Deployment and Initial Experience with Oscillation Detection Application at Bonneville Power Administration

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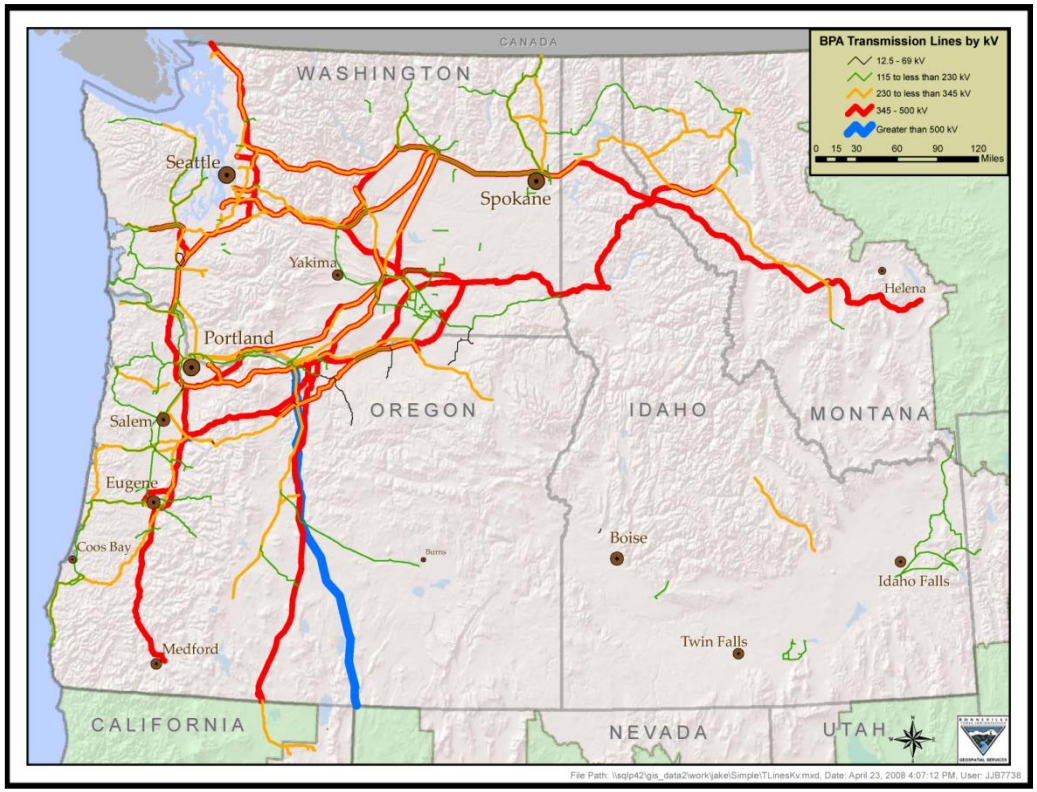
2016 IEEE Meeting

BPA Overview



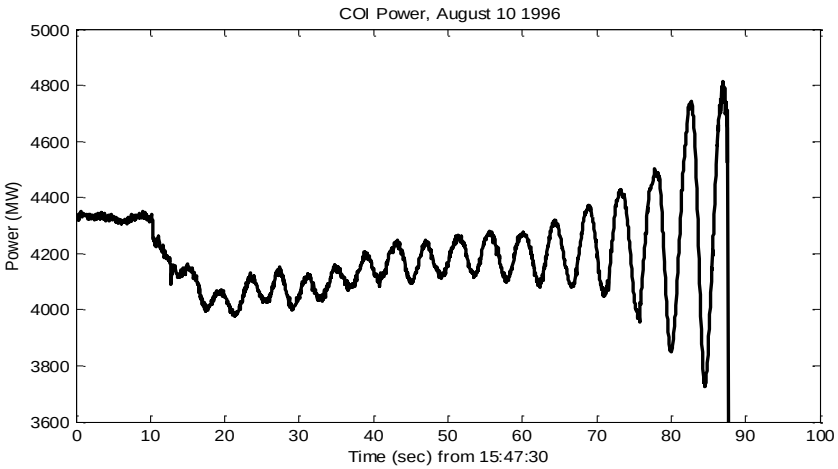
- Bonneville Power Administration (BPA) is a federal Power Marketing Agency in Pacific Northwest
- BPA markets power from 31 Federal dams and the Columbia Generating Station Nuclear Plant
- BPA operates more than 15,000 miles of transmission, including 4,735 miles of 500-kV lines

- BPA operates several large paths in the Western Interconnection – California Oregon AC Intertie (4,800 MW), Pacific HVDC Intertie (3,100 MW), Northern Intertie (3,100 MW), and Montana Intertie (2,200 MW)

History of Syncrophasors at BPA

- BPA has been one of the earliest adopters of synchrophasor technology since early 1990s

- BPA has greatly expanded PMU coverage and networking following 1996 outages



- BPA researched, prototyped and deployed several PMU applications for engineering analysis
- However, that PMU network was research-grade and was not reliable or secure for real-time control room applications

2010 Synchrophasor Investment Project

BPA initiated a capital investment project in 2010 to build a secure, reliable, control-grade synchrophasor network:

- 5-year, $35M project
- Part of DOE Smart Grid Program

- "Control" PMUs
  - Fully redundant architecture
  - 32 substations
  - 110 PMUs (55 redundant pairs)
- "Data" PMUs
  - 15 wind sites

- Total of 3,322 signals

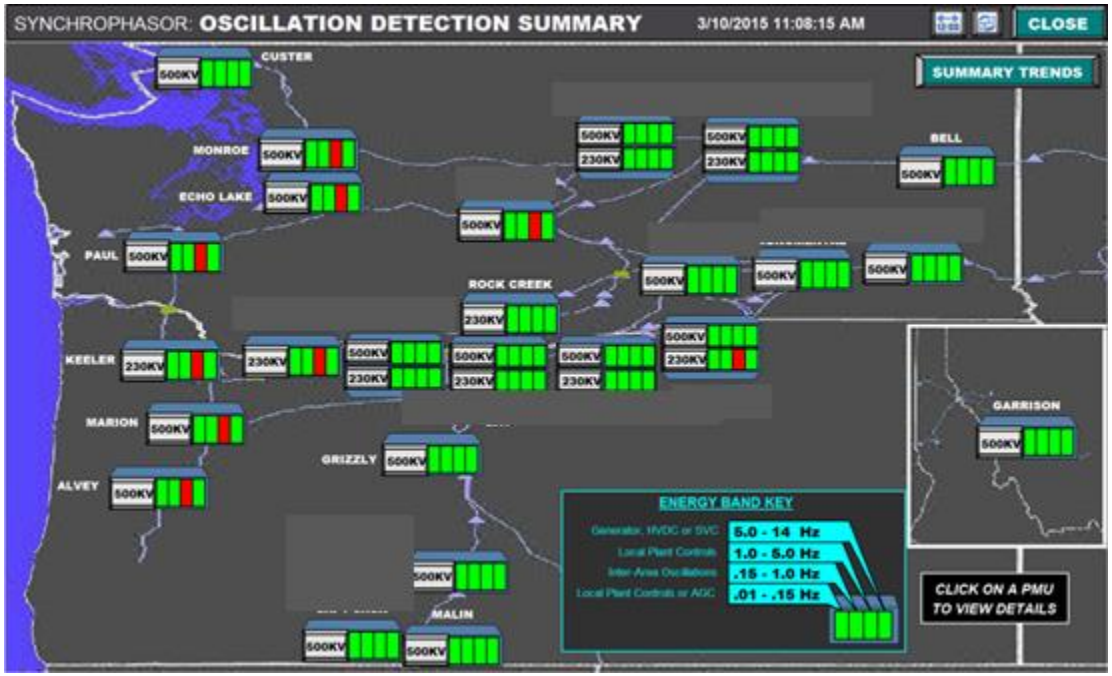
Platt's Global Energy Award

BPA synchrophasor investment project received 2013 Platt's Global Energy Award for Industry Leadership in Grid Optimization

BPA Oscillation Detection Application

Control Room: Oscillation Detection

BPA deployed Oscillation Detection in its control room in October 2013



Scans 100+ signals for signs of growing or sustained power oscillations

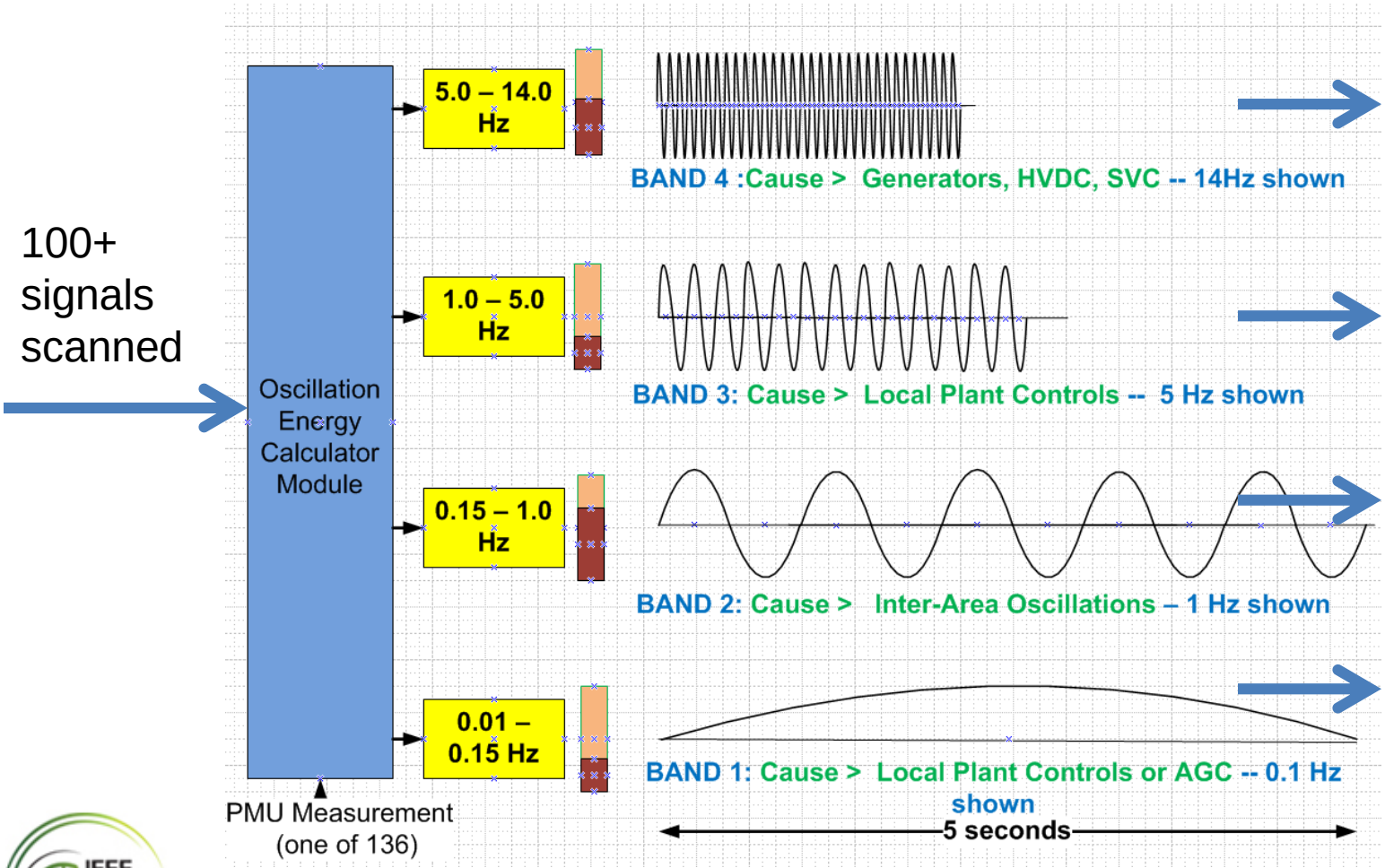
Alarms dispatchers when an oscillation is detected

Dispatcher training sessions are performed

Operating procedures are developed in 2016

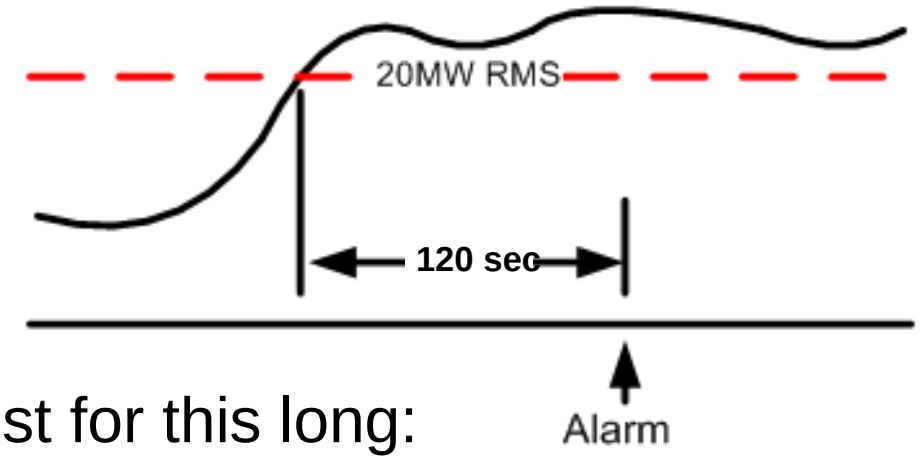
How are Oscillations detected?

The magnitude of the oscillation is calculated in 4 frequency bands



How alarm is generated

If the oscillation is strong enough, and lasts long enough then an alarm is issued



Must persist for this long:

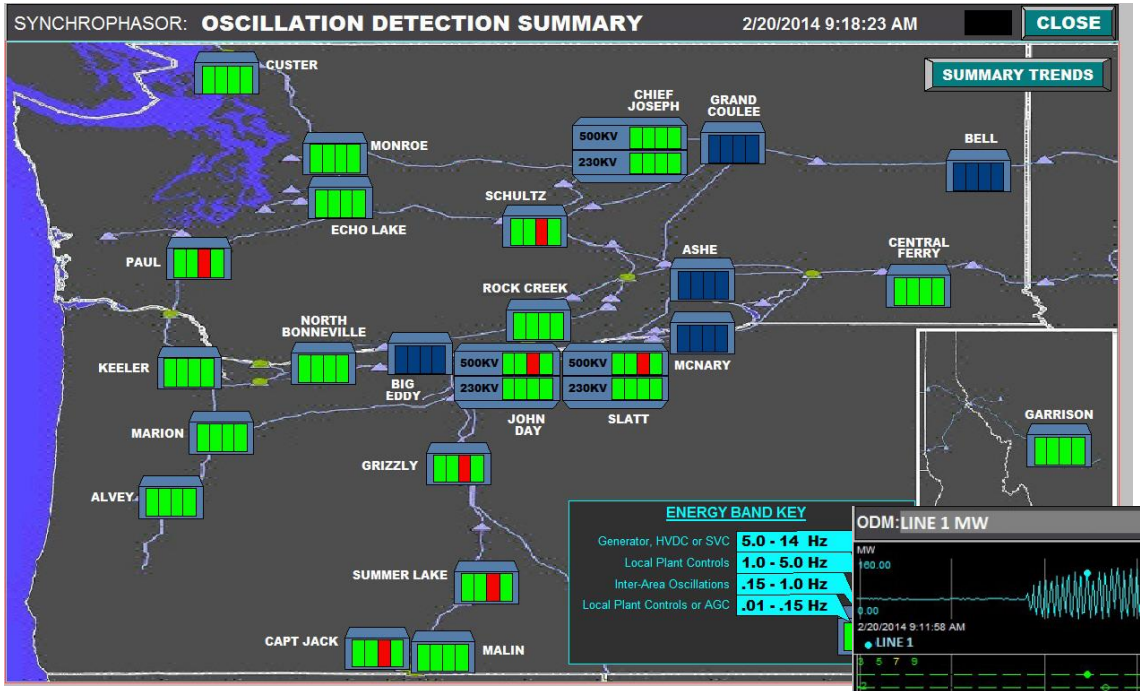
- Band 1 – (0.01- 0.15 Hz) >> 400 seconds
- Band 2 – (0.15 - 1.0 Hz) >> 120 seconds
- Band 3 – (1.0 - 5.0 Hz) >> 120 seconds
- Band 4 – (5.0 - 14.0 Hz) >> 120 seconds

Oscillation Detection Events

- Multiple events of oscillation are detected monthly
- Examples:
  - Generator control interactions
  - Wind generation oscillations
  - Bad operating point on a power plant
  - Pacific HVDC Intertie controls
  - Generator rotor angle oscillations
  - Etc

(a) Central Oregon Oscillation on February 20, 2014

Overview display



Detailed display

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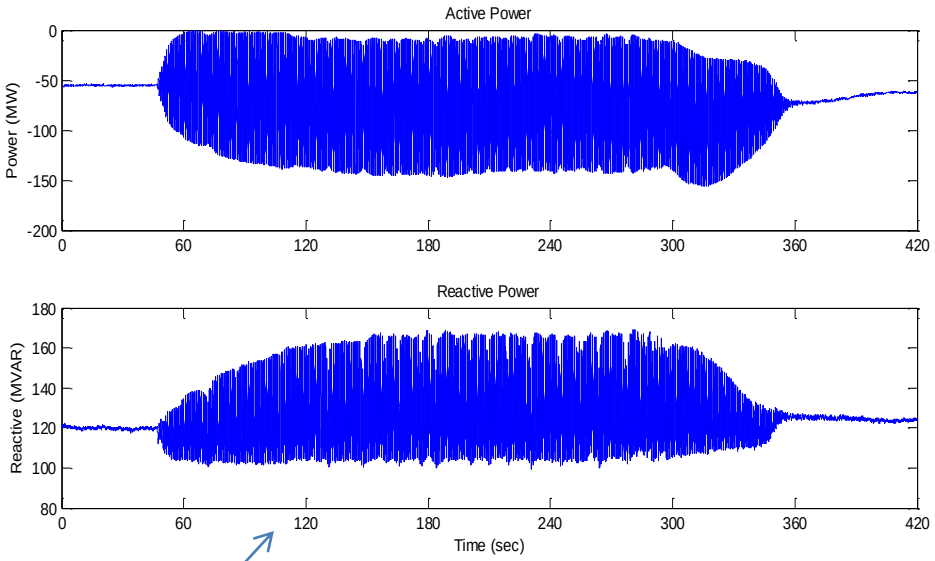
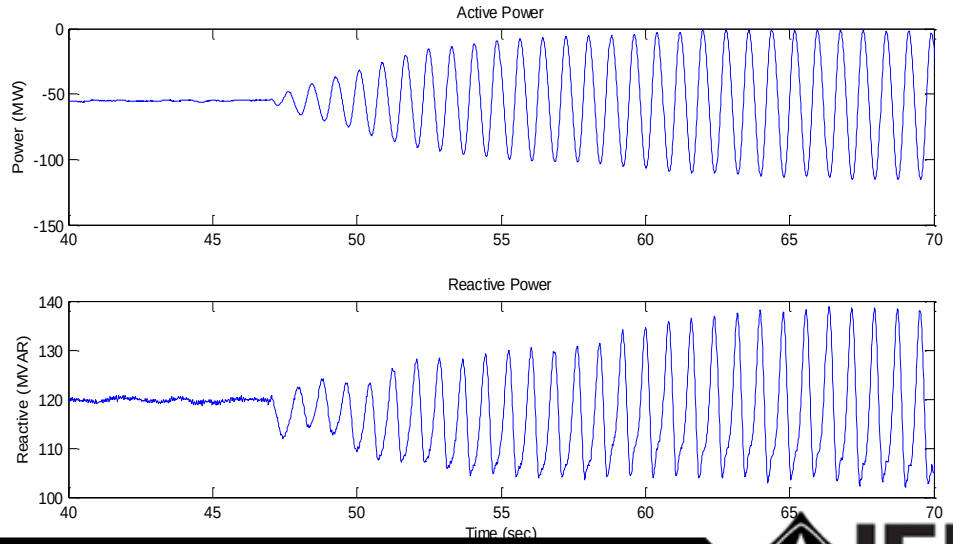
(a) Central Oregon Oscillation on February 20, 2014



CT failure resulted in plant developing a large power oscillations at 1.2 Hz frequency

7 minute plot



30-second plot

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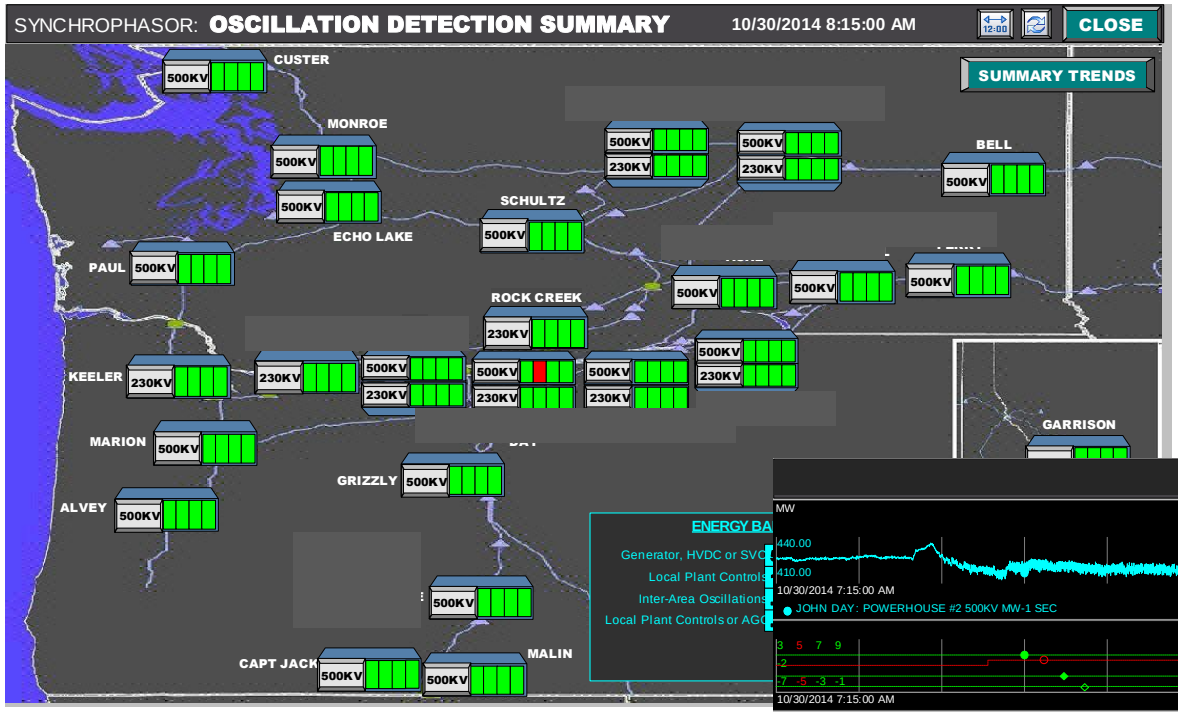
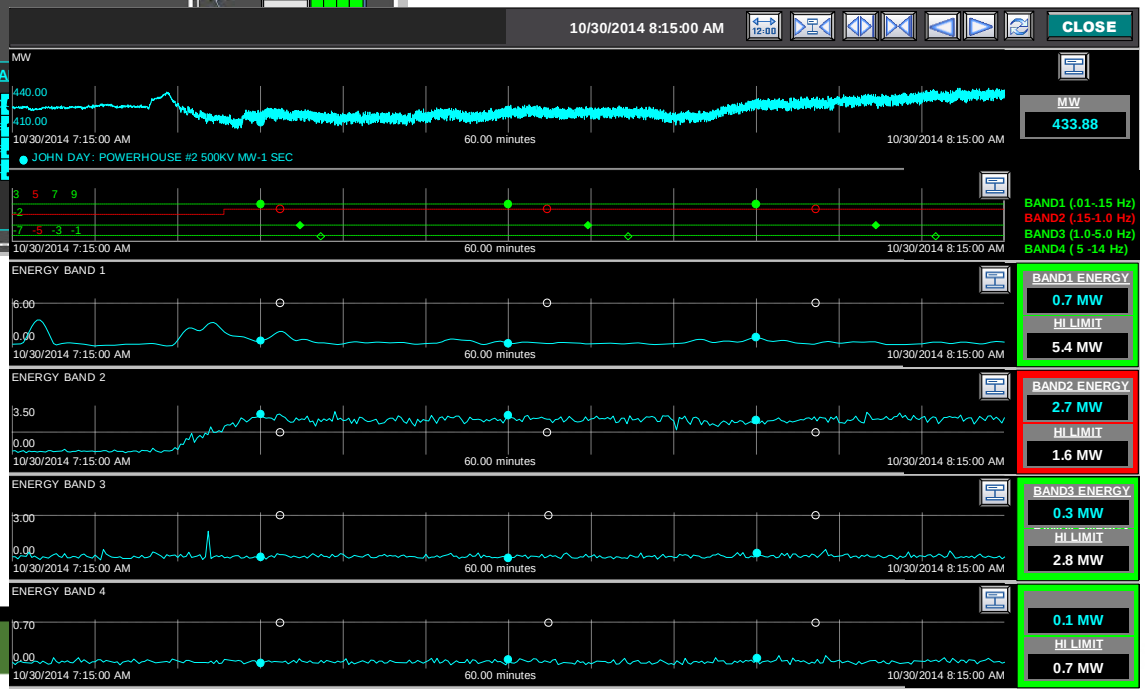
(b) Hydro Power Plant Oscillation

Overview Display





Oscillation Details

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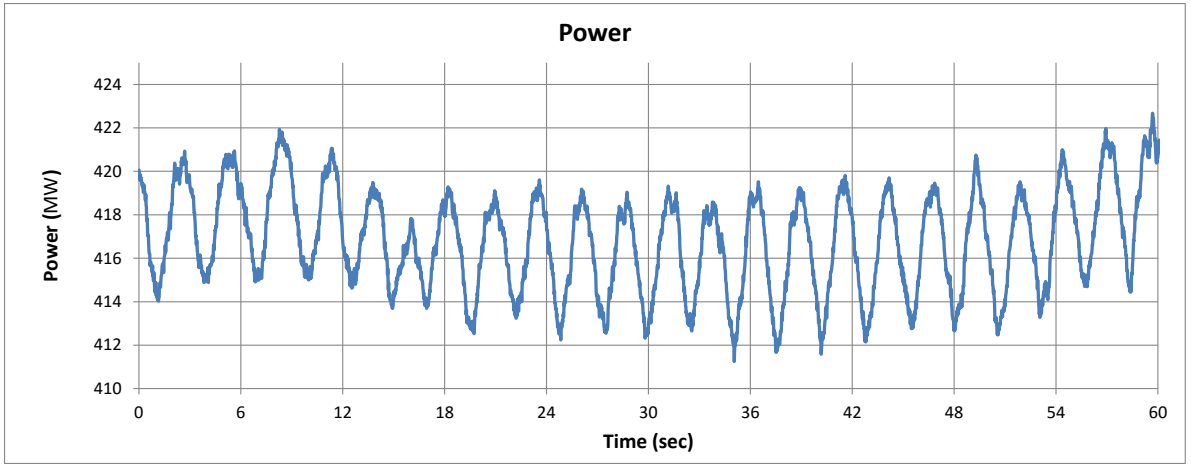
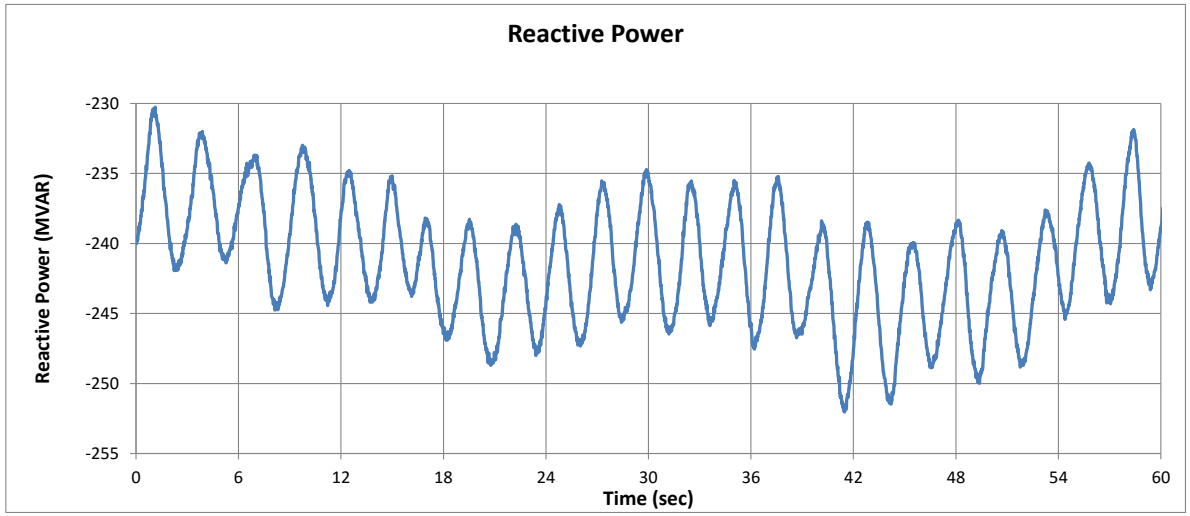
(b) Hydro Power Plant Oscillation



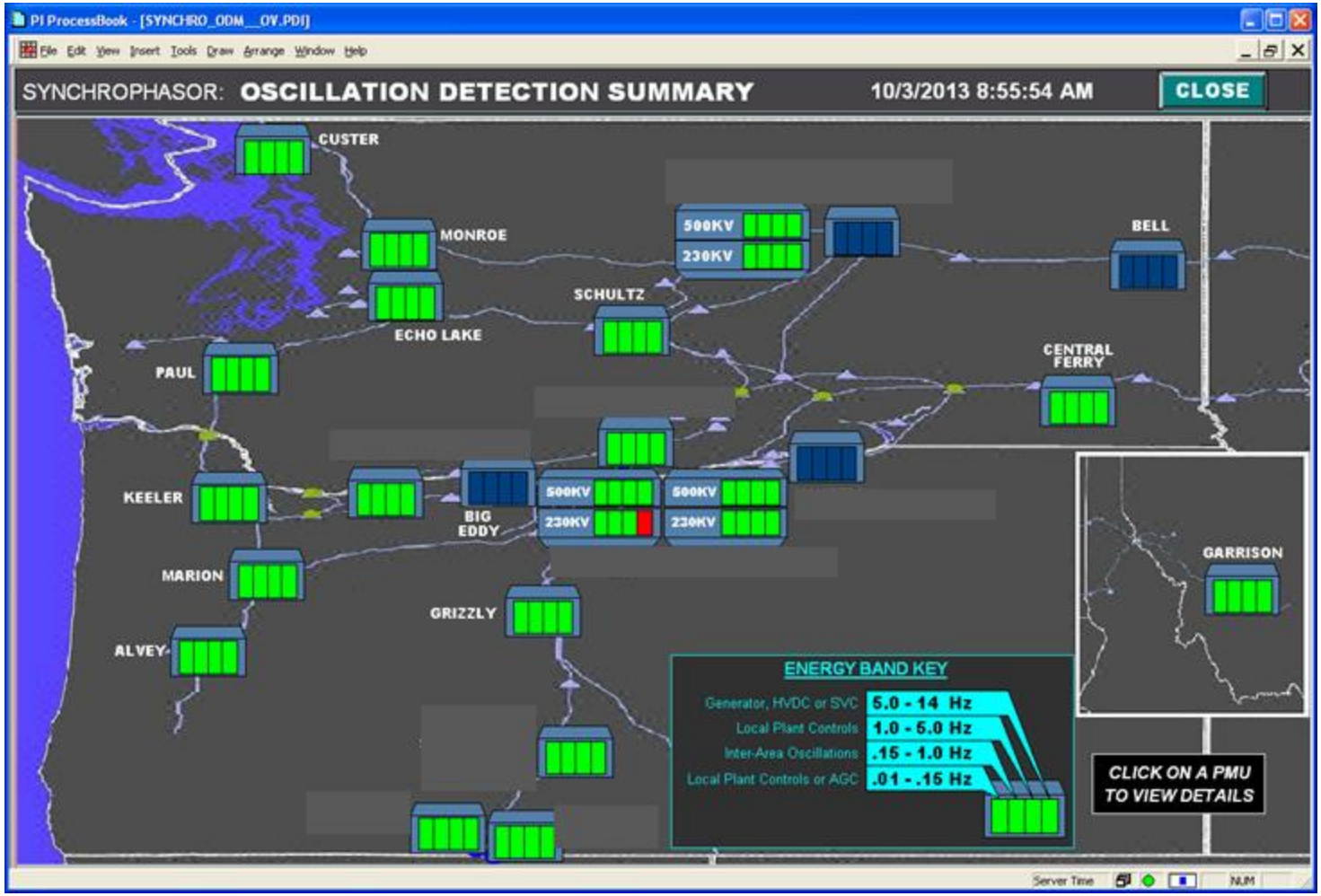


Period of oscillation is 3 seconds, oscillation frequency is 0.33 Hz, seen in both active and reactive power

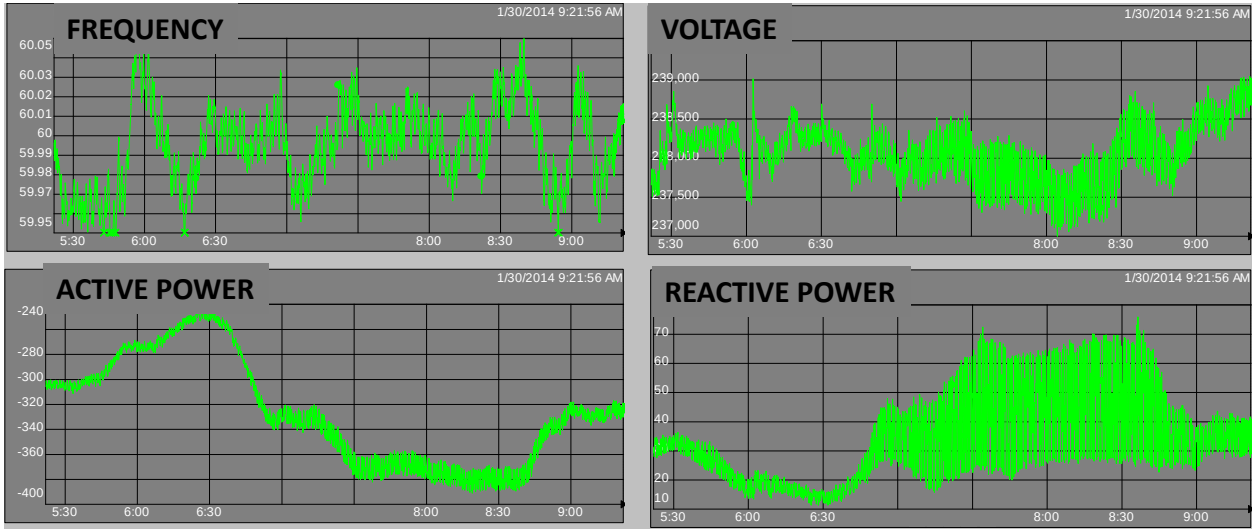
The oscillation is caused by a surging water vortex in one of the turbines operating at a partial load

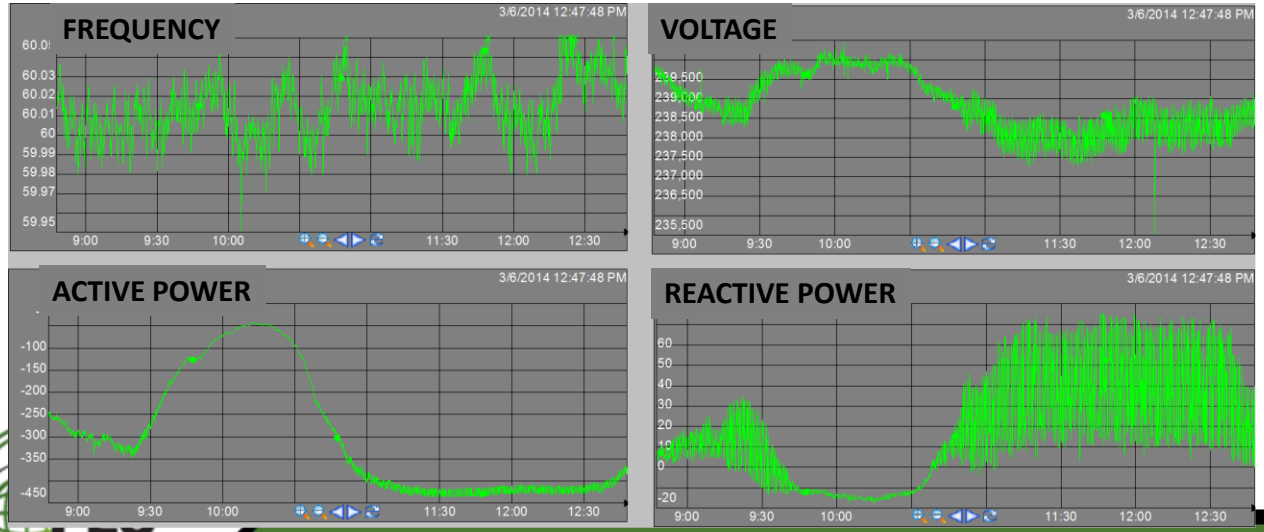
Plant was re-dispatched to a stable operating point

(c) Wind Power Oscillation



(c) Wind Power Oscillations





Oscillation is at 14 Hz, most visible in reactive power, indication of voltage control issues

Oscillations reached 80 MVAR peak to peak

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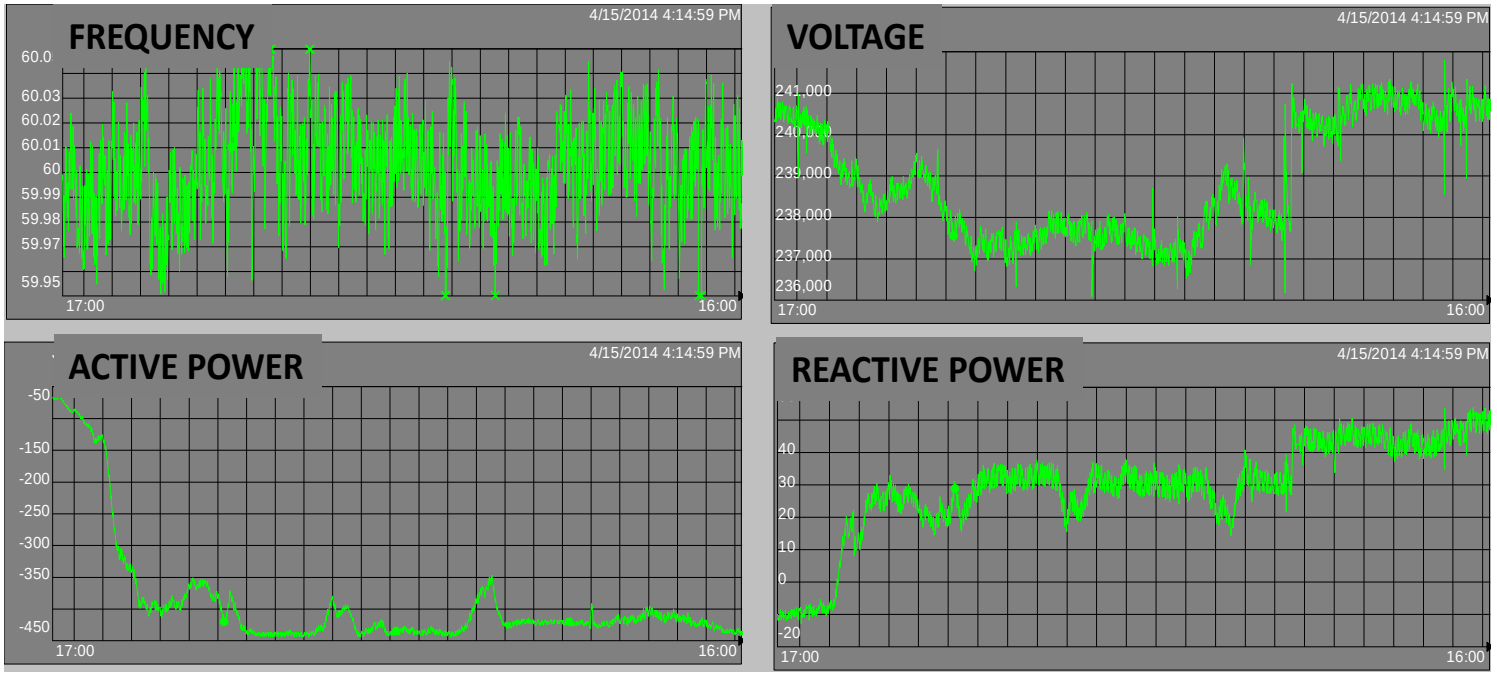
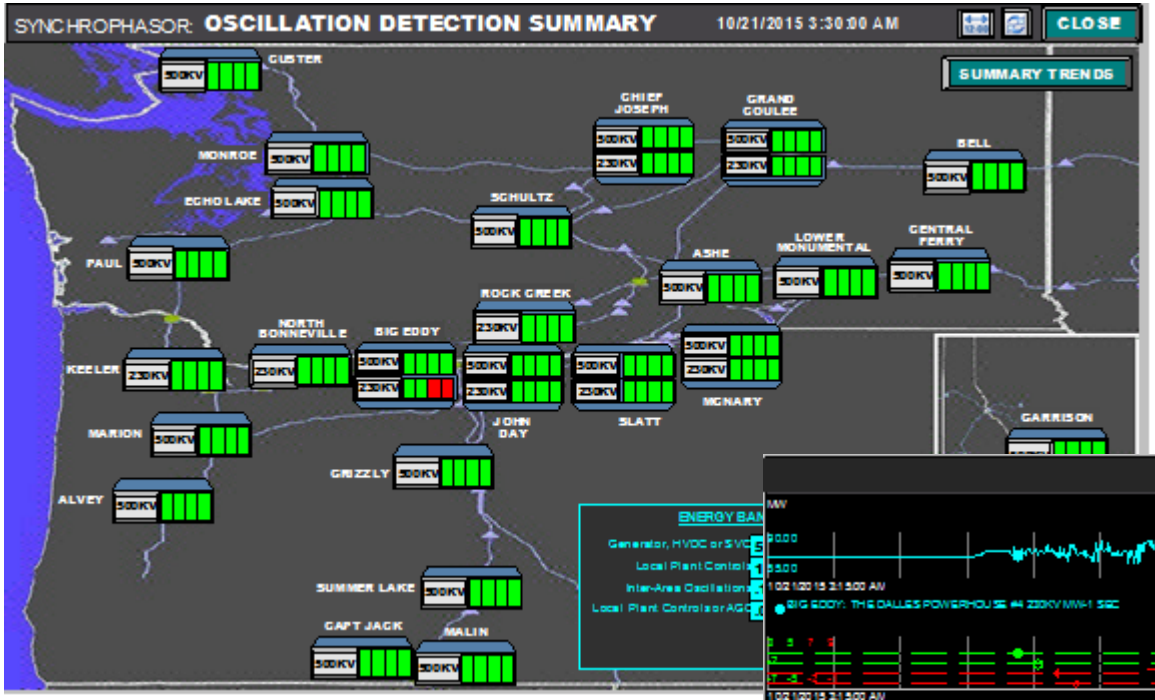
(c) Wind Power Oscillations

Manufacturer upgraded the controls in April 2014 to fix the oscillation problem



(d) Hydro Plant Control Interaction

Overview Display



Oscillation Details

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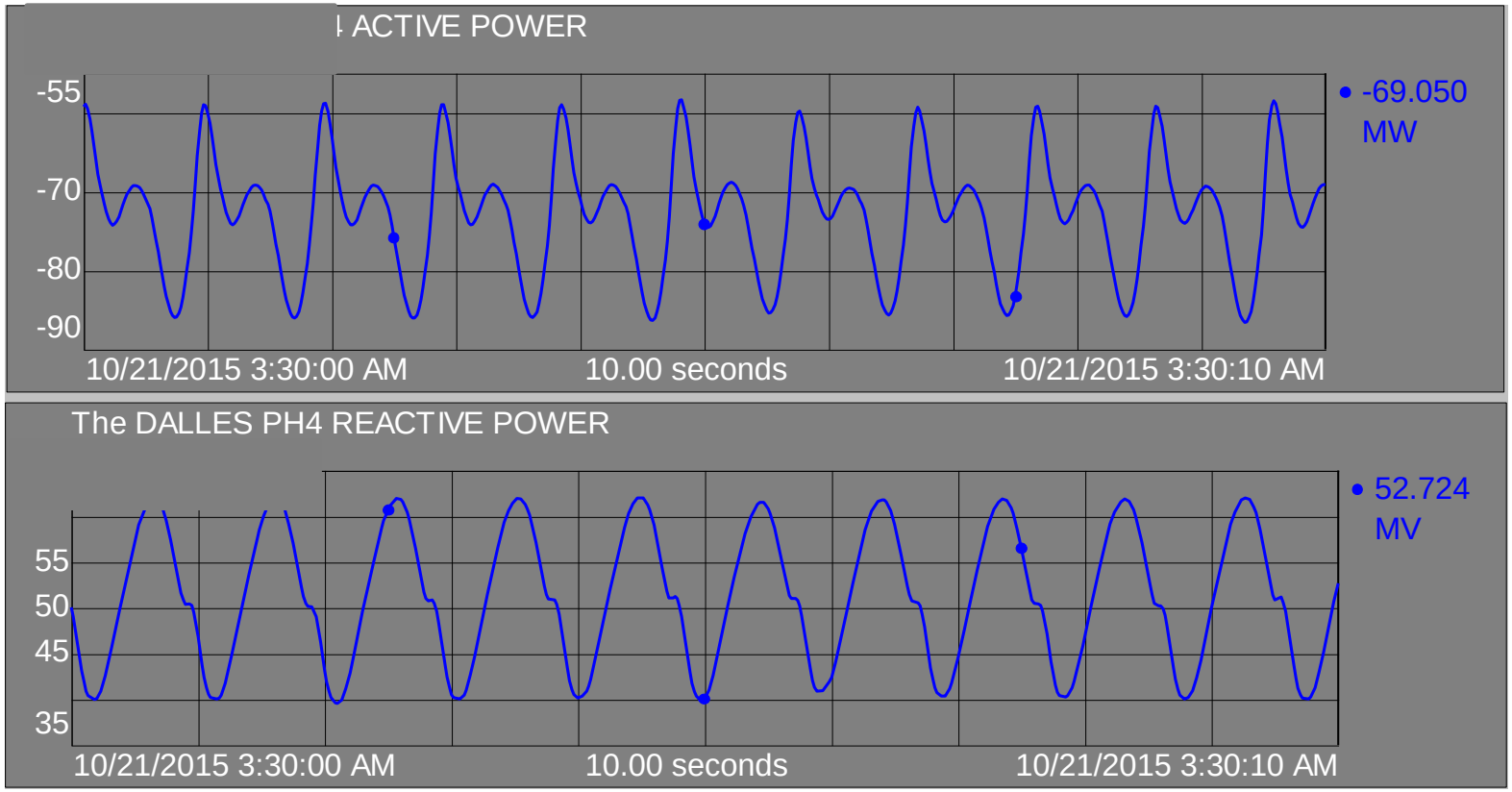
(d) Hydro Plant Control Interaction



Oscillation is caused by interactions between generator UEL and PSS

UEL was retuned in January 2016

Success Story

- BPA successfully deployed Oscillation Detection Module (ODM) in its control room
- ODM is developed by Dan Trudnowski at MTU
- ODM scans for 100+ signals for sustained high energy oscillations
- ODM was implemented in 2013, and displays have been in the control rooms since October 2013 – log alarm only
- Several dispatcher training sessions have been performed
- Dispatchers took actions based on ODM results
- Operating procedures are developed, in effect June 1, 2016
- Several control improvements are implemented, including UEL tuning at a hydro-power plant and control firmware upgrades at a wind power plant