An Introduction to the Problem of Oscillation Source Location

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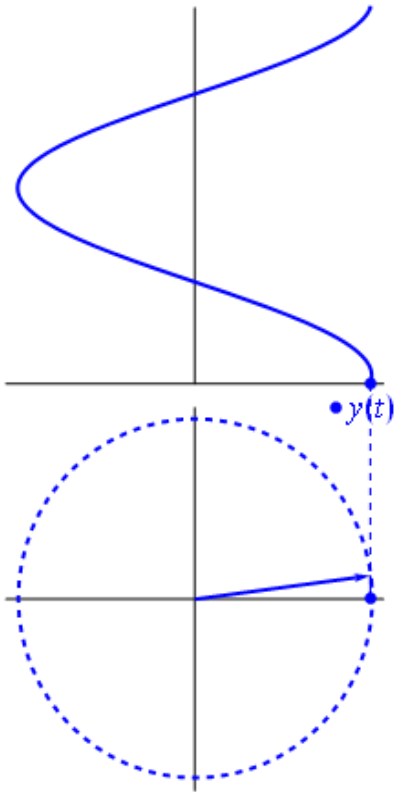
Phasor

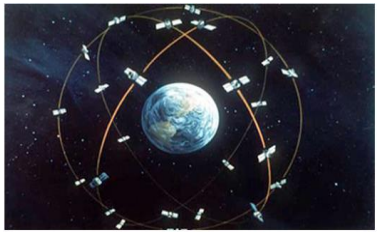
Time Domain –> Frequency Domain

- A vector that describes sinusoidal signals
  - voltage or current
- Fully characterized by
  - Frequency
  - Magnitude
  - Phase Angle

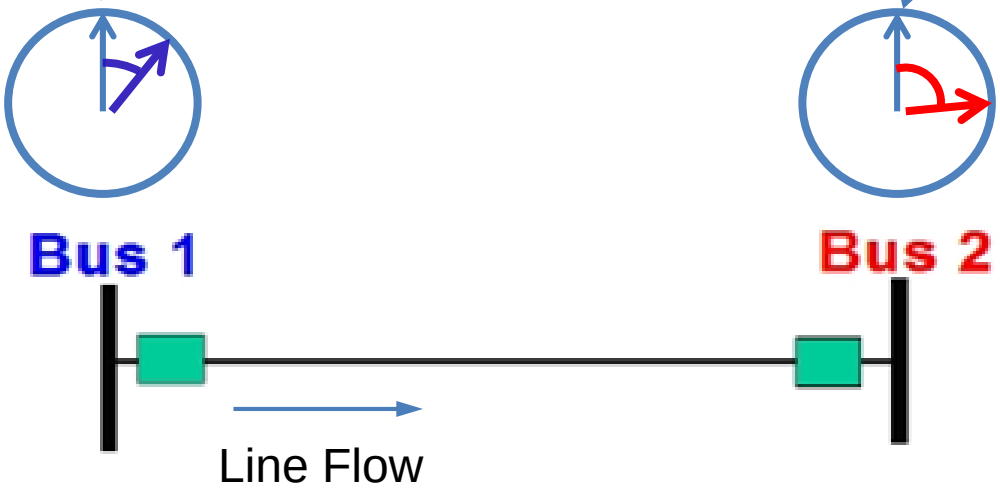


Phasor Representation

Synchrophasor



- Why **Synchro-**phasor?
  - Angles need a synchronized common reference.

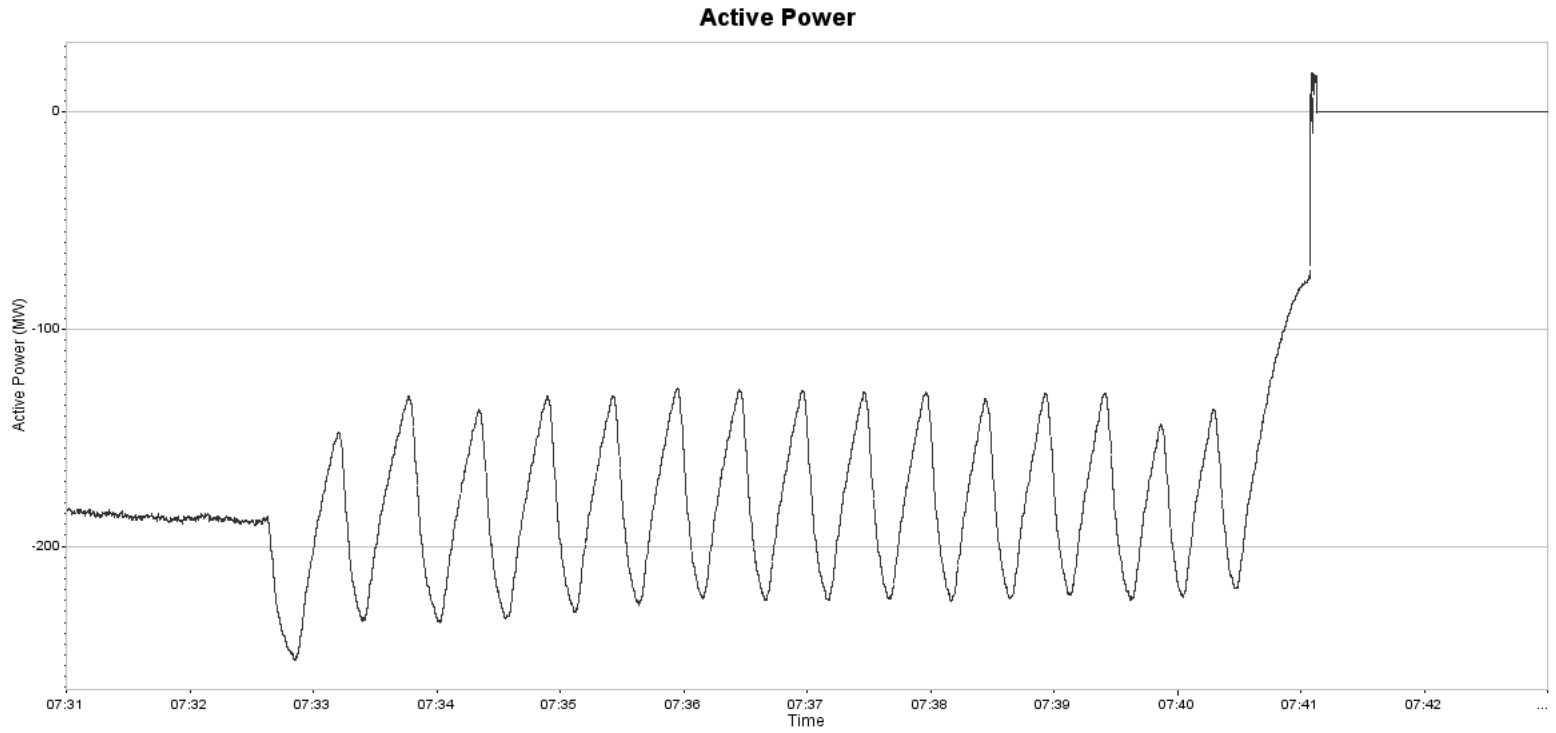


Synchrohasor = Phasor + GPS + high sampling rate

- PMU - Phasor Measurement Unit

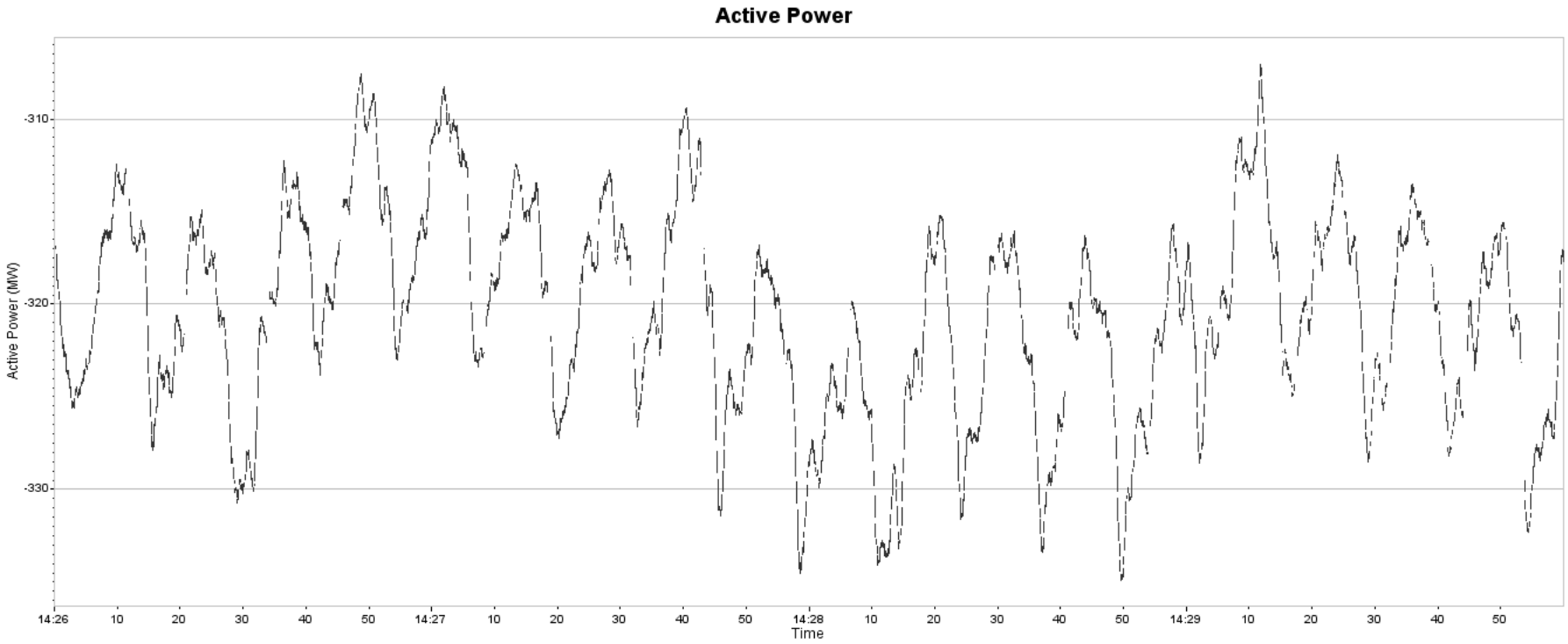
Phenomenon – 1

- 0.03 Hz oscillation before unit tripping



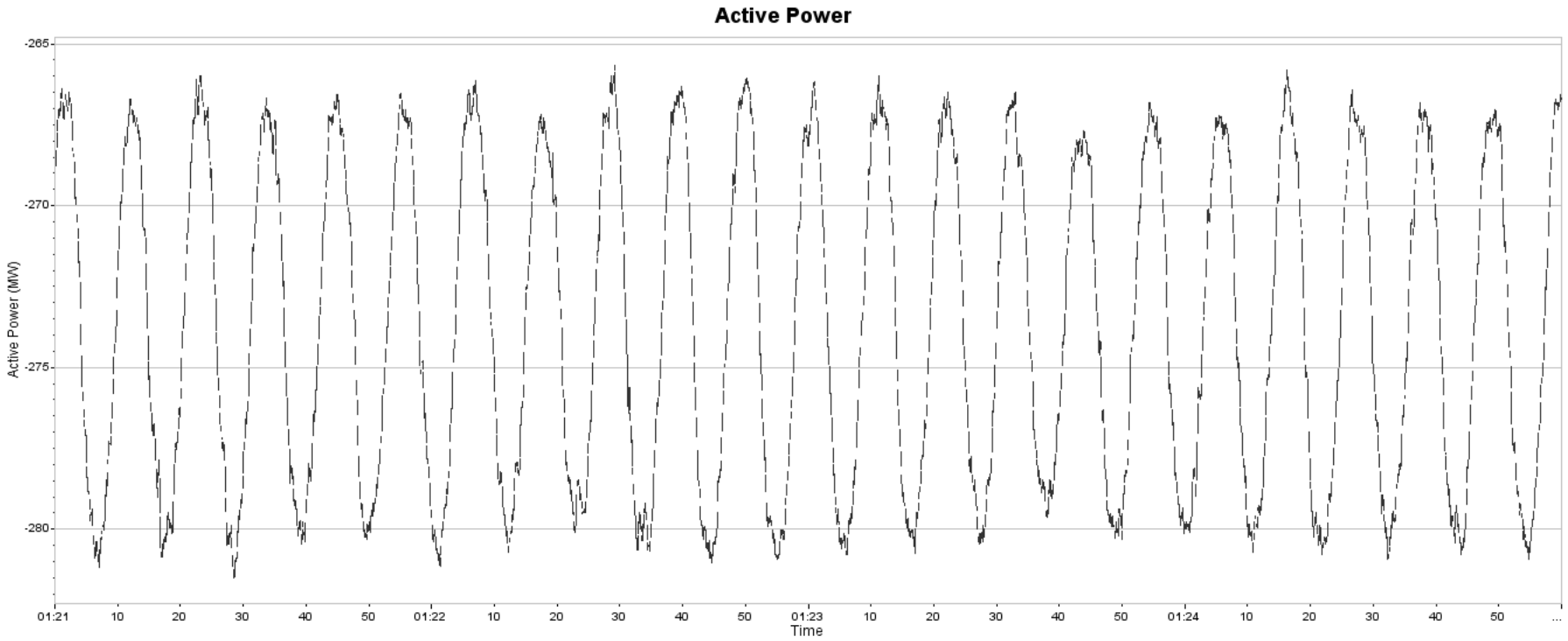
Phenomenon – 2

- 0.07 Hz sustained oscillation



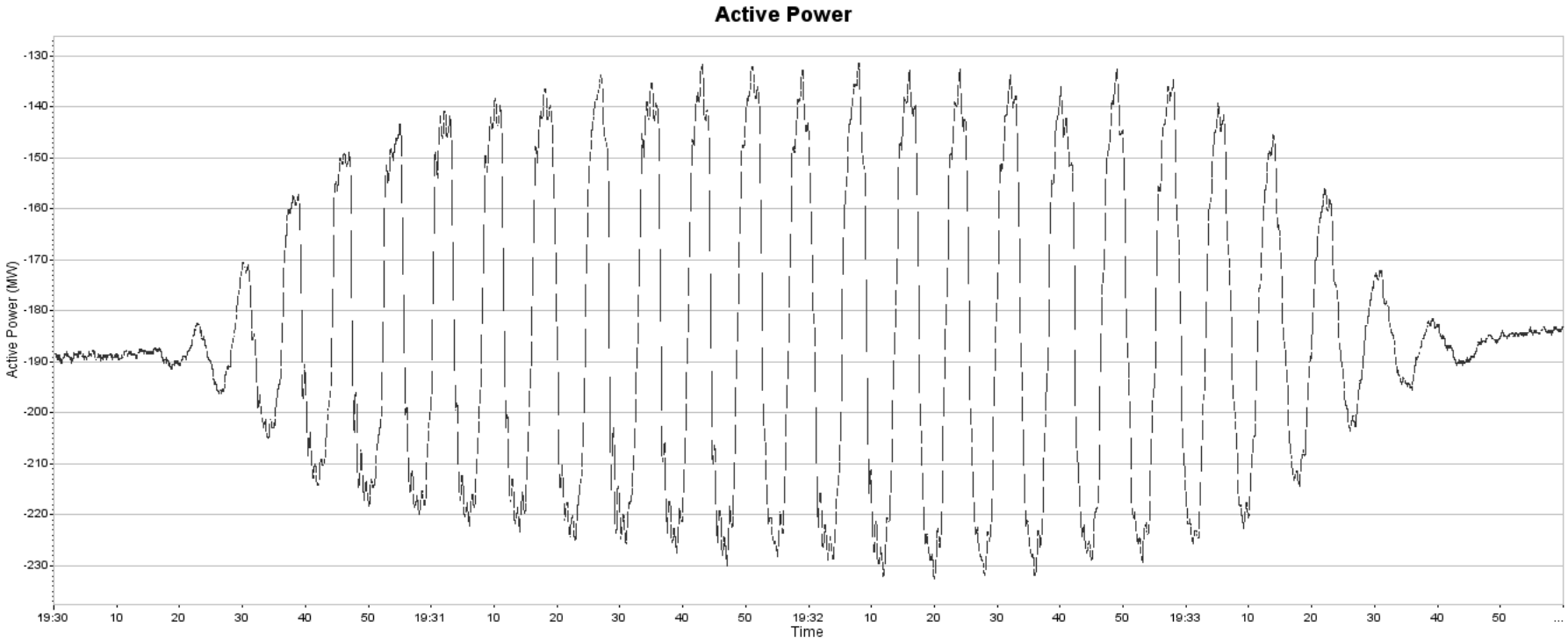
Phenomenon – 3

- 0.09 Hz sustained oscillation



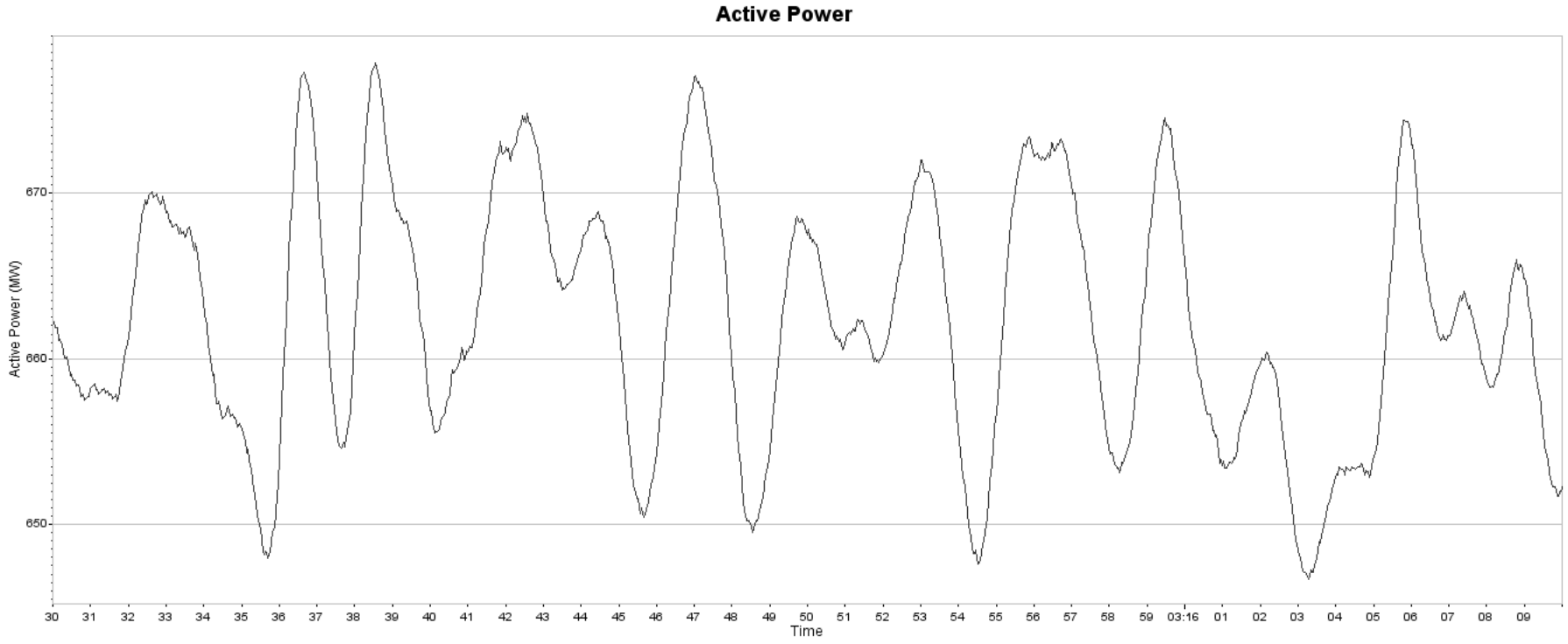
Phenomenon – 4

- 0.12 Hz oscillation



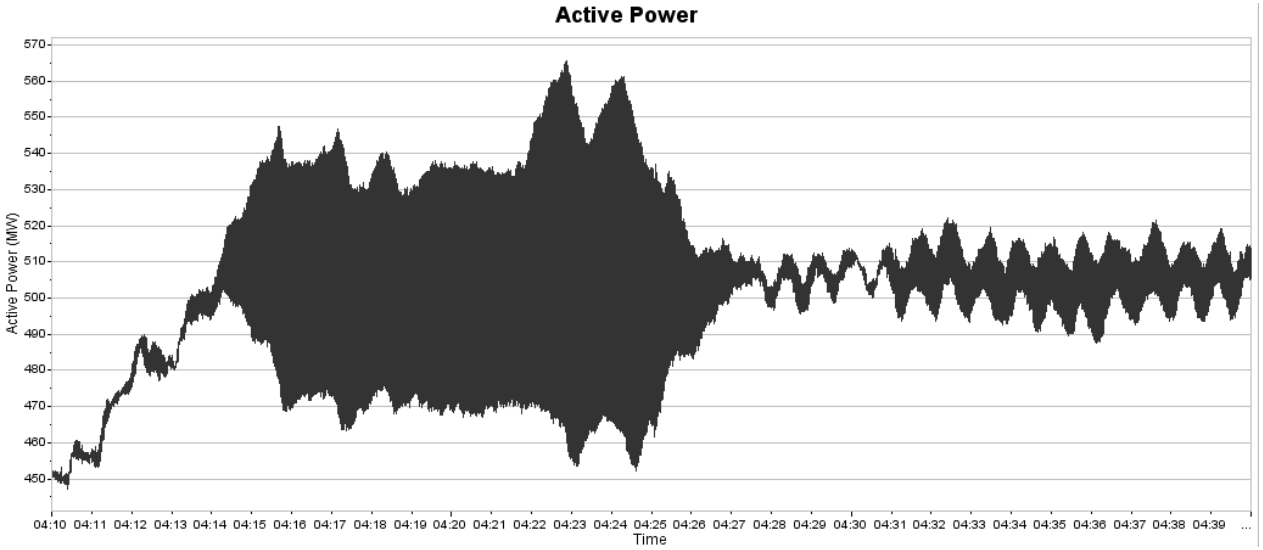
Phenomenon – 5

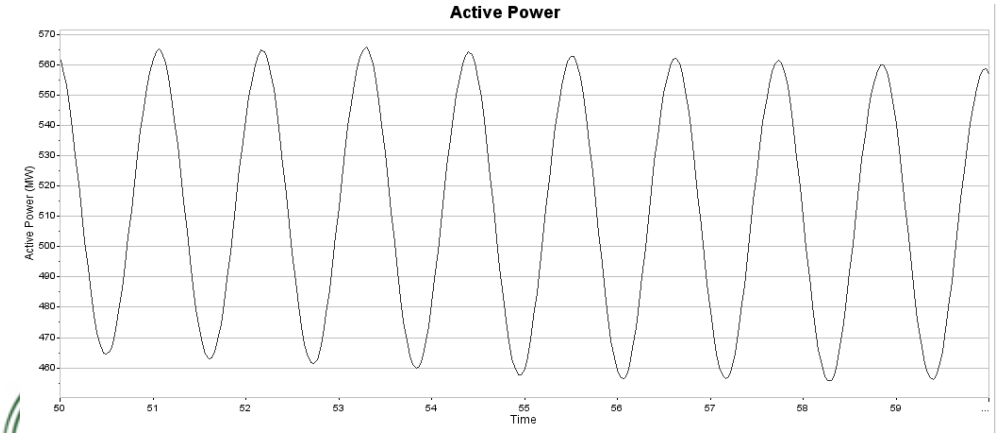
- 0.3 Hz inter-area oscillation

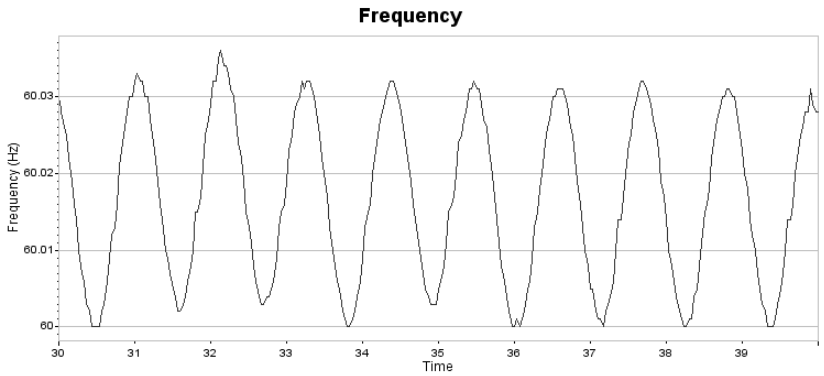


Phenomenon – 6

- 1 Hz sustained oscillation

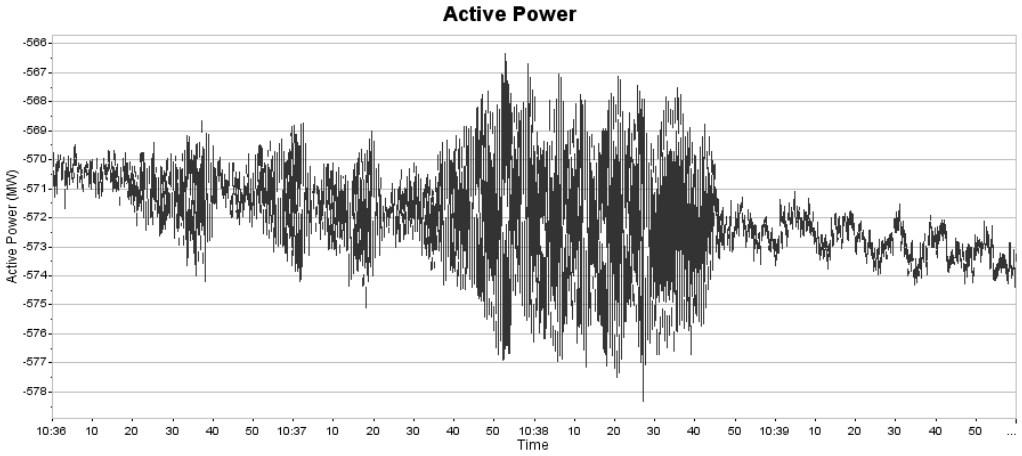


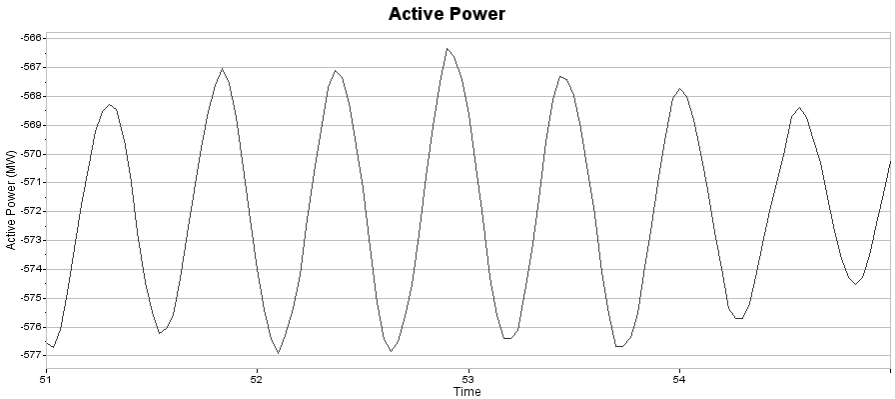


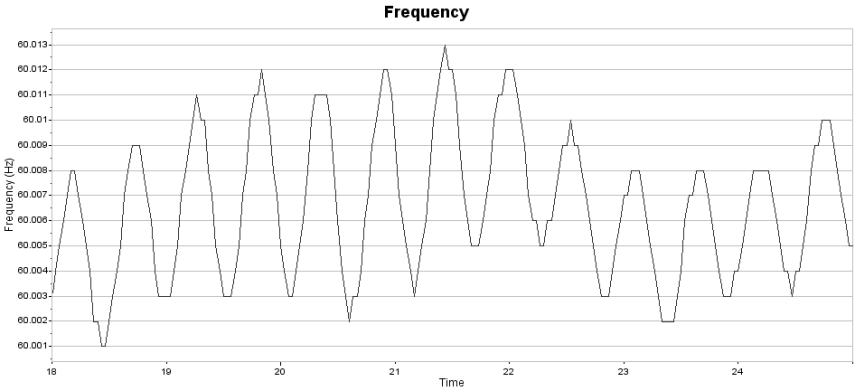


Phenomenon – 7

- 1.8 Hz sustained oscillation

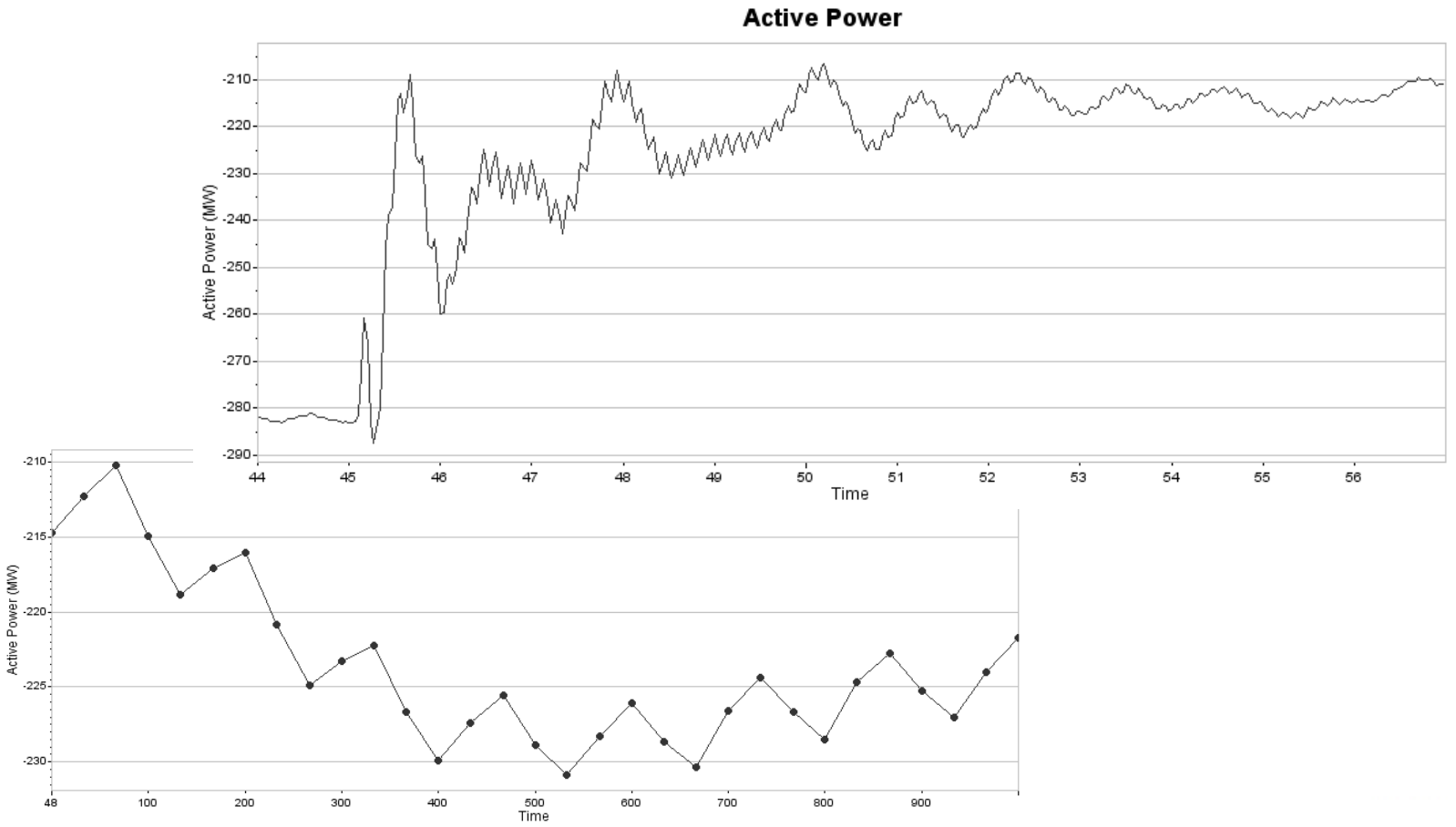






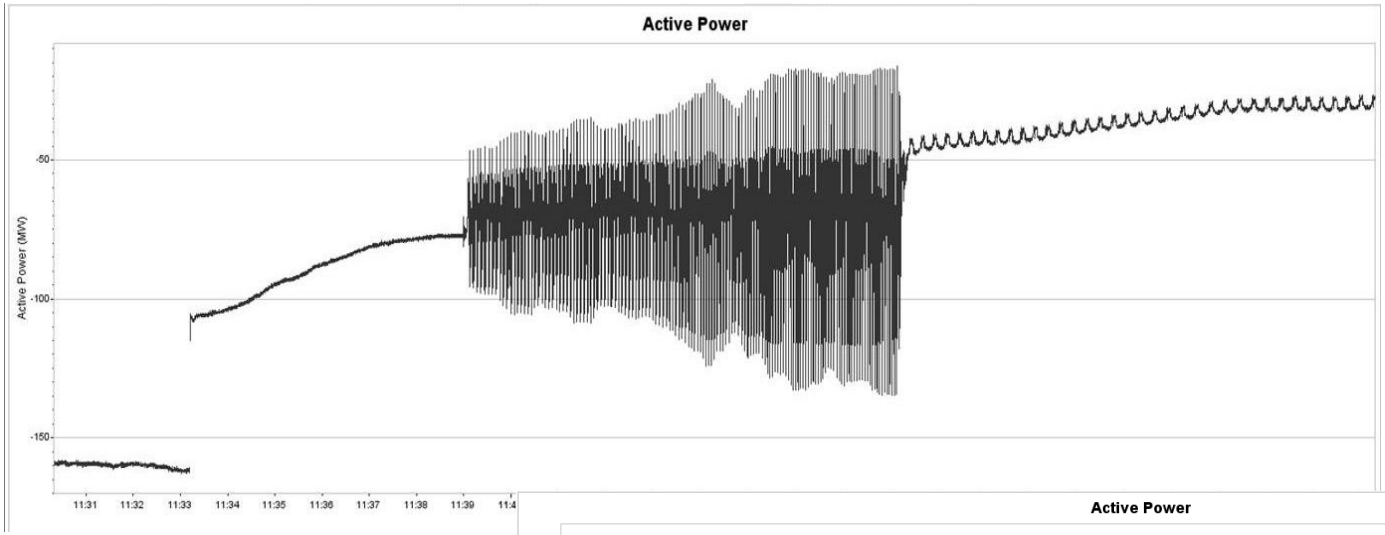
Phenomenon – 8

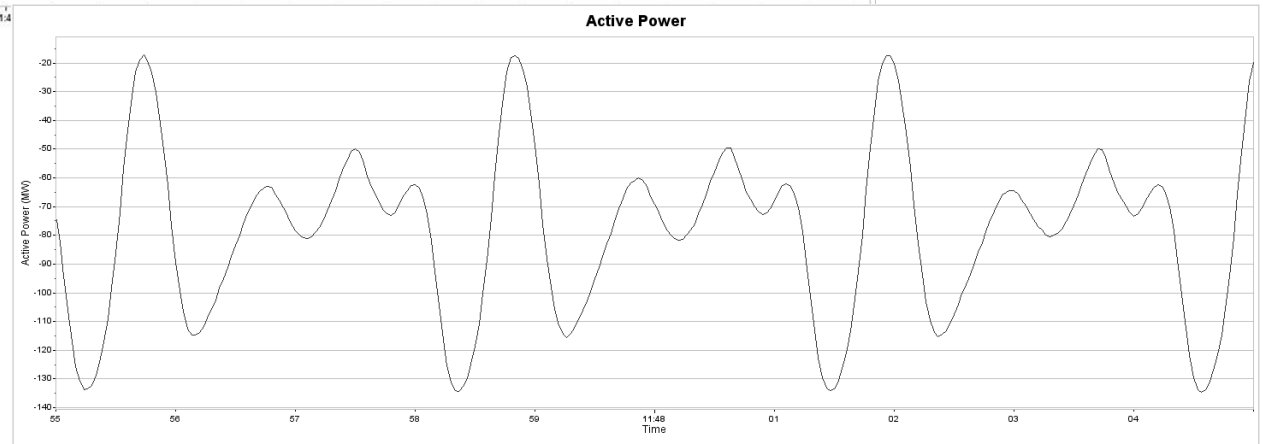
- 8 Hz (& 1 Hz) oscillation after a disturbance



Phenomenon – 9

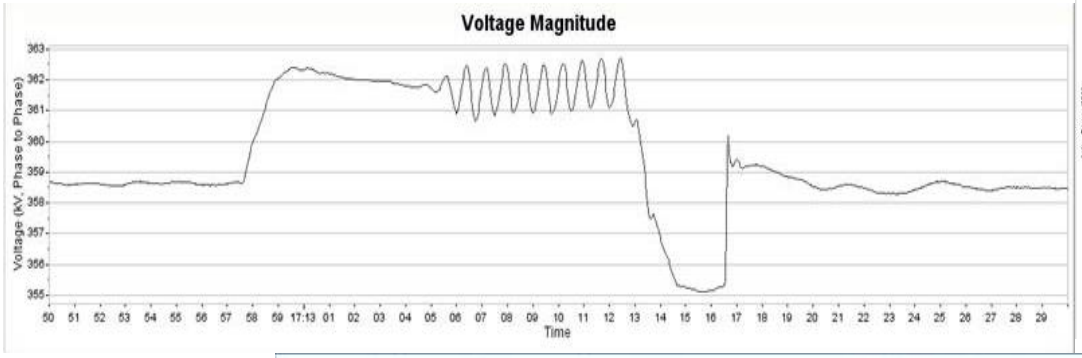
- Combined Cycle – 2x1 –> 1x1, with harmonics

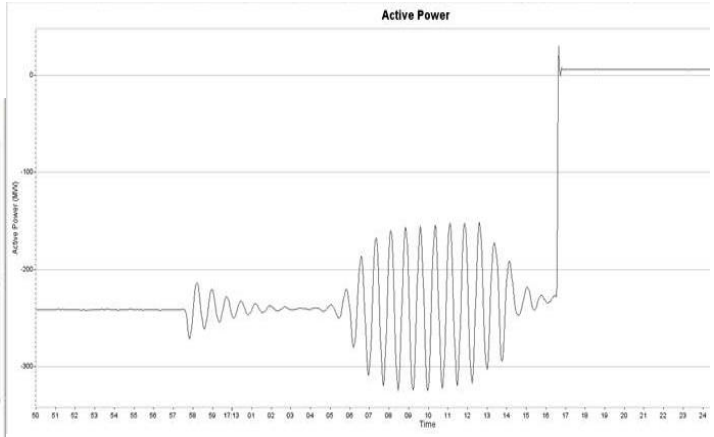


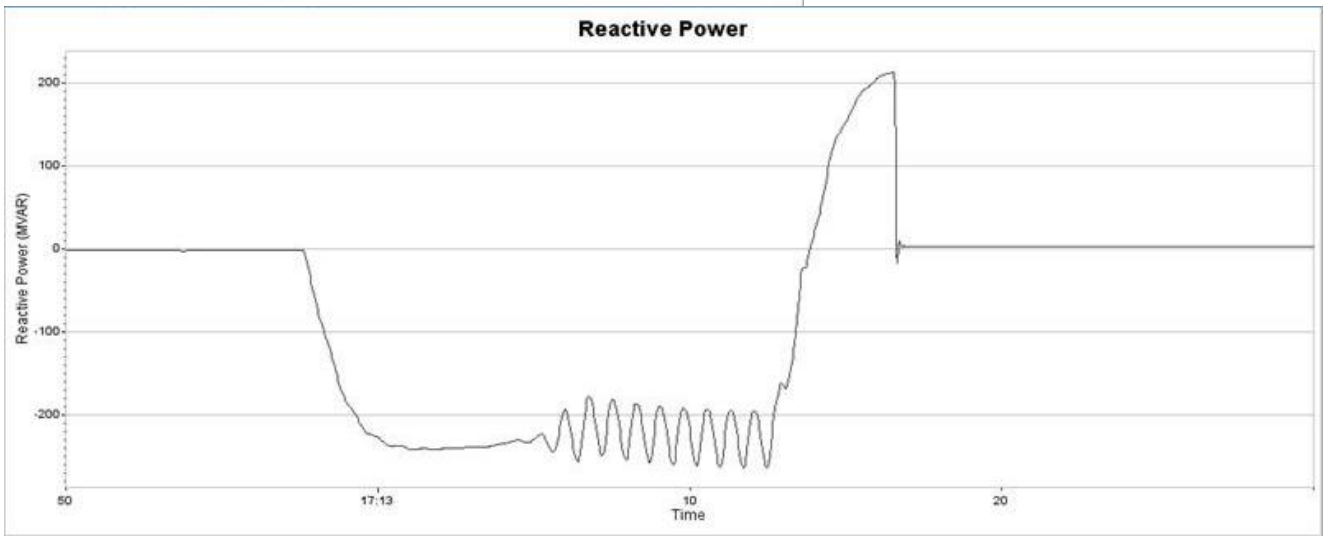


Phenomenon – 10

- Loss of excitation







Problems

- "New", "unknown" oscillations seen in PMU data
  - Most of them are forced oscillations
- Present a risk to the grid operations security
- Not seen in the model based study
- Need new study approaches
- Need to identify and mitigate in real-time
  - Actionable information
  - **Possibly the first killer app for PMU data**

Features Comparison

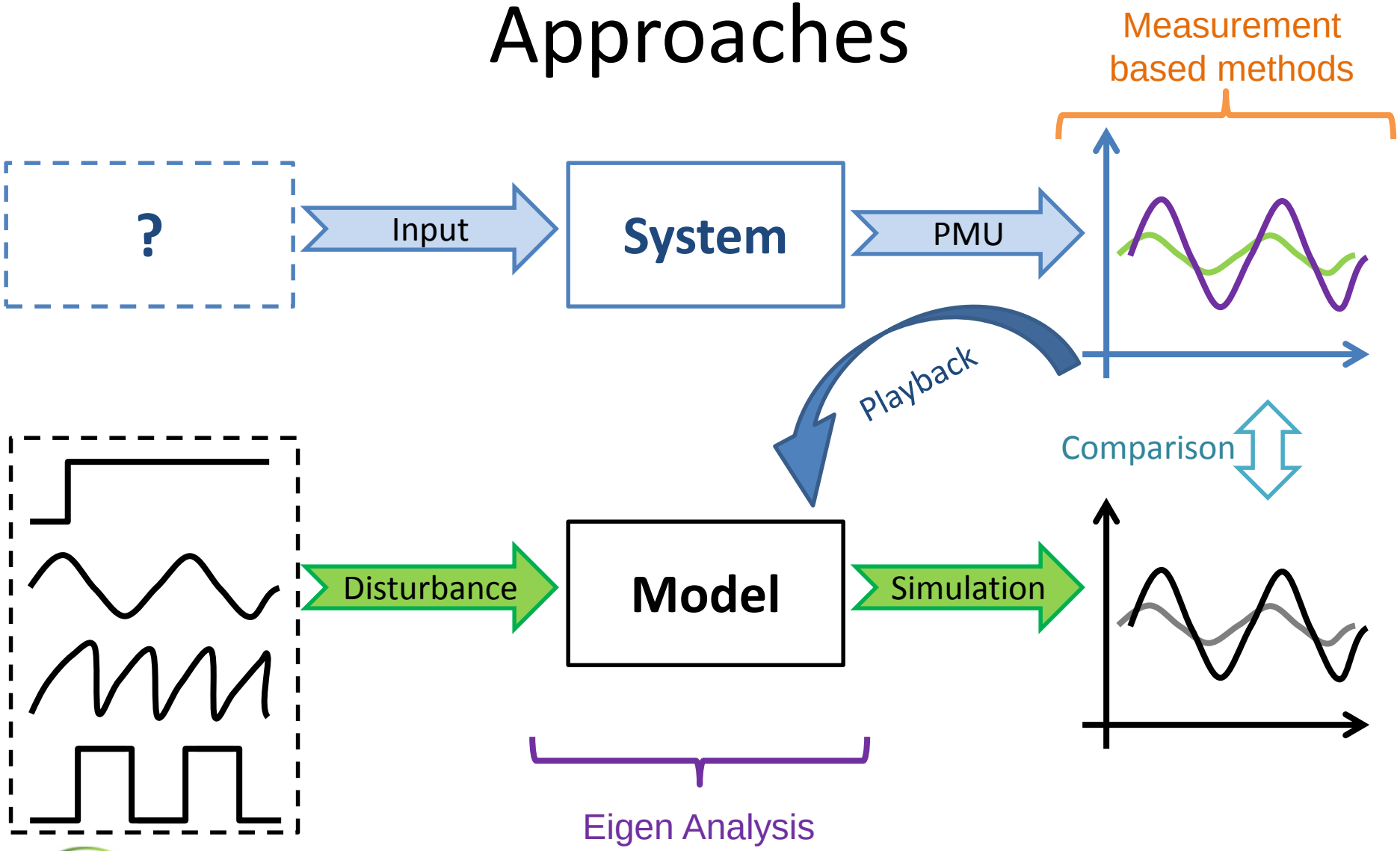
Natural Oscillations

- Specific frequencies
  - Normally no harmonics
- In the state matrix
  - No input needed
  - Excited by disturbances
- Steady State
  - Small signal stability
- Mature model based study

Forced Oscillations

- May have harmonics
  - Integral multiples of F_0
  - Source may not be sinusoidal
- Periodic input
  - Sustained input needed
  - Could resonate with natural modes
- Not steady state
  - Bounded Input Bounded Output (BIBO) stability
- Hard to replicate in model

Approaches


Measurement based methods
?
Input
System
PMU
Playback
Comparison
Disturbance
Model
Simulation
Eigen Analysis

ISO
new england