

DOE/OE Transmission Reliability Program

NERC-DOE Special Reliability Assessment: Oscillation Analysis

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Project Objectives

- Assist NERC Synchronized Measurements Subcommittee (SMS) in oscillation analysis of the North American power grid
- NERC Special Reliability Assessment in progress
- Aim to develop a report on the main oscillatory inter-area modes of the eastern, western and Texas interconnections
- Periodic data requests sent out to regional reliability coordinators by SMS. Interconnection wide PMU data collected by NERC for selected major events. Typically 30 minutes long. Hundreds of PMU signals available.

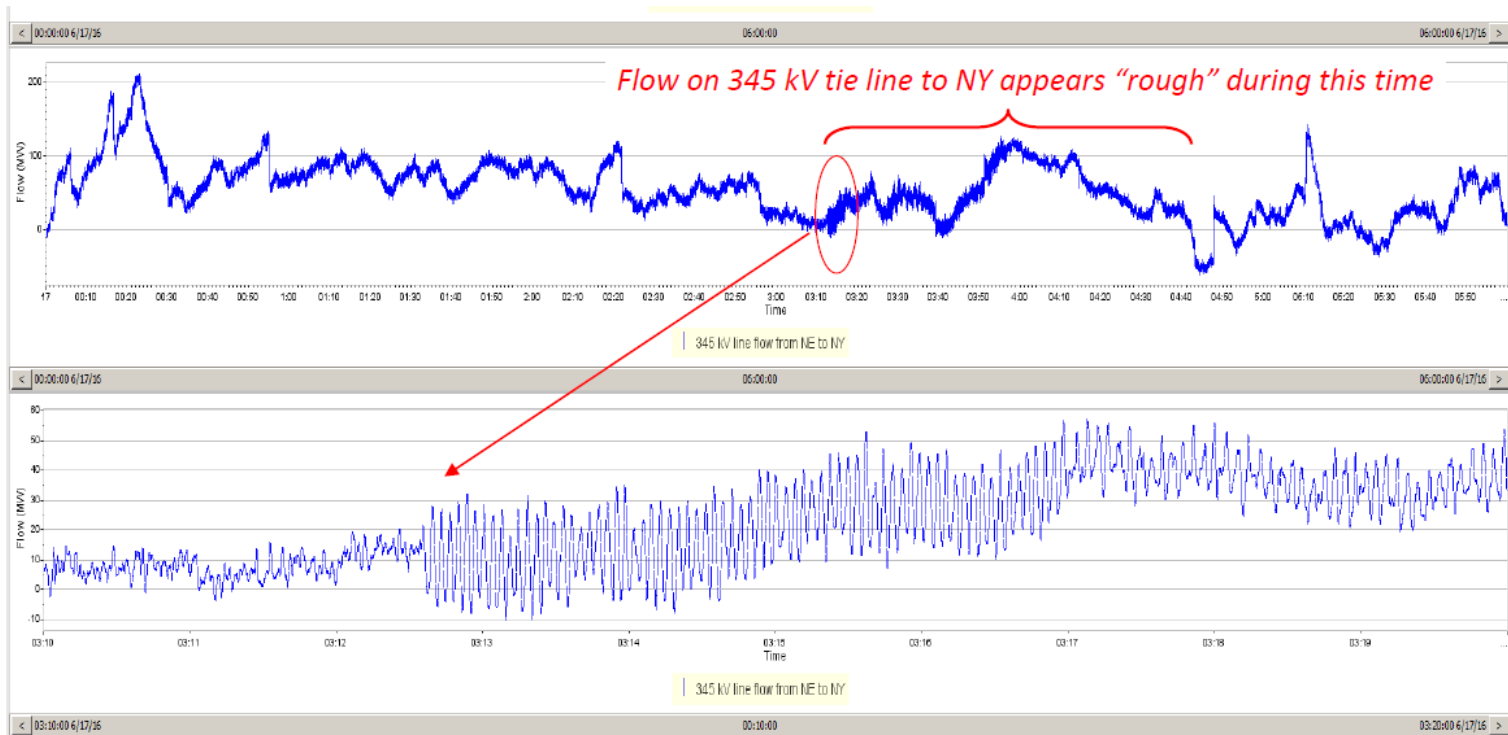


Oscillation Analysis

- **WSU tools Damping Monitor Offline and Event Analysis Offline developed in another CERTS project for simultaneous processing of hundreds of signals**
- **Other tools available in the community**
- **Report on basics of power system oscillations, inter-area modes and event analysis results**
- **Contracts are in place now and work is in progress**
- **Preliminary analysis of June 17 2016 eastern interconnection resonance event. Data collected from 2:00 AM CDT to 3:00 AM CDT.**
- **Oscillation alarms issued during the event at NE ISO, ATC, Entergy and Southern CO. Alarms ignored.**



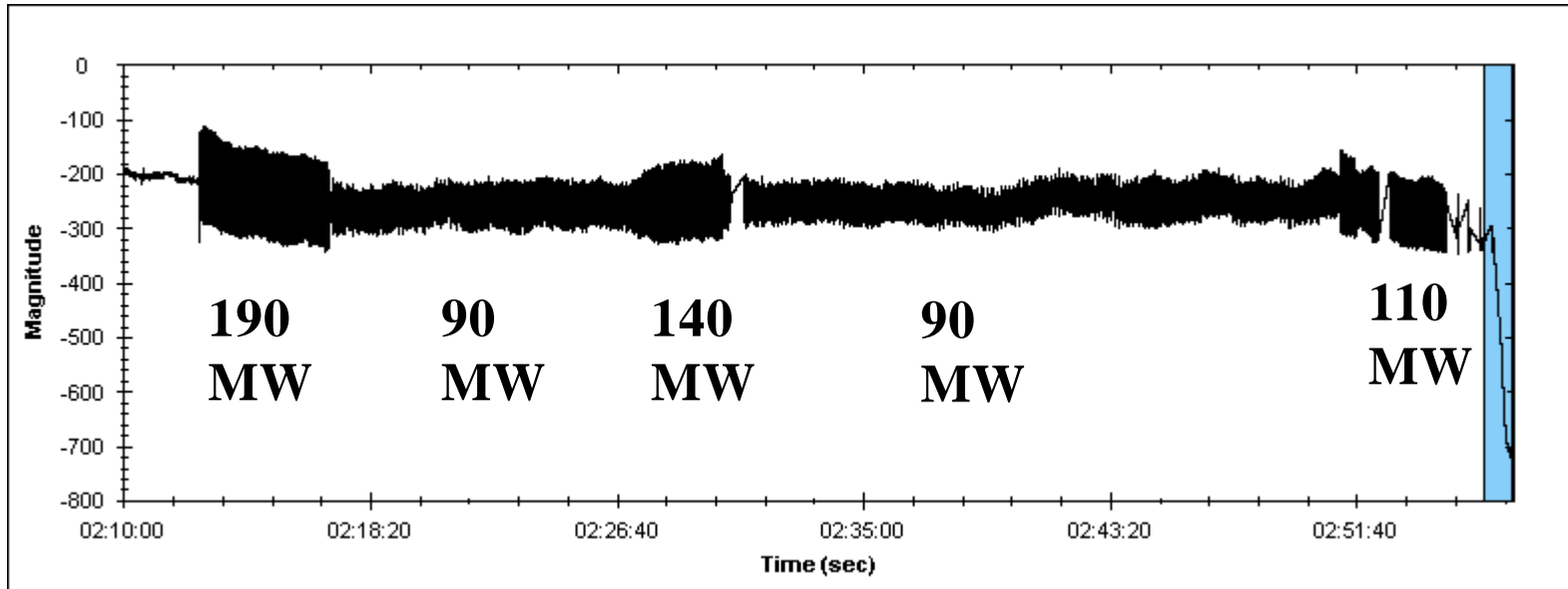
Oscillations seen in New England



- **2:12 to 2:17: 40 MW Oscillations seen in a 345 kV NE to NY tie-line.**
- **Source: Dave Bertagnolli, NE ISO**



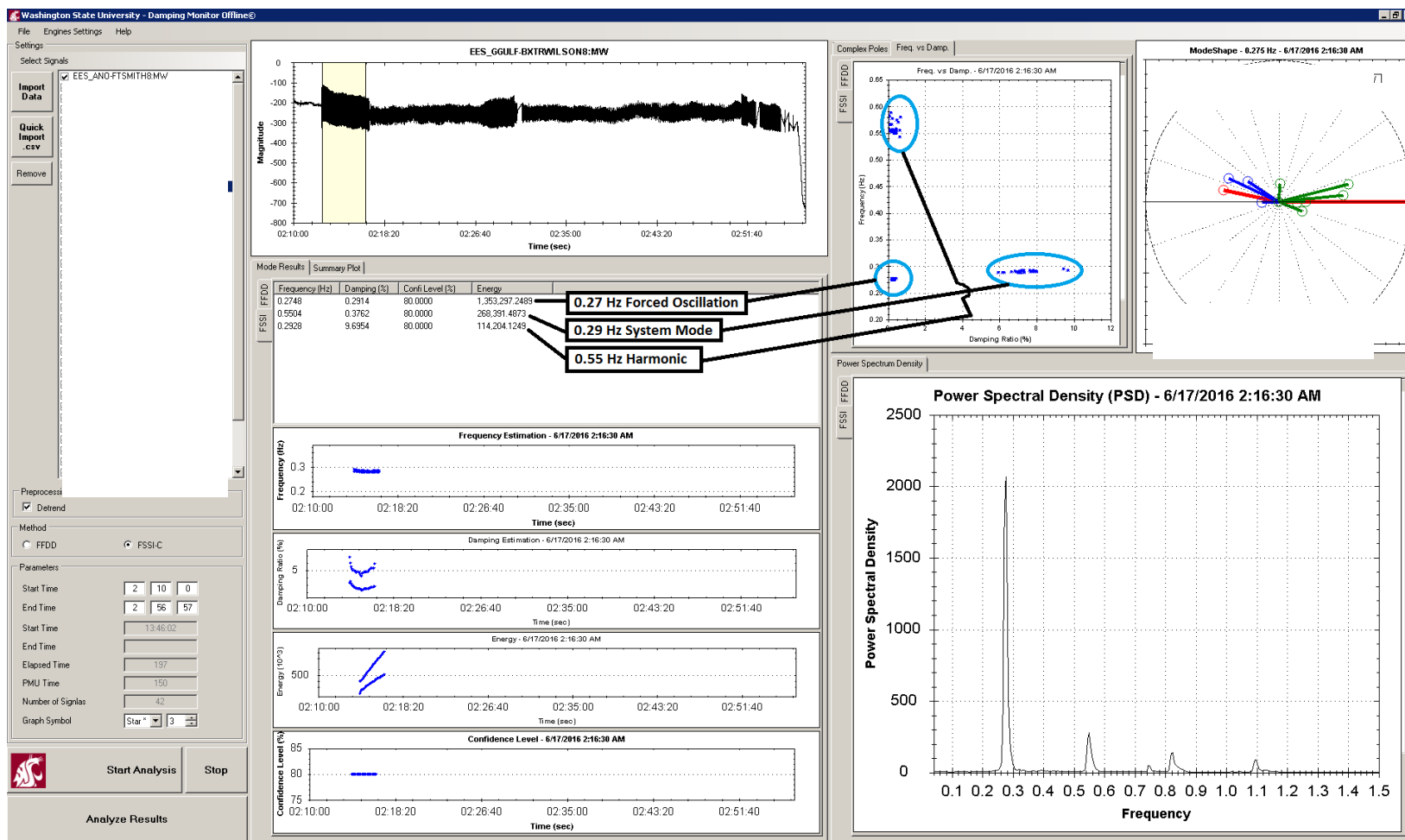
Entergy PMU MW Flow



- **2:12:30 AM CDT: Oscillations started; Amplitude varied between 90 MW and 190 MW.**
- **2:56:00 AM CDT: Oscillations stopped.**
- **Source: Floyd Galvan, Entergy and WSU**



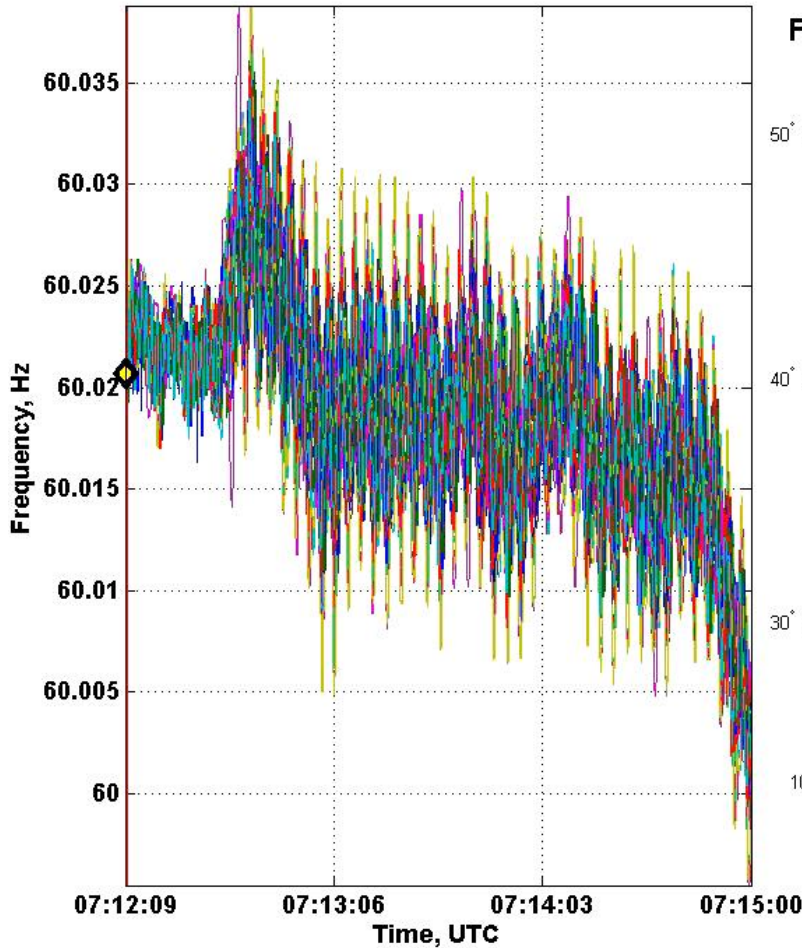
Oscillations and Eastern System Mode



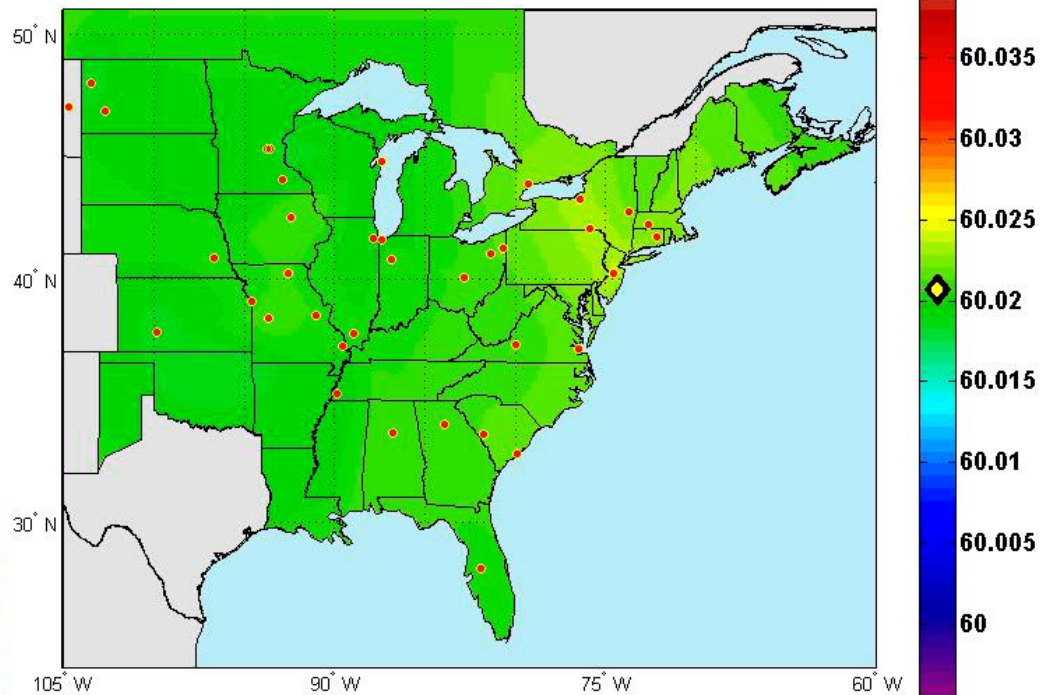
0.27 Hz Oscillations Likely Excited A 0.29 Hz Eastern System Mode. “Low” resonance effect.
Source: Floyd Galvan, Entergy and WSU



June 17 2016 Mississippi event

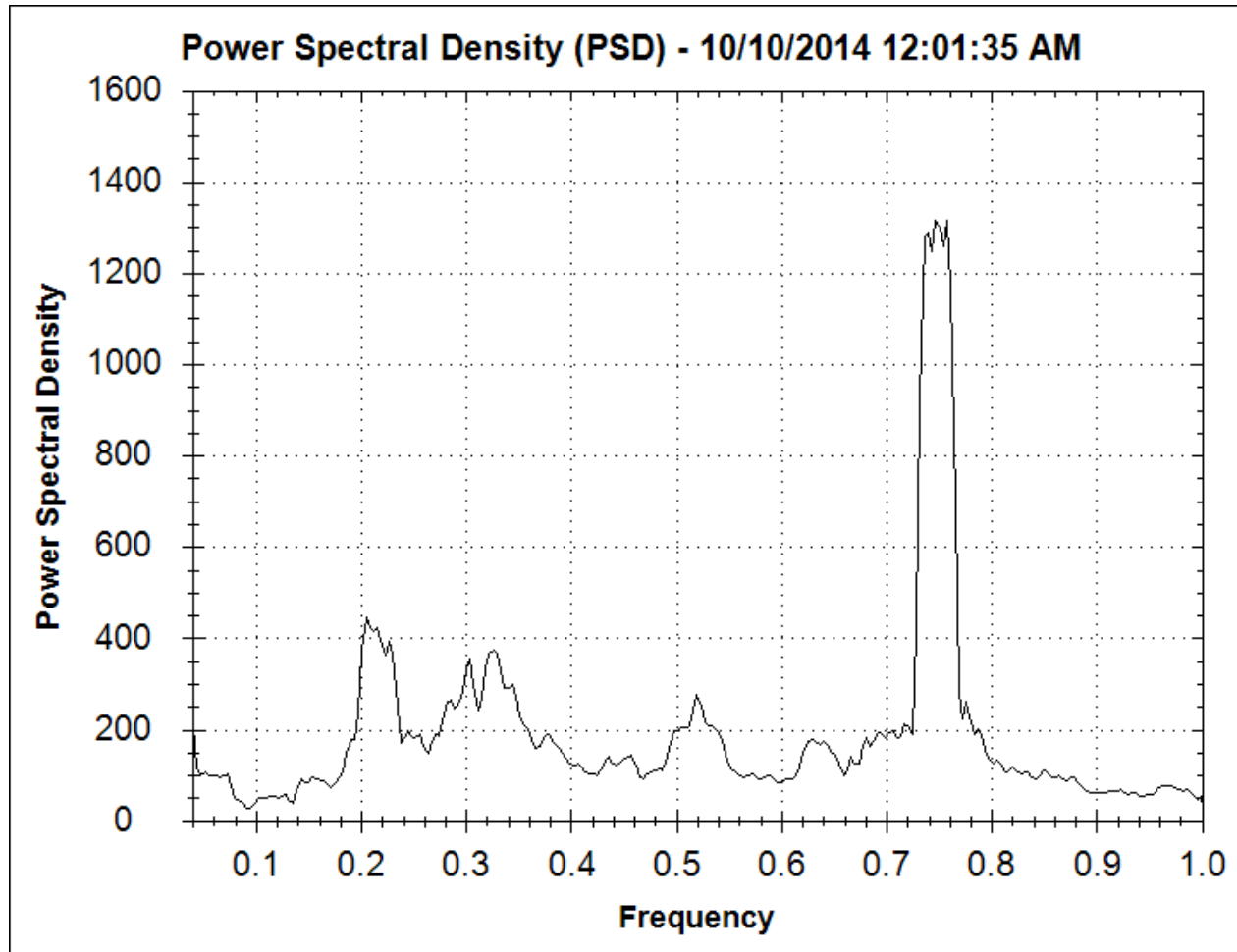


FNET Data Display [6/17/2016 Sustained Oscillation]
Time: 7:12:9.9 UTC 60.0207 Hz



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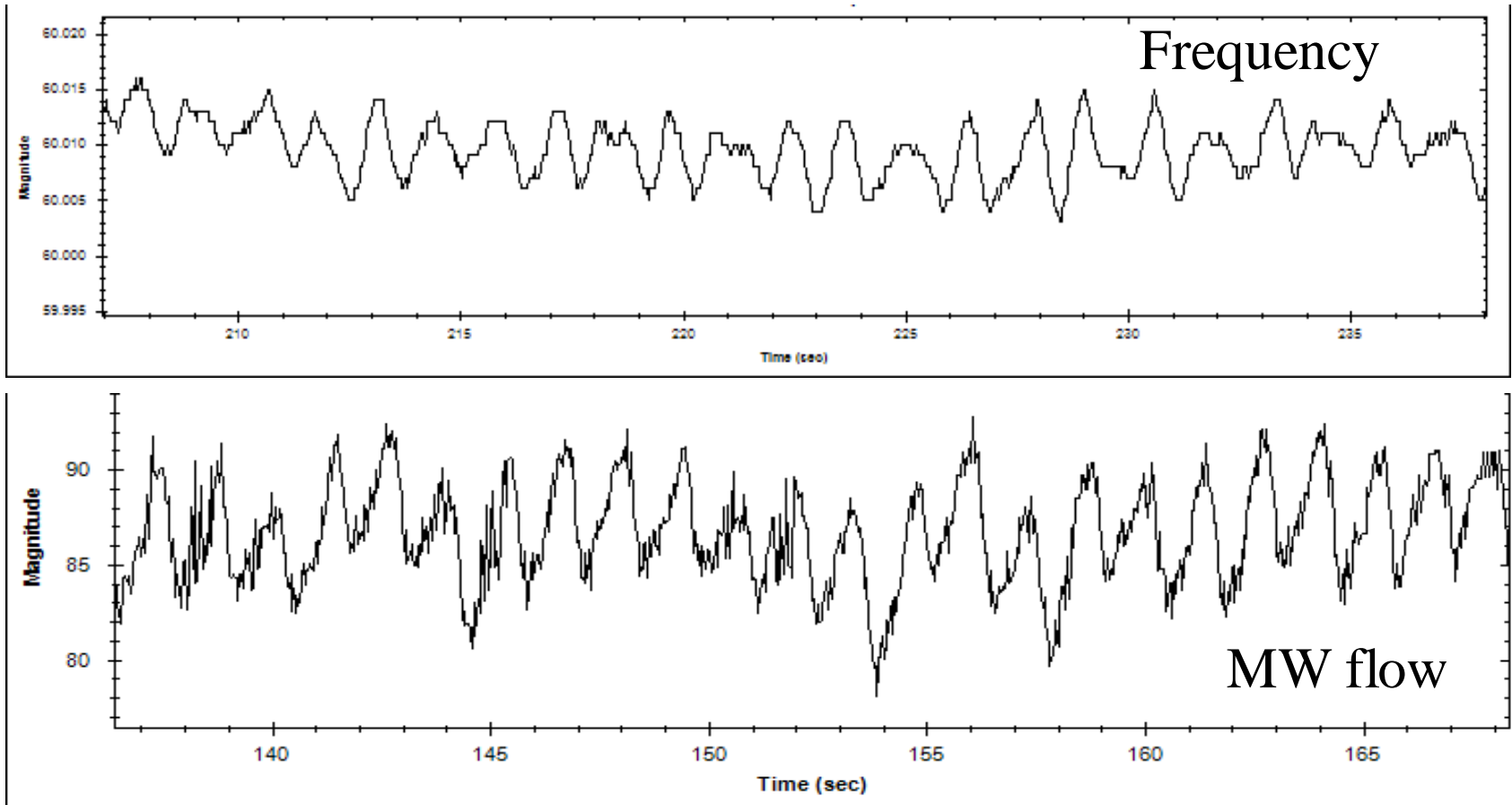
Frequency Signals Analysis



0.73 Hz Forced
oscillation
excites 0.74 Hz
system mode.
Mode shape
points to MISO.



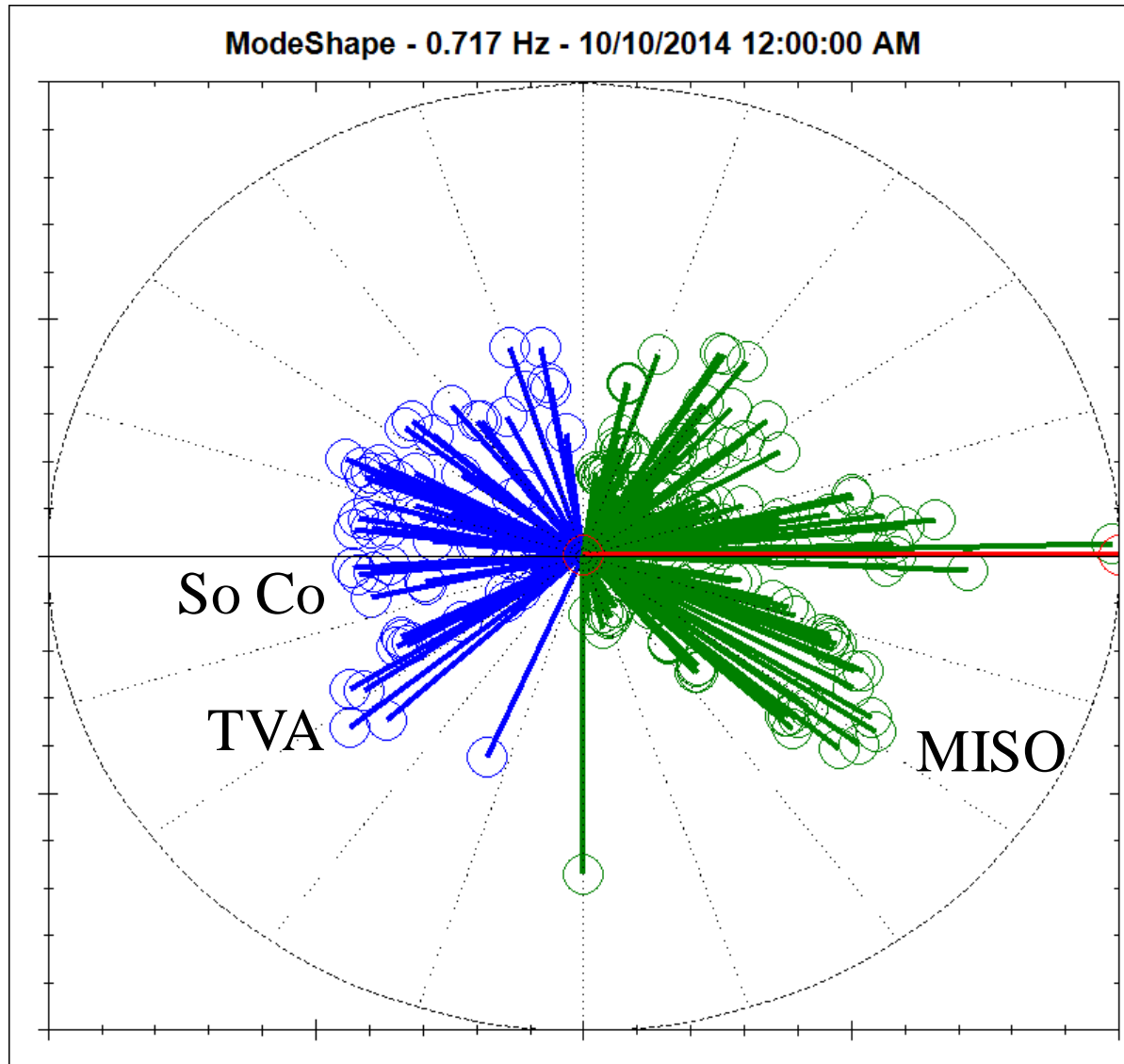
0.73 Hz Forced Oscillation



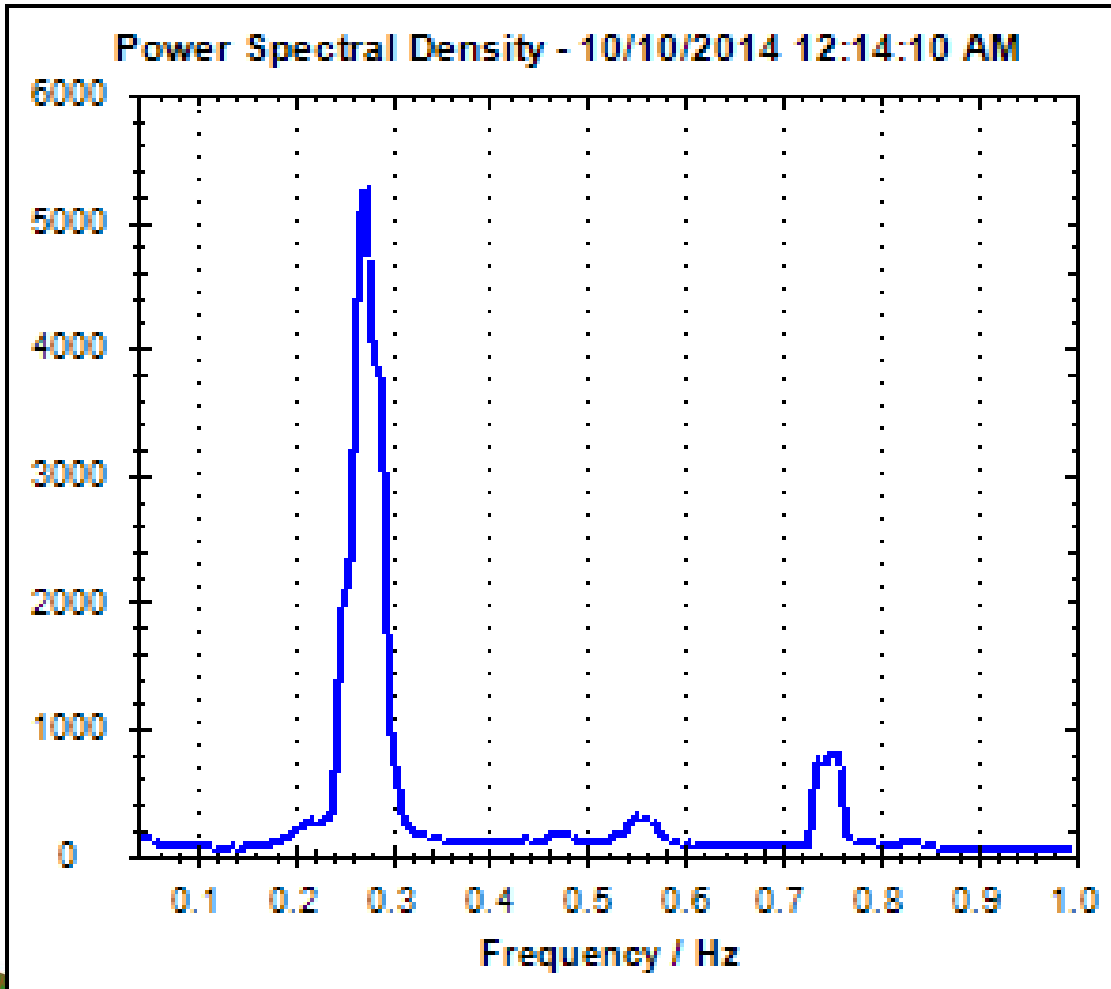
10 MW oscillations visible in several MISO signals. Present throughout.



0.72 Hz mode shape



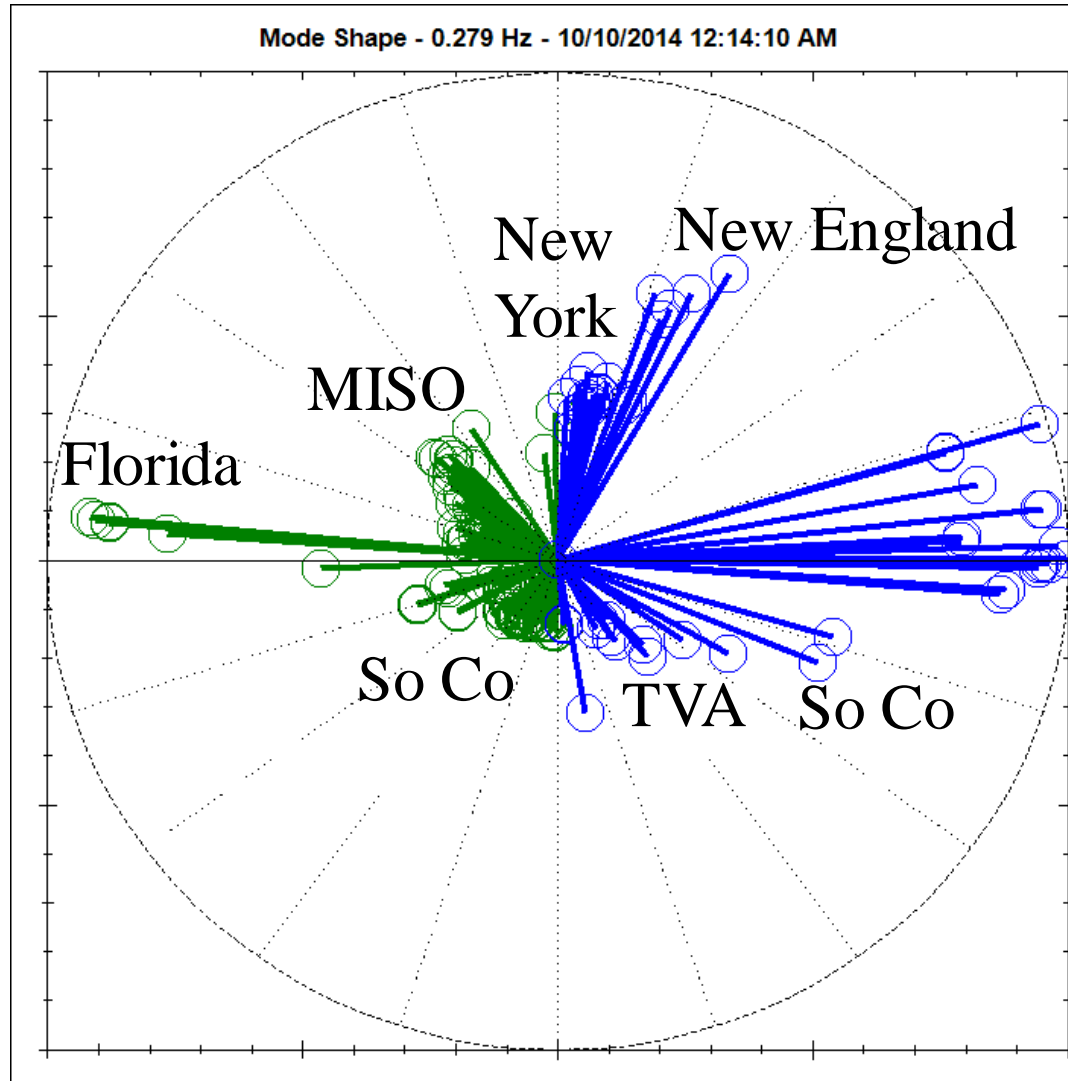
Mississippi oscillation starts



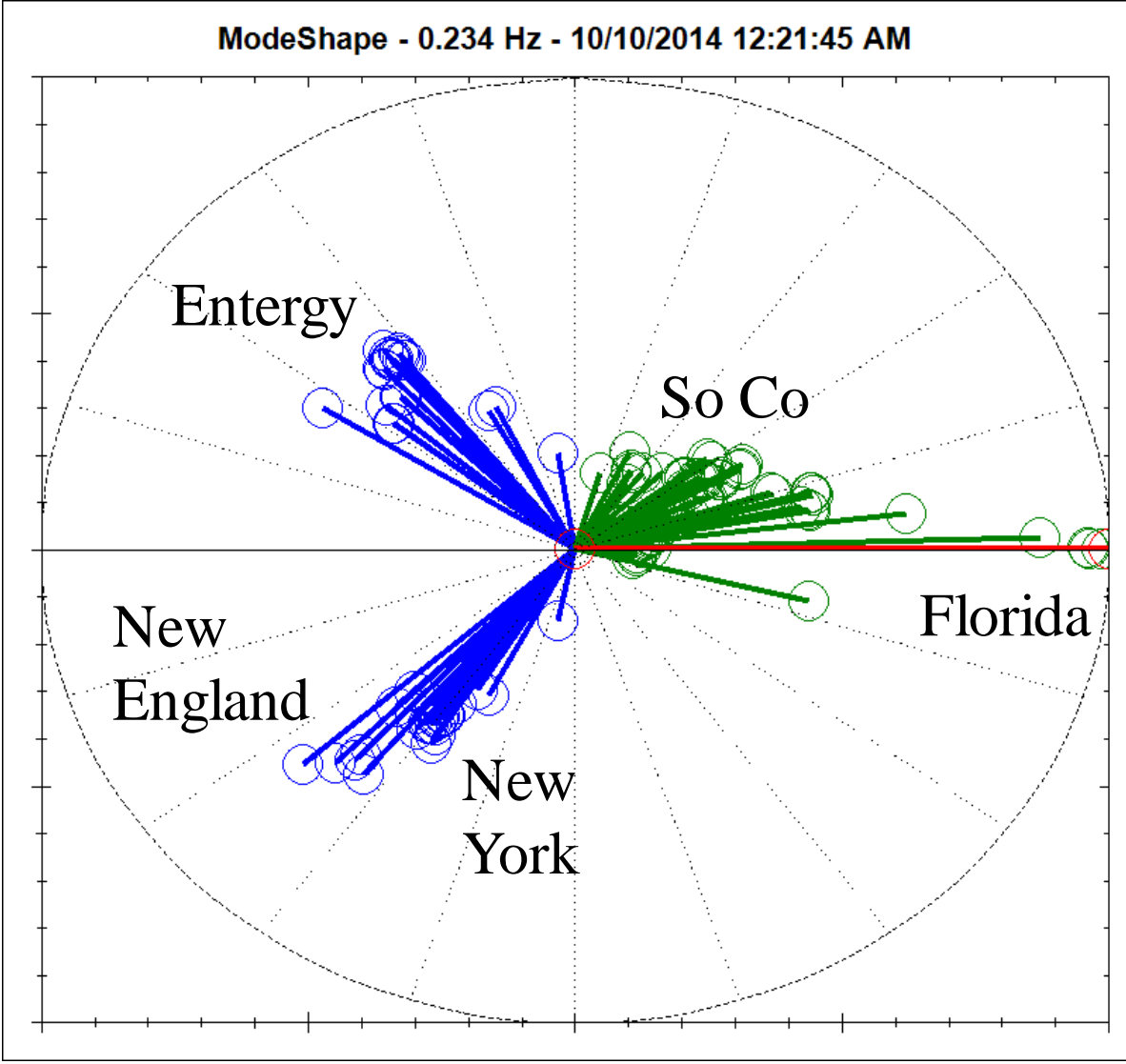
0.28 Hz Forced oscillation excites 0.29 Hz system mode.
Mode shape points to Entergy.



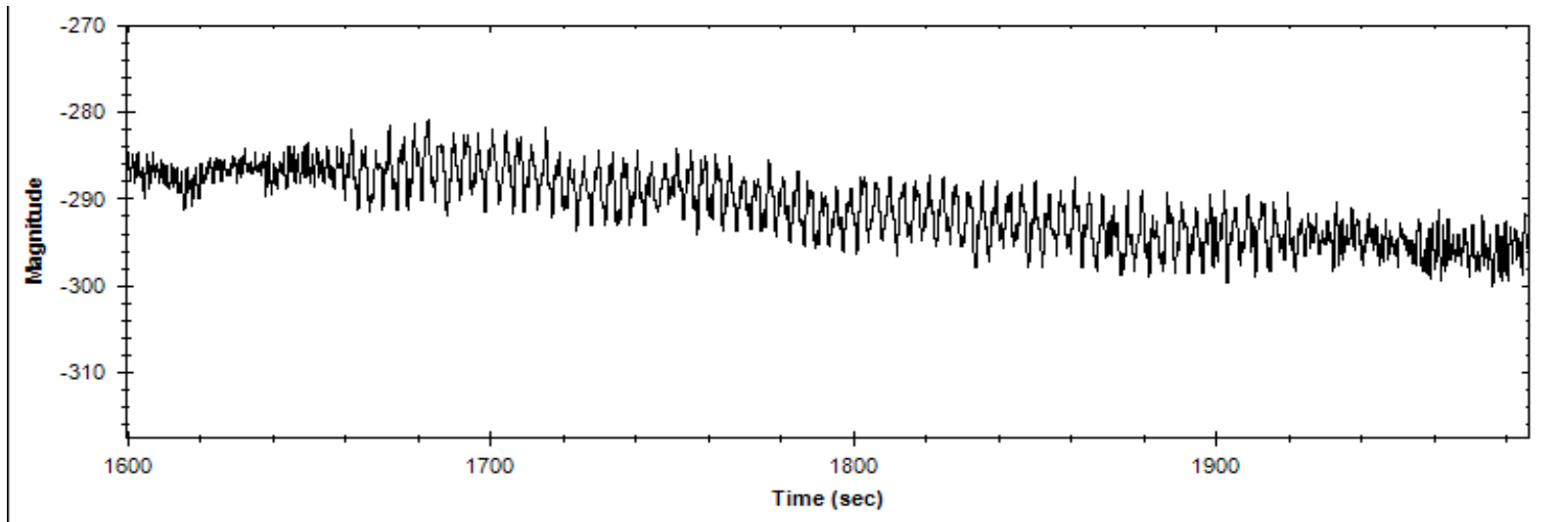
0.28 Hz Oscillation Mode Shape



0.23 Hz Oscillation Mode Shape



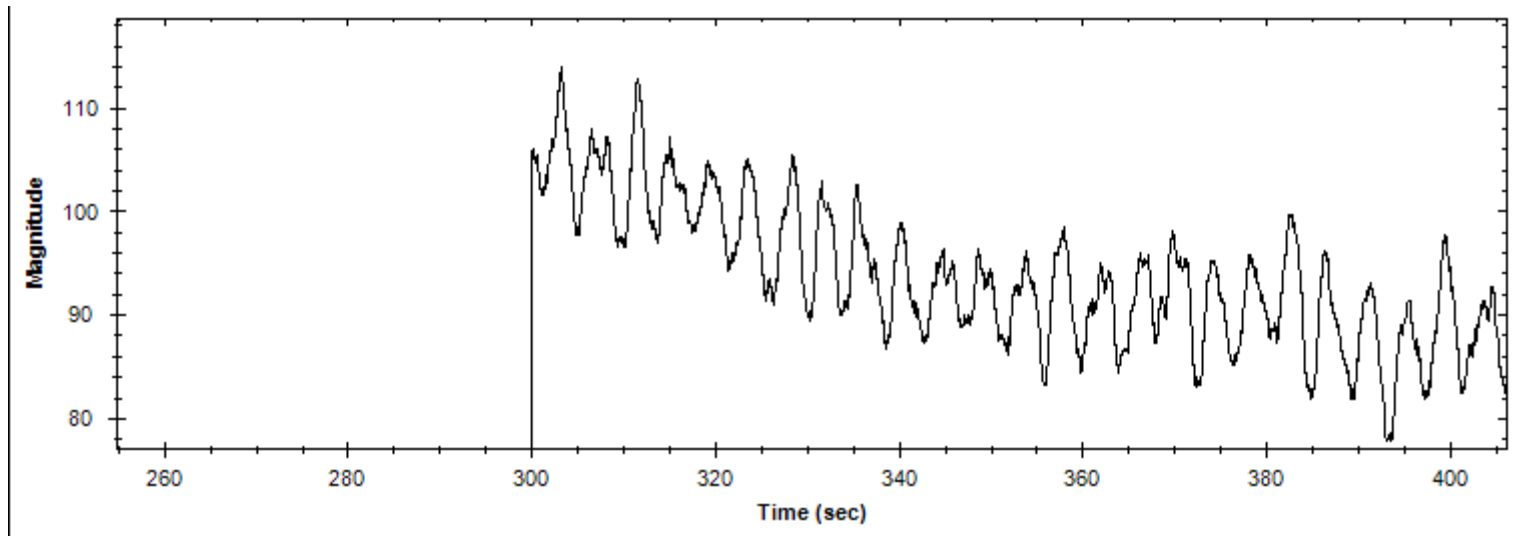
Different 0.27 Hz forced oscillation



Another 10 MW oscillation present for five minutes during the event. Oscillations on and off multiple times. Present from 2.06 AM CDT onwards.



Different 0.25 Hz Forced oscillation

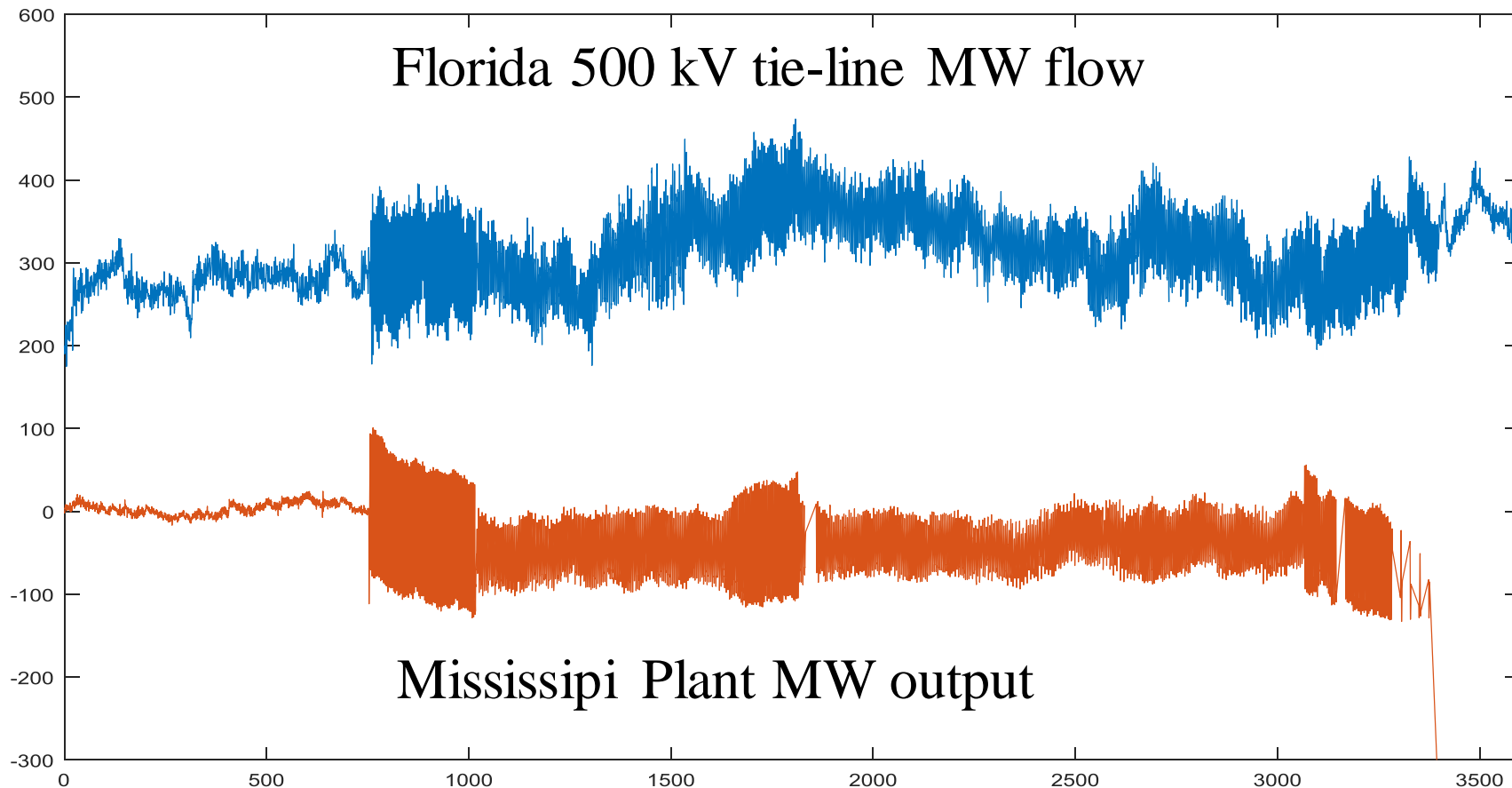


2.05 CDT: 0.25 Hz forced oscillation with amplitude 10 MW started. Acts like a probing test for the system mode.

2.12 CDT: 0.27 Hz forced oscillation with amplitude 190 MW in Mississippi triggered the main event. (Unrelated events)



Florida key player for the 0.25 Hz mode



Same Oscillation Amplitude 700 miles away.

Resonance effect with the system mode.



Oscillation Analysis

- Study of the inter-area modes in the eastern, western and Texas interconnections.
- Use rich prior knowledge of system modes in the west
- June 17 2016 eastern system event is significant
 - Inter-area oscillations were excited by resonance
 - Lasted about 44 minutes
 - Oscillation alarms at multiple utilities. No actions were taken.
 - Multiple forced oscillations present. 0.24 Hz, 0.73 Hz and the 0.27 Hz that was the main player for this event.
 - **Points to need for coordination.**
 - **Data and information exchange important.**

