Synchrophasor based Oscillation Detection at Bonneville Power Administration

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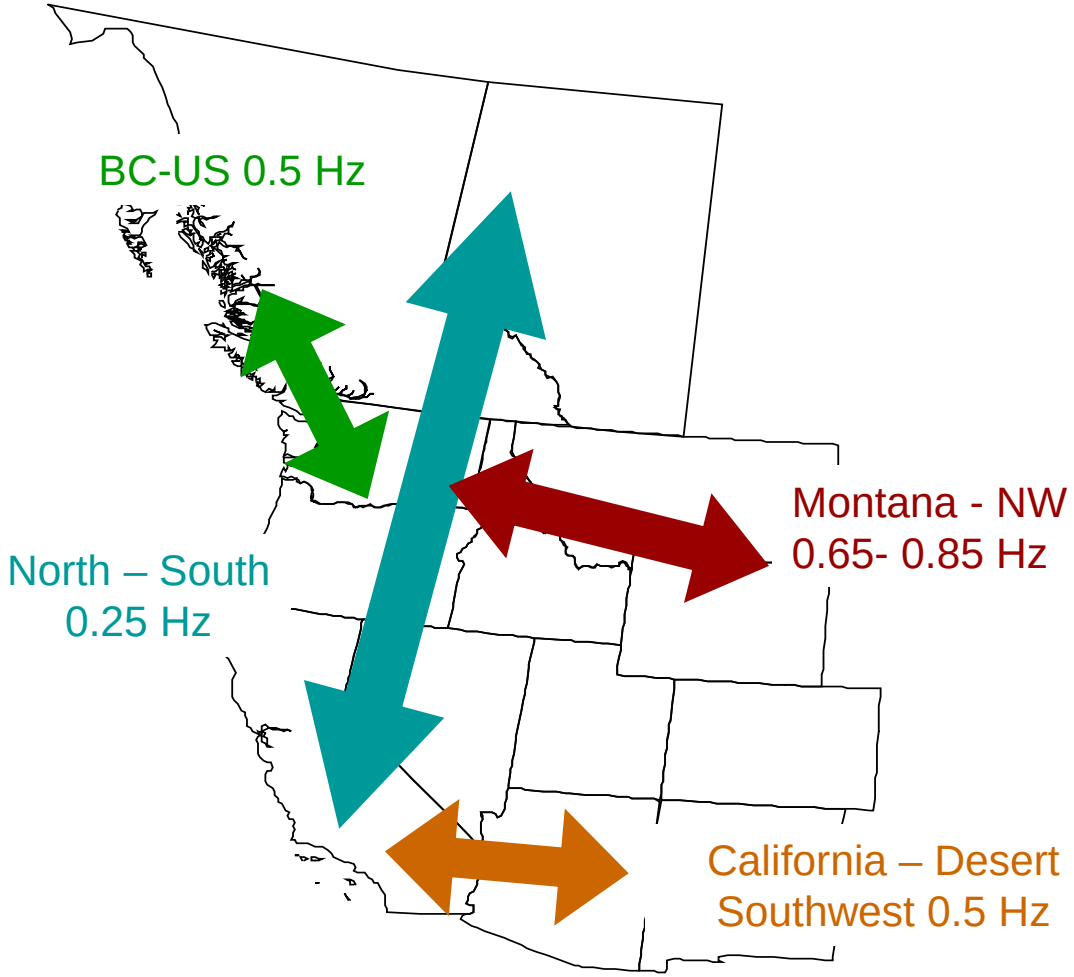
Presenting

- What is a power system oscillation
- The method used to detect oscillations
- How oscillations are presented to the dispatchers
- How the BPA Synchrophasor system detects oscillations

What is a Power System Oscillation?

- Low frequency cyclical change in the Voltage or Current
- Can detect oscillations from 0.01 Hz to 14 Hz. So 100 seconds to 70ms period
- Oscillations always there at a low level
- Excessive oscillations are problem, so we calculate the oscillation energy and alarm if it goes over a limit and persists

What causes Power system Oscillation?
Inter-Area Oscillations



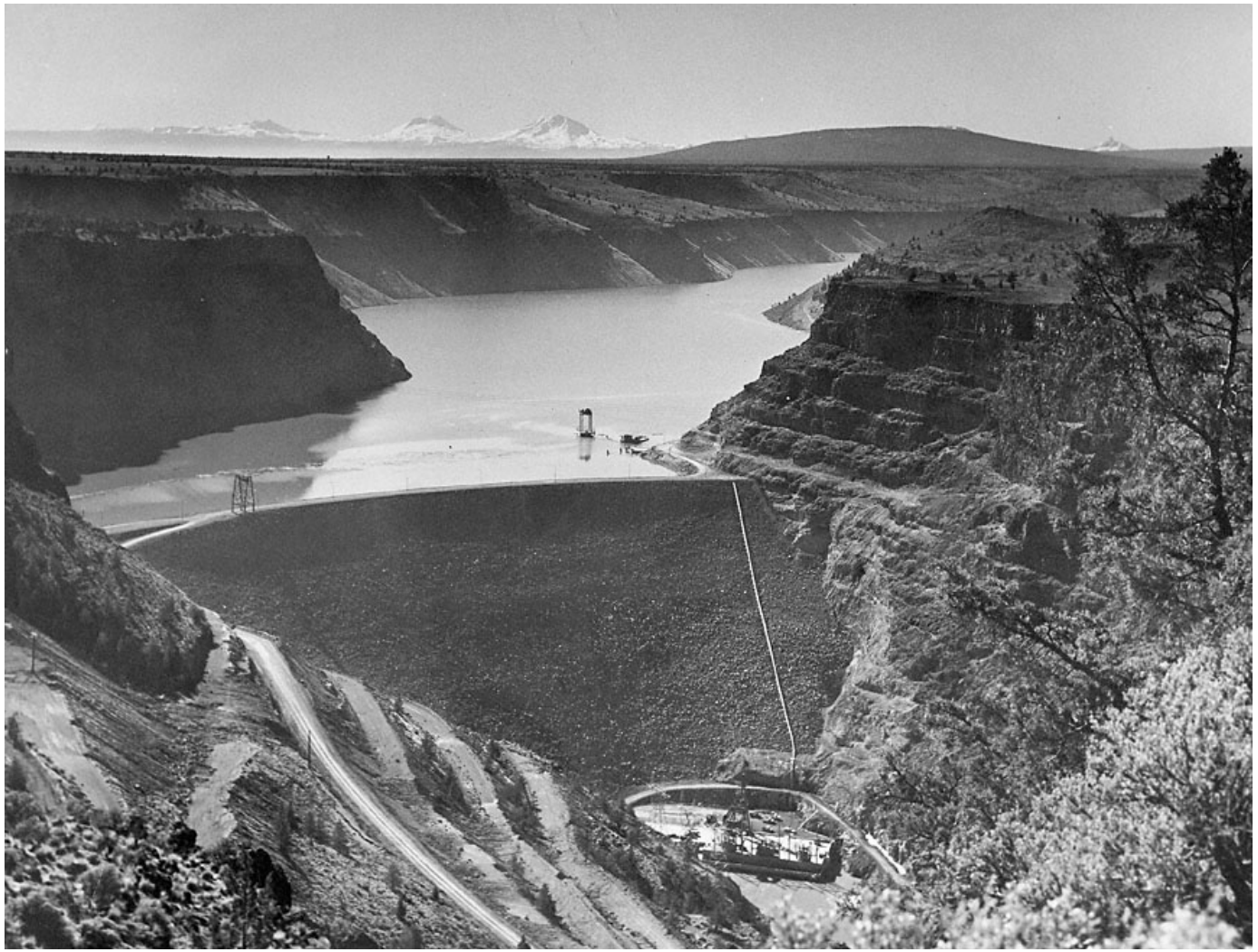
North – South

Montana – NW

BC – US

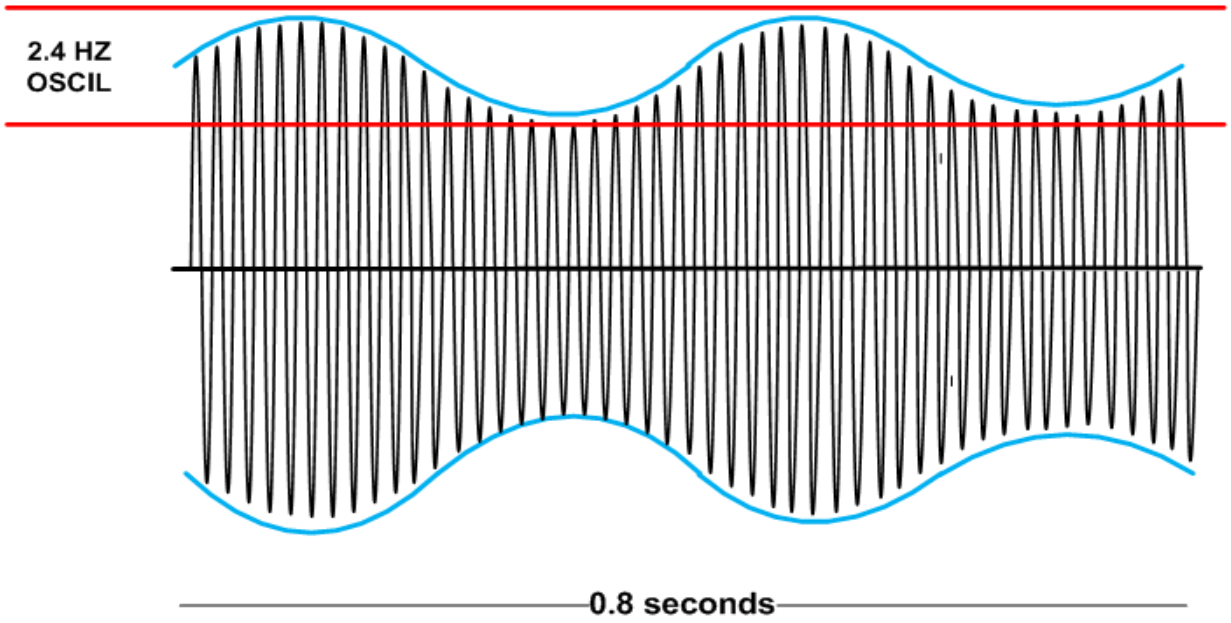
California - DSW

Generation site problems can also cause “Local” Oscillations



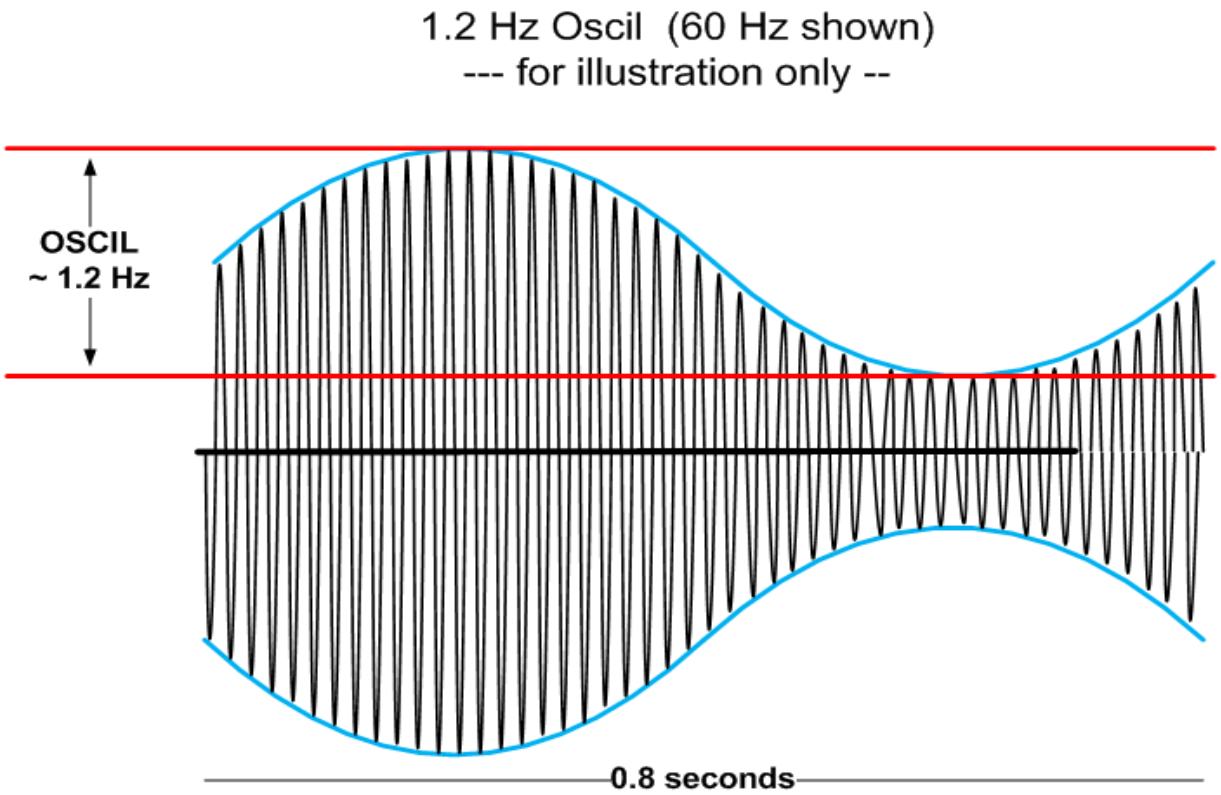
Example of a 2.4 Hz of Oscil

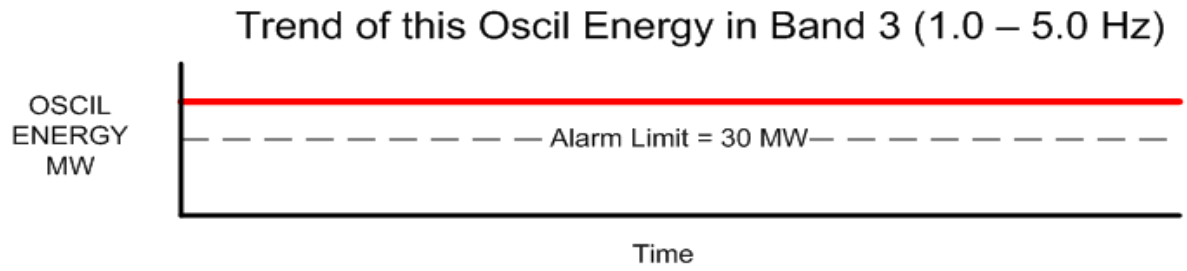
2.4 Hz Oscil (60 HZ shown)
--- for illustration only --



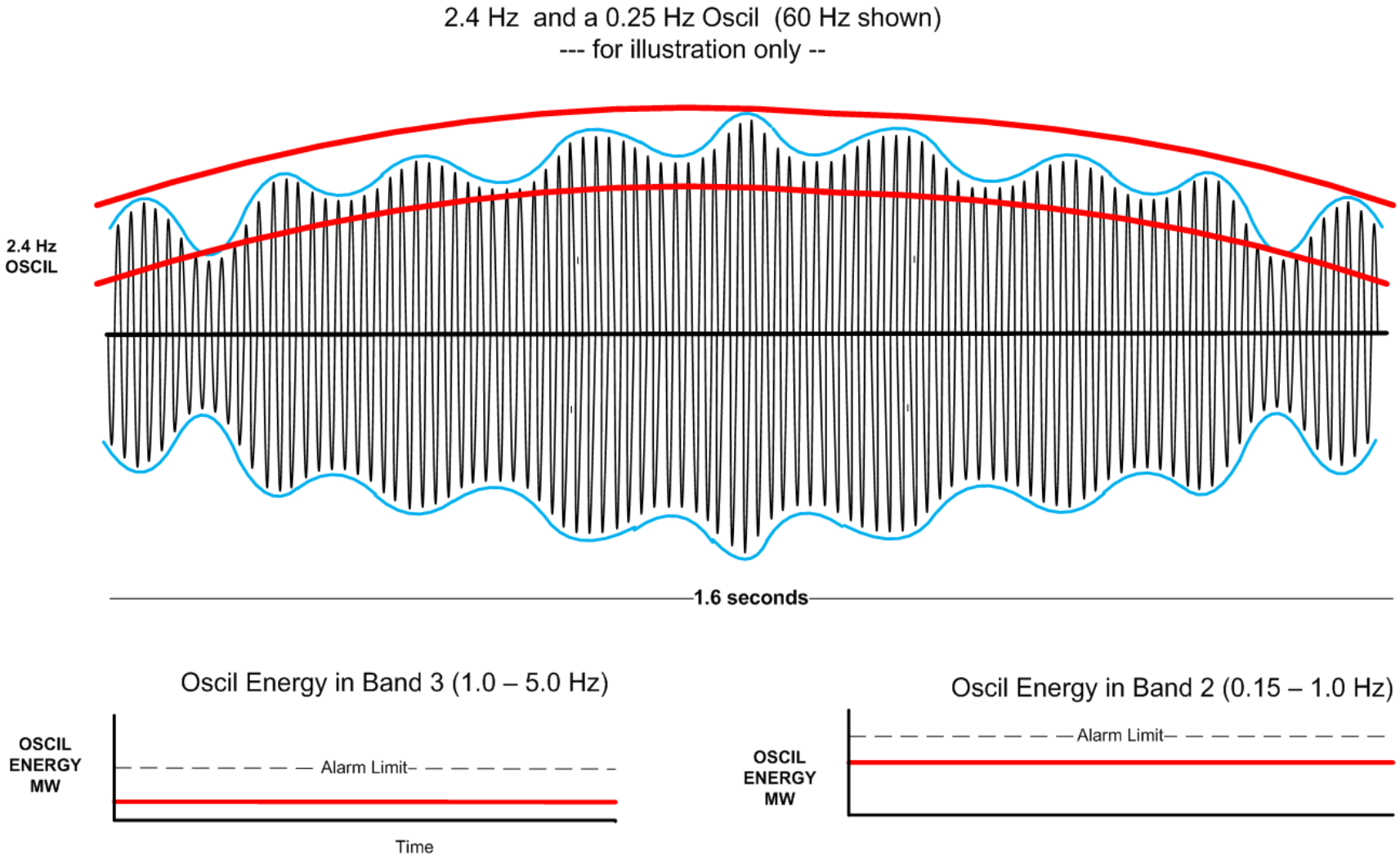
Trend of this Oscil Energy in Band 3 (1.0 – 5.0 Hz)

Example of a 1.2 Hz Higher Magnitude Oscillation

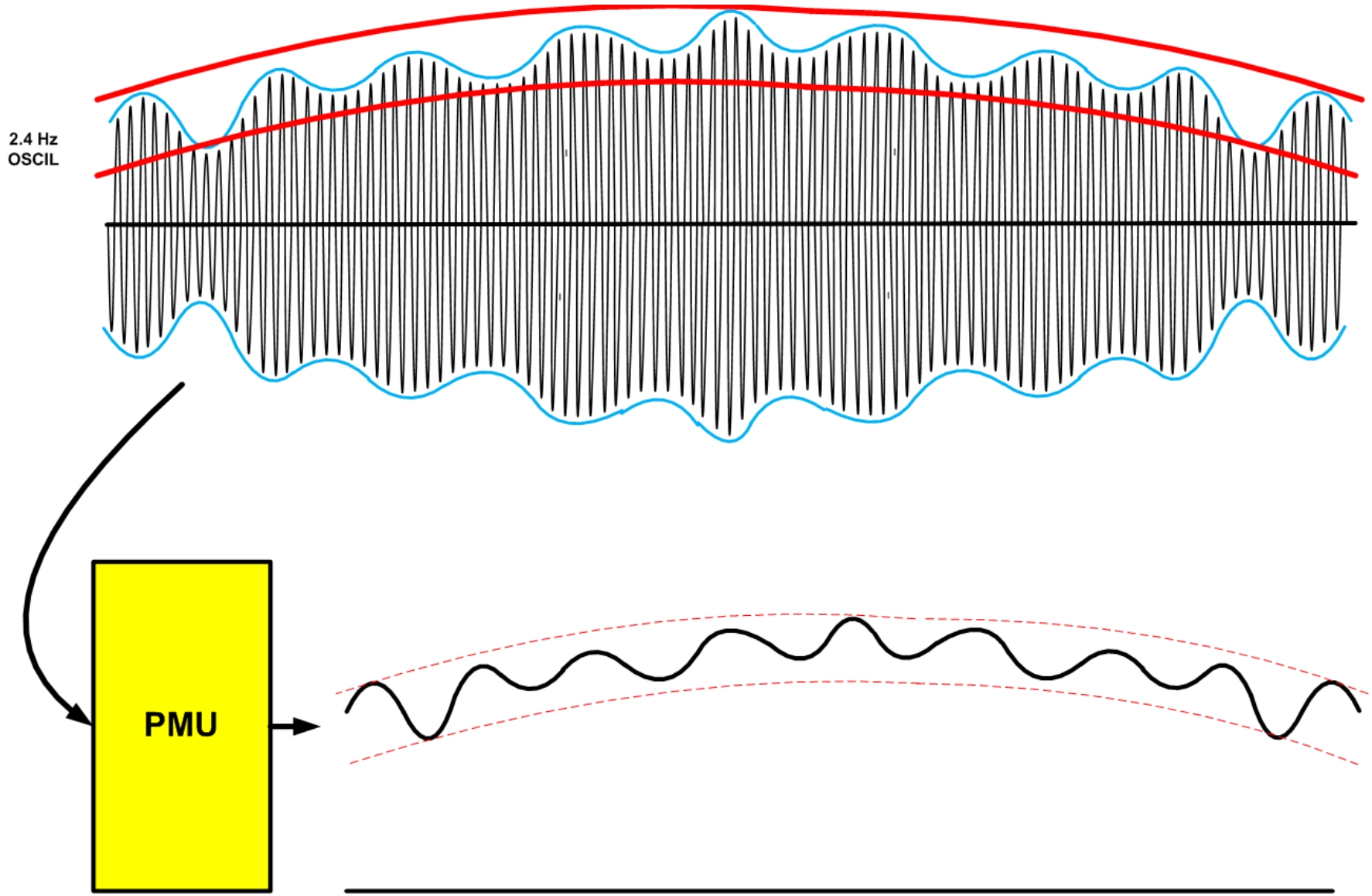




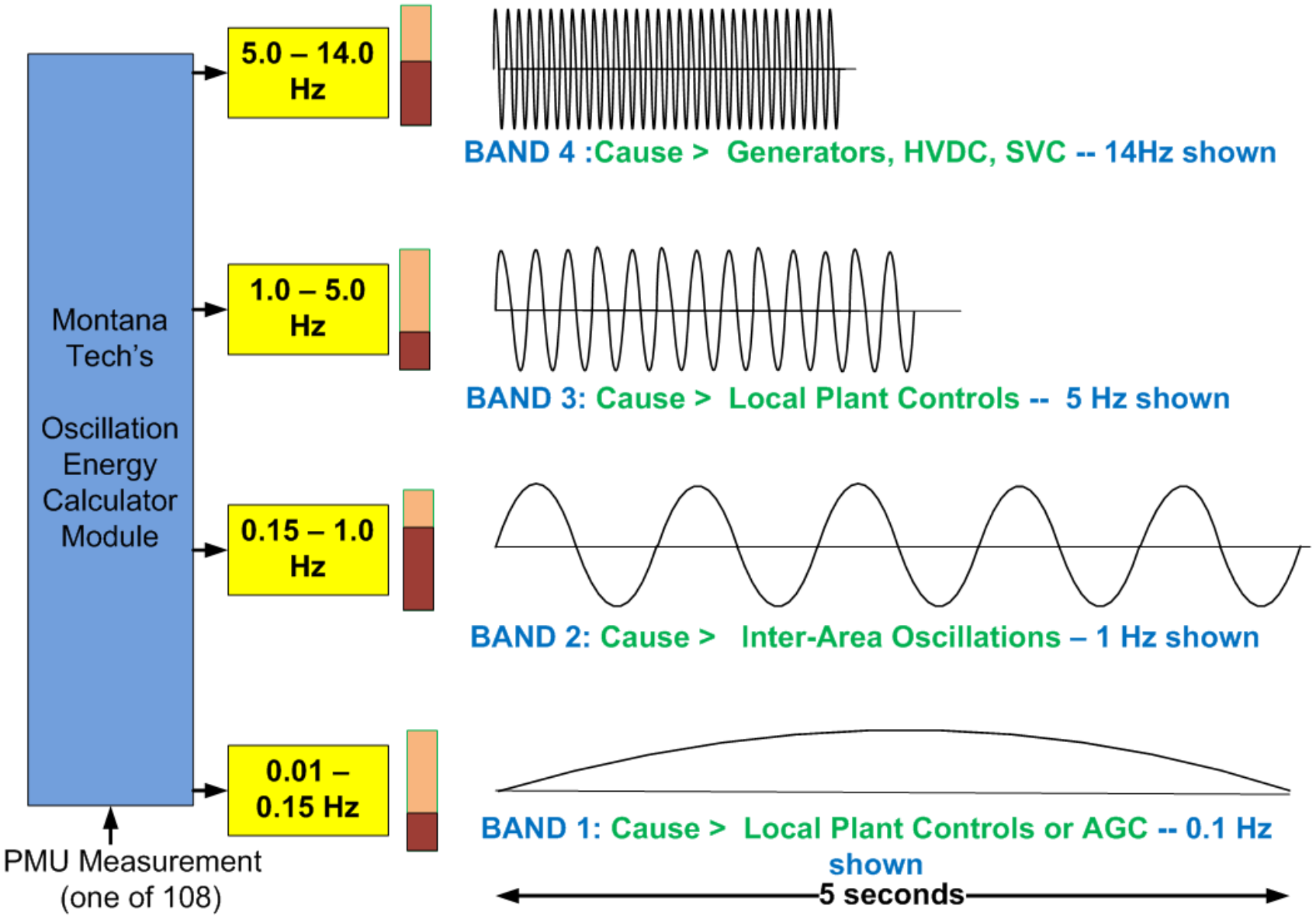
Closer to reality. Multiple Oscillations



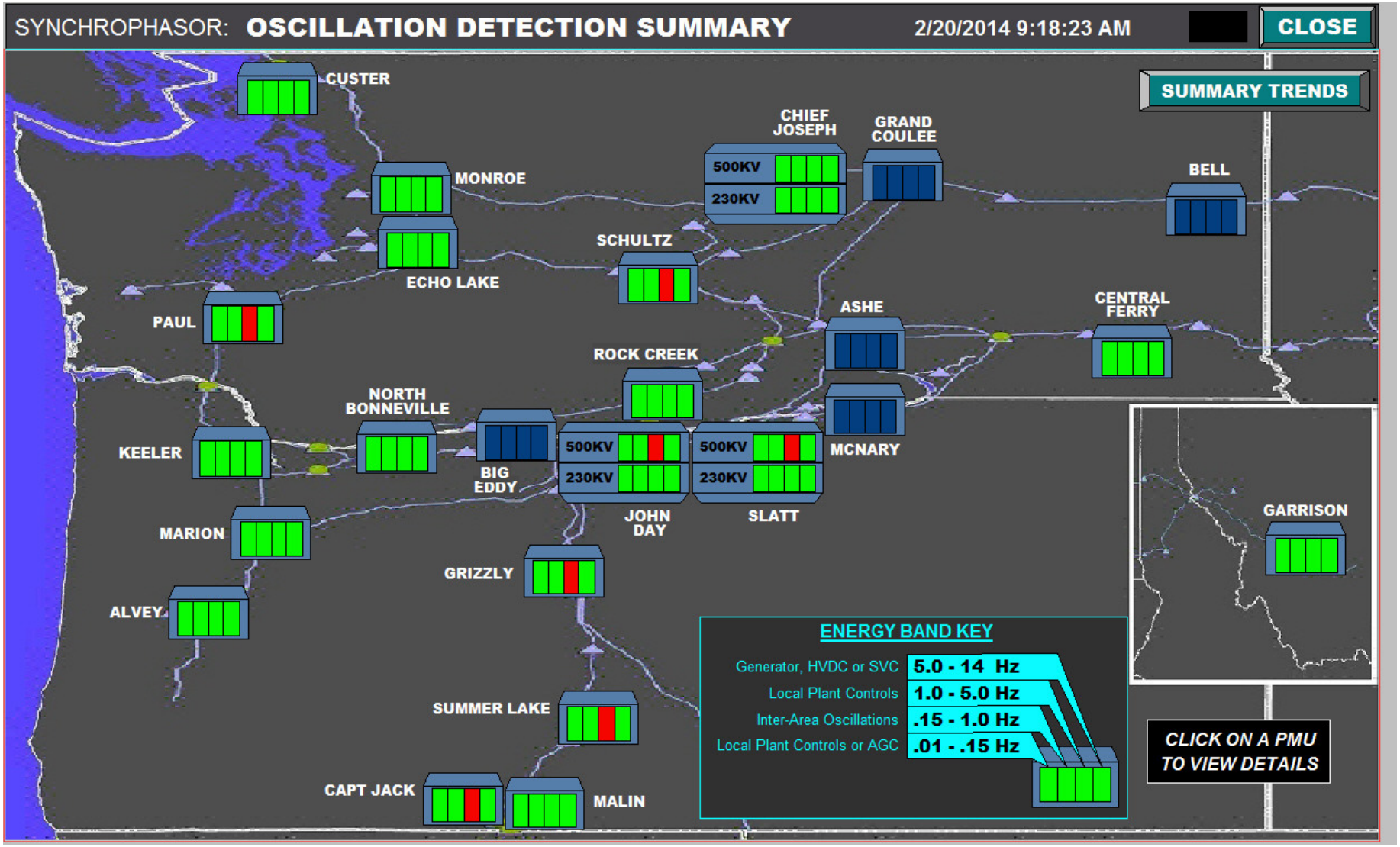
PMU removes 60 Hz



Montana Tech's ODM Calculates Oscillation Energy in 4 freq bands every 5 seconds

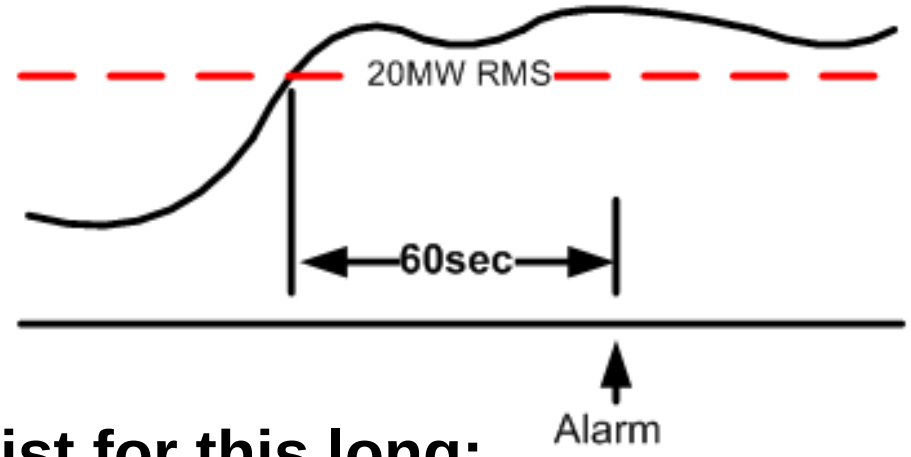


Dispatchers View of a Detected Oscillation



When should Dispatcher be notified?

Oscil Energy goes over a limit and stays there



Must persist for this long:

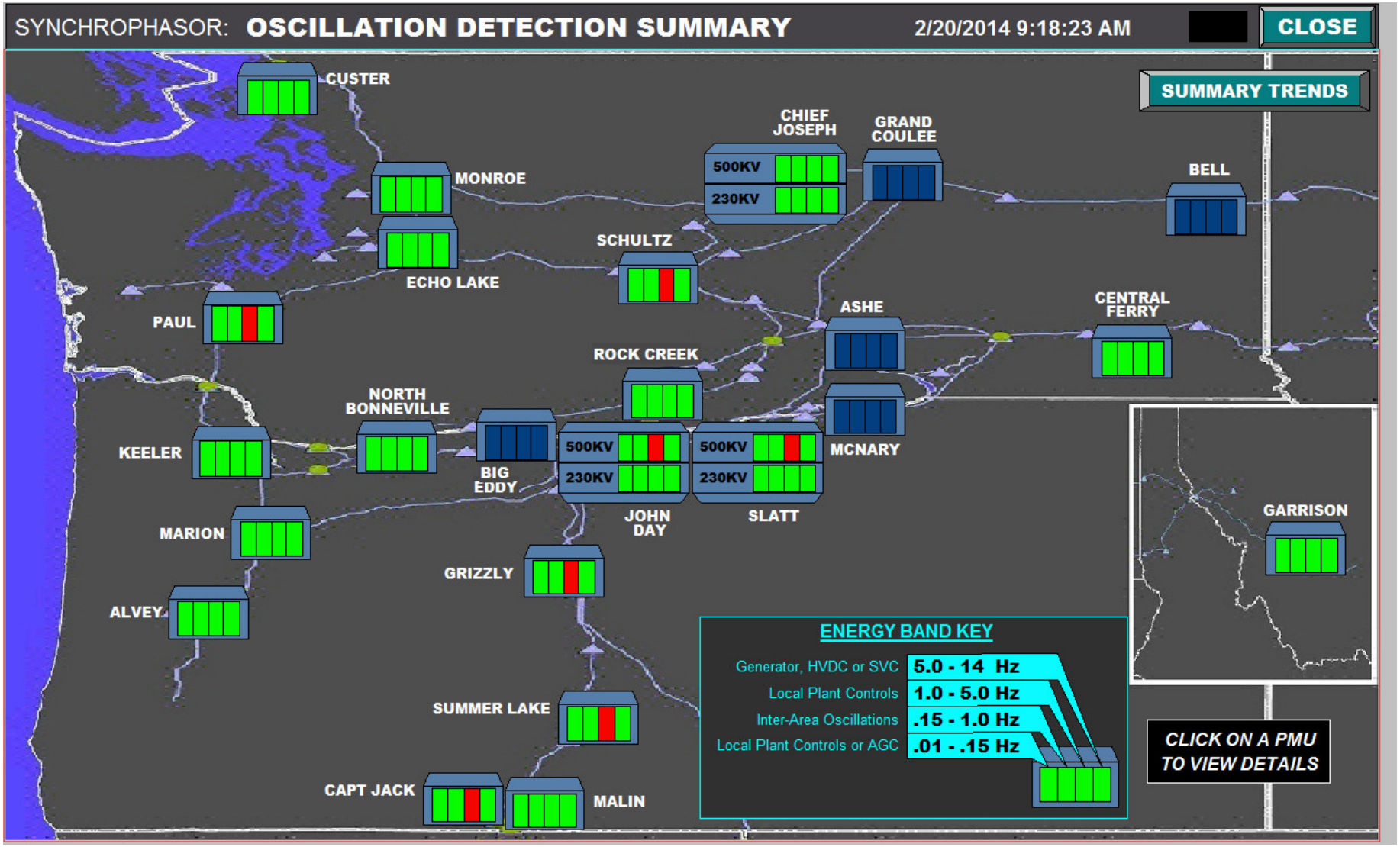
- Band 1 – (0.01- 0.15 Hz) >> 400 seconds
- Band 2 – (0.15 - 1.0 Hz) >> 60 seconds
- Band 3 – (1.0 - 5.0 Hz) >> 50 seconds
- Band 4 – (5.0 - 14.0 Hz) >> 50 seconds

What should Alarm limit be set to?

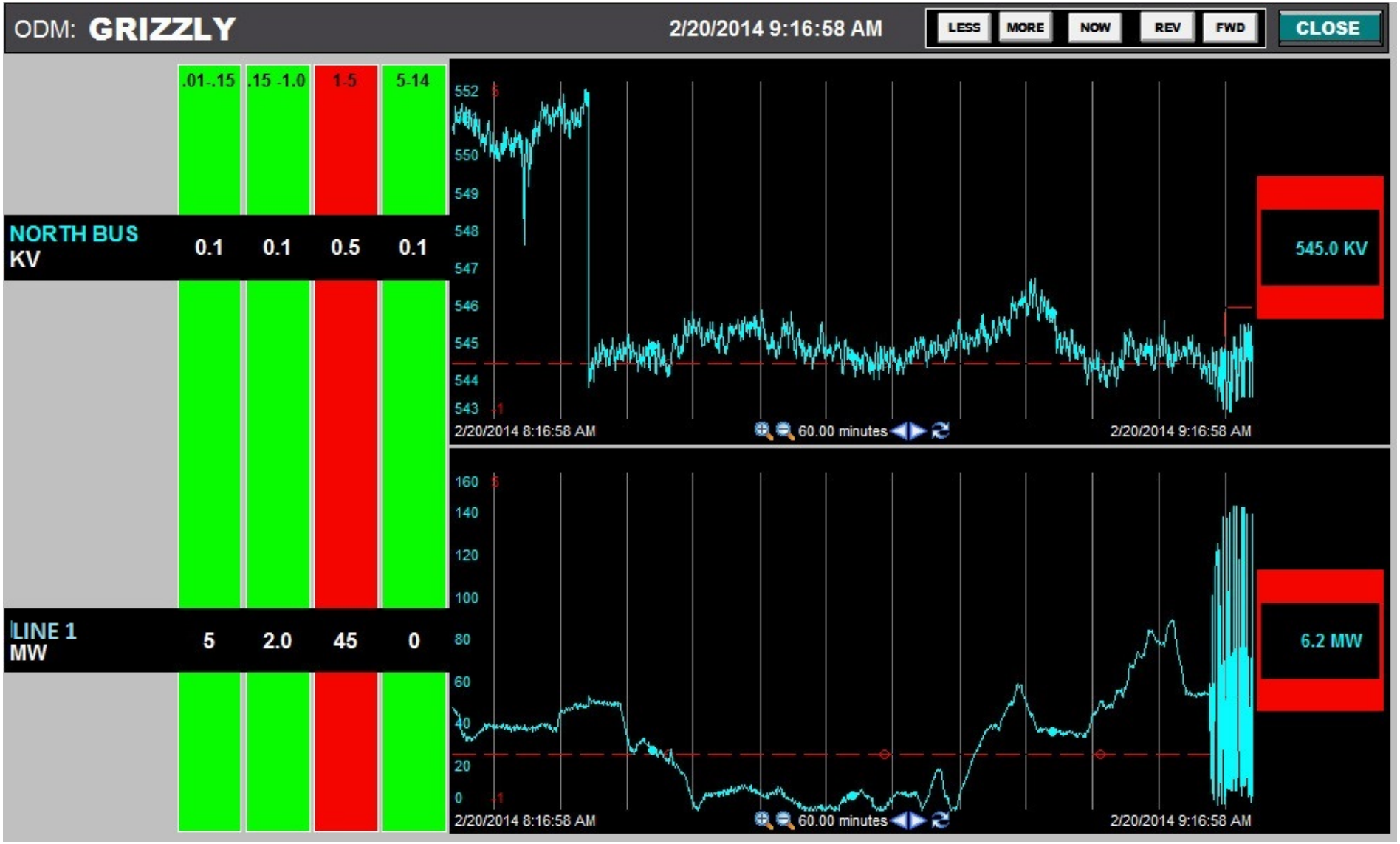
- **For Dispatchers** – Goal is to alarm if oscillation could be a threat to power system stability
- **For Engineers** – set limits lower and shorter. More sensitive (future).
- We set Dispatcher limits to 5 or 6 times the **ambient** oscillation energy, as recommended by Dr. Dan Trudnowski (Montana Tech), based on his 20 years of oscillation analysis experience.
- Ambient oscillation energy = Mean + 1 STD.
- We calculated the ambient oscillation energy for each of the 108 measurements based on about a week of data

Let’s see how the dispatcher would use the tool

After Alarm – Dispatcher sees ‘red’ bands on the video wall



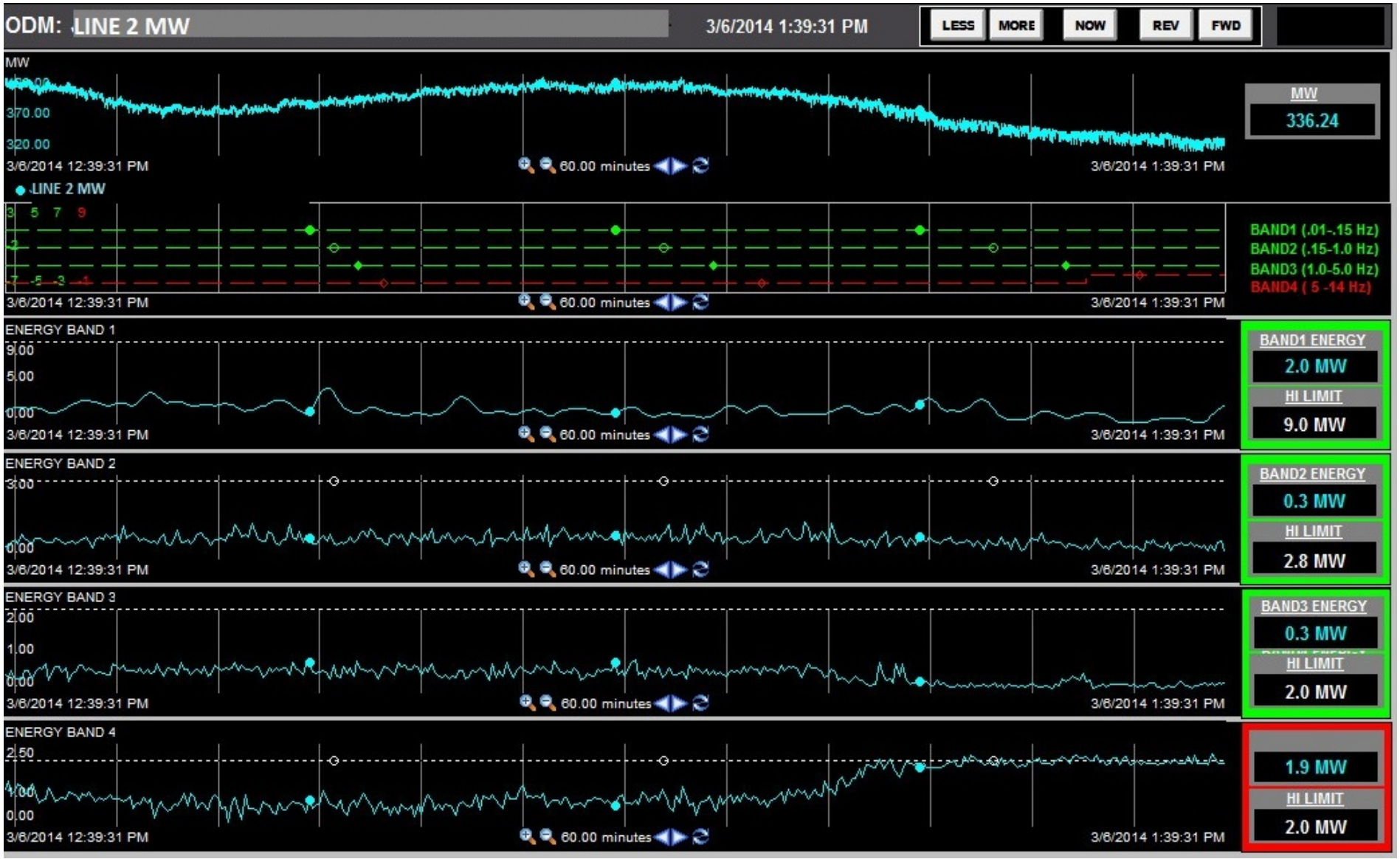
Clicking on a ‘red’ PMU shows oscillation energy for all monitored measurements



Clicking on ‘Line 1’ shows 60min trend of the oscillation energy for all 4 bands

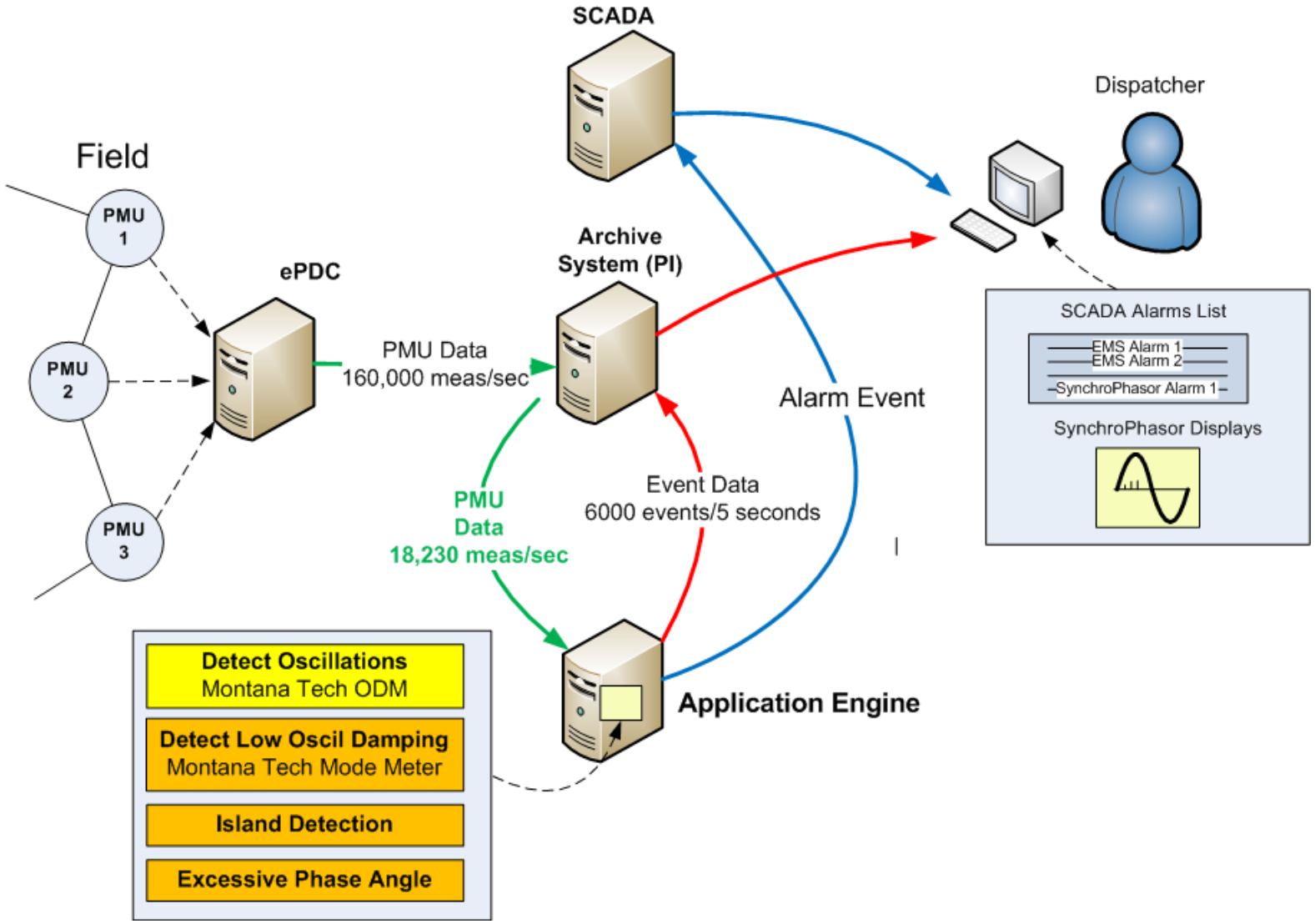
See 10 minute trend of same oscillation using LESS - time. MORE - time
REV- back in time. FWR - forward

Example of 14Hz Oscil from high wind generation

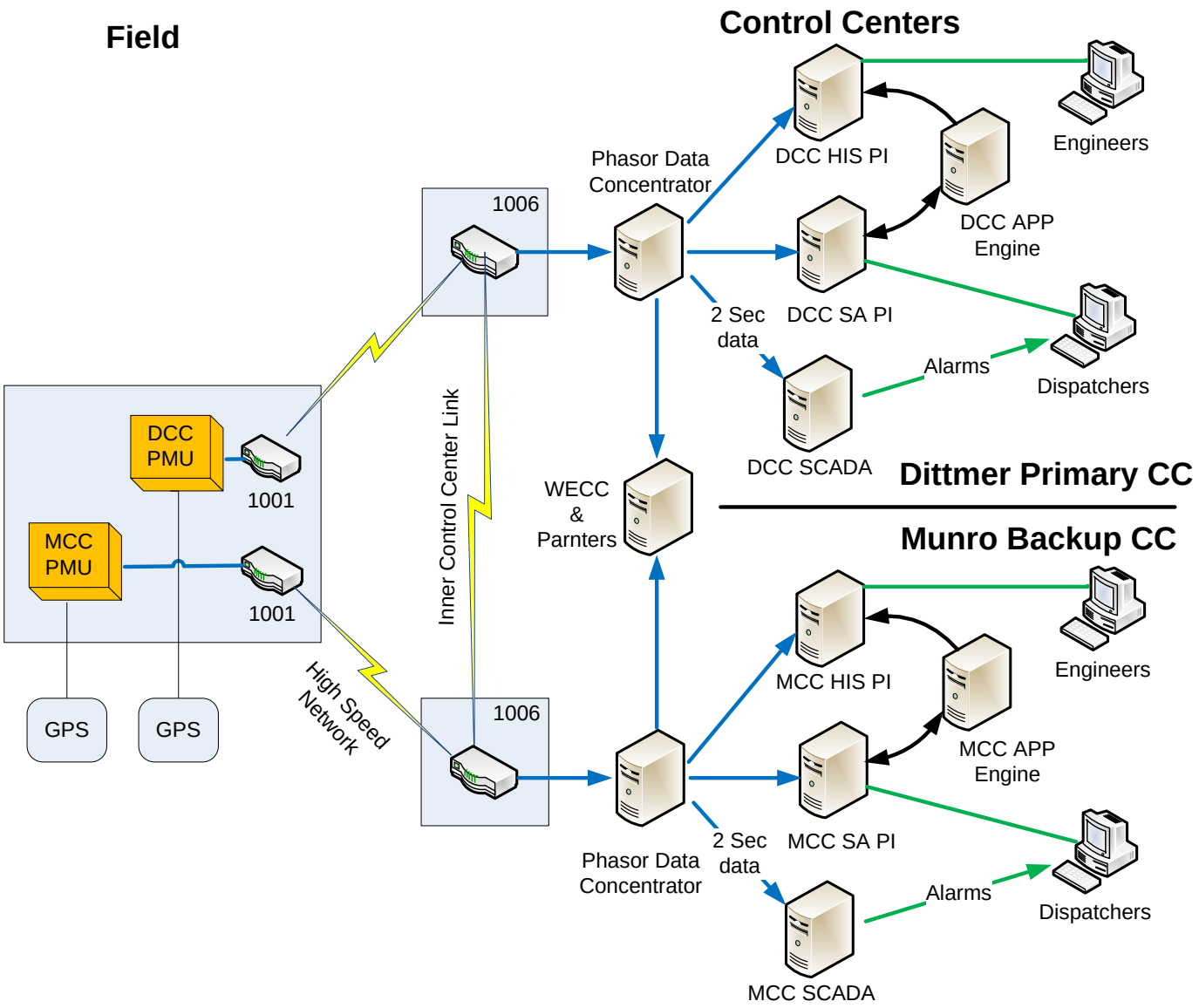


Same high wind gen 14Hz Oscil – 1.3 days

Control Center Processing and Alarming



Redundant Architecture



Current Operational Status

- Monitoring 108 PMU measurements (Gen and Ties) detecting previously unseen oscillations
- Overview display on video wall
- Detailed displays on all dispatcher consoles
- Only ‘general’ dispatcher standing orders for Oscillations
- Log-only alarms for Oscillation events
- NERC/CIP compliant PMUs by Sept

Questions?