NYISO Case Studies of System Events Analysis using PMU Data

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NASPI Work Group Meeting

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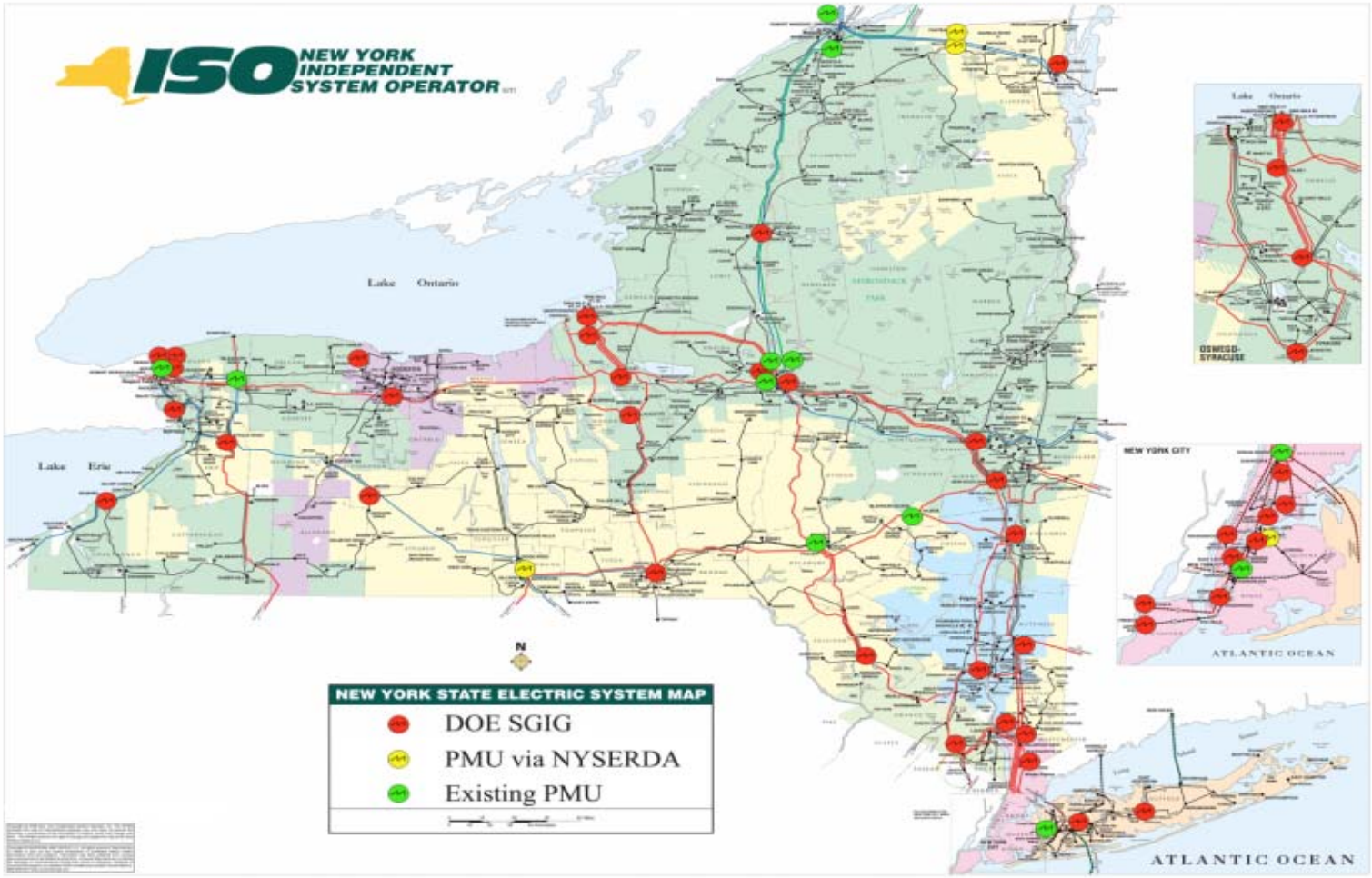
NYISO PMU Network



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System Events Analysis

- **Usage of Phasor Data concentrator (ePDC) and Phasor Grid Dynamics Analyzer (PGDA):**
  - ***Reduced time for system events reporting and analysis since PMU data and tools (ePDC, PGDA) are readily available***
  - ***PMU data accessibility using ePDC for system events reporting***
  - ***In depth system event analysis using PGDA features***
  - ***Communicate with TO personnel on details of events***
- **System events analysis using PMU data were utilized for NYISO Operators' training for practical PMU applications**

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System Event Analysis Tool

- **PGDA for off-line analysis of system events (e.g. BPS line tripping, force outage above 300 MW generation, other system events)**
  - ***Frequency response***
  - ***Transient voltage recovery***
  - ***Modal analysis***
  - ***Ringdown analysis***
  - ***System Stress analysis (Voltage phase angle differences)***
  - ***Other analysis if needed:***
    - **Response validation of system component response (SVCs, StatCom)**
    - **Power system control system responses**

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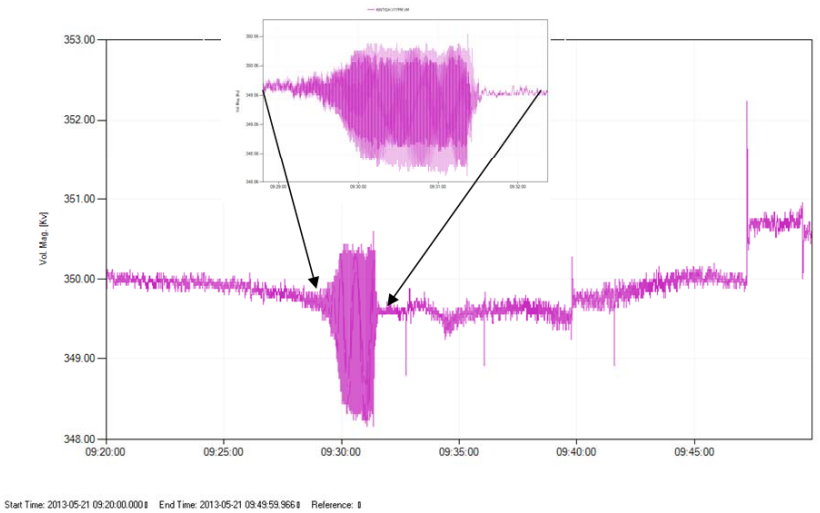
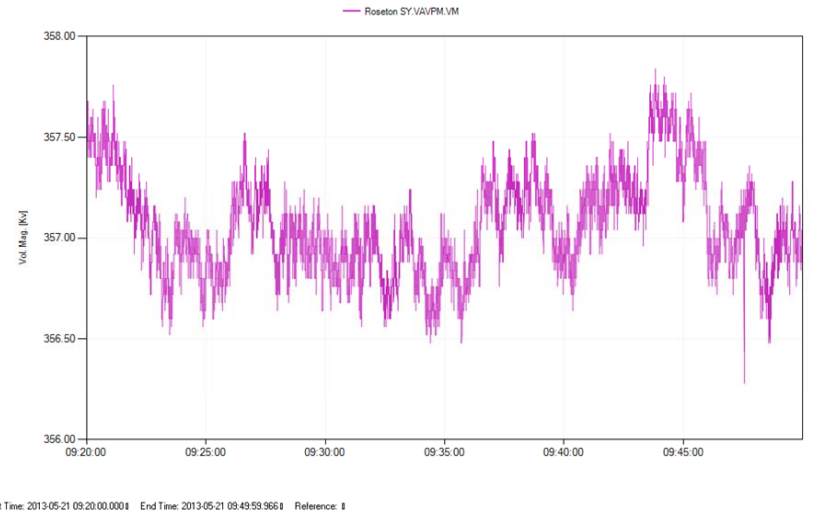
May 21, 2013 – Local Oscillation

- **Time : 0930 HRS**
- **Event : Malfunctioning Generator AVR Control System**
- **Observations:**
  - ***Nearby 345 kV buses oscillated ±2 kV (most western buses had this)***
  - ***Farther 345 kV buses did not oscillate unlike western buses***
  - ***Voltage oscillation was local***
    - **1.25 Hz oscillatory mode was present during the oscillation**



Transient voltage performance at Kintigh 345 kV bus.



Transient voltage performance at Roseton 345 kV bus.

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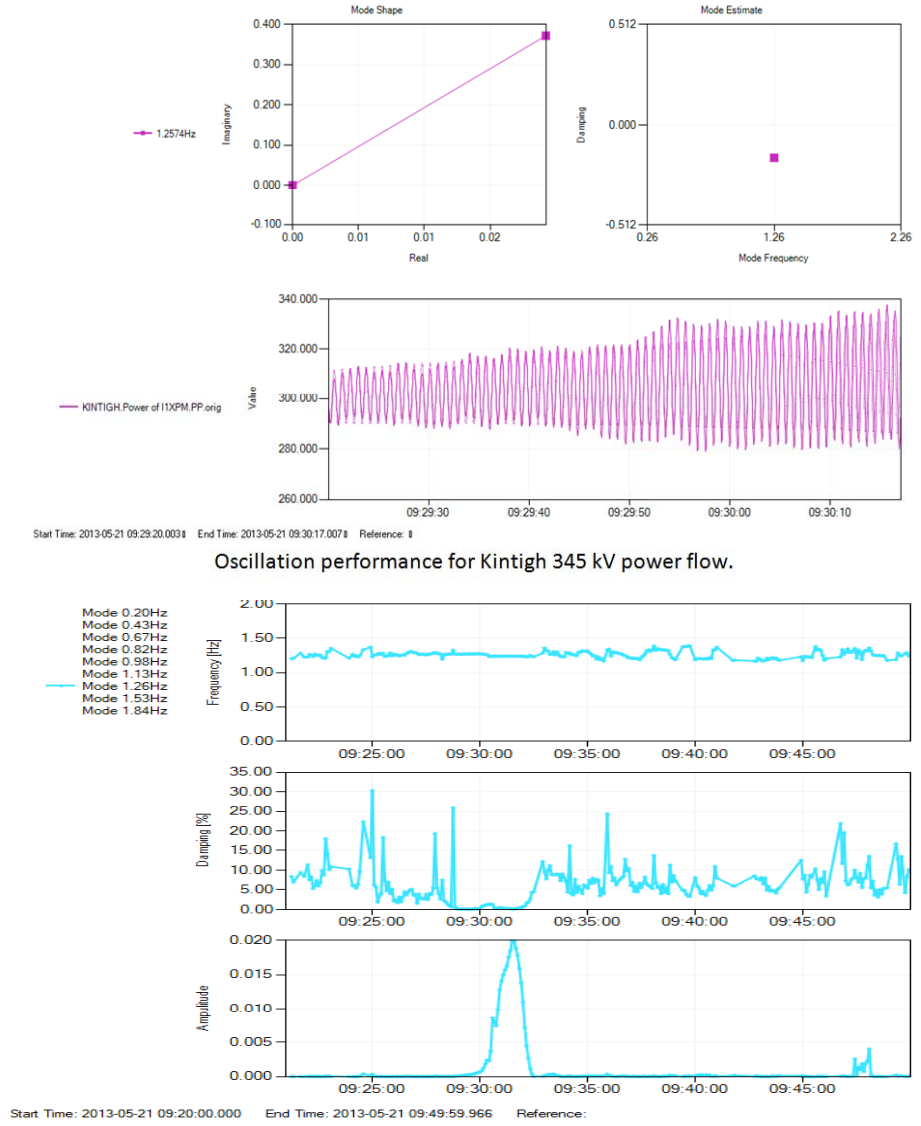

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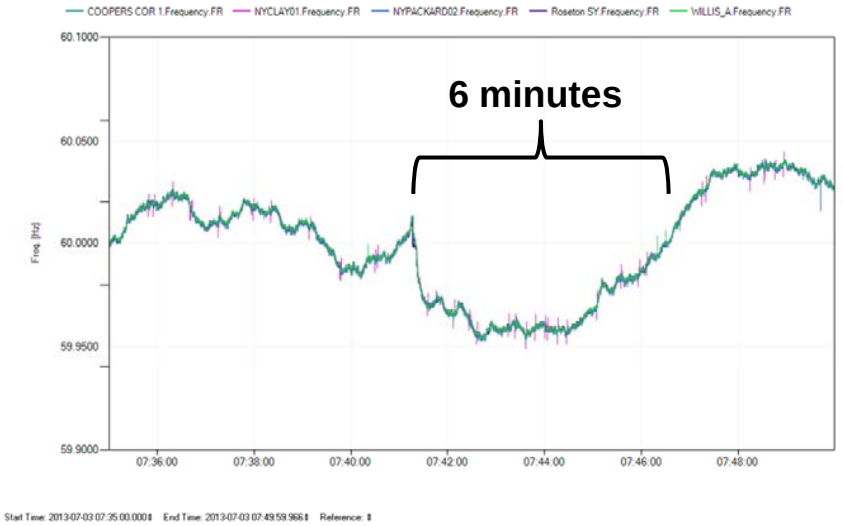
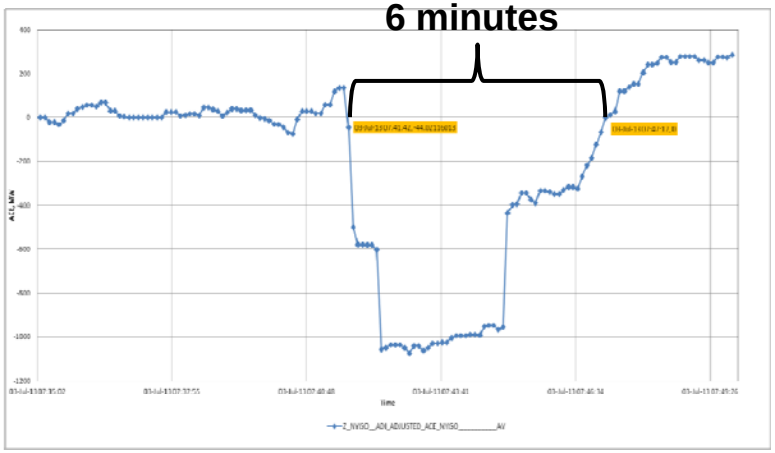
July 3, 2013 – Generation Trip

- **Time : 0742 HRS**
- **Event : Generation Unit trip 1018 MW**
- **Observations:**
  - ***Frequency dipped to about 59.96 Hz and recovered in 6 minutes***
    - **1018 MW loss resulted to 0.04 Hz frequency dip**
  - ***ACE performance from PI validates frequency recovery from PMUs***



Frequency performance from 0735 to 0750 HRS.



ACE performance from 0735 to 0750 HRS

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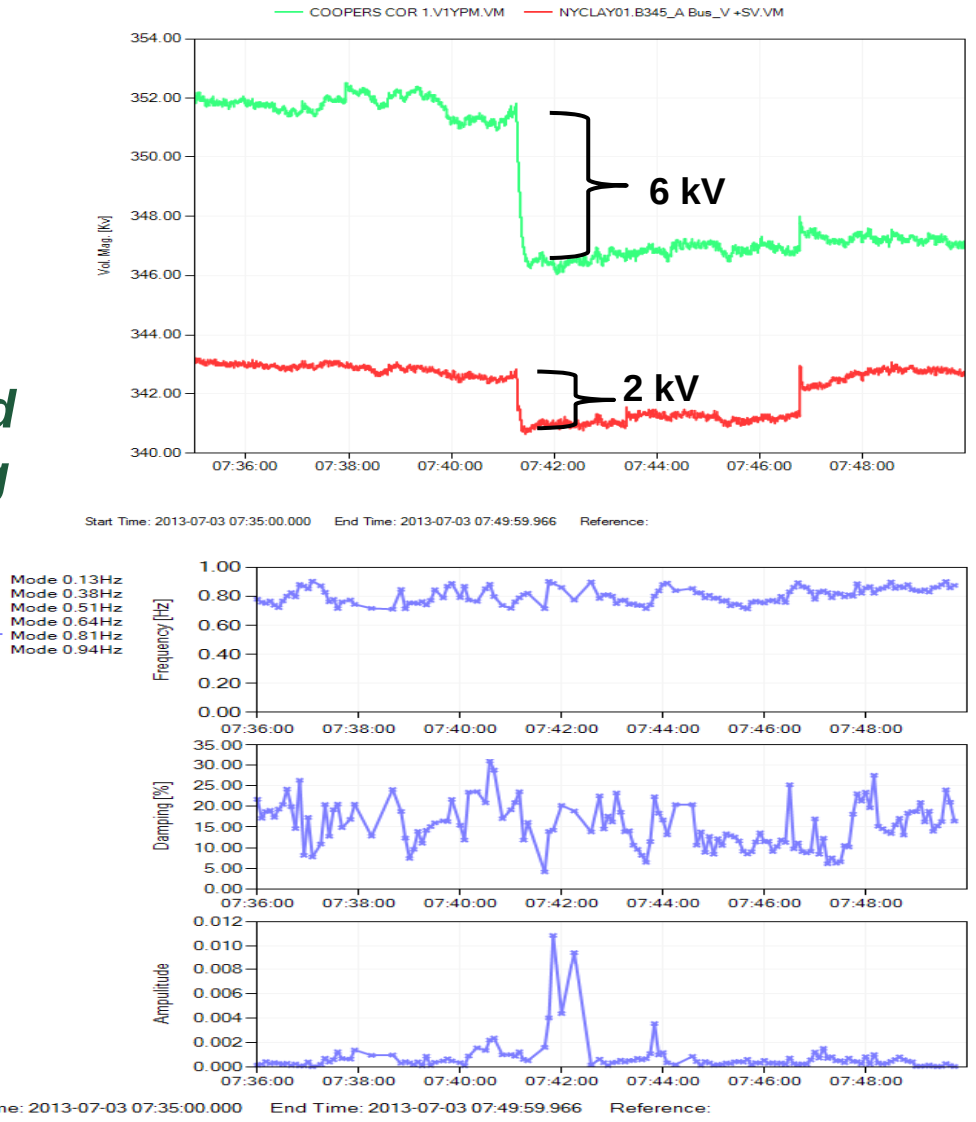
July 3, 2013 – Generation Trip

- **Time : 0742 HRS**
- **Event : Generation Unit trip 1018 MW**
- **Observations:**
  - ***Upstate voltages dropped to magnitudes depending on their proximity to tripped unit due to increase power transfer from west to east***
  - ***Identified 0.81 Hz oscillatory mode***



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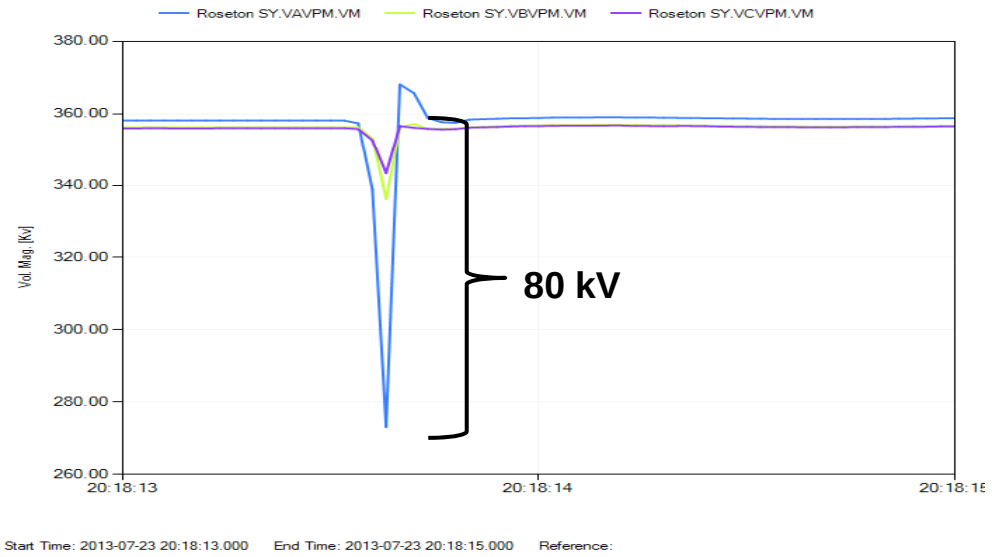
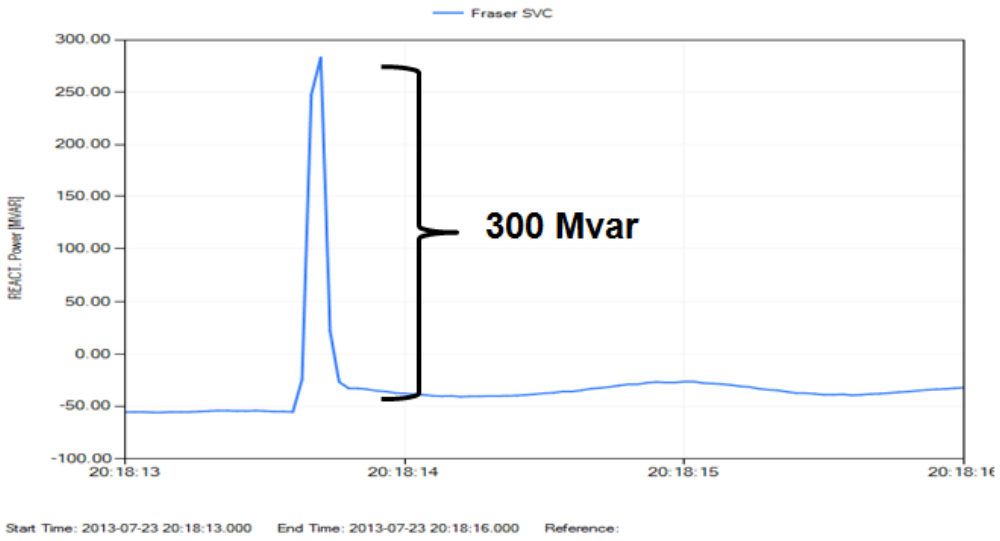
July 23, 2013 – SLG Fault with Generation Trip

- **Time : 2018 HRS**
- **Event : Generation 300 MW trip caused by SLG Fault at a 345 kV bus**
- **Observations:**
  - ***Voltages dropped but recovered very quickly, less than a second***
    - **Phase A voltage has 80 kV drop, phases B and C voltages have less than 20 kV drop**
  - ***SVC boosted system voltages by providing Mvar***
    - **Compensated about 300 Mvar**





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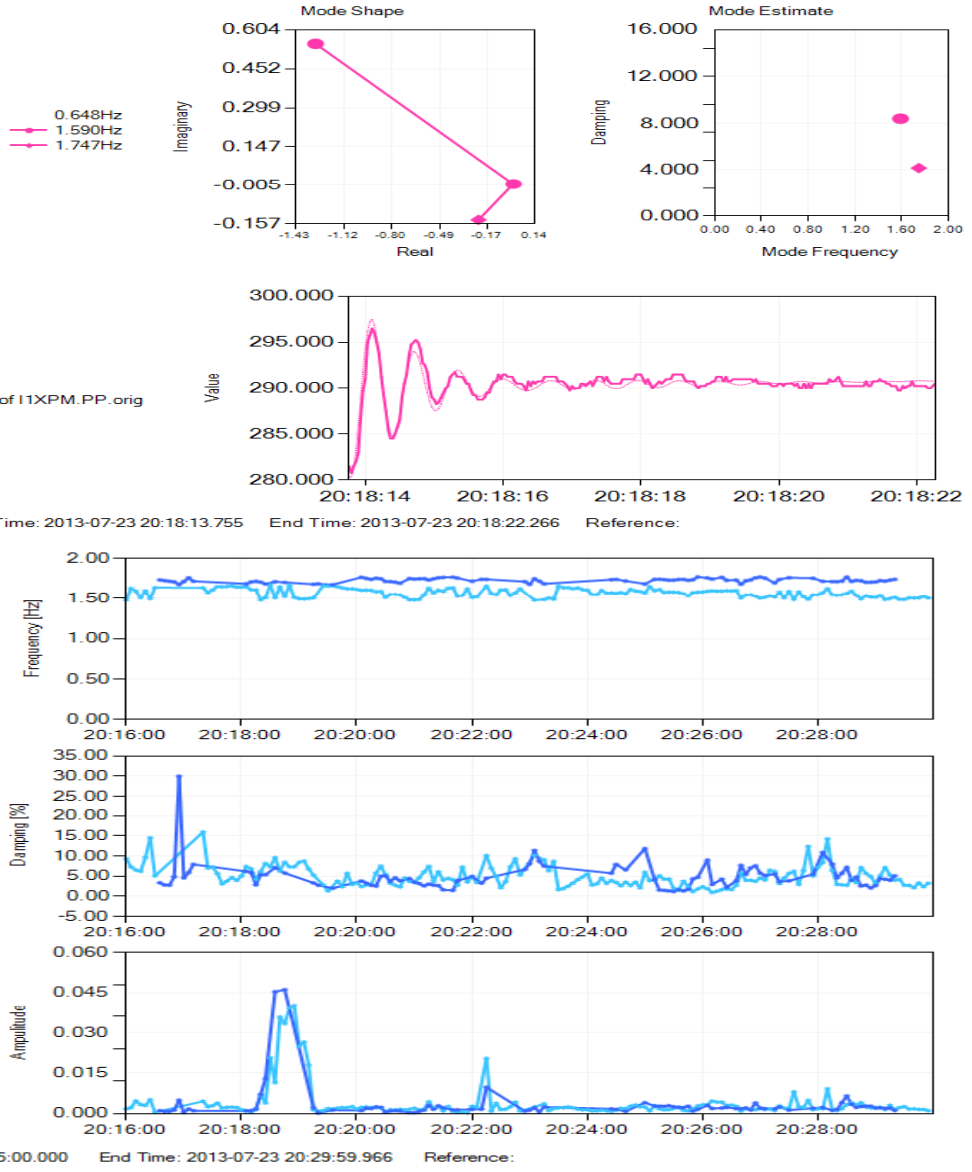
July 23, 2013 – SLG Fault with Generation Trip

- **Time : 2018 HRS**
- **Event : Generation 300 MW trip caused by SLG Fault at a 345 kV bus**
- **Observations:**
  - ***Post fault resulted to oscillatory modes, 1.59 Hz and 1.74 Hz***



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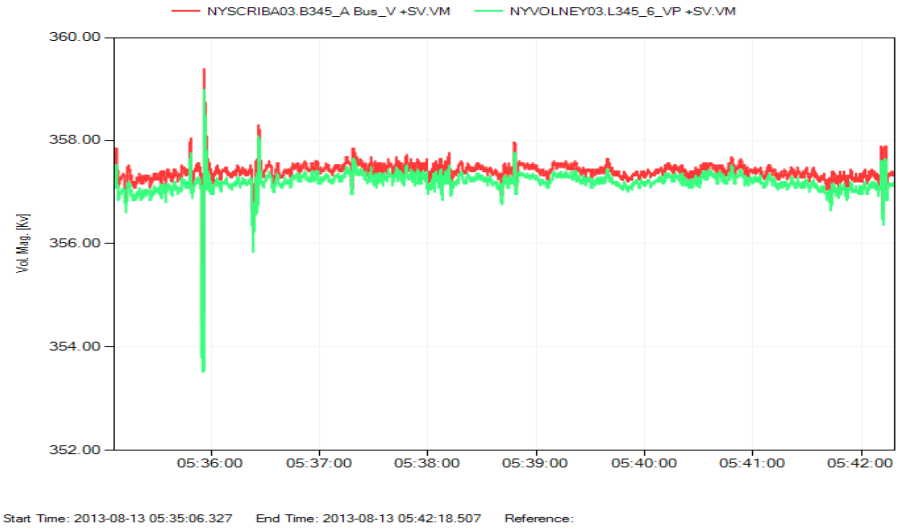
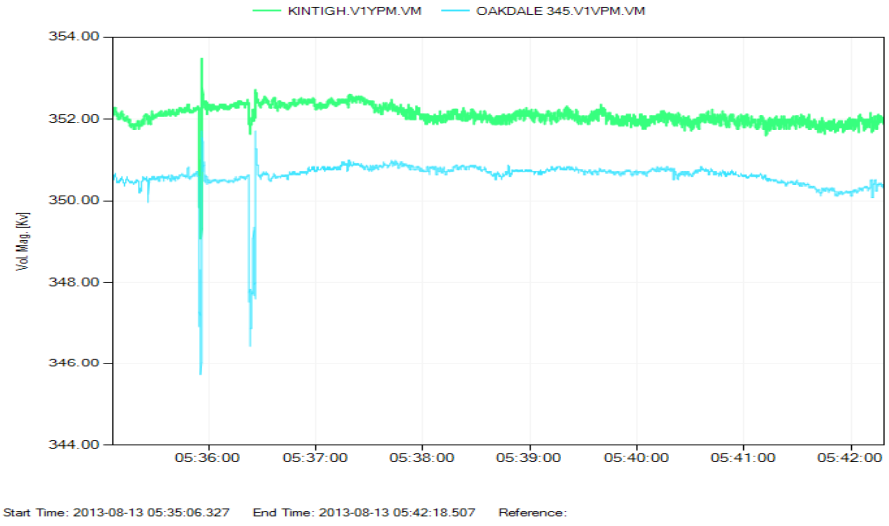
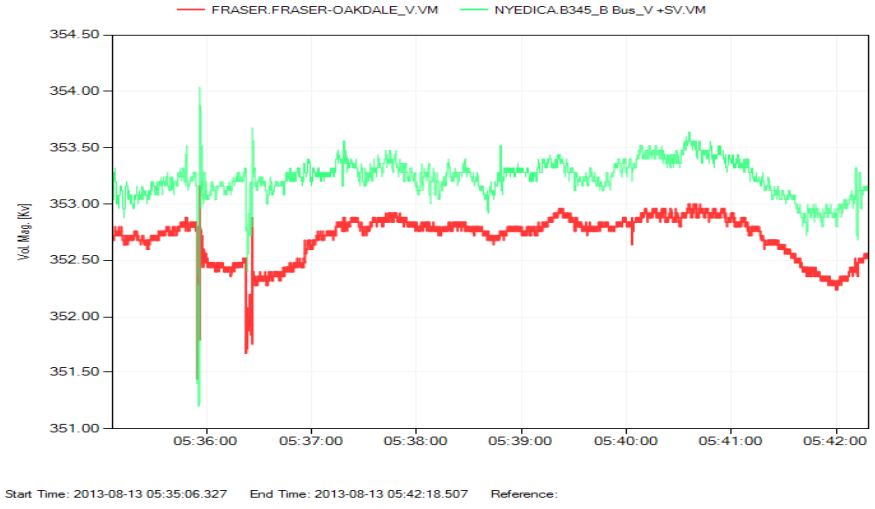
August 13, 2013 – Generator Oscillations

- **Time : 0536 HRS**
- **Event : Malfunctioning Generator PSS**
- **Observations:**
  - ***Voltages oscillated not only near the vicinity of generation complex***
  - ***Identified oscillatory mode 0.90 Hz***







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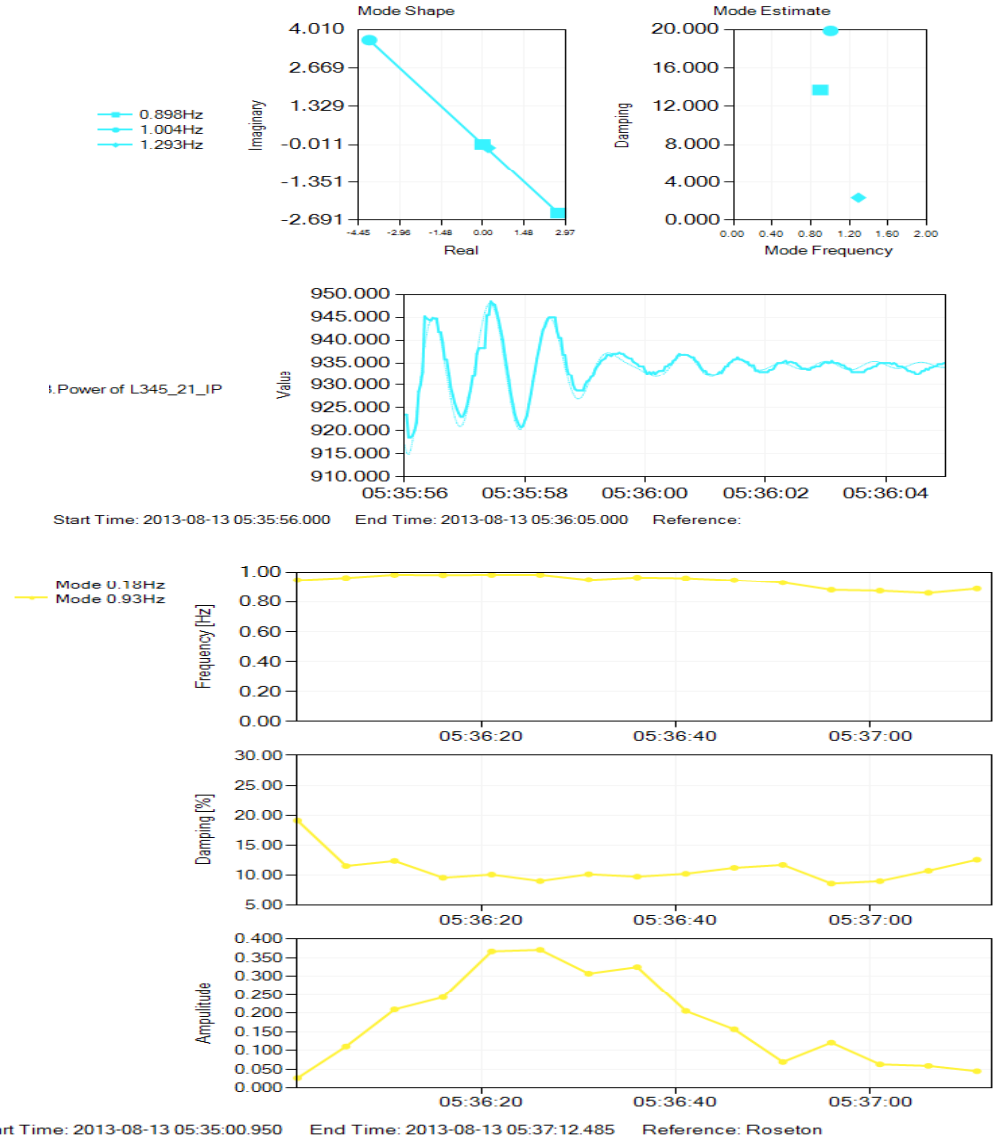

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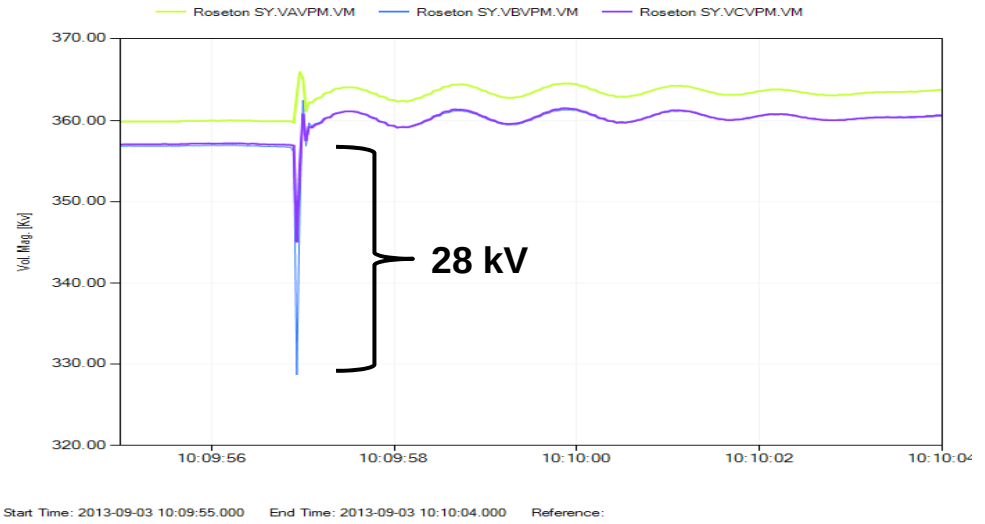
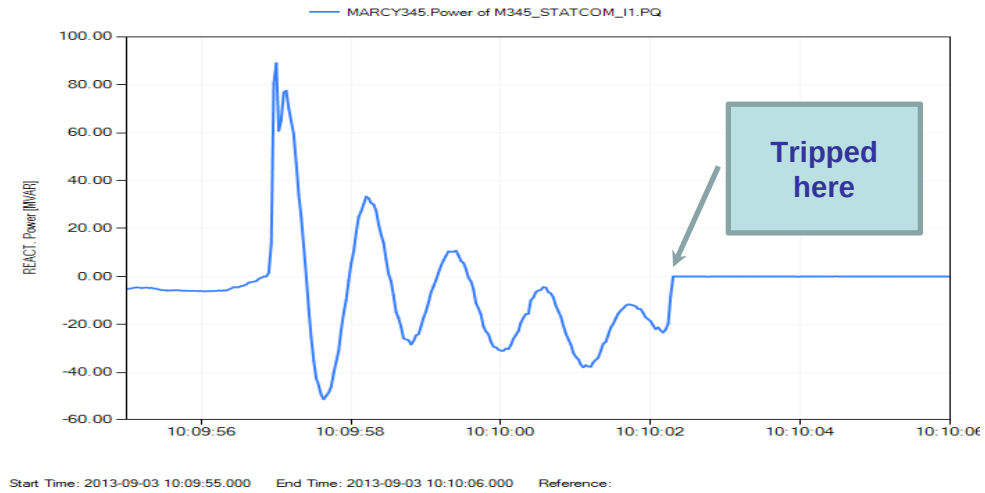
September 3, 2013 – Multiple Elements Tripping

- **Time : 1010 HRS**
- **Event : 2 – 765 kV lines and FACTS Tripping**
- **Observations:**
  - ***SLG fault at Phase B : phase B voltage dropped the most***
  - ***FACTs trying to provide Mvar/damping support before tripping***





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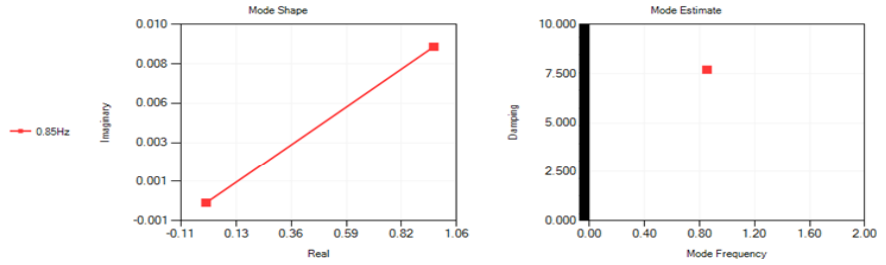
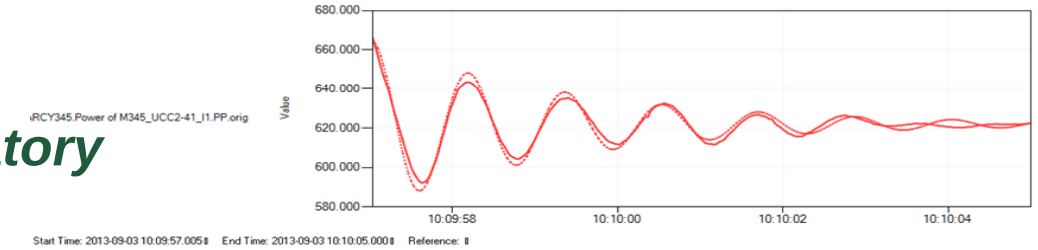
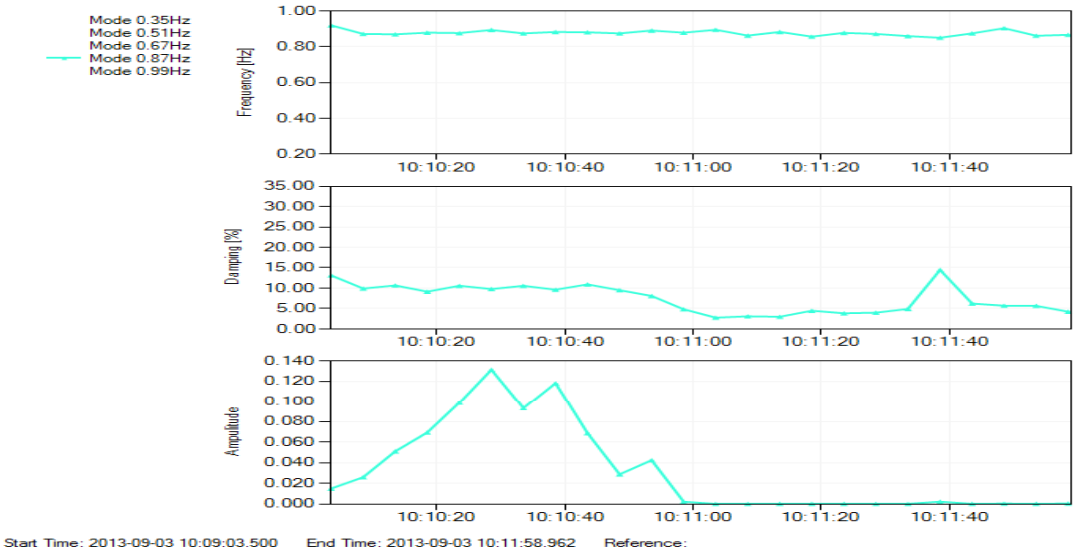
September 3, 2013 – Multiple Elements Tripping

- **Time : 1010 HRS**
- **Event : 2 – 765 kV lines and FACTS Tripping**
- **Observations:**
  - ***Identified 0.85 Hz oscillatory mode***





Ringdown analysis for Marcy to Coopers Corners 345 kV (UCC2-41) line power flow.



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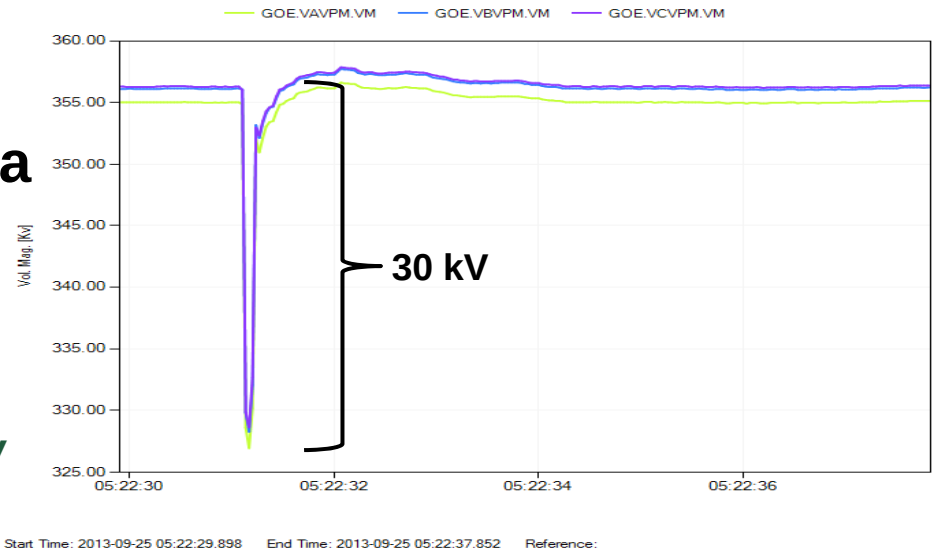
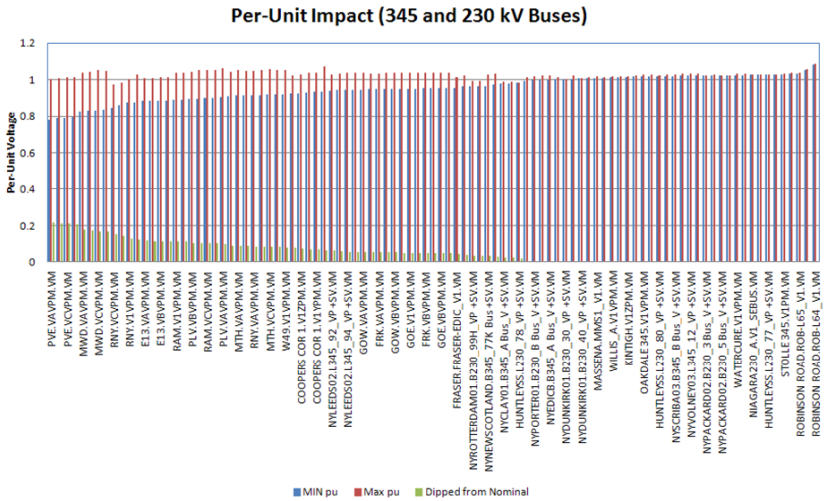
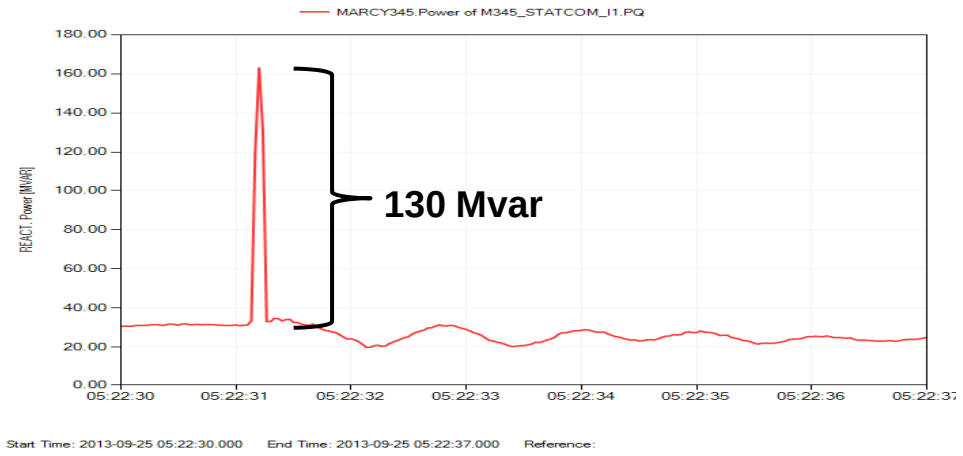
September 25, 2013 – Three-Phase Fault

- **Time : 0522 HRS**
- **Event : Three-phase fault at a 138 kV bus**
- **Observations:**
  - ***Voltage profiles reveal that the highest voltage dip was in New York City***
  - ***StatCom voltage response***





Per-unit voltage profile for 345 kV and 230 kV buses during the three-phase fault at Dunwoodie 138 kV bus.



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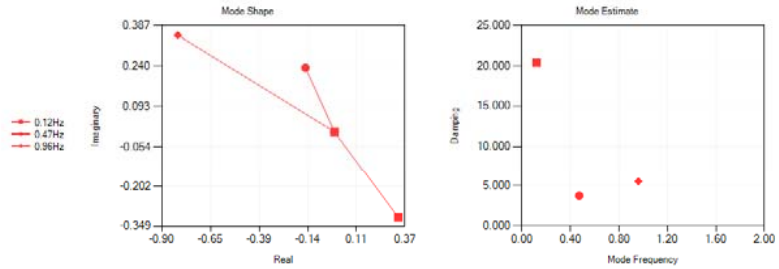
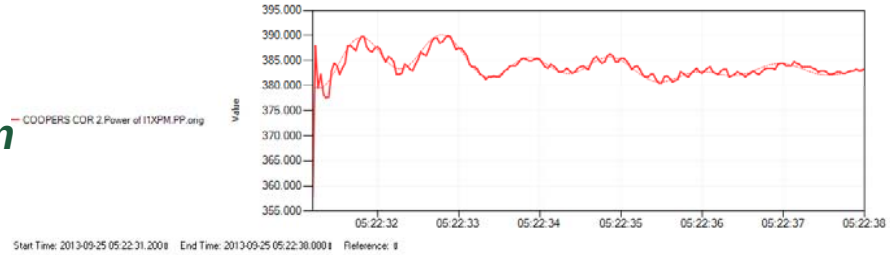
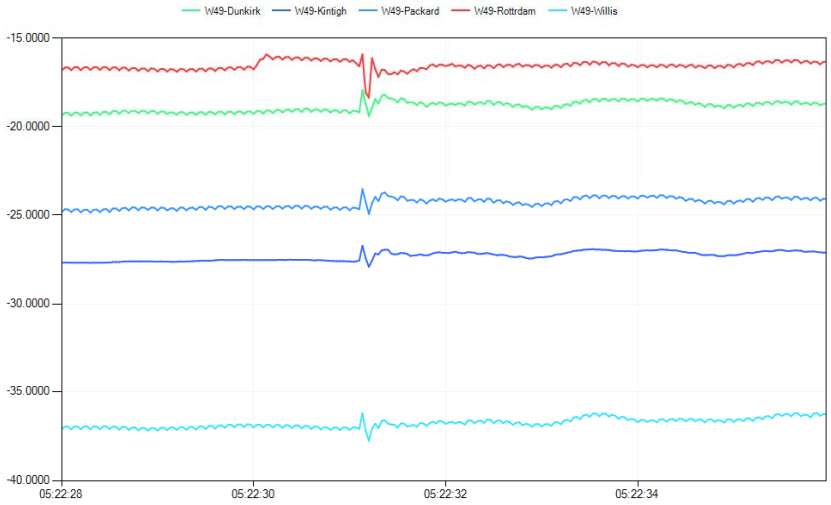
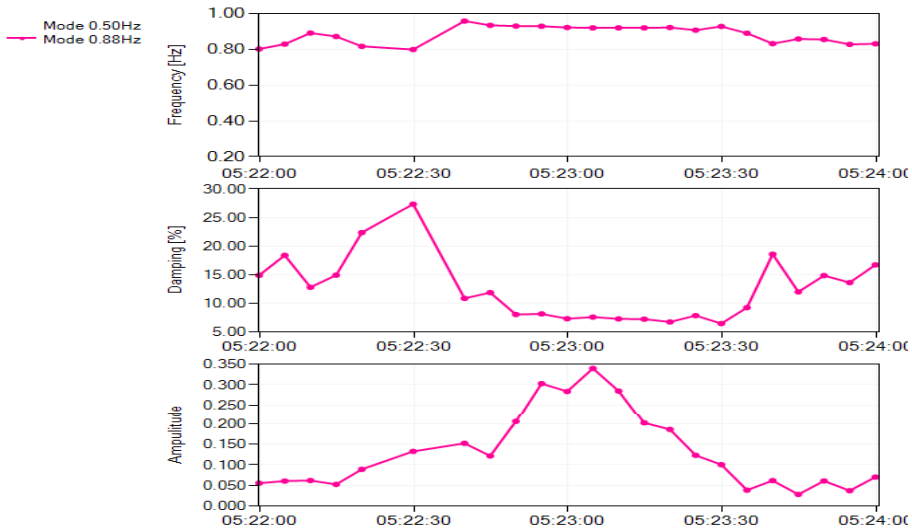
September 25, 2013 – Three-Phase Fault

- **Time : 0522 HRS**
- **Event : Three-phase fault at a 138 kV bus**
- **Observations:**
  - ***Identified 0.90 Hz oscillatory mode***
  - ***Angle differences are in synchronism all throughout the disturbance indicating system security***









Start Time: 2013-09-25 05:20:59.866 End Time: 2013-09-25 05:24:00.604 Reference:

Start Time: 2013-09-25 05:22:27.976 End Time: 2013-09-25 05:23:26.000 Reference:

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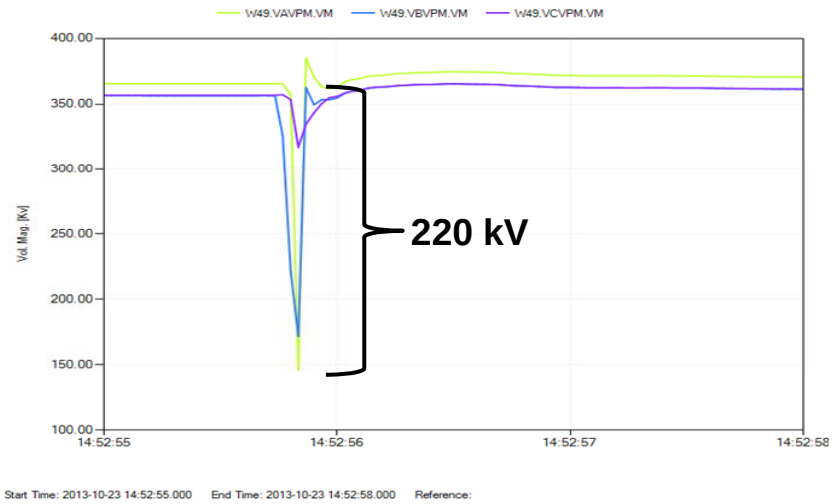
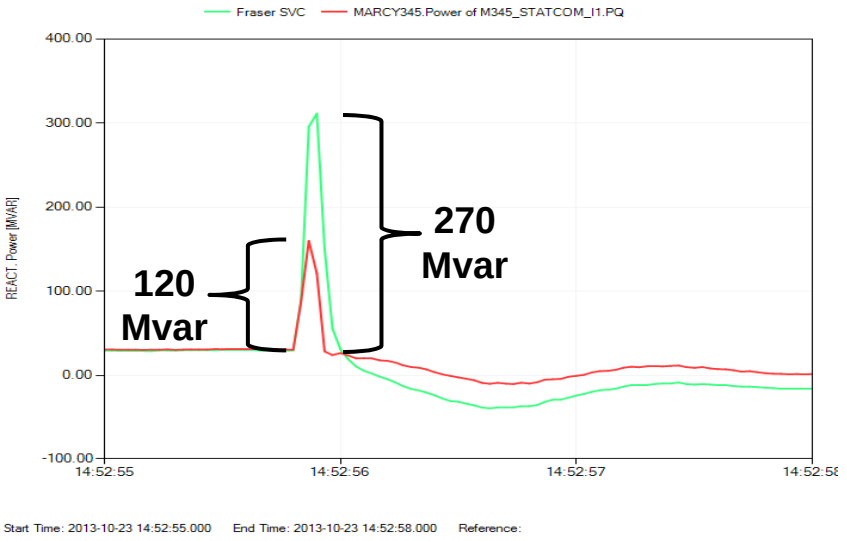
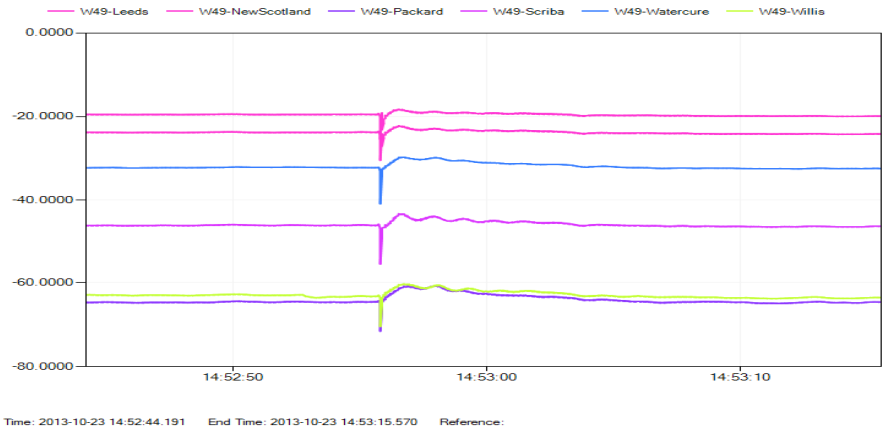
October 23, 2013 – Double-line to Ground Fault

- **Time : 1453 HRS**
- **Event : Double line to ground fault at 138 kV bus (tripped several elements and load)**
- **Observations:**
  - ***Voltage response at bus confirms LLG fault (AB fault)***
  - ***StatCom and SVC response***
  - ***Angle differences are in synchronism all throughout the disturbance indicating system security.***



Transient voltage performance at West 49th 345 kV bus.





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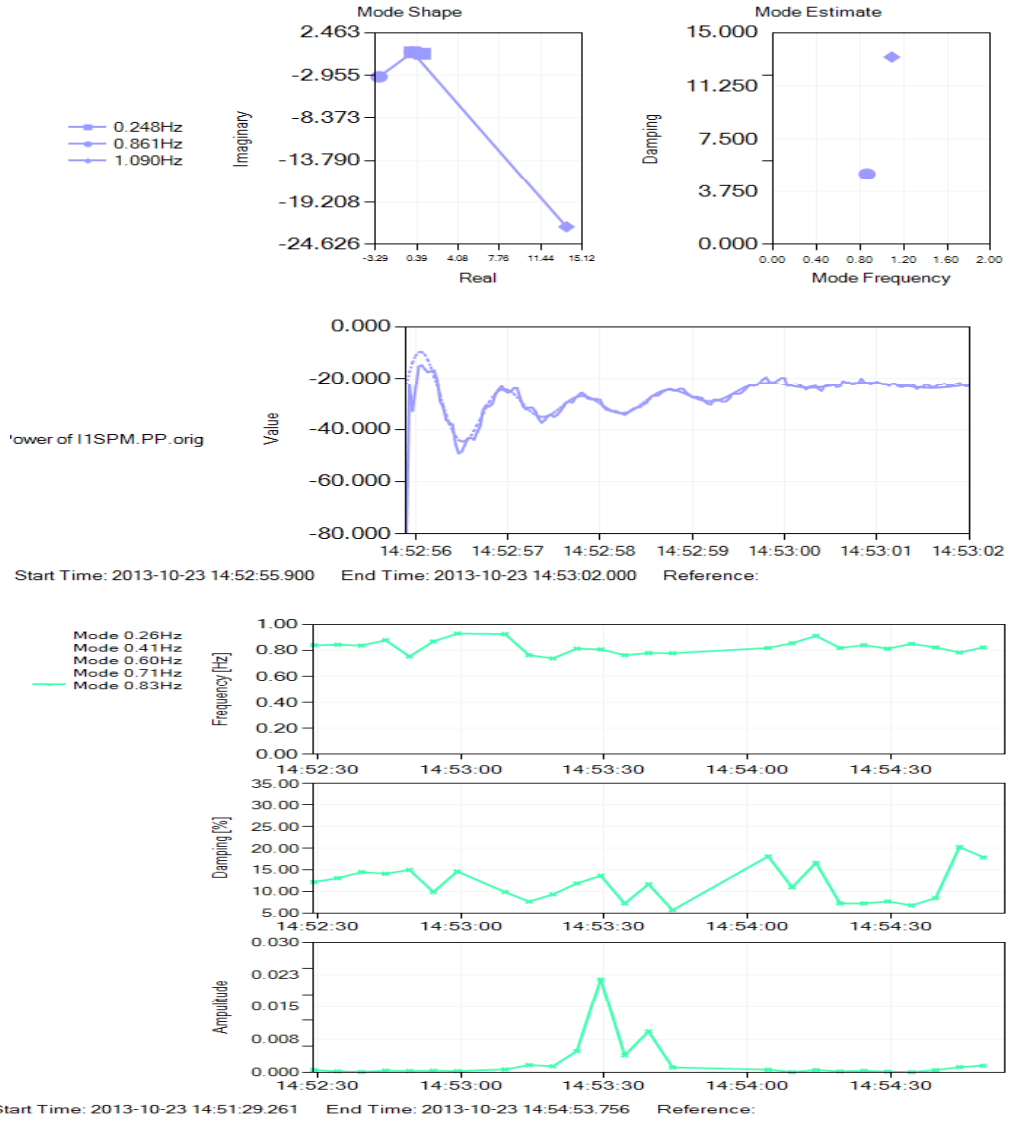
October 23, 2013 – Double-line to Ground Fault

- **Time : 1453 HRS**
- **Event : Double line to ground fault at 138 kV bus (tripped several elements and load)**
- **Observations:**
  - ***Identified 0.86 Hz oscillatory mode***



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Using PMU Data for System Events

- **Synchronized system dynamics**
  - ***Reduced time for system event reporting and data gathering***
  - ***Wide area visualization***
  - ***Understanding system and equipment responses***
- **Confirm what we know and beyond**
  - ***Frequency response during system events***
  - ***Voltage response to faults***
  - ***Equipment response to system events***
  - ***Oscillation analysis***
- **Confirm what we are seeing and what others are seeing**
  - ***EI oscillatory modes***
  - ***Fault data from TOs***
  - ***Neighbor ISOs***

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