Ensuring Reliability using Forced Oscillation Monitoring and Mitigation

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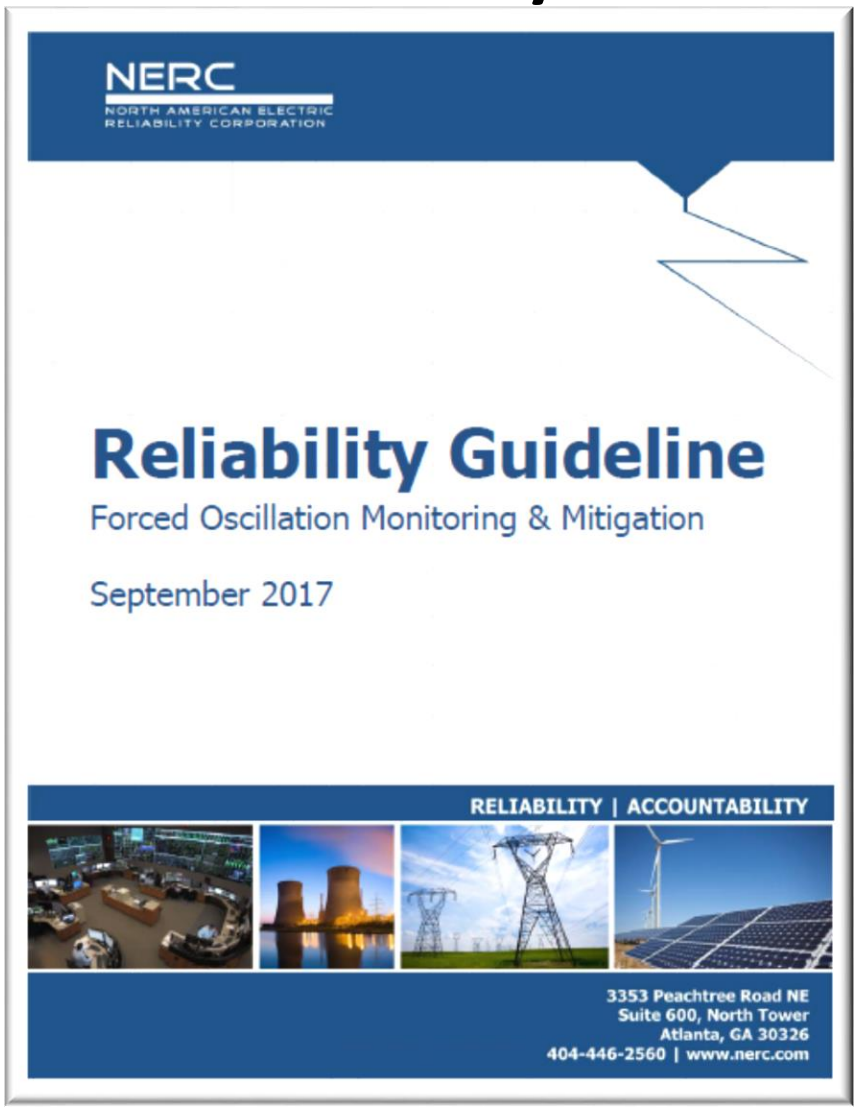
NERC Reliability Guideline



Characteristics of Oscillations

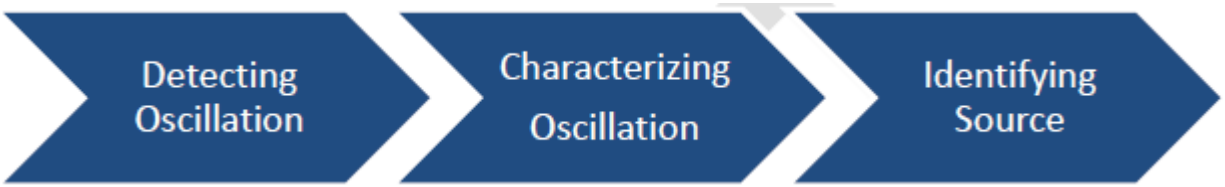
Characteristic	System	Forced
Oscillation Mode	Natural property of electro-mechanical system; characterized by frequency, damping ratio, and shape.	Not described by oscillation modes due to external forcing function acting on system.
Mode Shape	Explains how parts of system interact with one another.	Forced oscillations are not described by system mode shapes; they have response based oscillatory characteristics.
Frequency	Frequency at which oscillation is occurring; explains type of phenomena occurring in the BPS depending on range.	Can occur at any frequency; often includes harmonic content of the fundamental forced oscillation frequency.
Damping Ratio	Expresses how quickly an oscillation decays; tied to system stability.	Typically very near zero since FOs caused by an external persistent input signal; does not necessarily mean the system is unstable.

Considerations

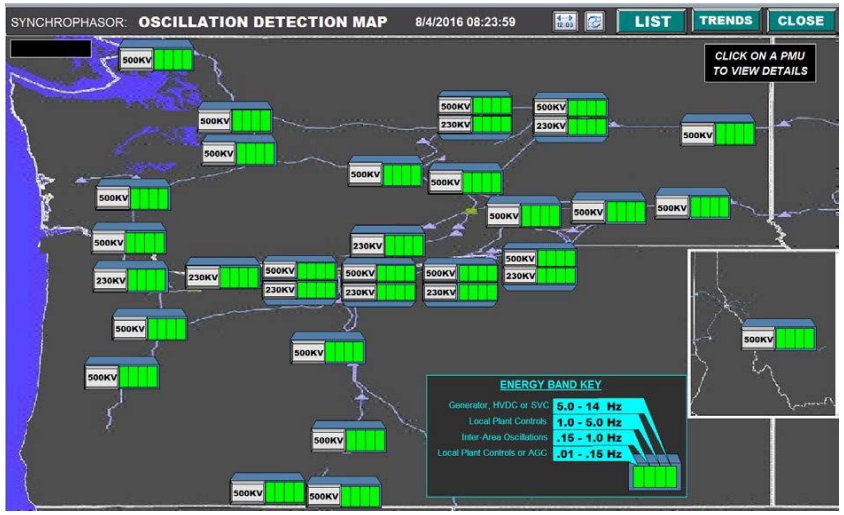
- Sources of forced oscillations: generation, load, controls
- Monitoring devices: PMUs, DFRs, DDRs
- Measurements: reporting rates, filtering, electrical quantities, locations
- Interactions between system and forced oscillations – widespread vs. localized

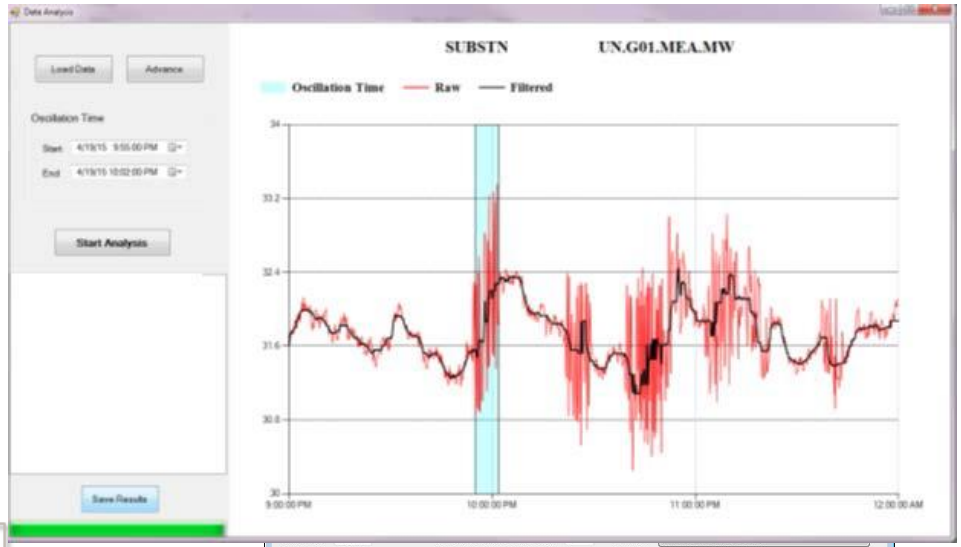
Mitigating Measures

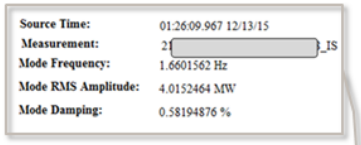
- **Step 1:** Identify occurrence of forced oscillation
- **Step 2:** Determine oscillation frequency and magnitude
- **Step 3:** Determine “containment” of oscillation
- **Step 4:** Determine location or general proximity of oscillation
- **Step 5:** Determine specific system component oscillating

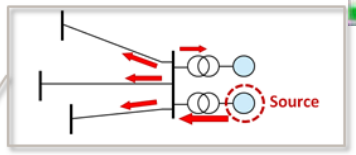


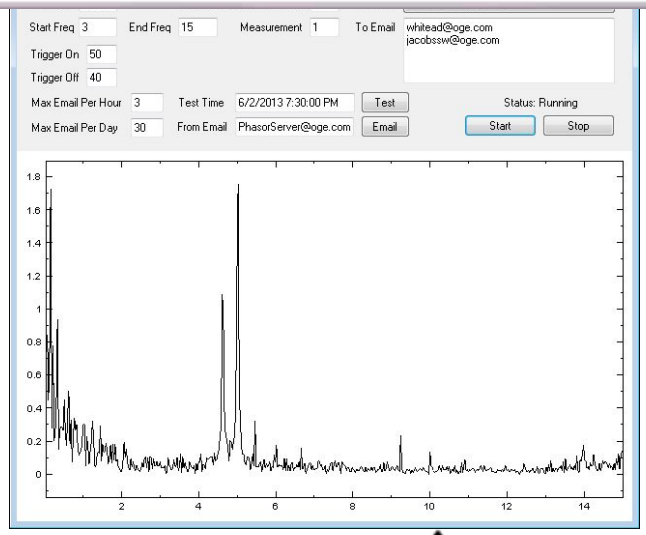
Operational Tools

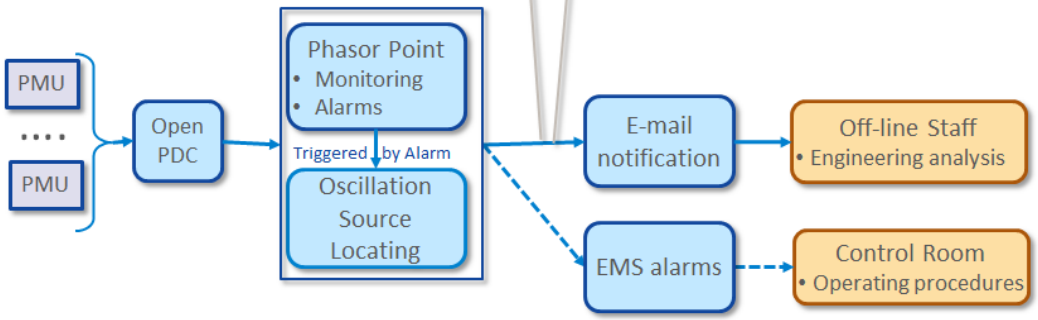




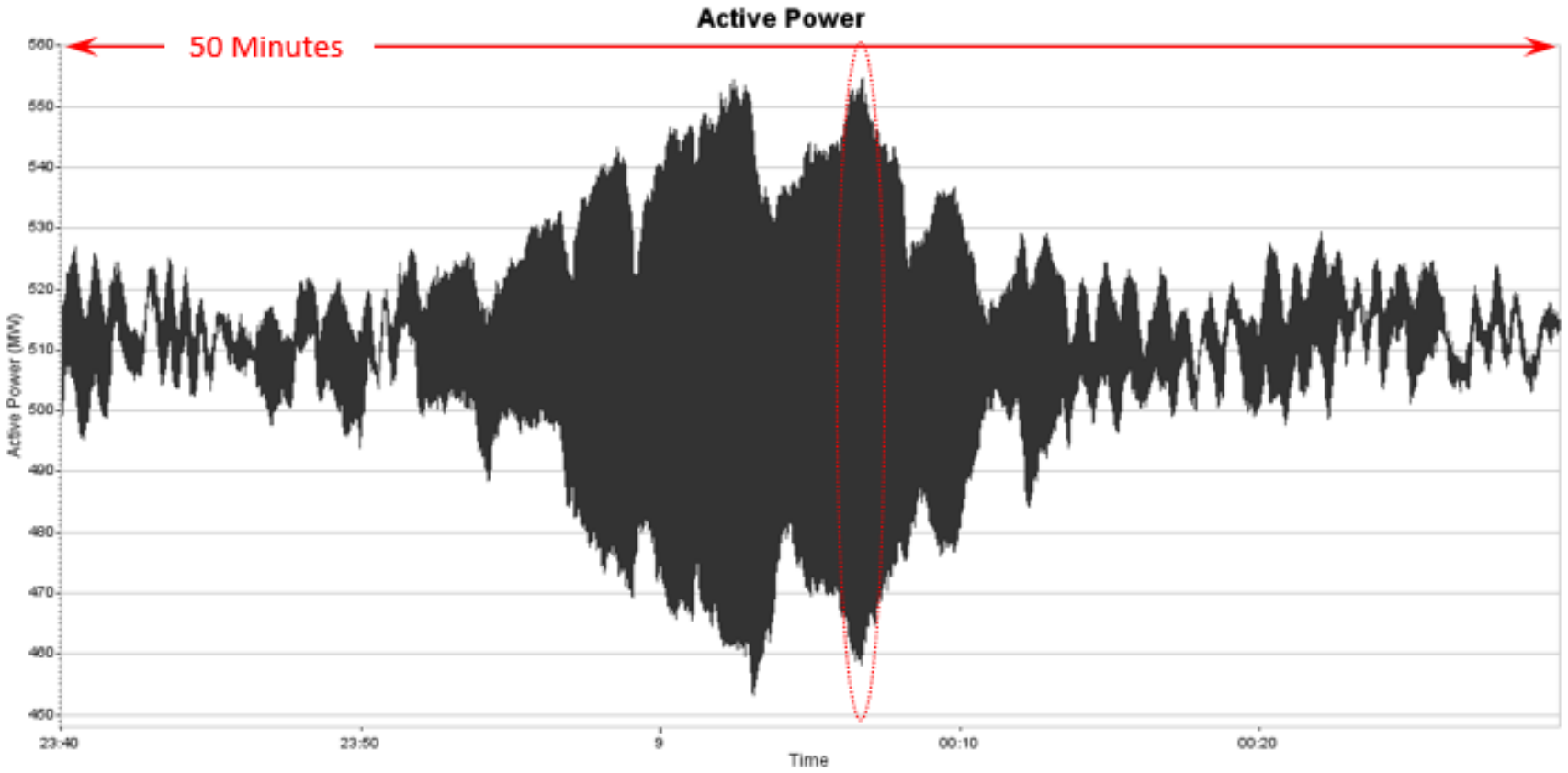




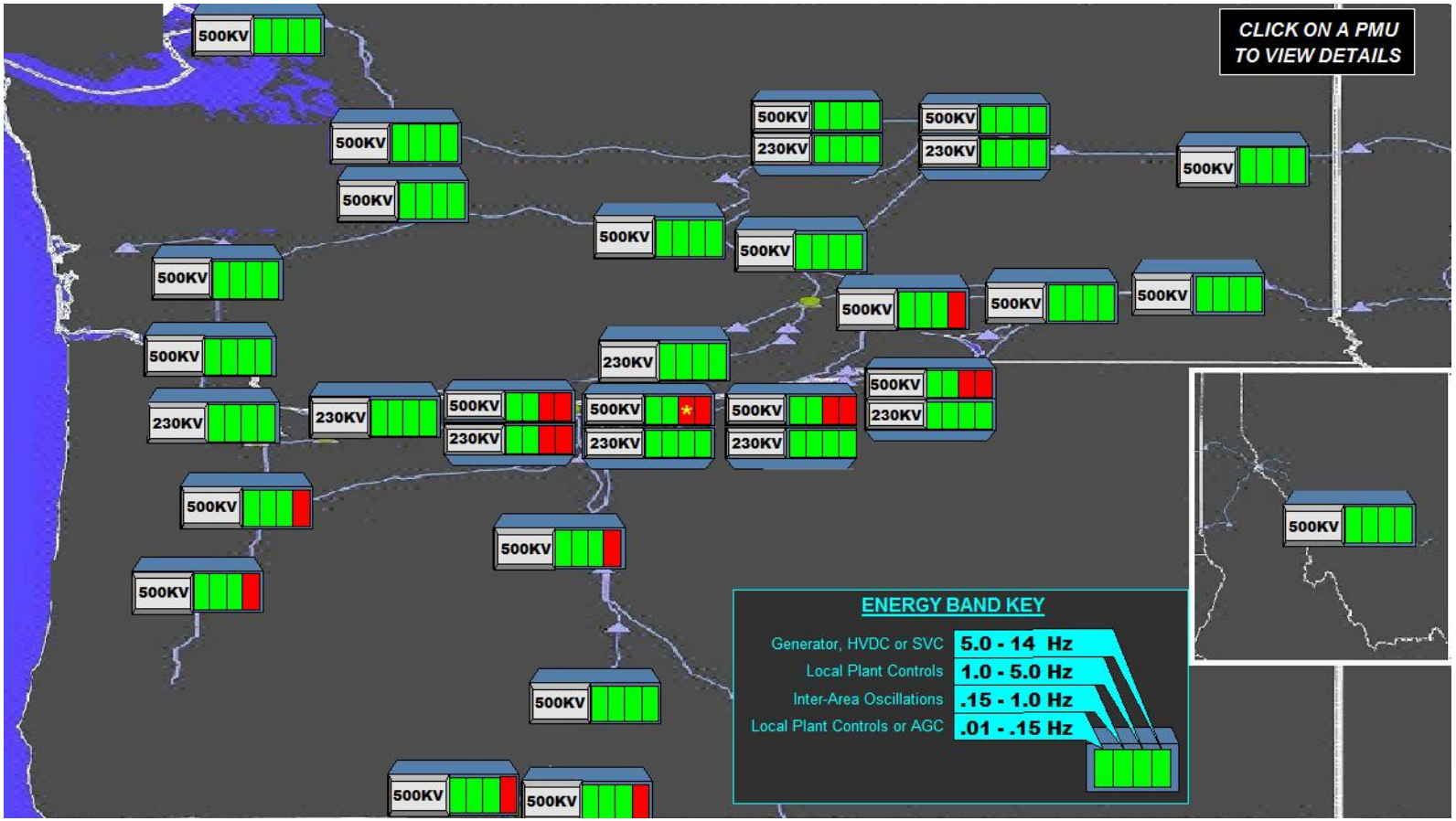




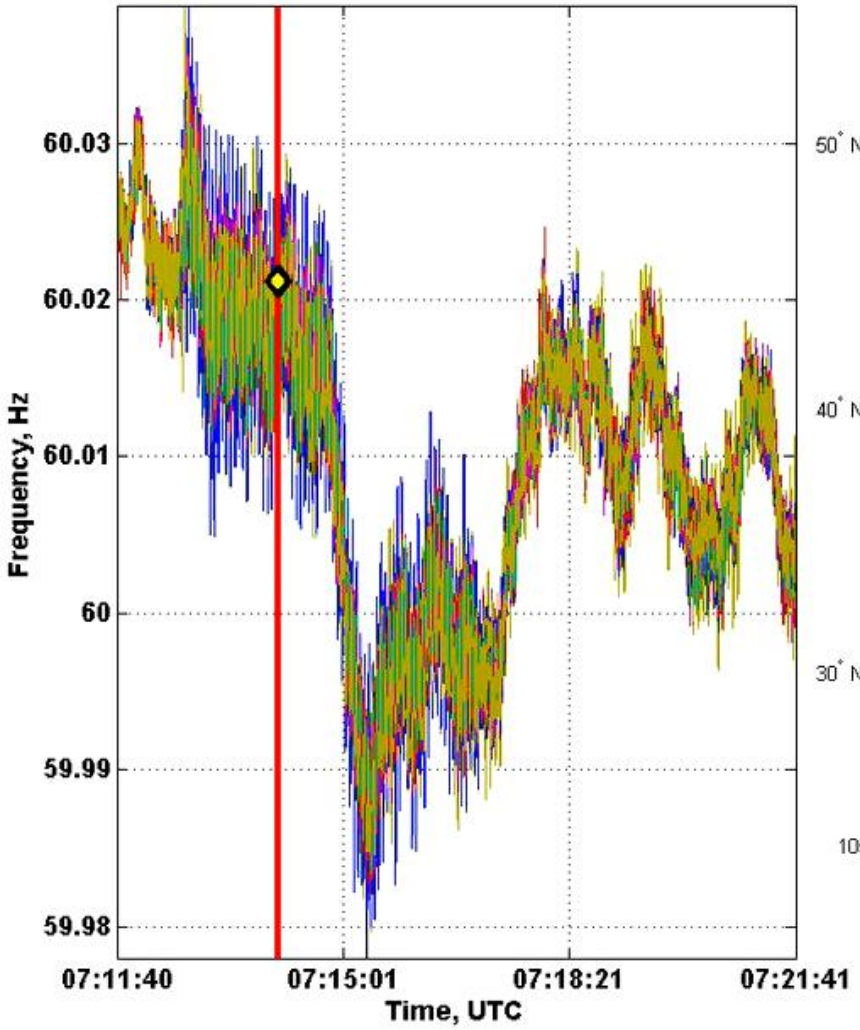
Localized Forced Oscillations

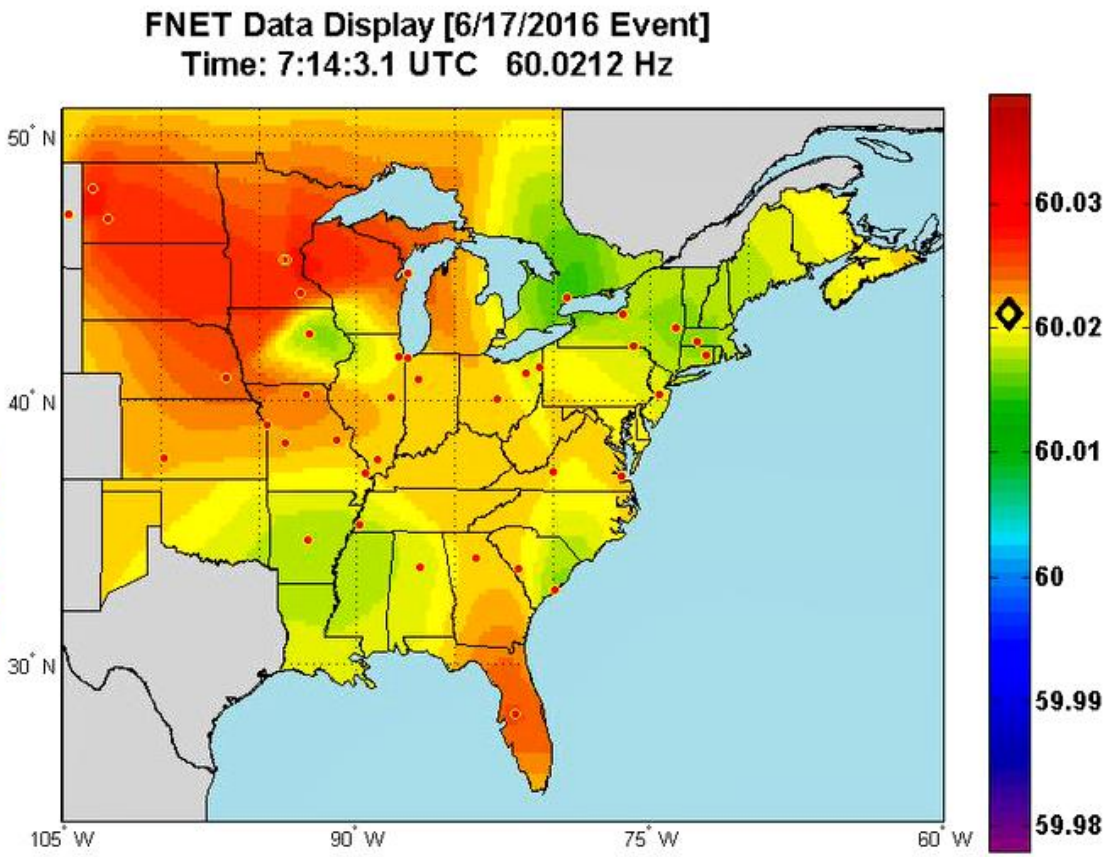


Regional Forced Oscillations



Wide-Area Forced Oscillations





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Real-World Scenario

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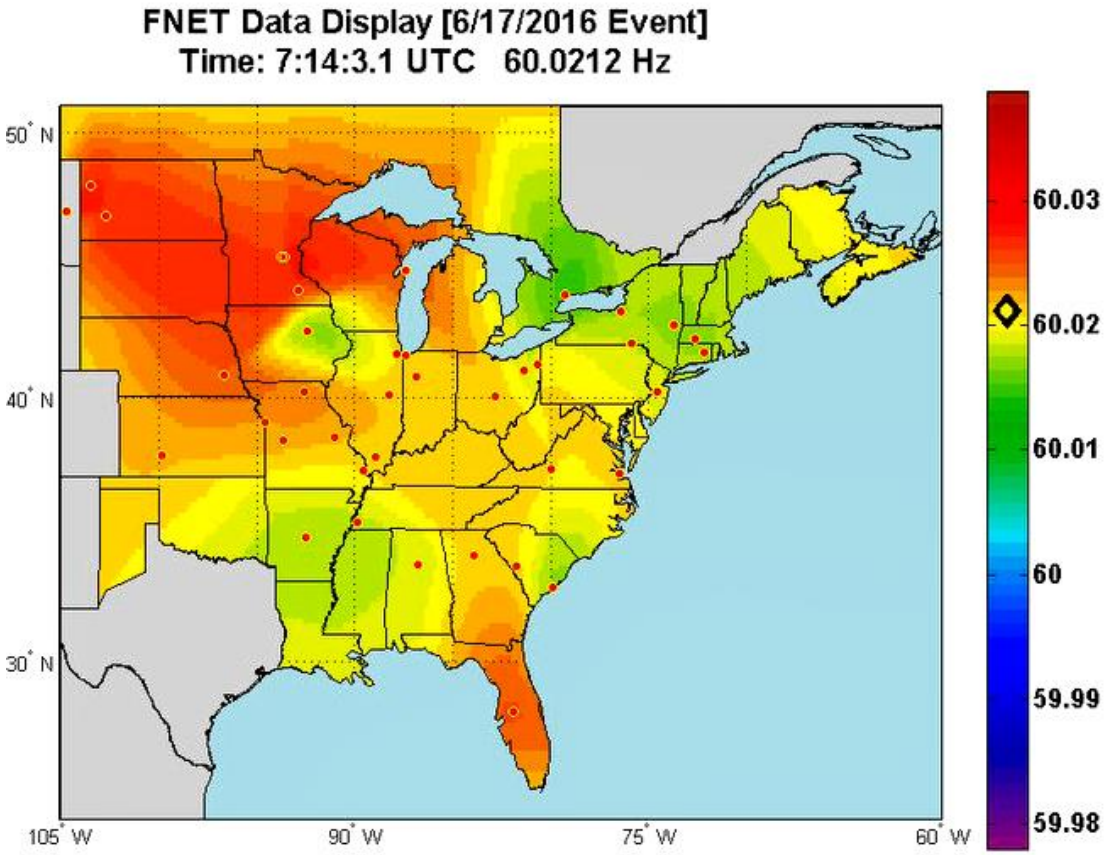
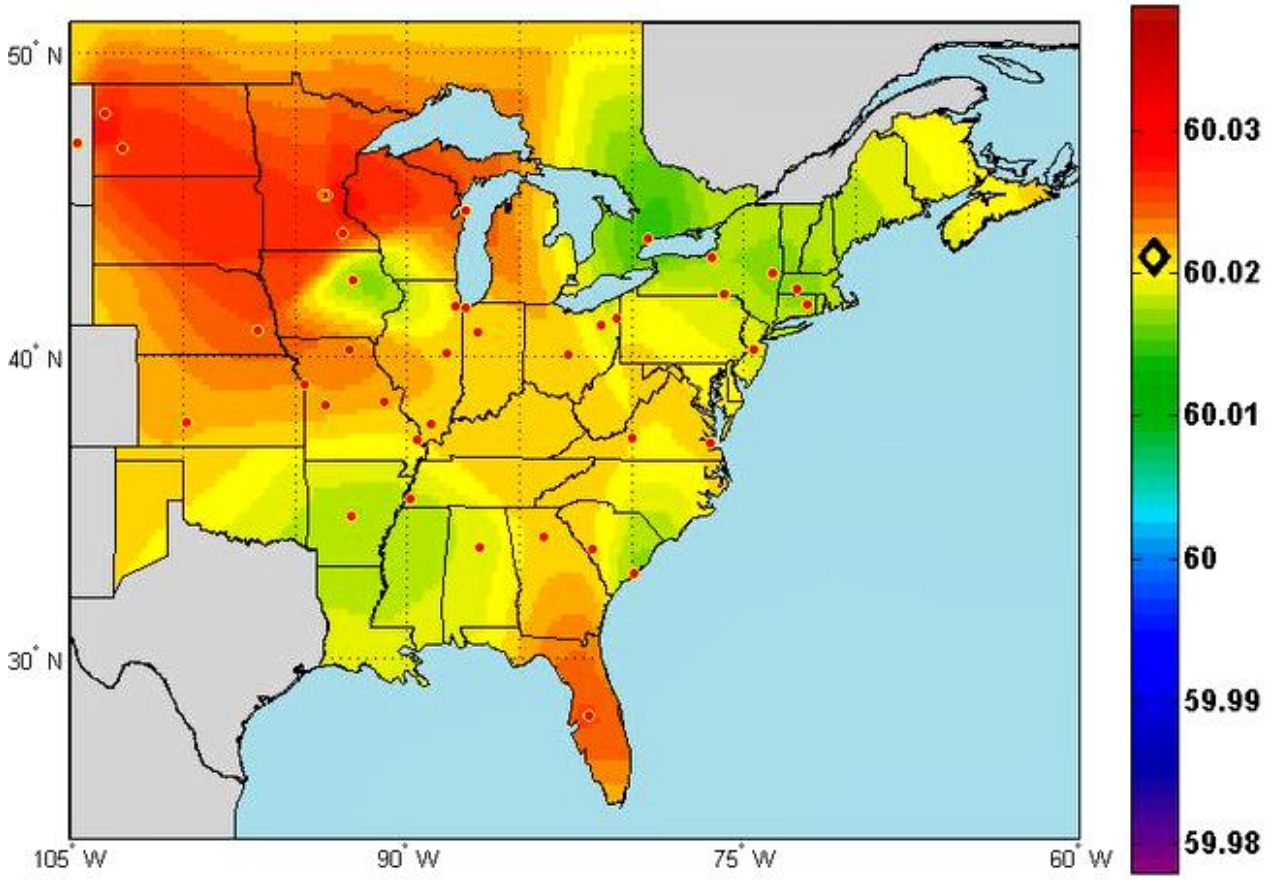


Operating Plans



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Questions and Answers

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