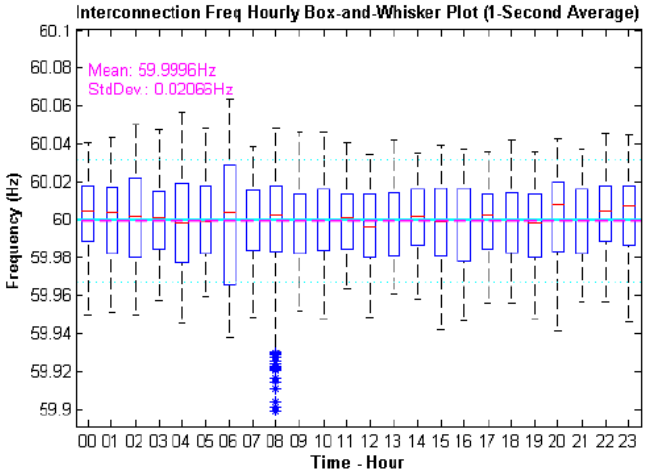
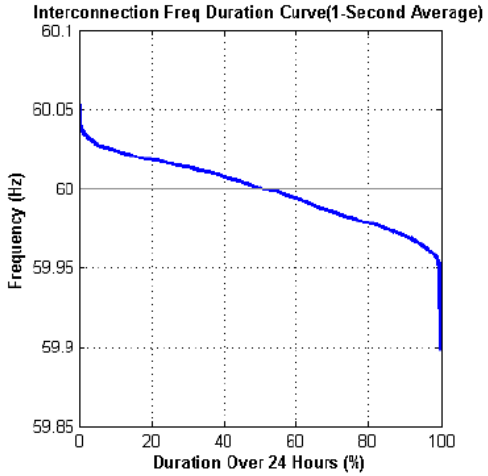
RTDMS/PMU Daily Performance Report

9th October, 2013 Report (Contd)

Interconnection Frequency Trends & Statistics

Wednesday, October 09, 2013 (Central Daylight Time)





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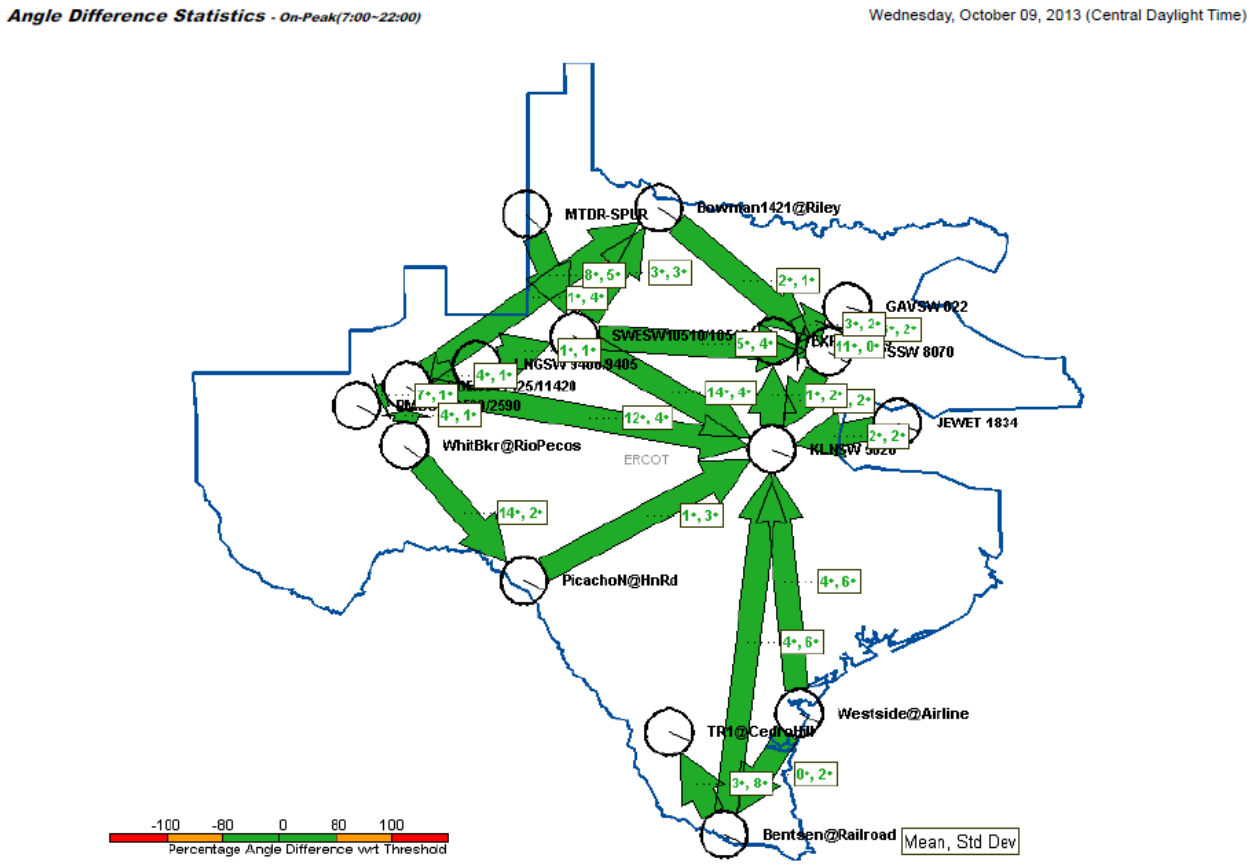
RTDMS/PMU Daily Performance Report

9th October, 2013 Report (Contd)



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RTDMS 2012 Deployment Status

- **Project Started**
- **New server configuration – ERCOT**
  - Server installation Completed.
- **RTDMS 2012 implementation status – ERCOT**
  - Installation complete
  - ERCOT Testing completed.
  - Client (TO) Testing in progress
    - Initial issues with ONCOR Client side
    - AEP connected
  - Working on porting new profiles/config from EPG

- **RTDMS 2012 Client Access to ERCOT display**
  - Working on providing same displays that ERCOT operators would see since this provides wide area visualization of the system

RTDMS 2012 Operator Training

- **Training on RTDMS and PGDA by EPG completed at ERCOT (25-27 Sept, 2013)**
  - Total of 41 (21 from TOs and 20 from ERCOT) participants
  - Hands-on exercises based on ERCOT use cases was very much appreciated

PRESENTATIONS AT ERCOT STAKEHOLDER MEETINGS

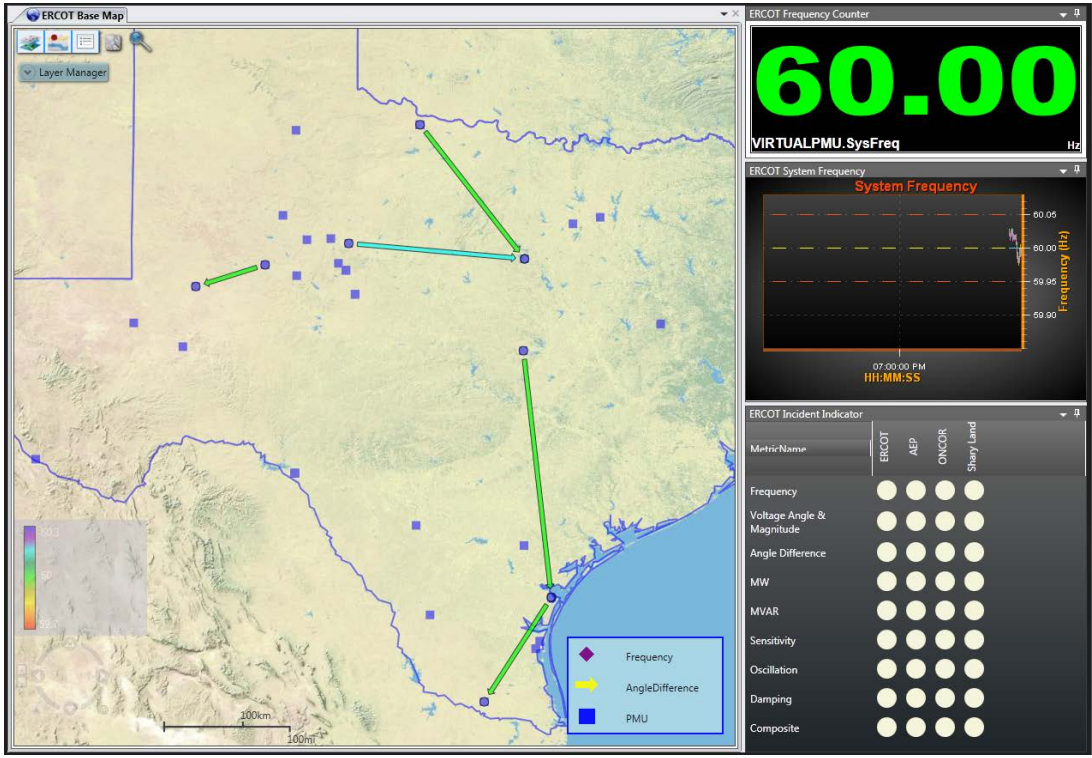
- **Made preliminary presentations at ERCOT stakeholder meeting**
  - PDCWG Meeting
  - DWG Meeting
- **Made presentation at ERCOT ROS meeting**
  - Task Force is formed

Uses for PMUs within ERCOT

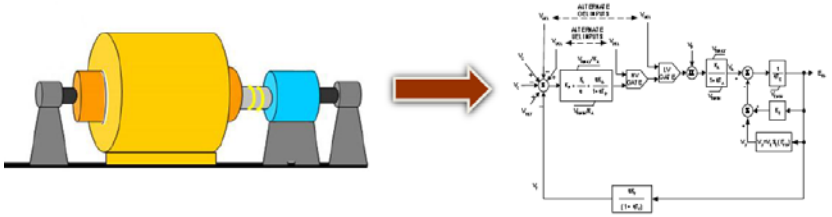
Examples of experience using PMU data

WIDE AREA MONITORING

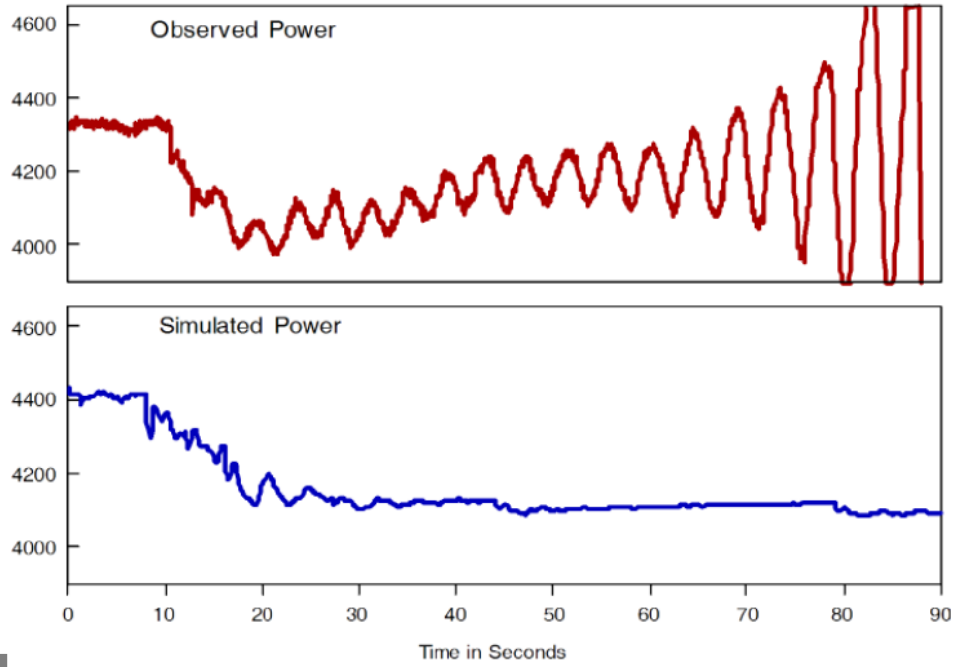
- **Angular limits**
- **Oscillatory Dampening**
- **Voltage Deviations**
- **Frequency Deviations**

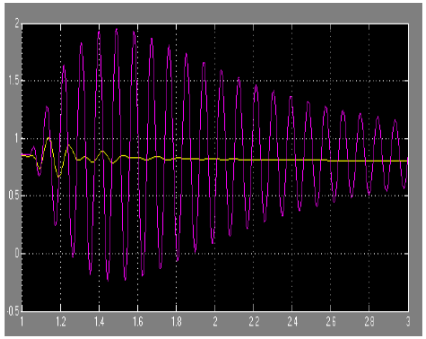


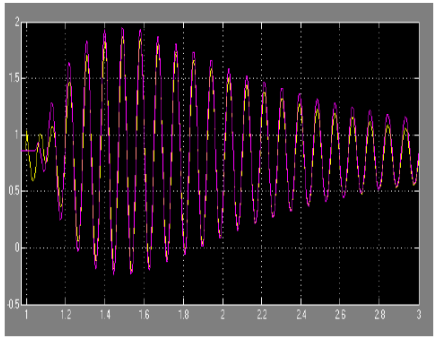
EXAMPLES OF HOW PMUS CAN BE USED WITHIN ERCOT FOR MODEL VALIDATION



Challenge: Build a good dynamic model for a Generator/Excitation System that matches the actual equipment in the field and validate it through offline/online testing

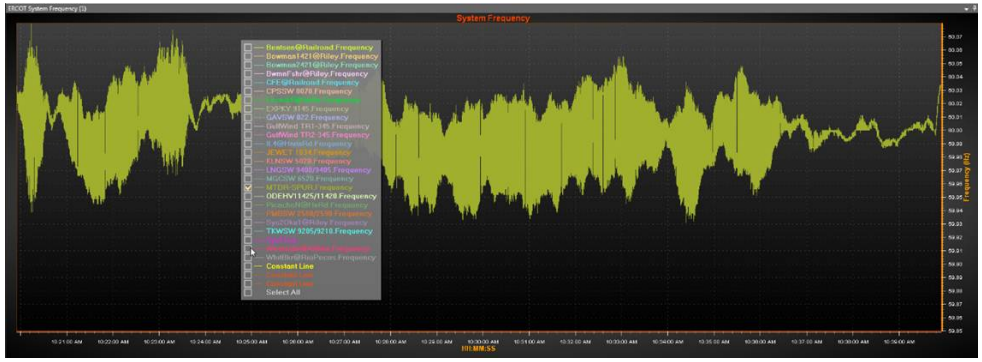


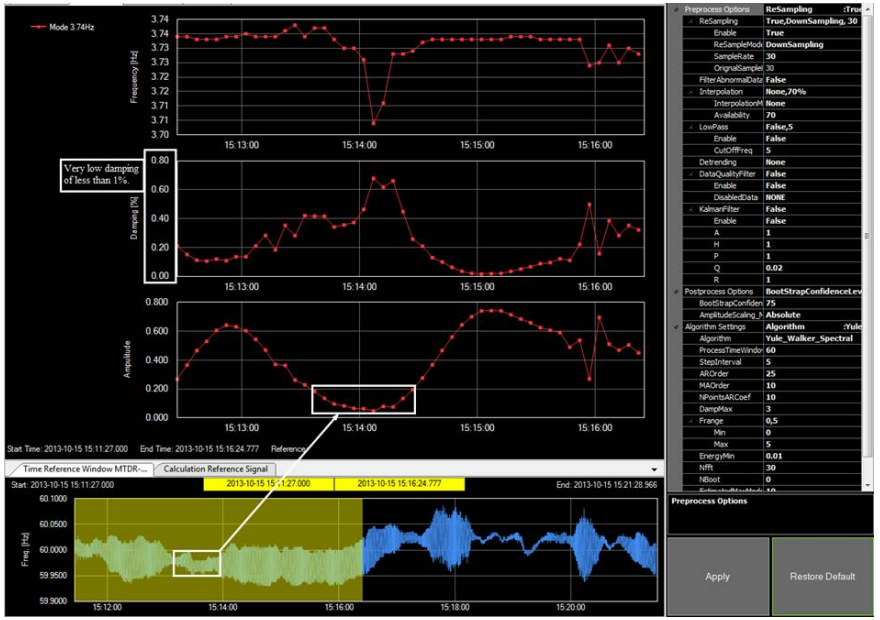


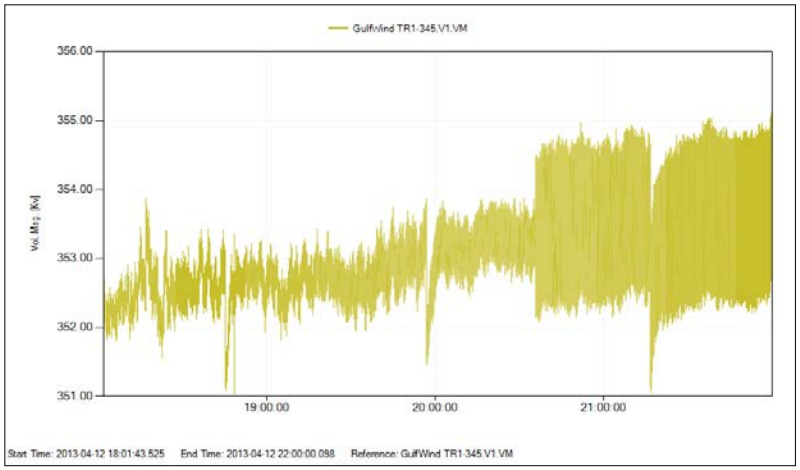


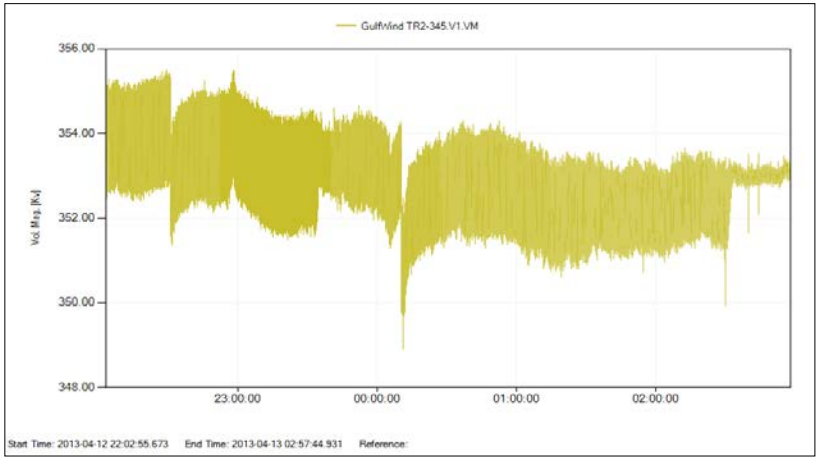
WSCC August 10, 1996 disturbance

EXAMPLES OF ISSUES PMUS IDENTIFIED WITHIN ERCOT DUE TO CHANGES IN TOPOLOGY OR BAD SETTINGS FOR VOLTAGE CONTROL





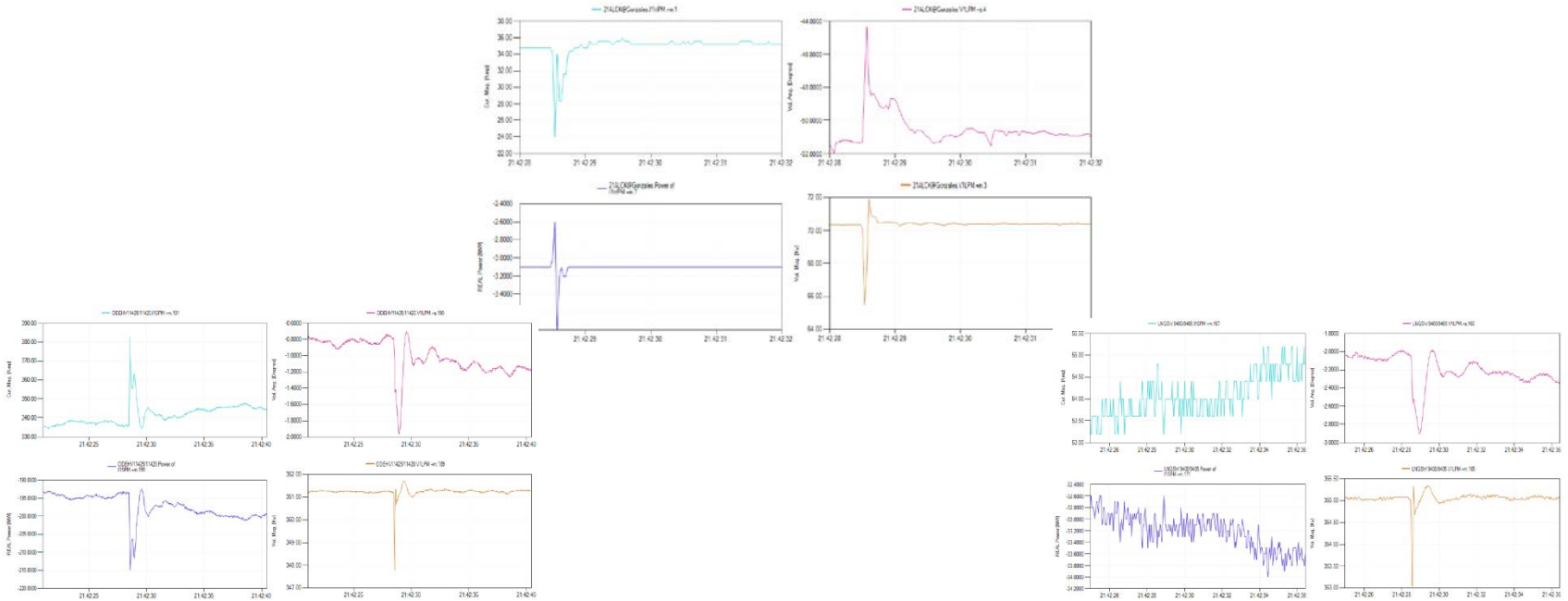




Event Identification

- **System Events have distinct characteristics**
  - Unit trips cause “ramp-down” in frequency
  - Line trips cause “step” changes in voltage angle
    - Accompanying drop in voltage and drop/rise in current would indicate a system fault
  - Capacitor/Reactor switching causes “step” changes in voltage magnitude
  - Oscillation Events can indicate:
    - Poorly tuned controllers (> 1 Hz)
    - Absence or Offline Status of PSS in nearby generation (< 1 Hz)
- **Characterization needs to be developed and formulated**
  - Should be easily programmable in software
  - Should be easy for the Operators to understand and use in day-to-day functioning.
  - Should be incorporated (once developed) into a system of protocols for Operators both at ERCOT and TSPs to follow

POST EVENT ANALYSIS SYSTEM FAULT



A fault should in general cause an impulse drop in voltage and a corresponding rise in current.
In the report, the Odessa (345 kV) , Permian Basin (138 kV) and Morgan Creek (345 kV) all indicated a drop in voltage similar to expected response and also a sharp, temporary increase in current magnitude. Even the PMUs at CPSSW and GAVSW showed minor indications of the fault but the deviation at these locations was small.

The interesting responses were recorded at LNGSW and Gonzales.

At Gonzales, the current magnitude also saw a sharp drop along with the voltage. But looking at the power (MW) plot showed the reason. In general power was flowing into Gonzales from the rest of the system. So a major portion of the current flow would be redirected into the fault, thereby *reducing* the current flowing into Gonzales by a proportionate amount.

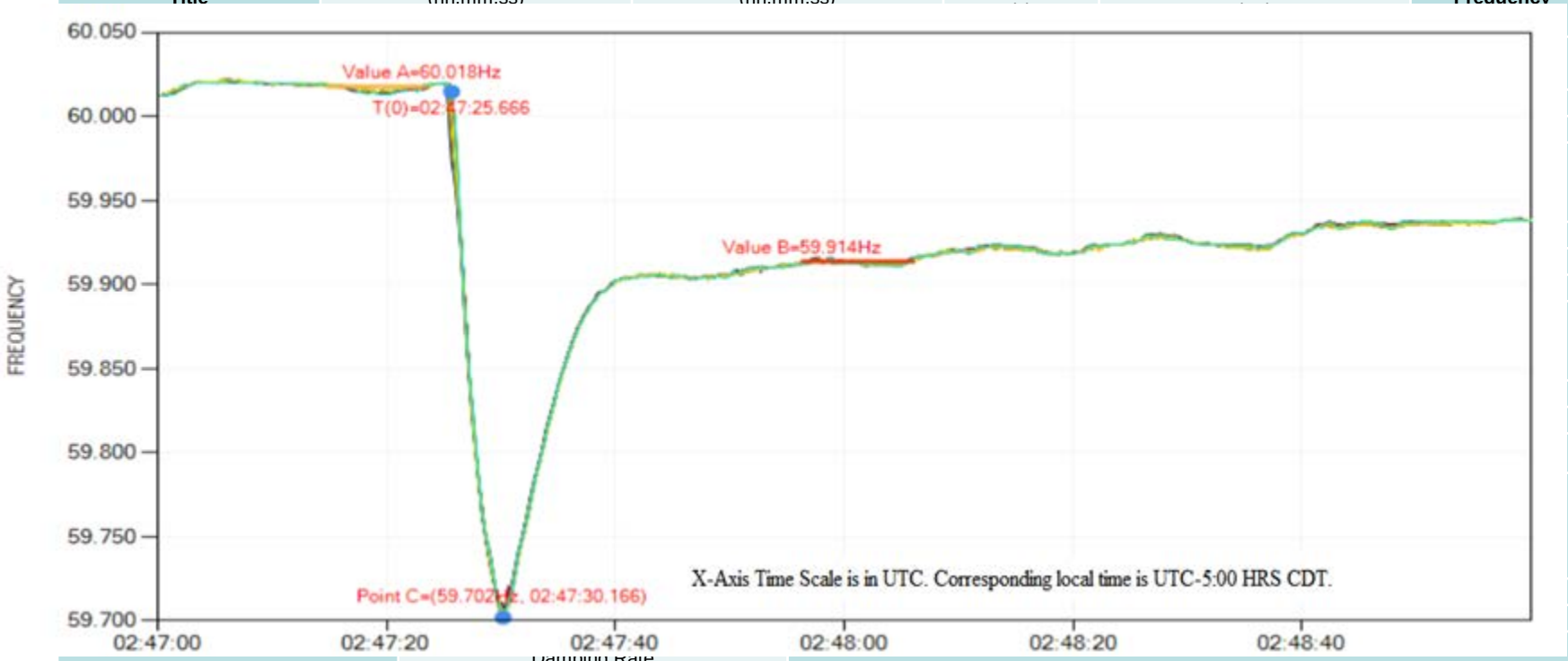
Even more interesting is the fact that *there was little to no fault current recorded at LNGSW*, even though it is located in between Morgan Creek and Odessa both of which showed fault current. The reason is that *the PMU at LNGSW directly measures the output of 3 wind farms*. Since wind farms produce little to no fault current, the PMU only recorded the sharp change in voltage (magnitude and angle) and no change in current or power flow (MW).

POST EVENT ANALYSIS FREQUENCY

Phasor Dynamics Event Summary

The RTDMS captured the following event at the time of 21:47:25 on XX/XX/XXXX. The Advanced Network Applications group studied the dynamic characteristics of this event based on recorded phasor data from 55 available PMUs. The system frequency recovered to 59.95 Hz in around 110 seconds.

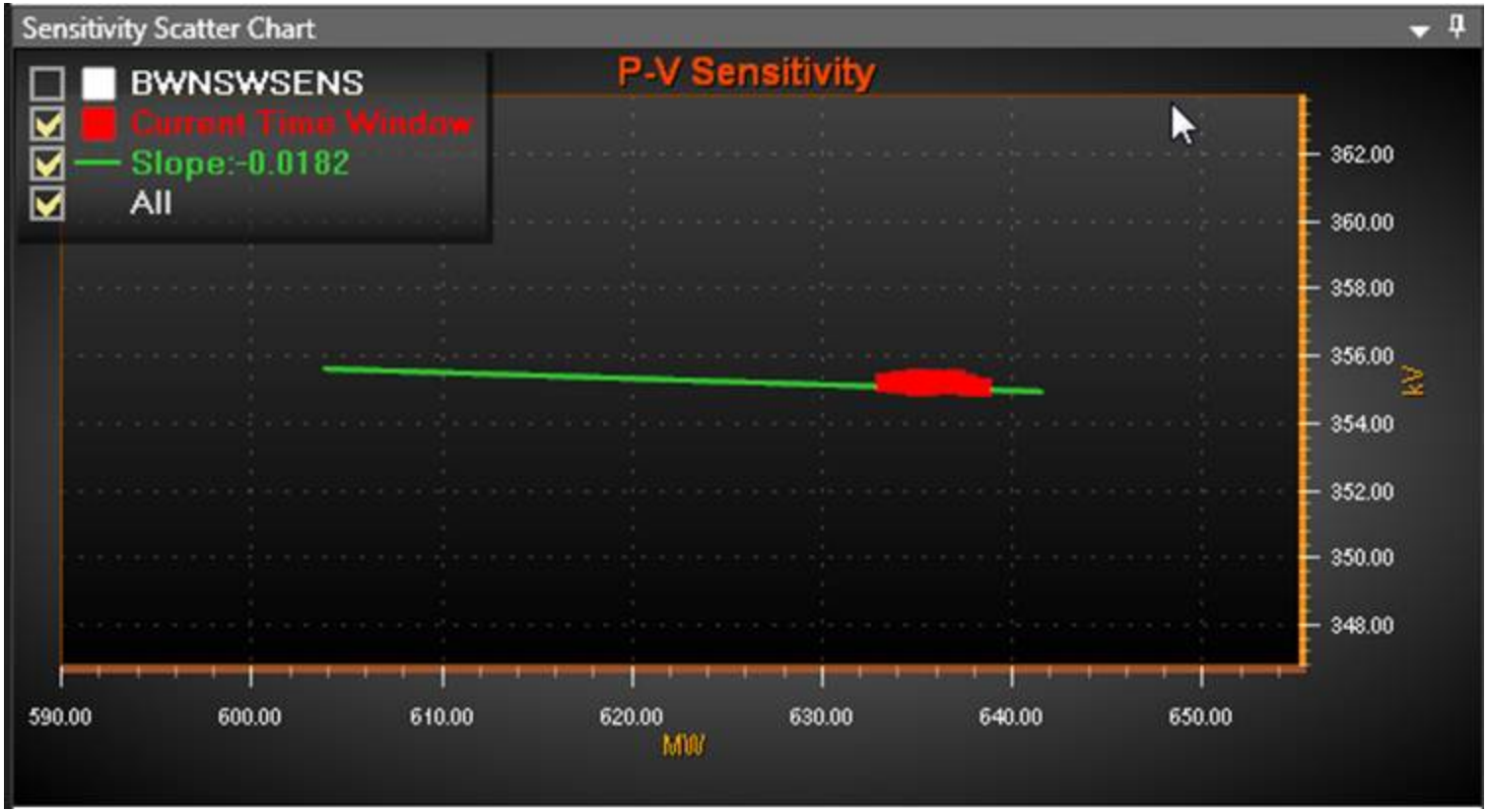
Event Title	Start Time (hh:mm:ss)	Recovery Time (hh:mm:ss)	Event Duration	Pre-Event Frequency	Lowest Event Frequency

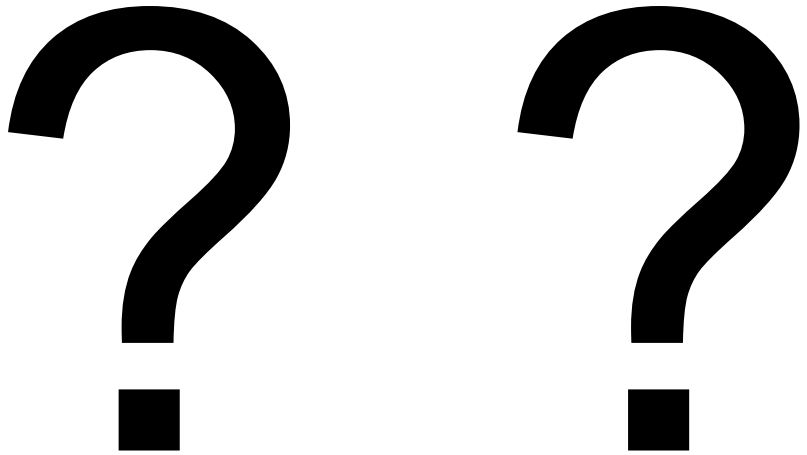


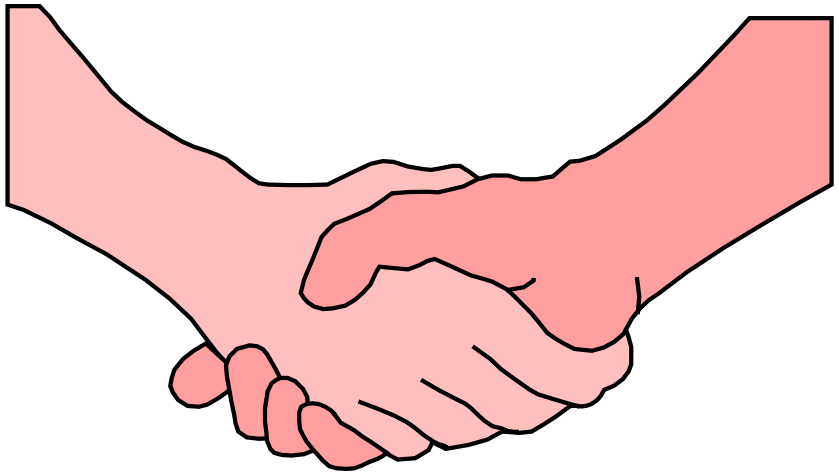
Frequency (Hz)	Damping Rate (%)	Mode Shape Description
0.64	8.6	

Identified by analysis of voltage angle data of PMUs in Central, North and West Texas referred to KLNSW

Examples of how PMUs can be used within ERCOT for PV sensitivity







Thank U !!