

# NERC Special Reliability Assessment

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## Analysis of June 17, 2016 Event

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NASPI Oscillations Workshop

September 2017



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**NERC**  
NORTH AMERICAN ELECTRIC  
RELIABILITY CORPORATION

**CERTS** CONSORTIUM *for*  
ELECTRIC RELIABILITY  
TECHNOLOGY SOLUTIONS

# June 17, 2016 Oscillation Event

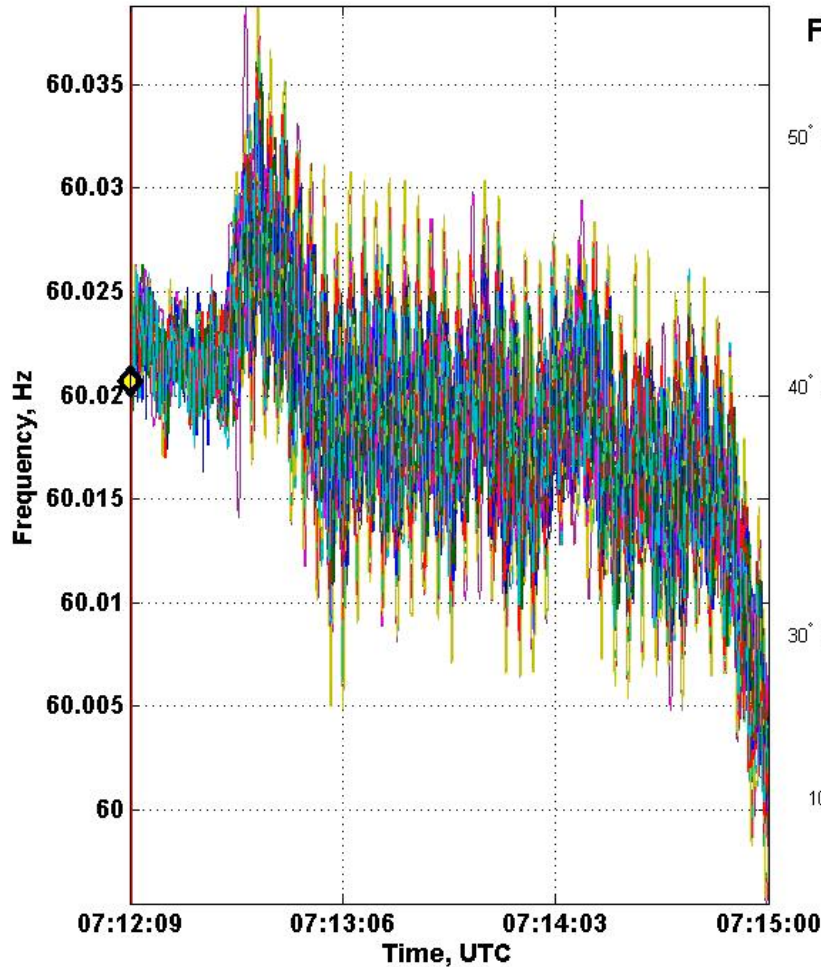
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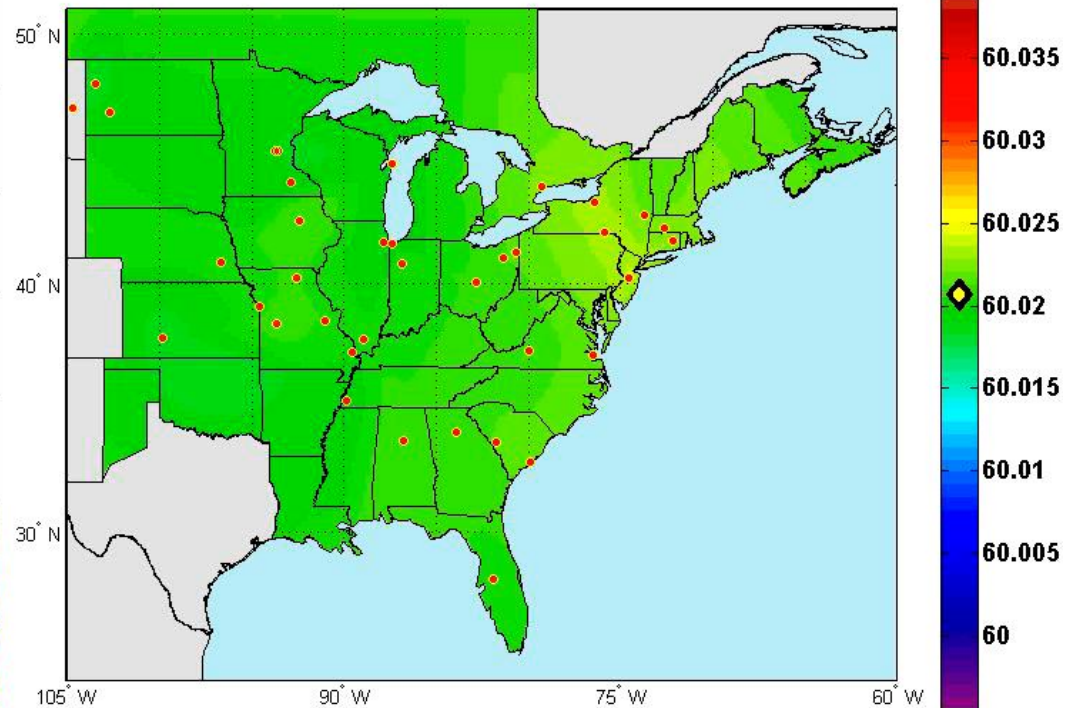
We thank all the reliability coordinators for providing PMU data.



# June 17 2016 Event

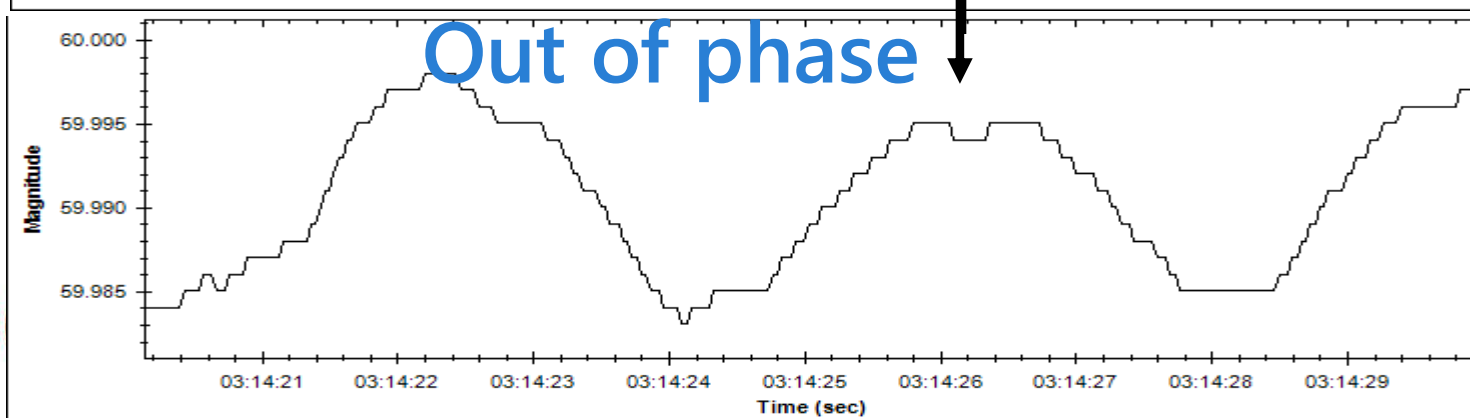
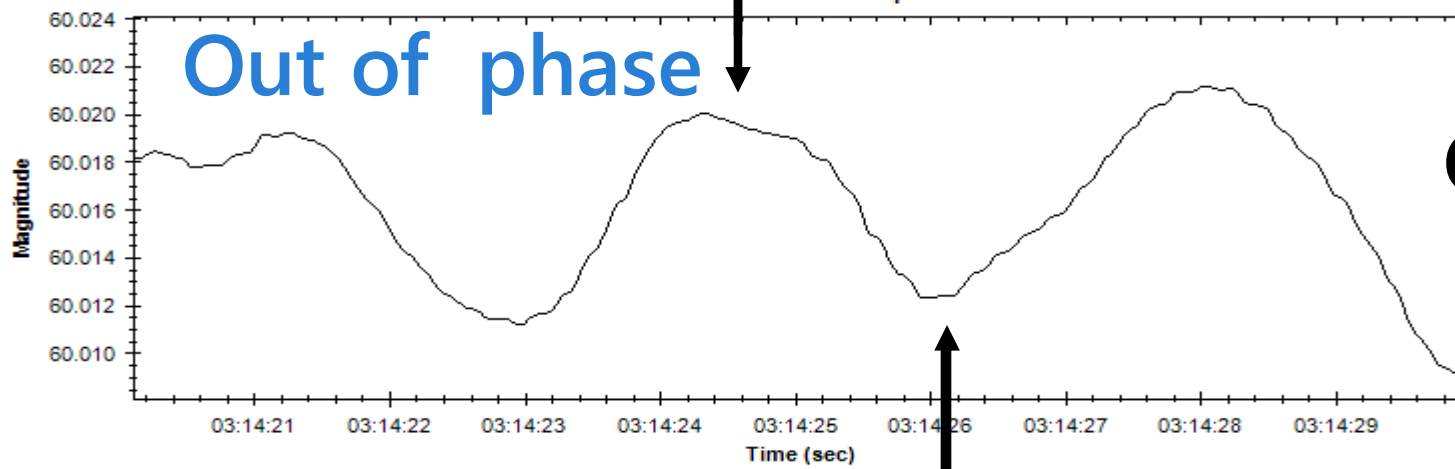
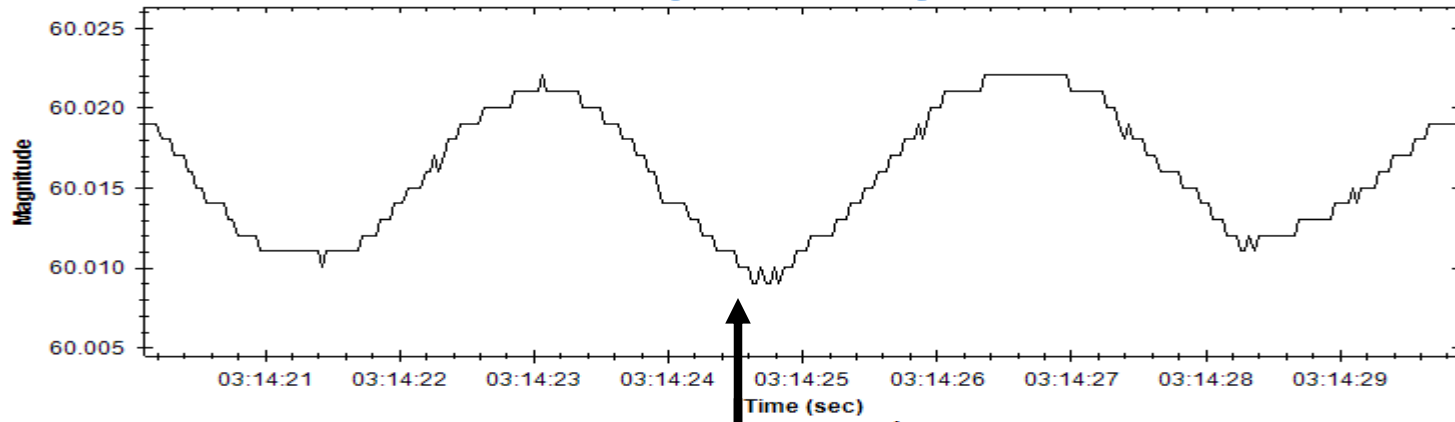


FNET Data Display [6/17/2016 Sustained Oscillation]  
Time: 7:12:9.9 UTC 60.0207 Hz



CONSORTIUM for  
ELECTRIC RELIABILITY  
TECHNOLOGY SOLUTIONS

# Bus Frequency Time Plots

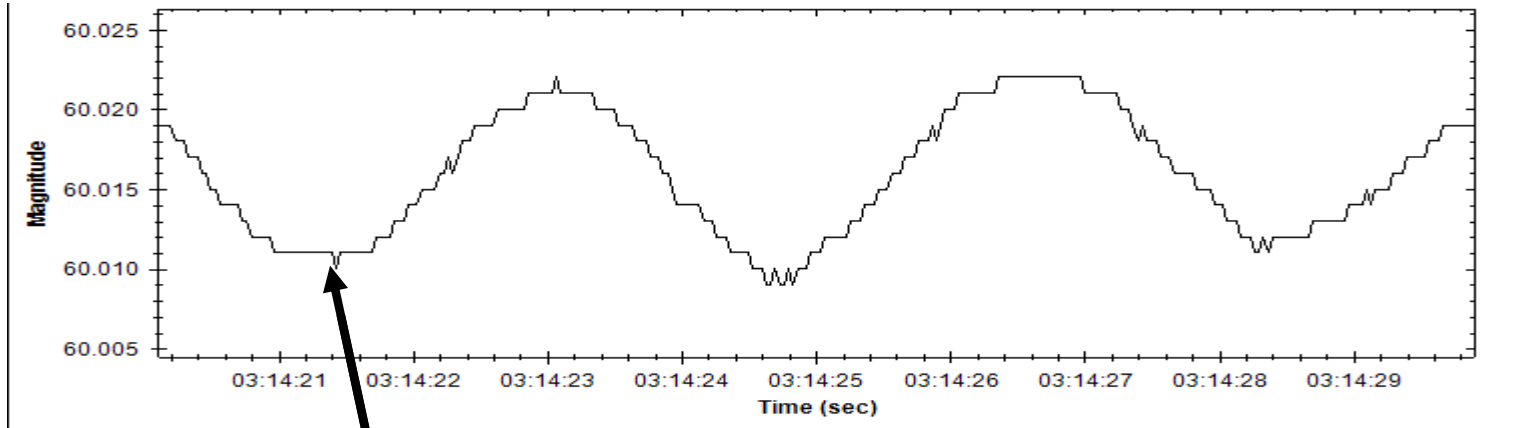


Maine  
(NE)

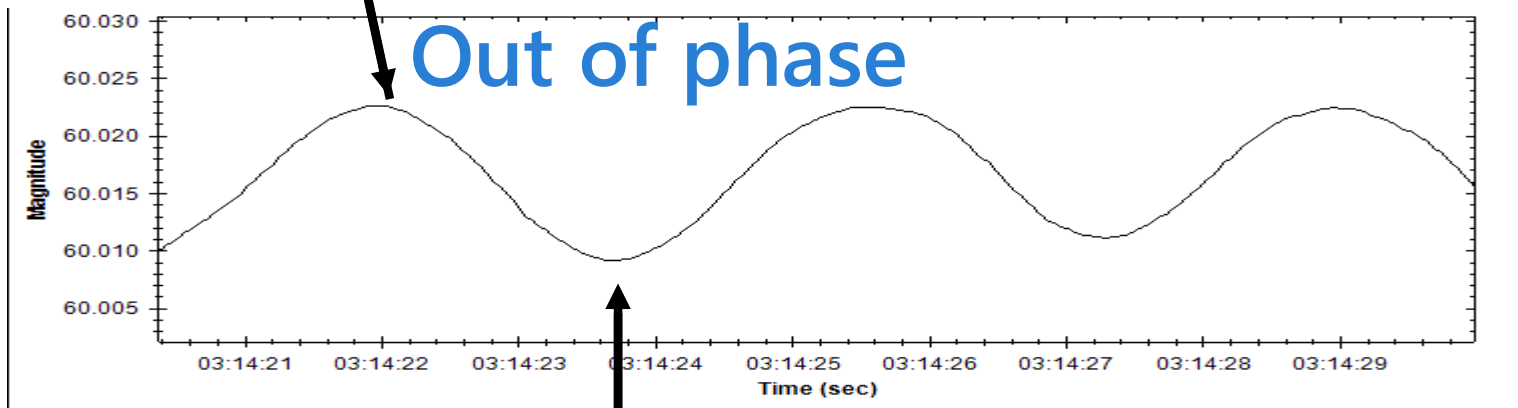
Oklahoma  
(SW)

North  
Dakota  
(NW)

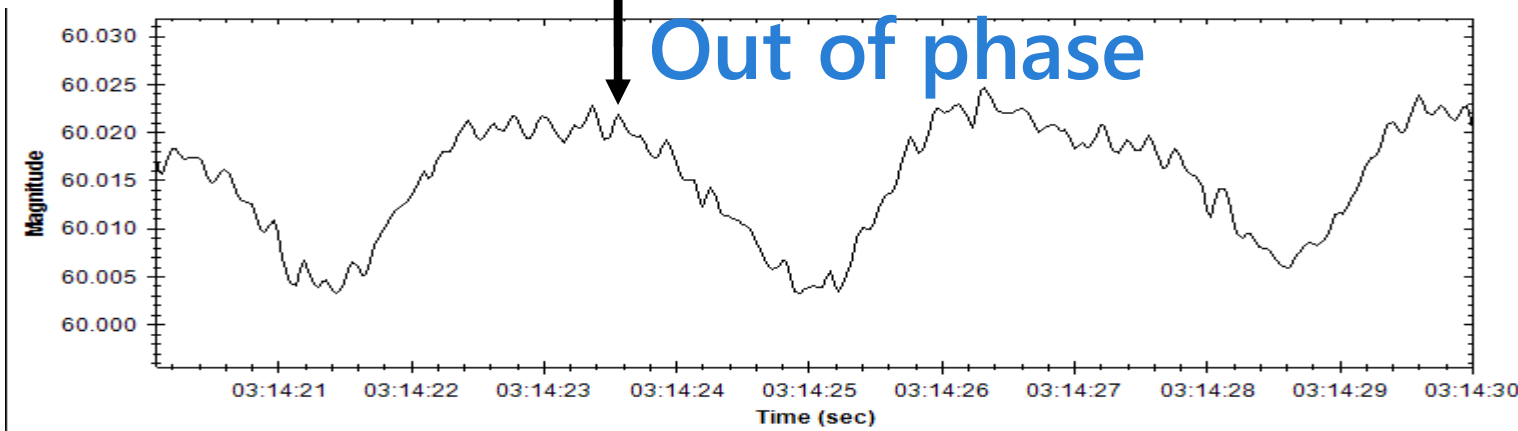
# Bus Frequency Time Plots



**Maine  
(NE)**

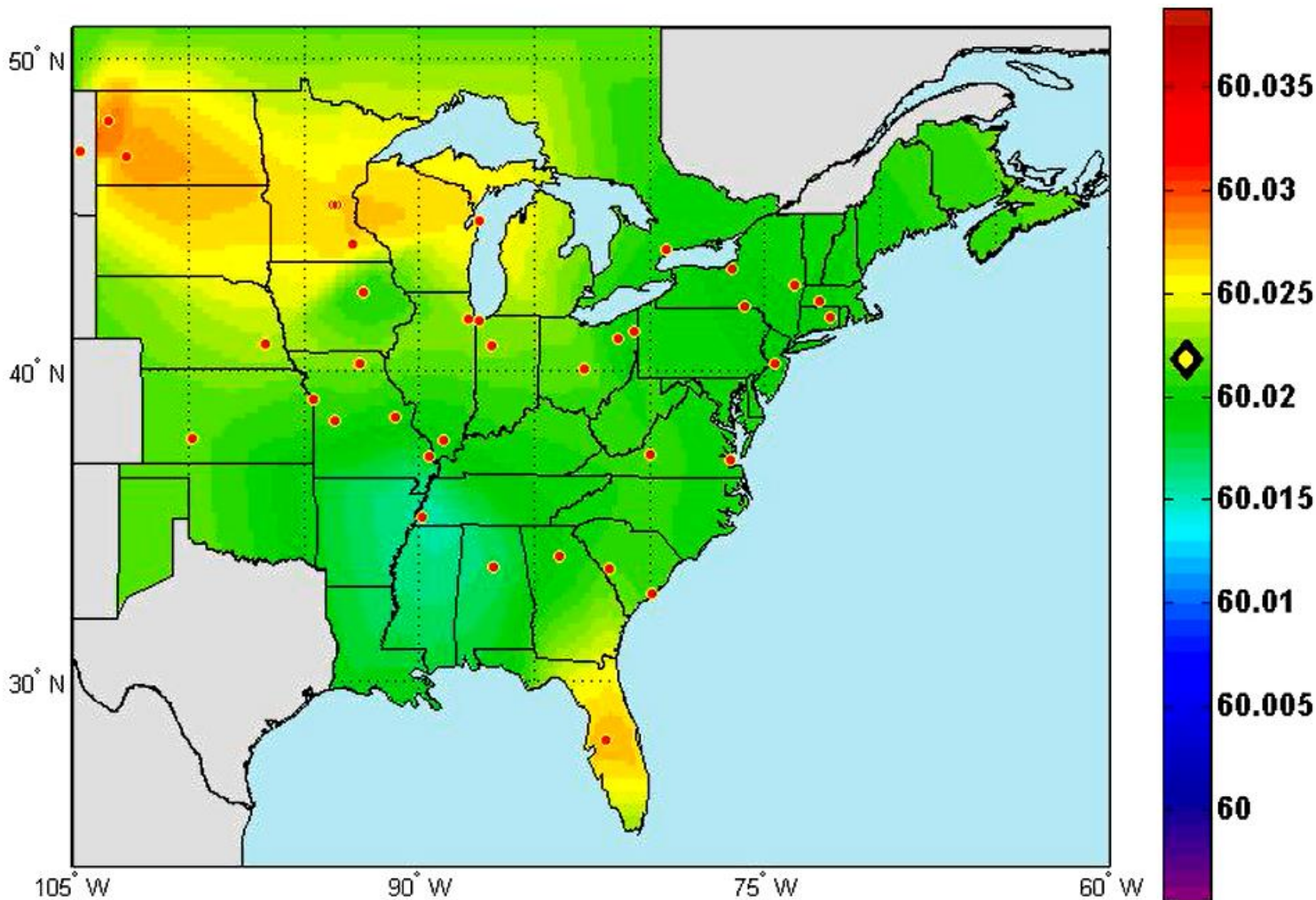


**Florida  
(SE)**



**Texas  
(SW)**

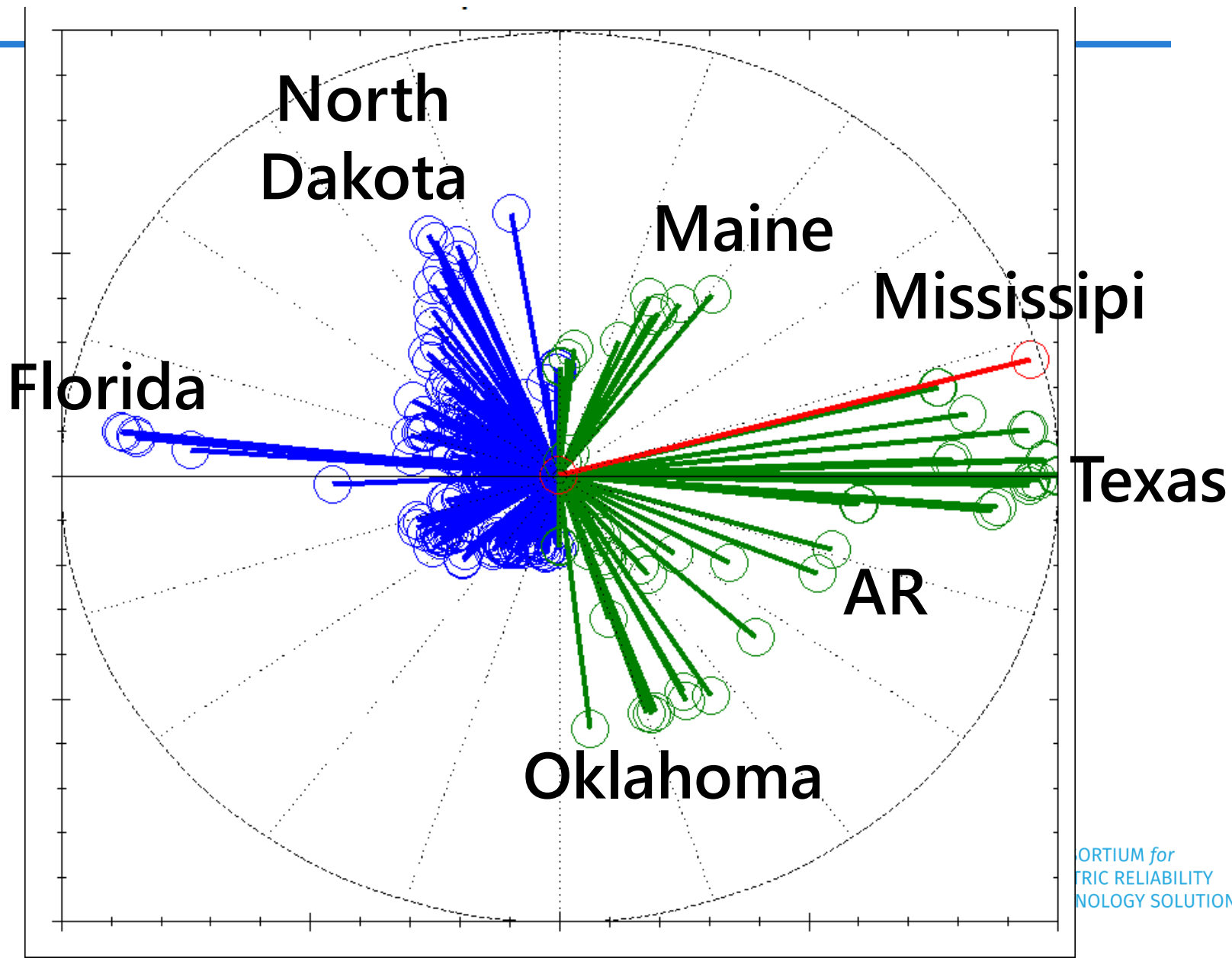
# Fnet Video - In Phase Regions



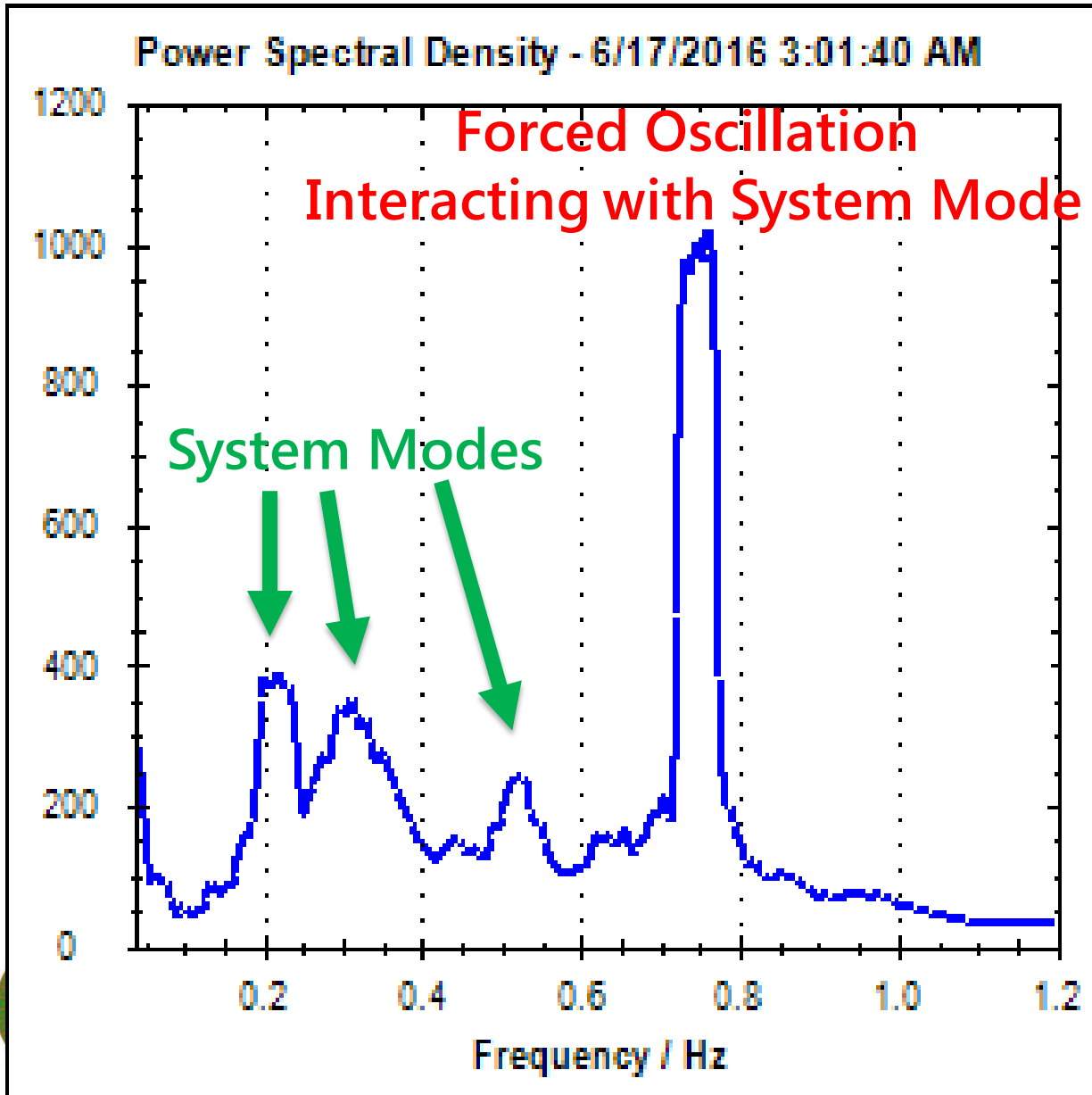
North  
Dakota  
and  
Florida  
nearly  
in  
Phase



# 0.28 Hz Oscillation Mode Shape



# Power Spectrum @ 3:01 AM (Before)



## Main modes

0.2 Hz

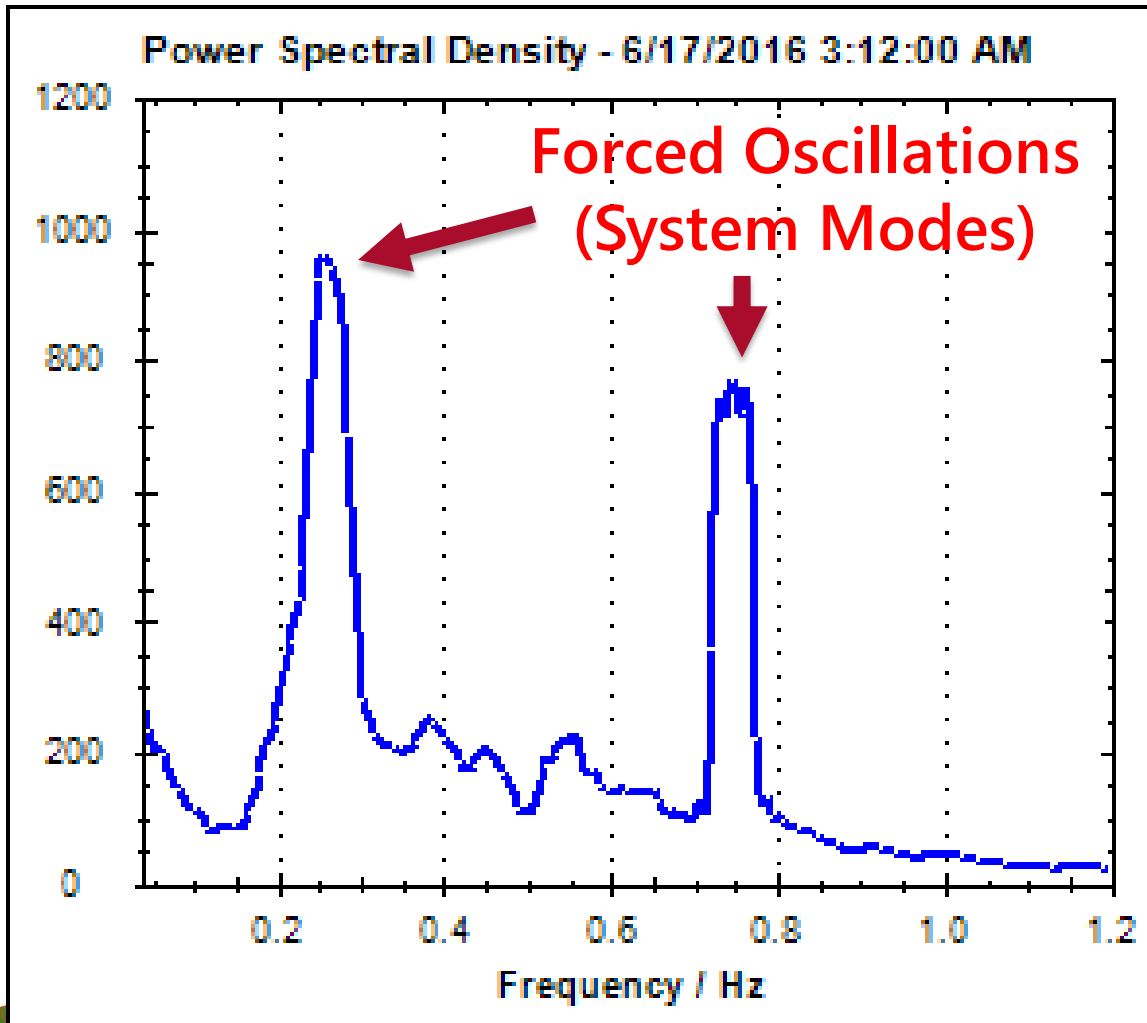
0.3 Hz

0.5 Hz

0.75 Hz



# Power Spectrum @ 3:12 AM (Before)



## Main modes

0.25 Hz

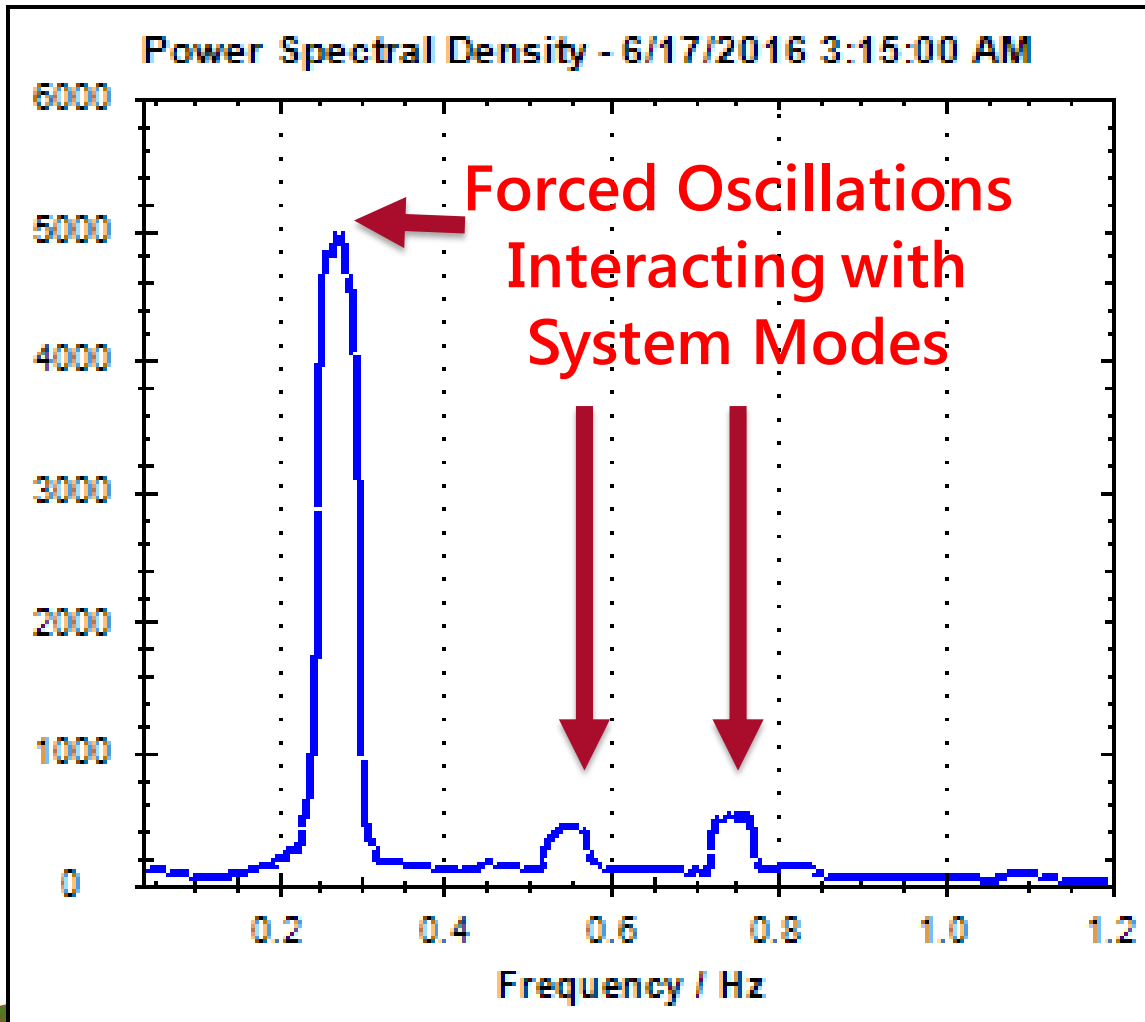
0.30 Hz

0.52 Hz

0.75 Hz



# Power Spectrum @ 3:15 AM (During)



## Main modes

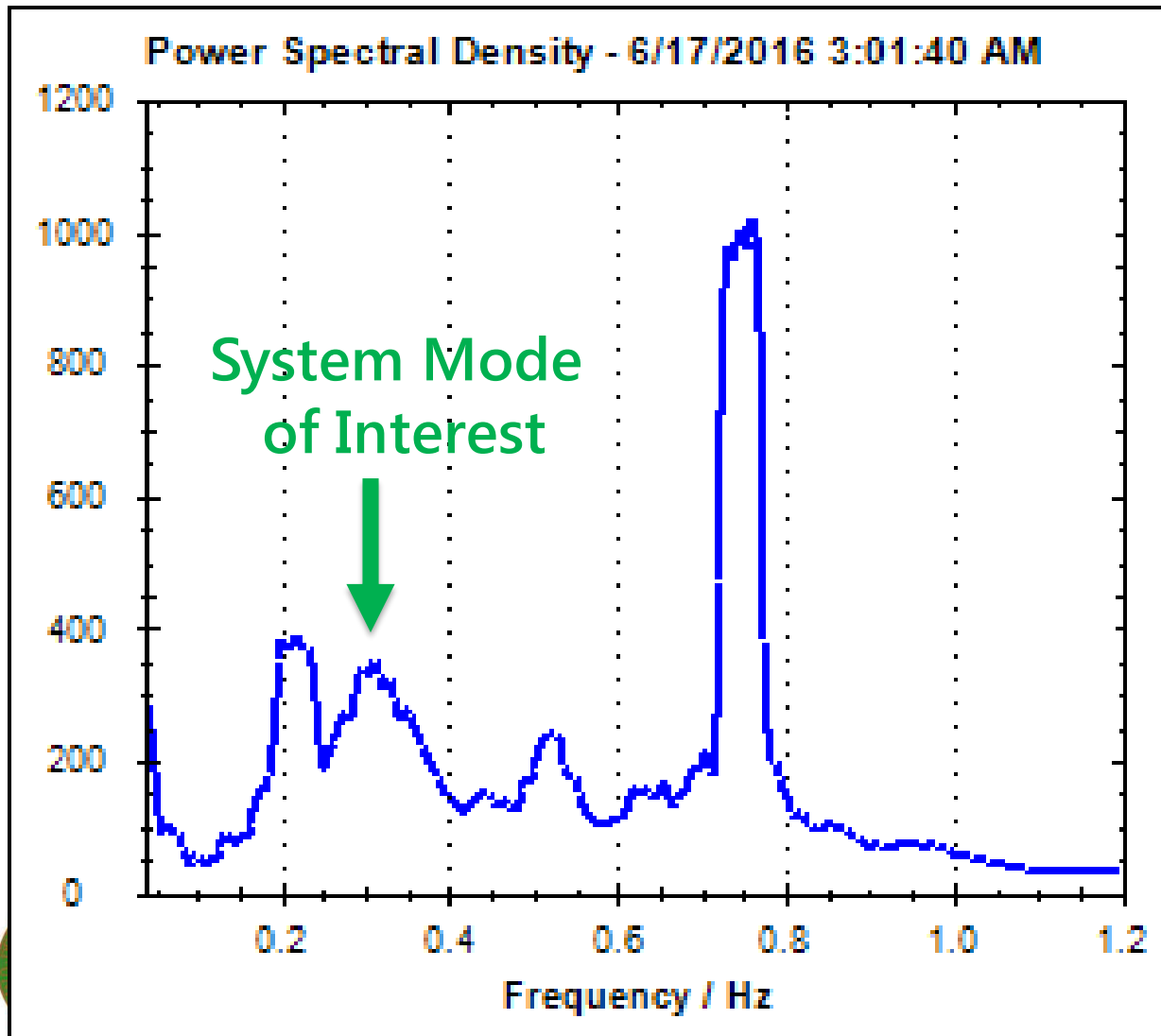
0.28 Hz

0.56 Hz

0.75 Hz



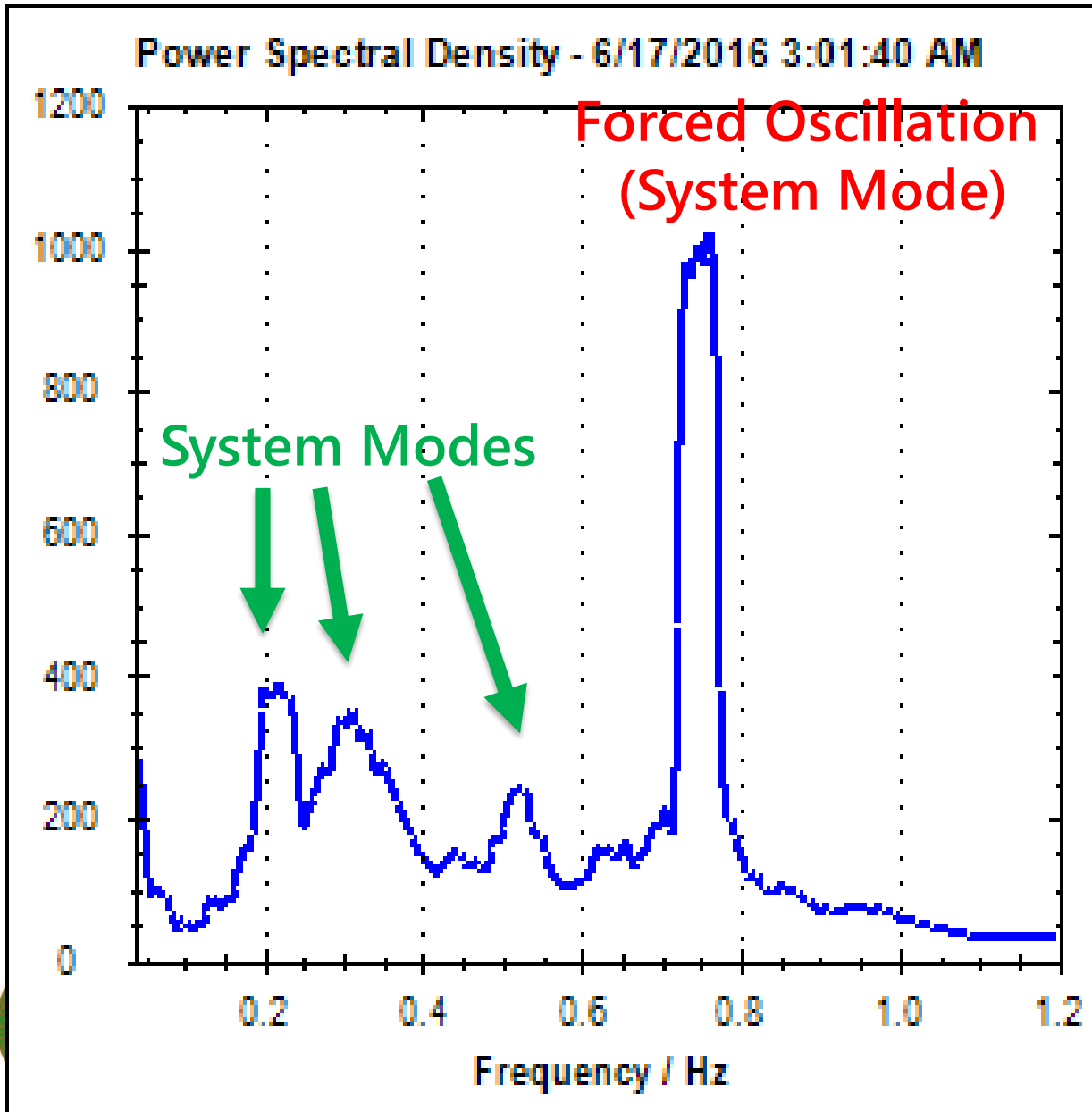
# Power Spectrum @ 3:01 AM (Before)



**Forced  
Oscillation  
at 0.28 Hz  
from 3:12:30.**

**System Mode  
at 0.3 Hz  
likely excited.**

# Power Spectrum @ 3:01 AM (Before)



## Main modes

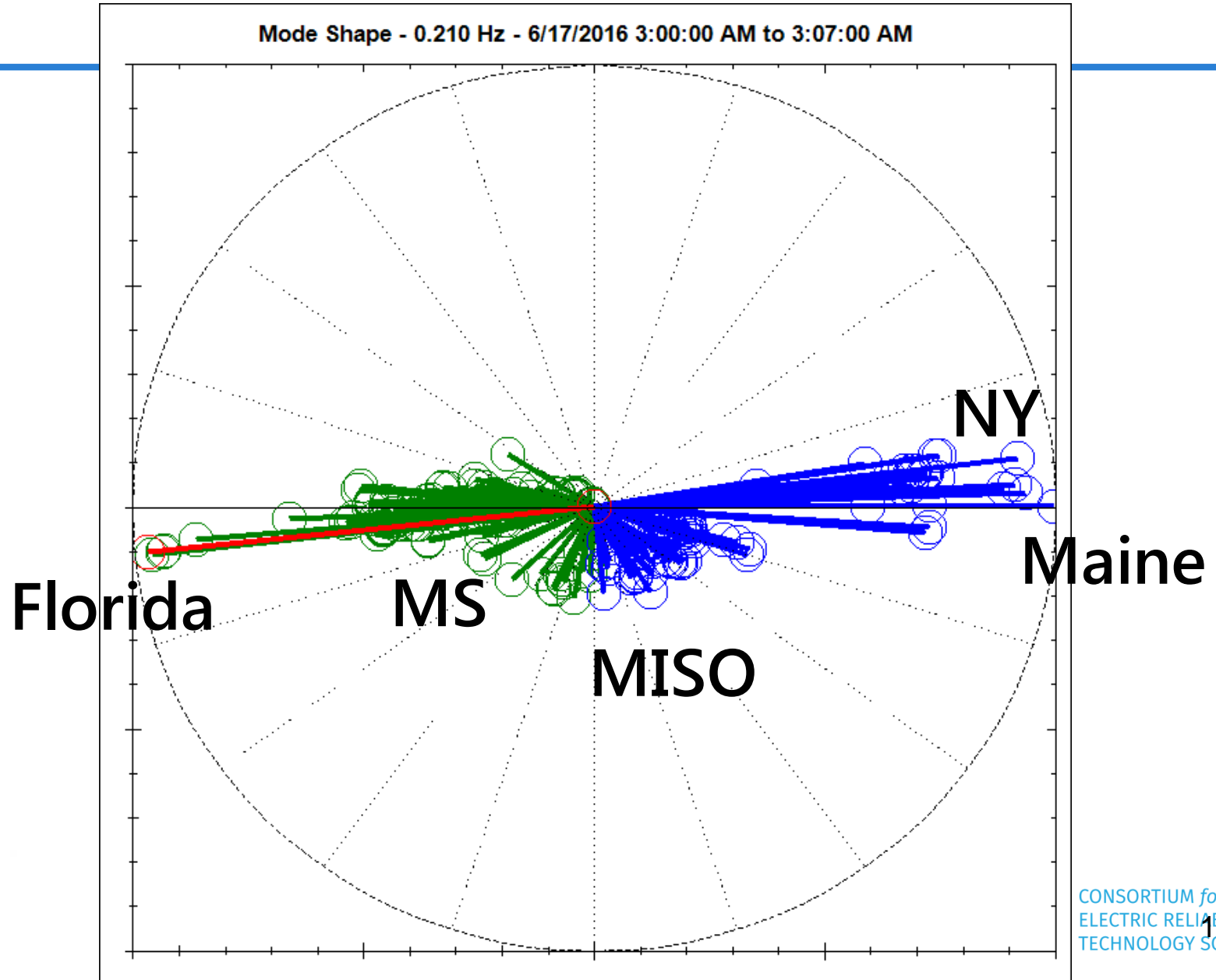
0.2 Hz

0.3 Hz

0.5 Hz

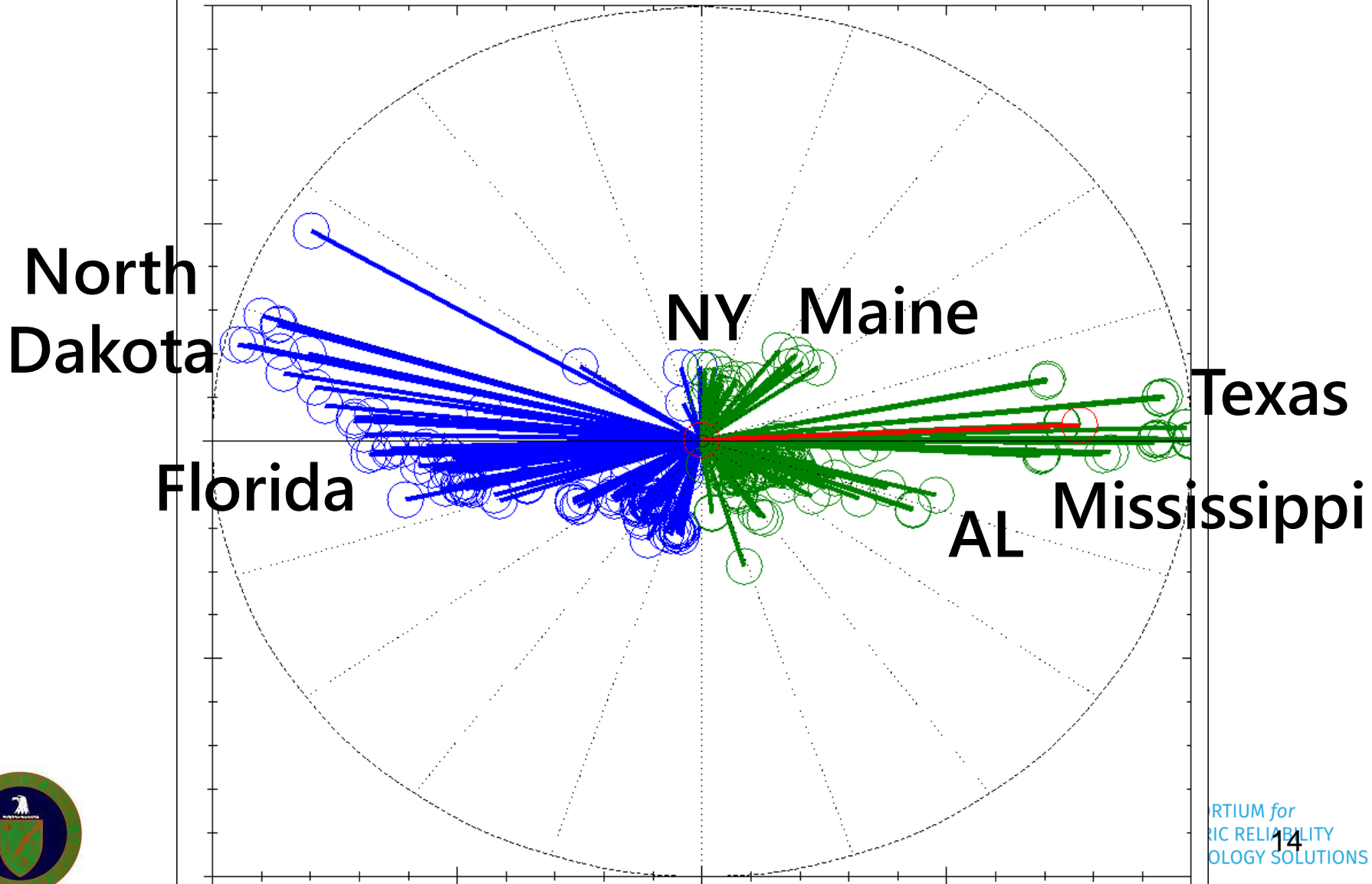
**0.75 Hz**

# 0.2 Hz North-South Mode from FSSI

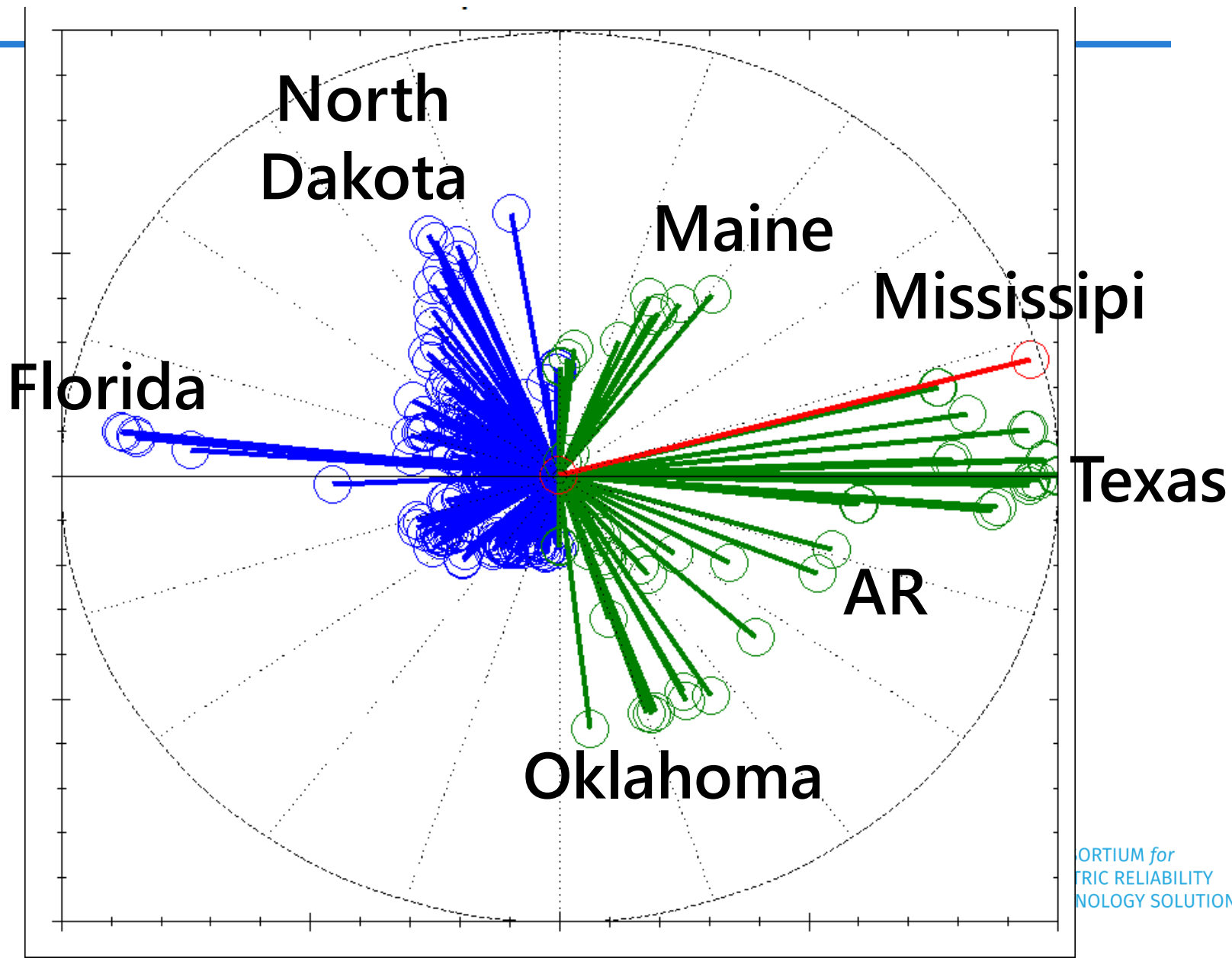


# 0.3 Hz North-South Mode from FFDD

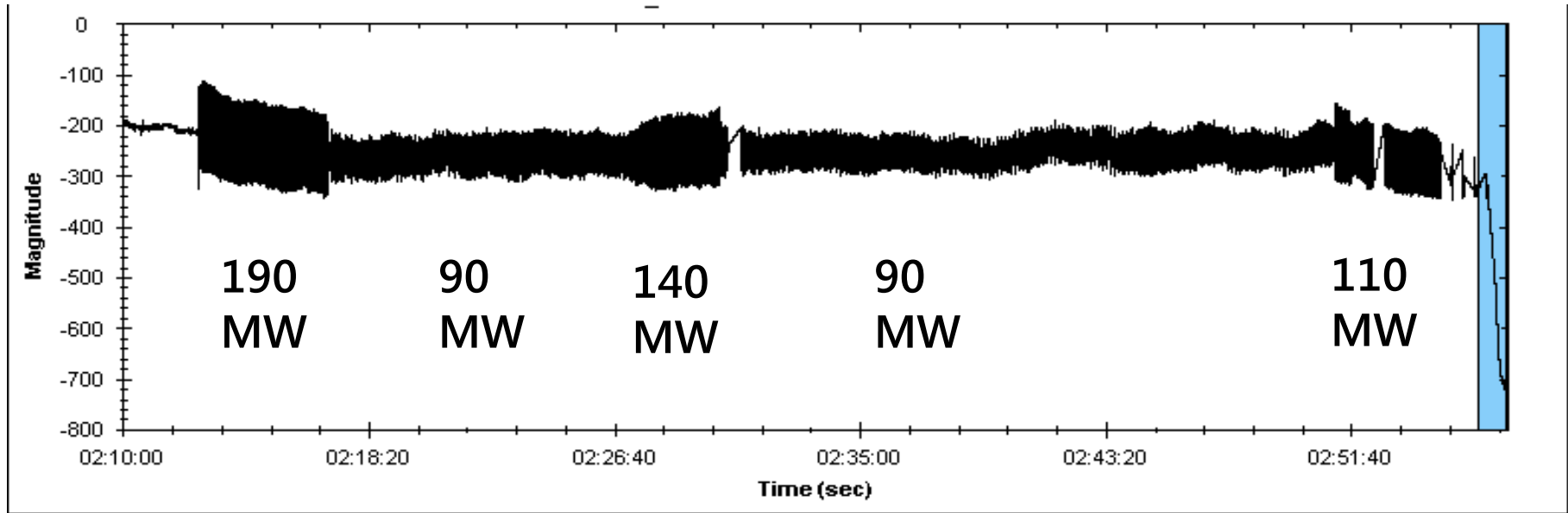
ModeShape of the Mode @ 0.298 Hz - 6/17/2016 3:00:00 AM to 3:05:00 AM



# 0.28 Hz Oscillation Mode Shape



# Forced Oscillation Source

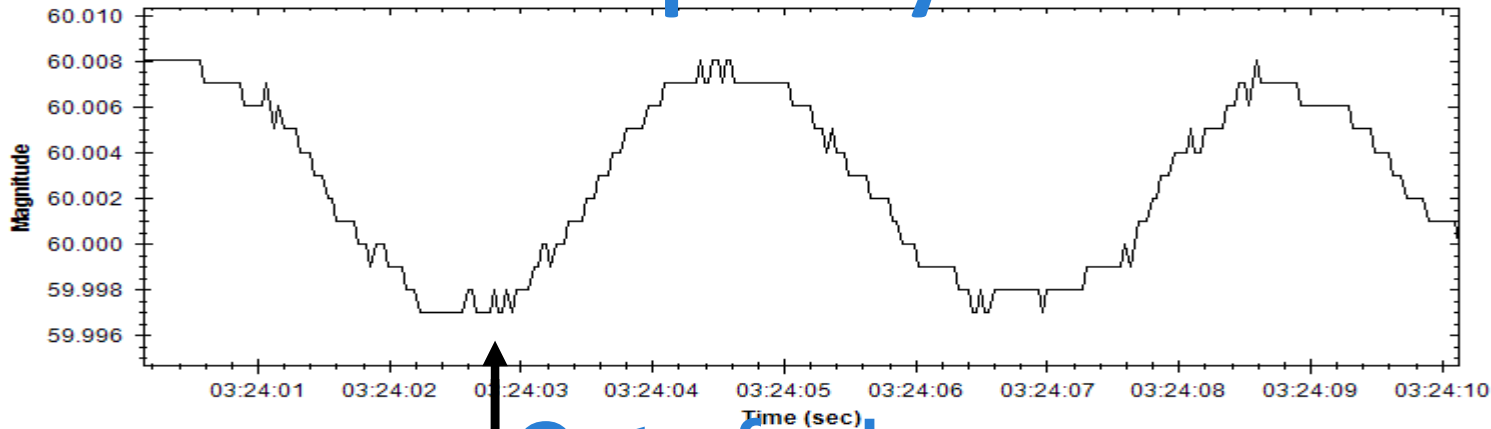


- 2:12:30 AM CDT: Oscillations started; Amplitude varied between 90 MW and 190 MW.
- Osc freq varied between 0.28 Hz and 0.23 Hz.
- 2:56:00 AM CDT: Oscillations stopped.
- Oscillation Source: Generator in Mississippi (FSSI).

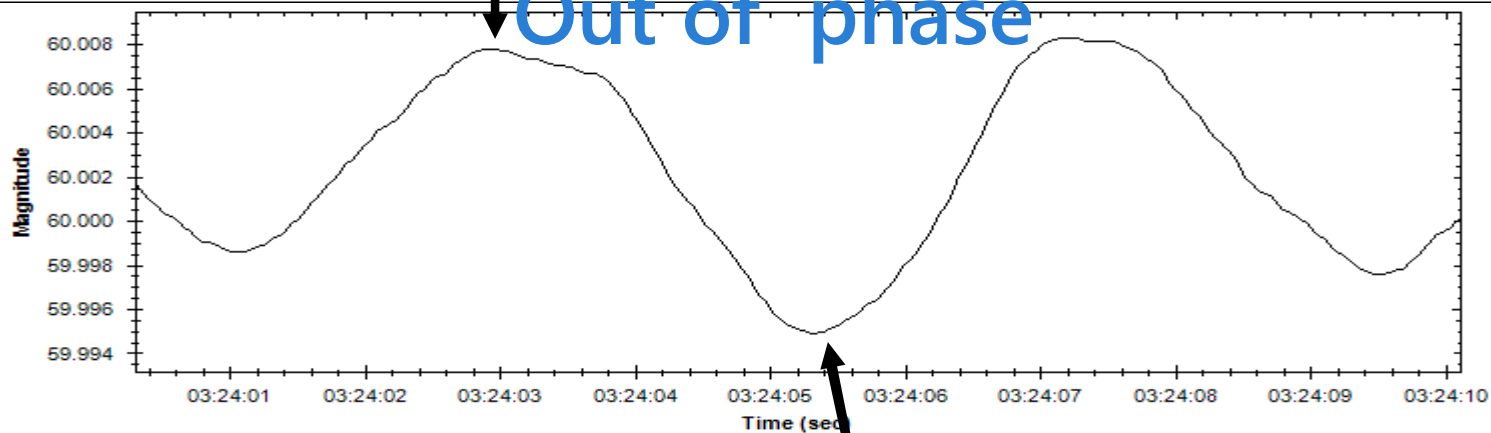




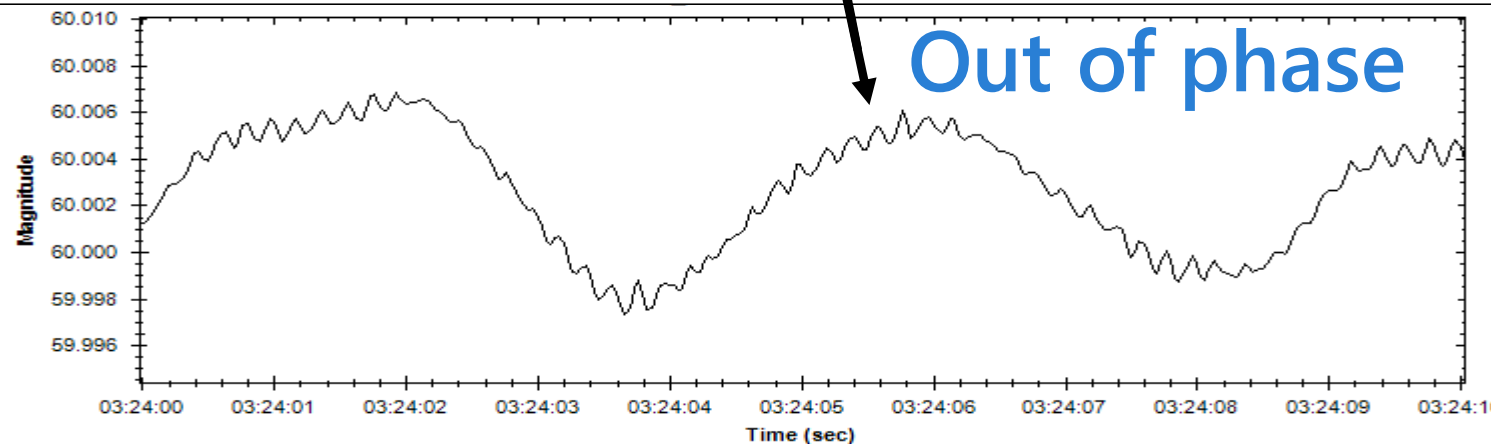
# Bus Frequency Time Plots



Maine  
(NE)

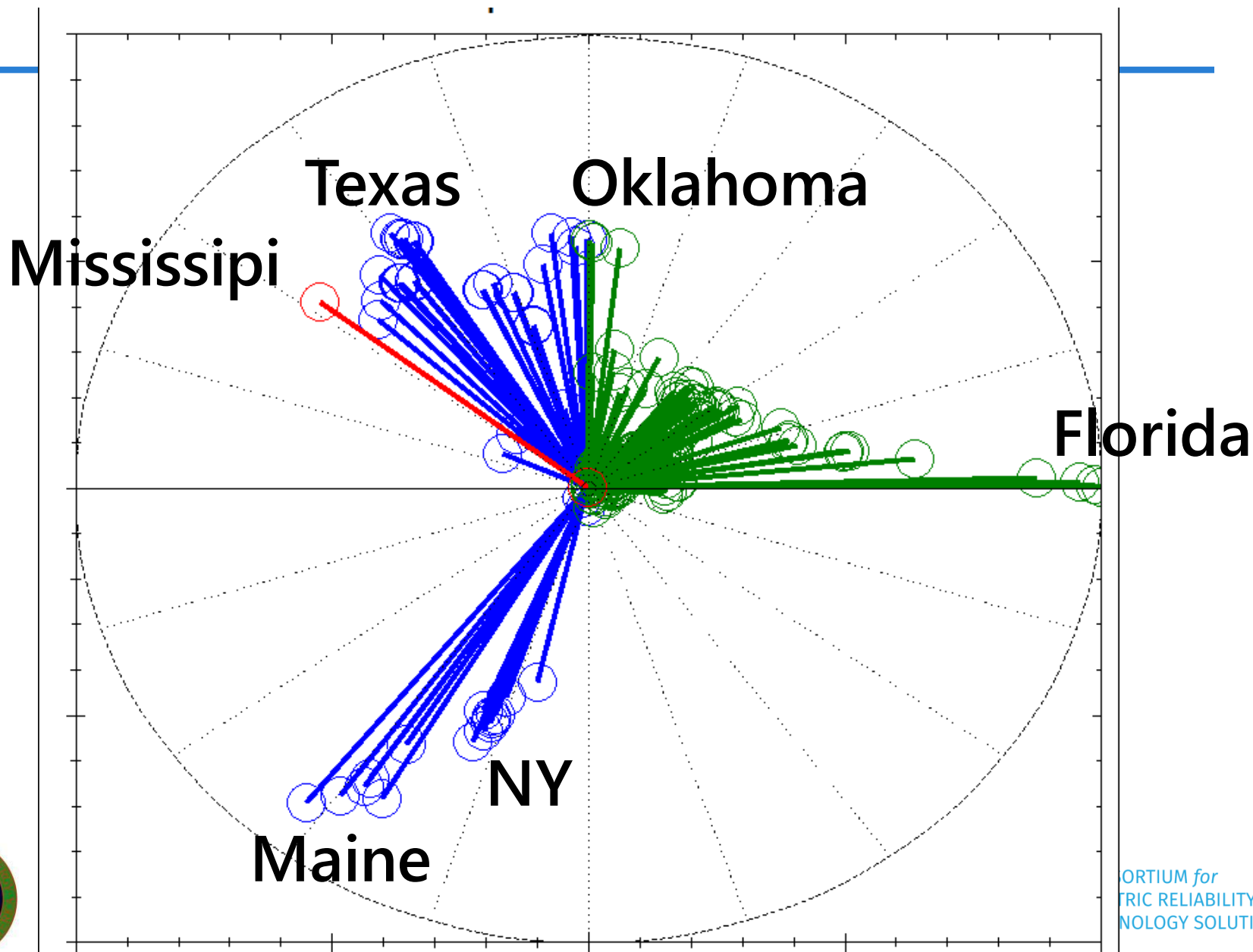


Florida  
(SE)



Texas  
(SW)

# 0.23 Hz Oscillation Mode Shape



# Resonance with Inter-area Mode

**Resonance effect high** when:

(R1) Forced Oscillation freq near System Mode freq

(R2) System Mode poorly damped

(R3) Forced Oscillation location near the two distant ends (strong participation) of the System Mode

**Resonance effect medium** when:

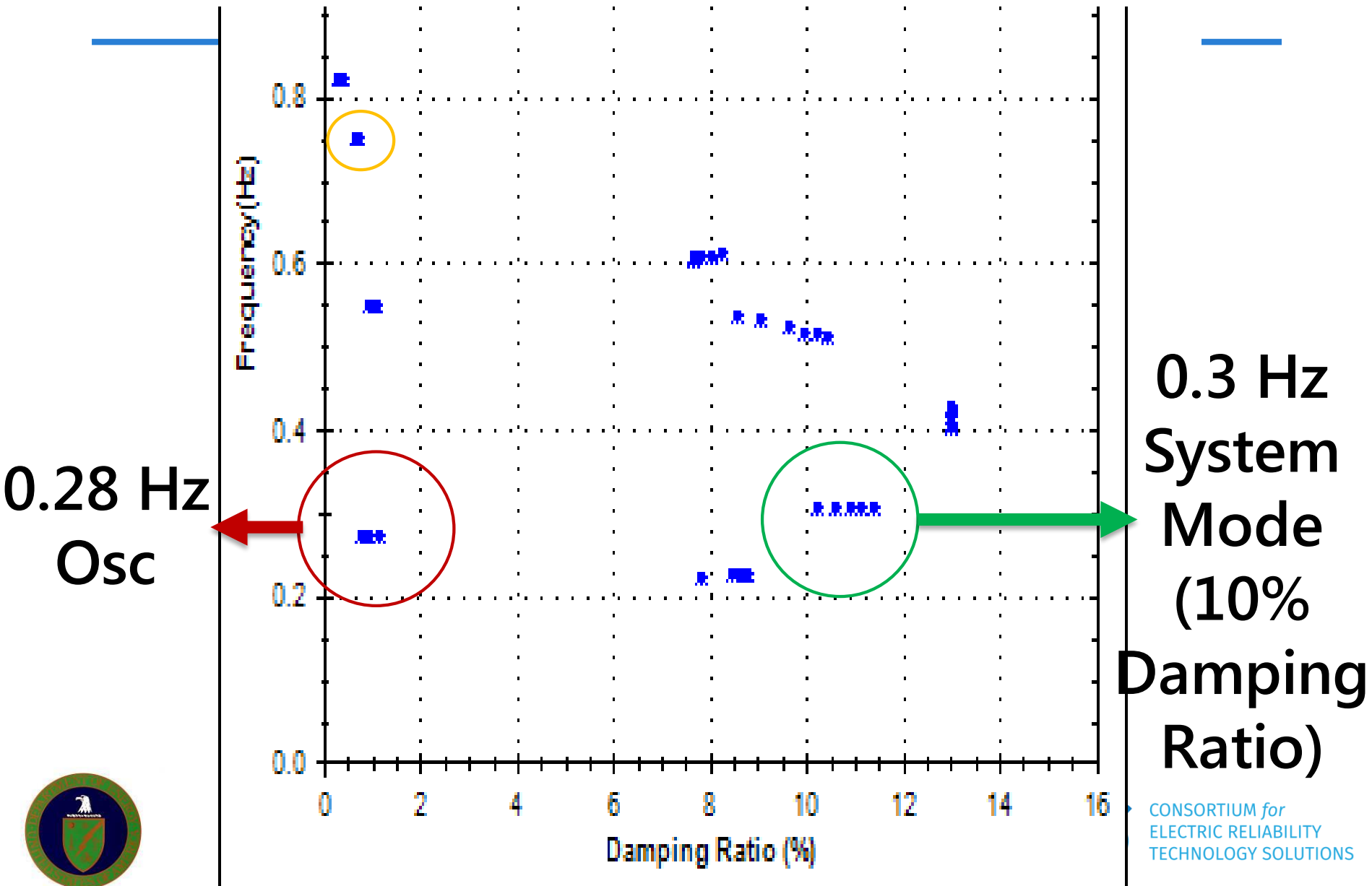
- Some conditions hold

**Resonance effect small** when:

- None of the conditions holds

(Source: Our recent paper in IEEE Trans. Power Systems)

# FSSI Estimates During Event



# Resonance Conditions (Event start)

(R1) Forced Osc freq near System Mode freq (**close**)

- **0.28 Hz Oscillation versus 0.3 Hz Mode**

(R2) System Mode poorly damped (**invalid**)

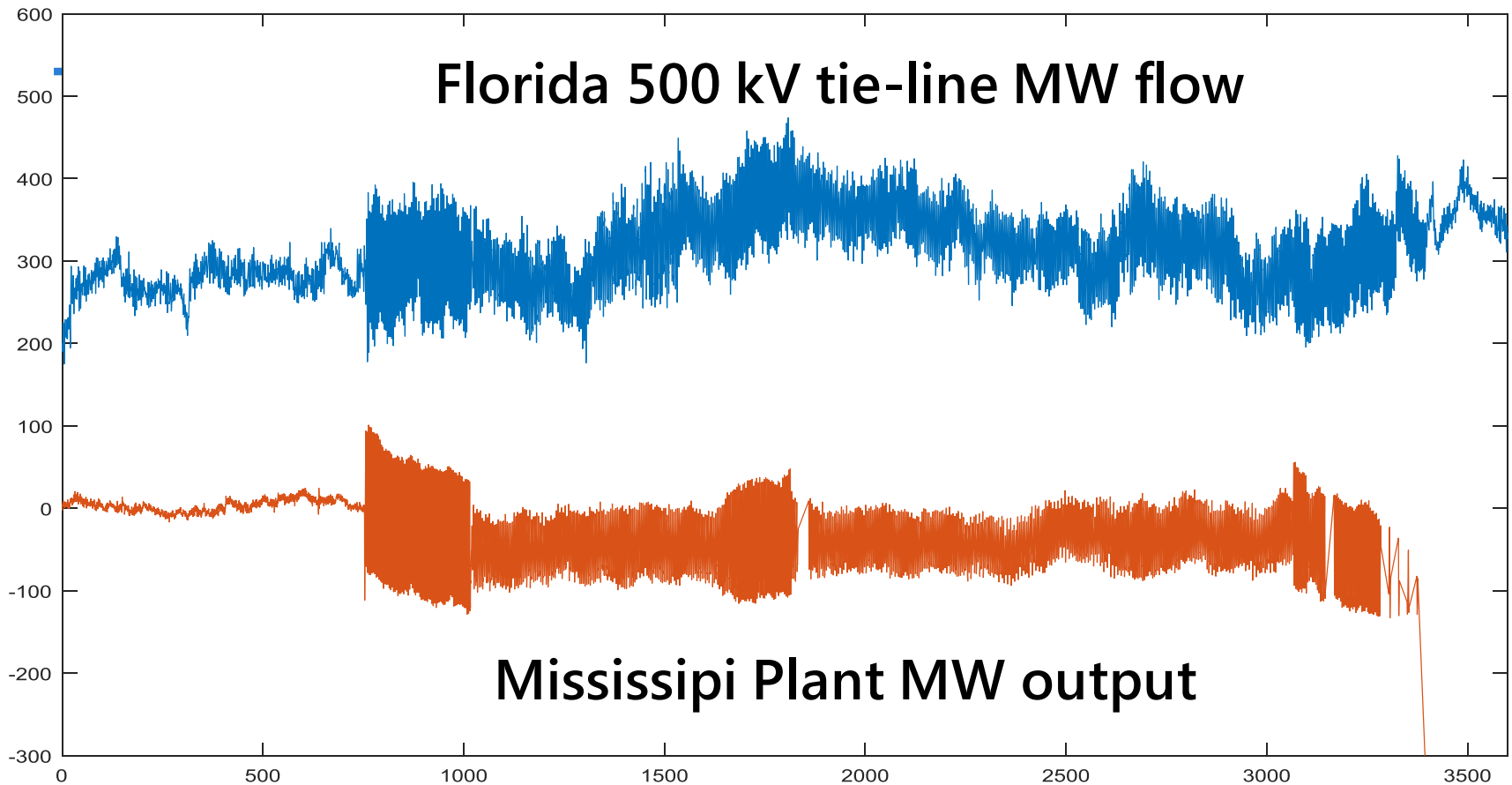
- **0.3 Hz Well-damped (10% Damping Ratio)**

(R3) Forced Osc location near the two distant ends (strong participation) of the System Mode (**true**)

- **Mississippi Sensitive Location for the Mode**

**Only 1+ conditions valid: Resonance effect small.**

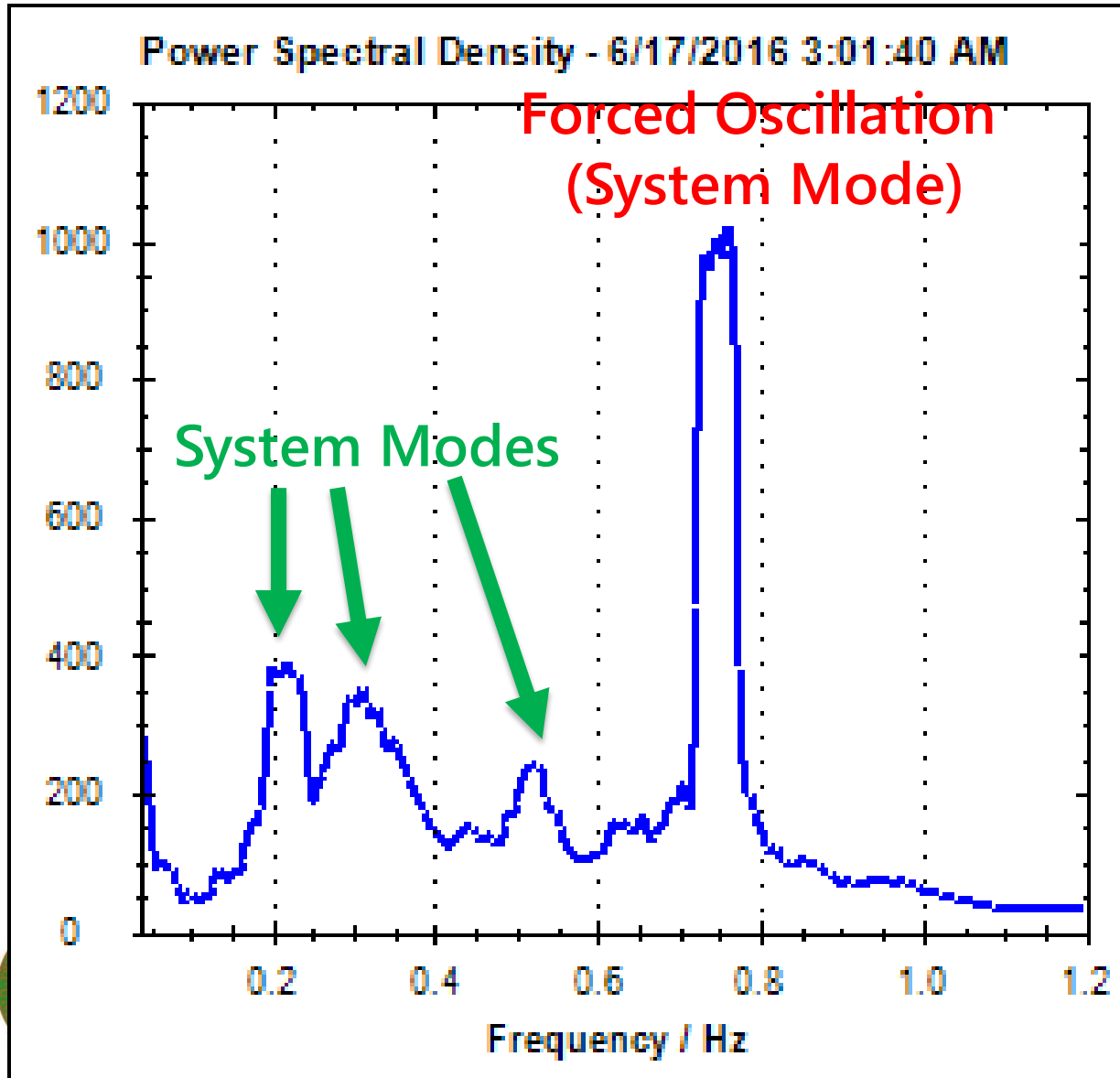
# Florida key player for all the N-S modes



Same Oscillation Amplitude 700 miles away.  
Because of Resonance effect with the system mode.



# Power Spectrum @ 3:01 AM (Before)



## Main modes

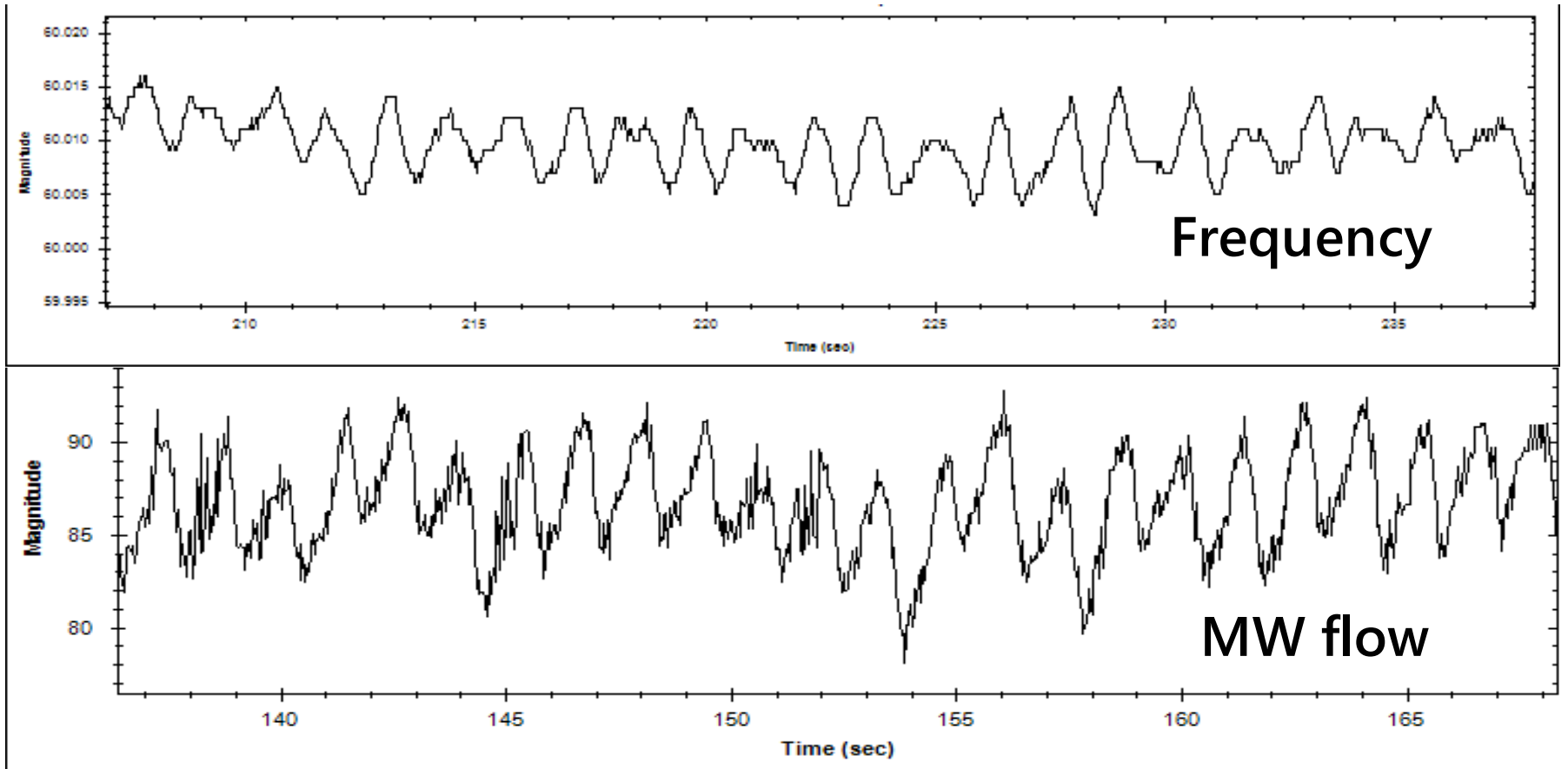
0.2 Hz

0.3 Hz

0.5 Hz

**0.75 Hz**

# 0.73 Hz Forced Oscillation

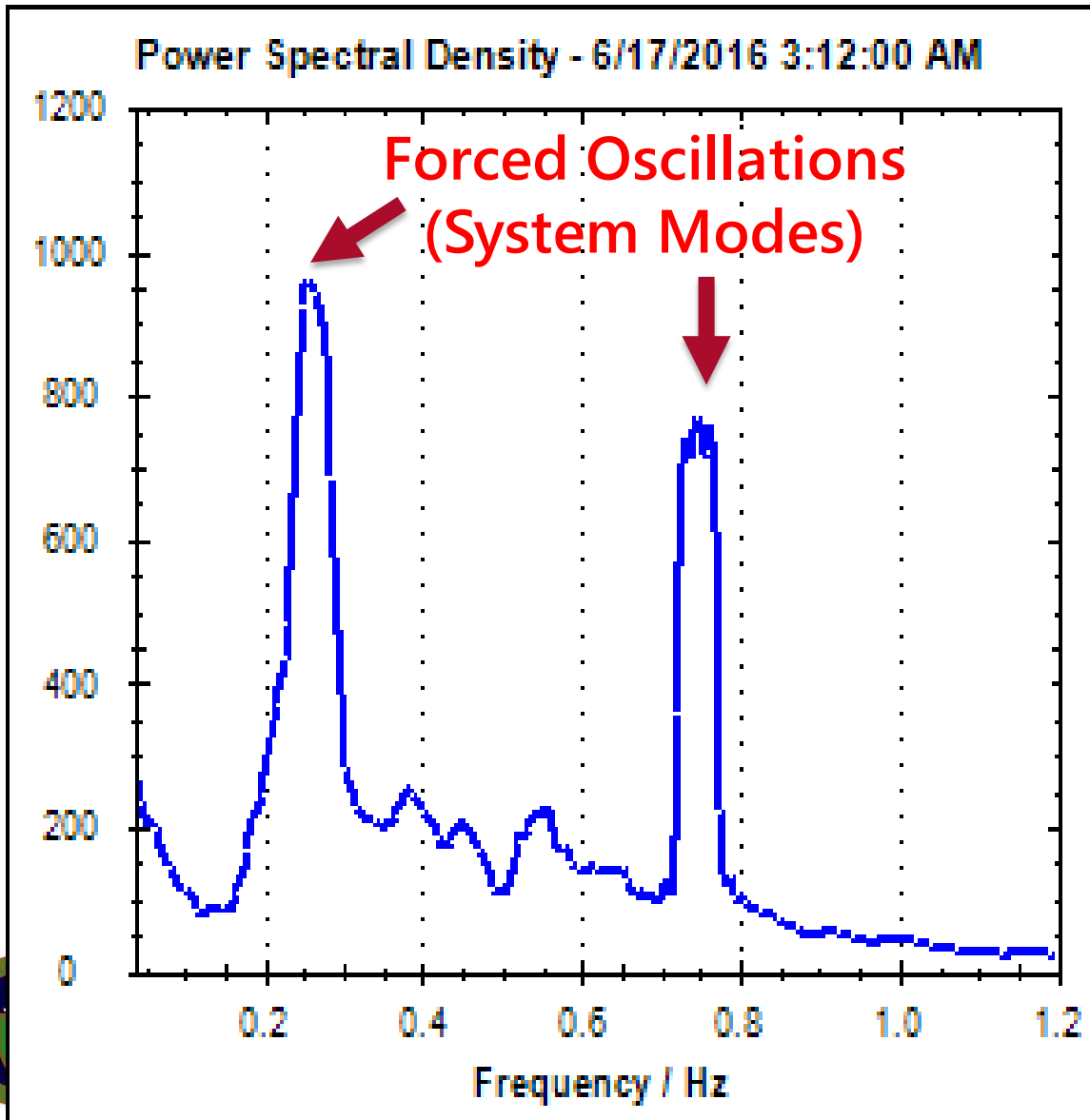


10 MW oscillations visible in several MISO signals. Present throughout. Unrelated to the 0.28 Hz Mississippi Oscillations.





# Power Spectrum @ 3:12 AM (Before)



## Main modes

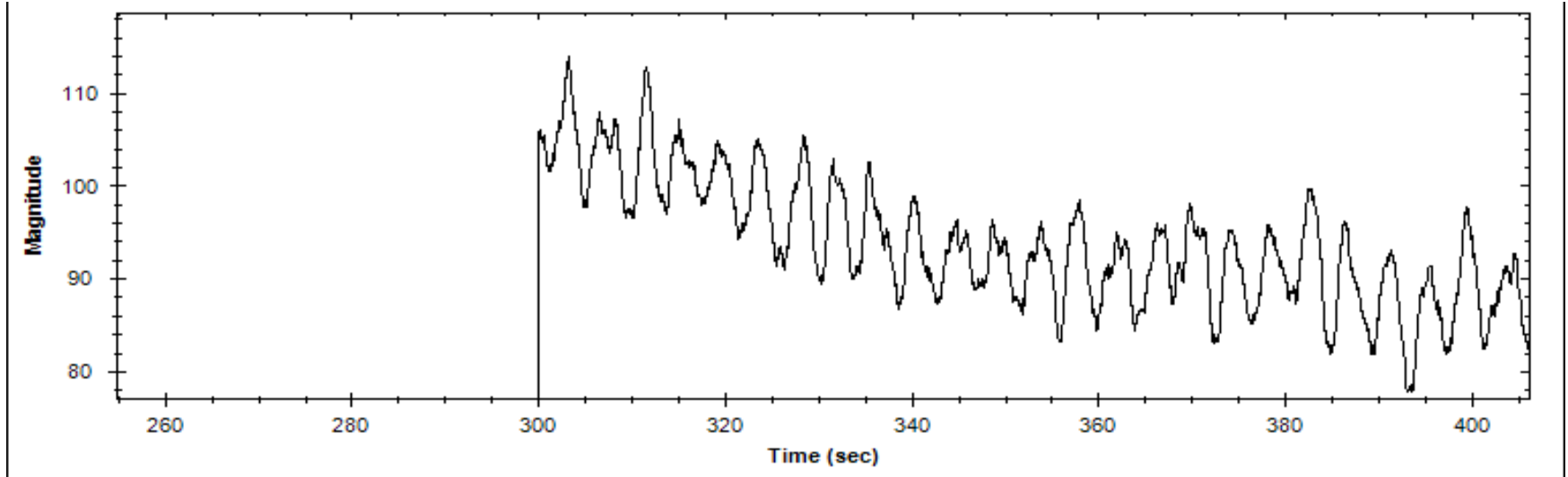
0.25 Hz

0.29 Hz

0.52 Hz

0.75 Hz

# 0.25 Hz Forced oscillation



3.05 EDT: 0.25 Hz forced oscillation with amplitude 10 MW started (Midwest). **Corresponds to the spike in PSD energy plot.** Changed to 0.27 Hz during the event.

3.12 EDT: 0.28 Hz forced oscillation with amplitude 190 MW in Mississippi triggered the main event. (Unrelated events?)



# June 17 2016 Event Summary

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- 0.3 Hz North-South Eastern System Mode has a complex mode shape
- Oscillation source in Mississippi was a sensitive location for the 0.3 Hz Mode
- Oscillation frequency 0.28 Hz slightly off (fortunately)
- 0.3 Hz System mode well-damped (excellent)
- Resonance effect was mild
- Different 0.27 Hz oscillation in Midwest during event
- 0.75 Hz forced oscillation present throughout



# June 17 2016 Event Analysis

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