Synchrophasor-Based Power System Control in Central America

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Wide-Area Protection and Control Scheme Maintains Central America's Power System Stability

WPRC – October, 2012

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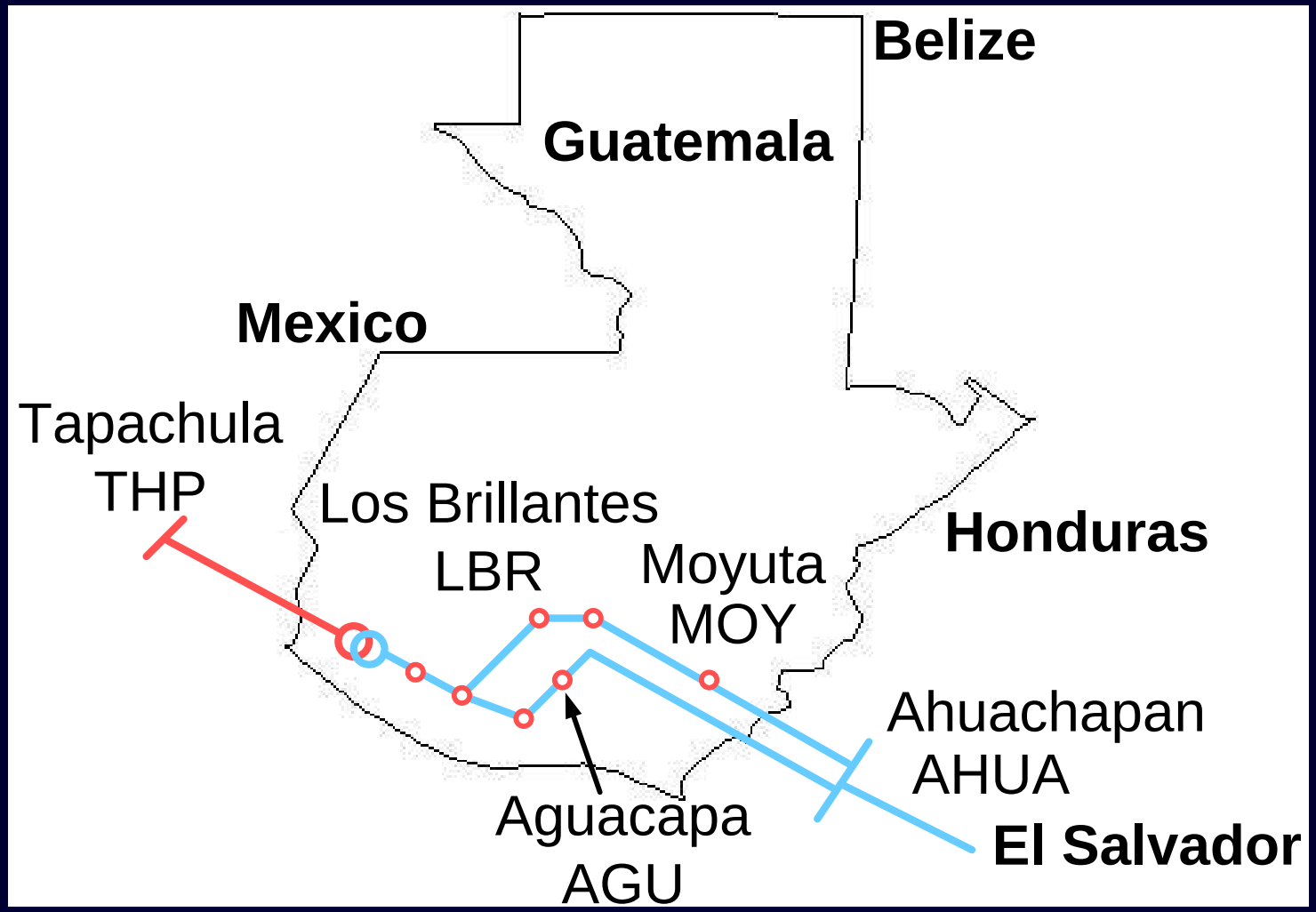
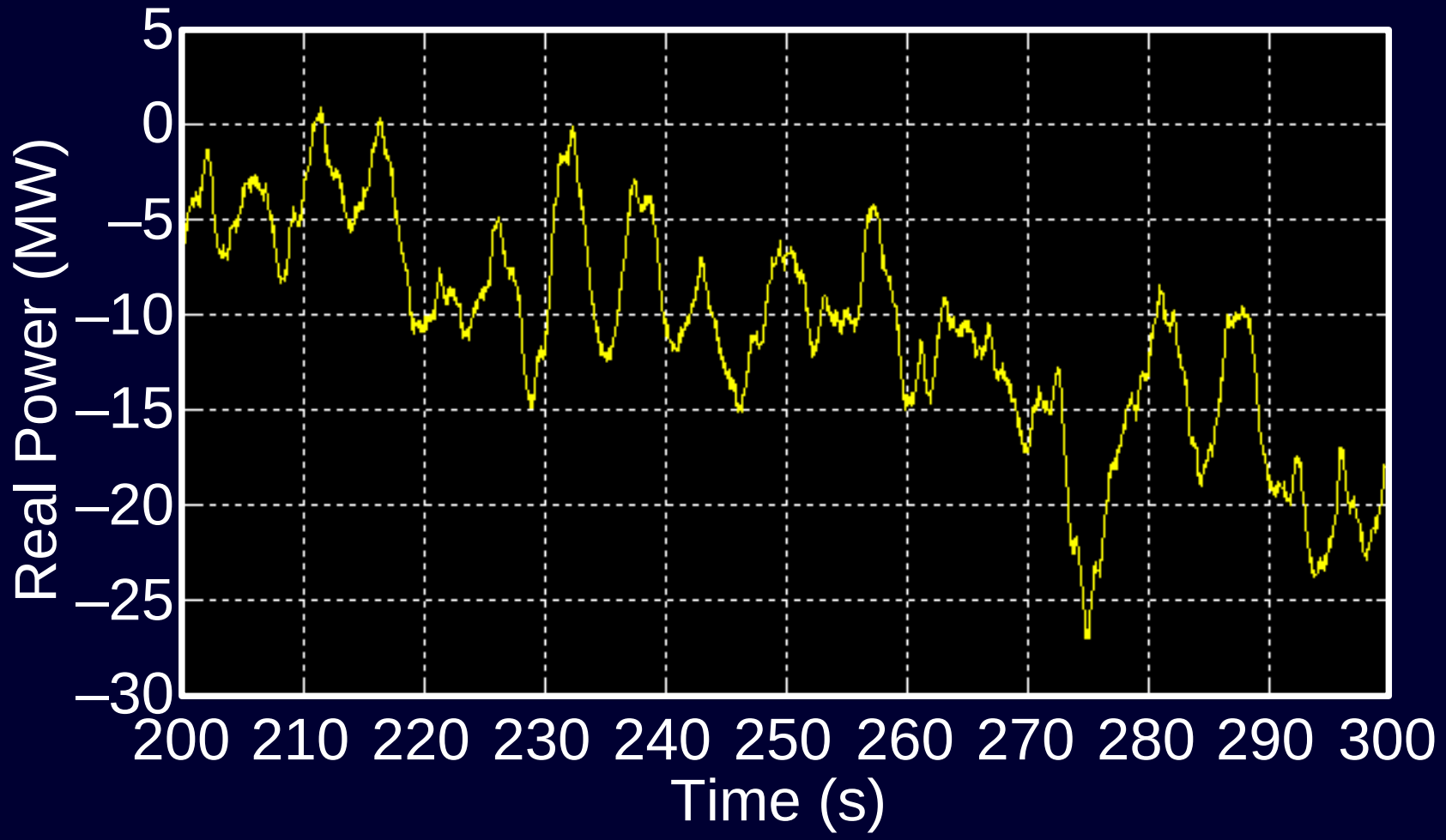
230 kV Backbone Connects Countries From Guatemala to Panama

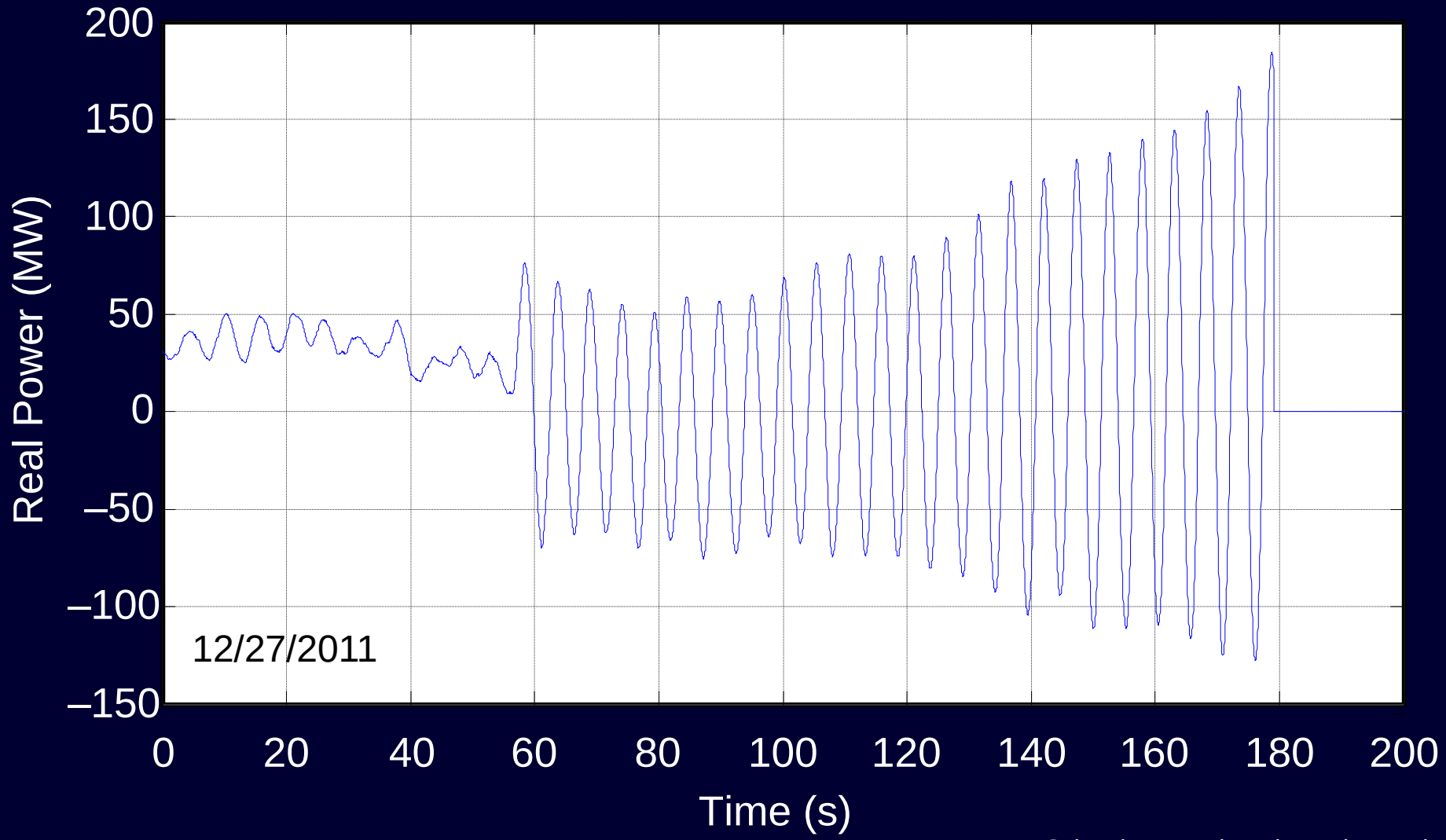
Guatemala Wheels Power From Mexico to Central America



Example Oscillations



Unstable Oscillation Separates Guatemala From Rest of Central America



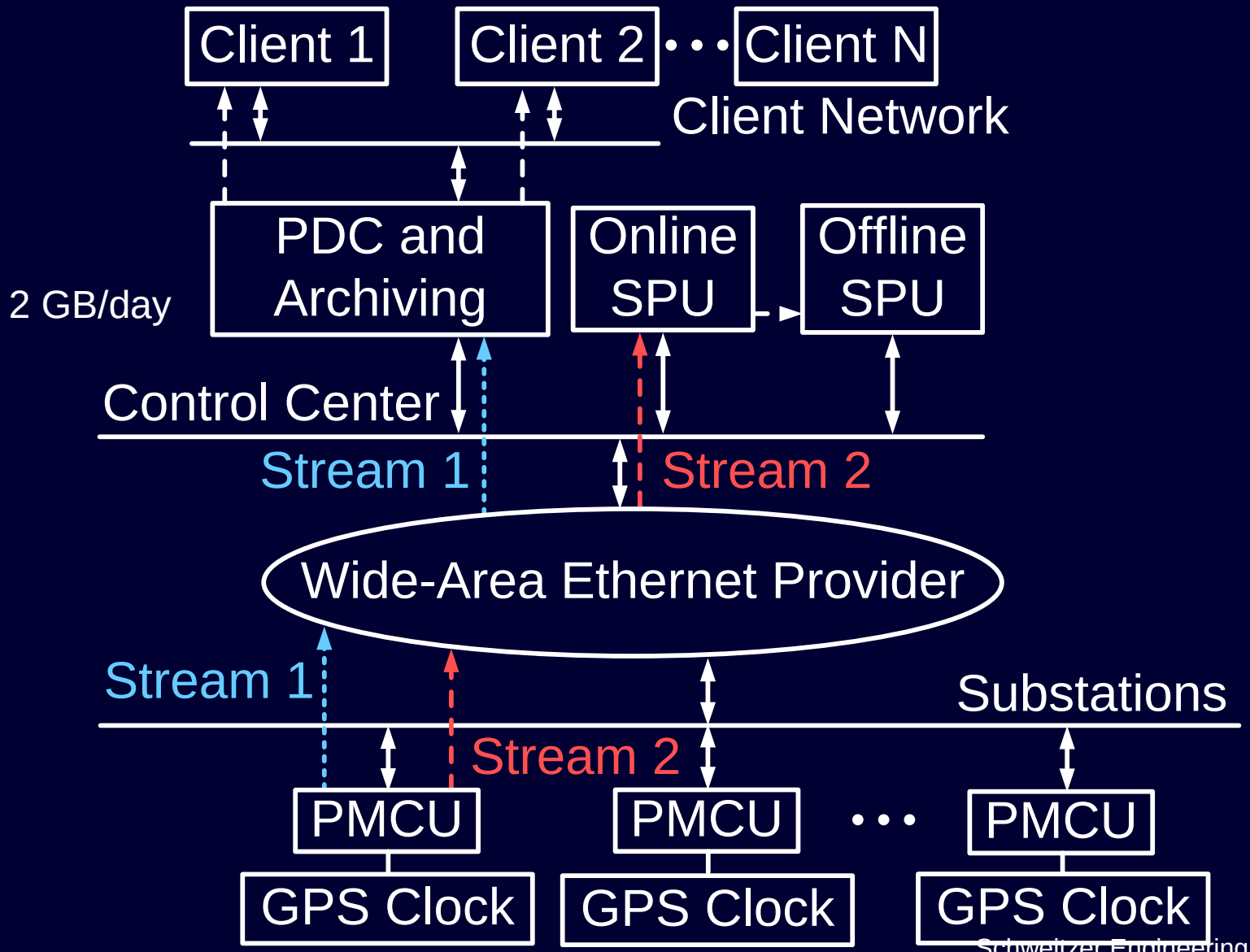
Synchrophasor Technology in Guatemala

- 2008 – AMM identified synchronized measurements
- 2011 – AMM implemented system of synchrophasors
- 2012 – AMM enabled modal analysis scheme

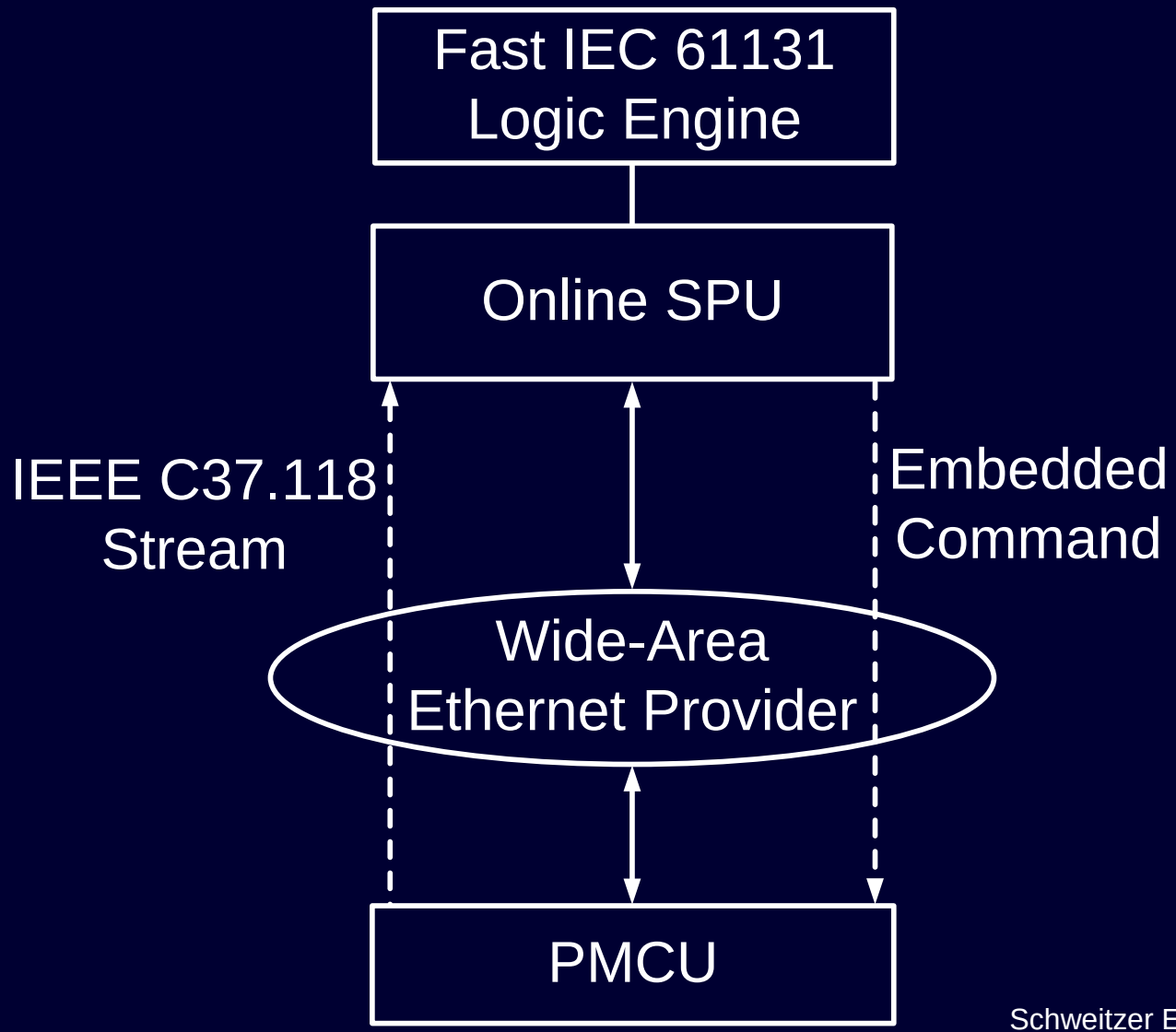
Synchrophasor System Details

- 23 PMUs
- 30 samples per second
- Software PDC at control center
- Synchrophasor processing units (SPUs)
- System visualization and analytics
- Wide-area control
- Leased communications network

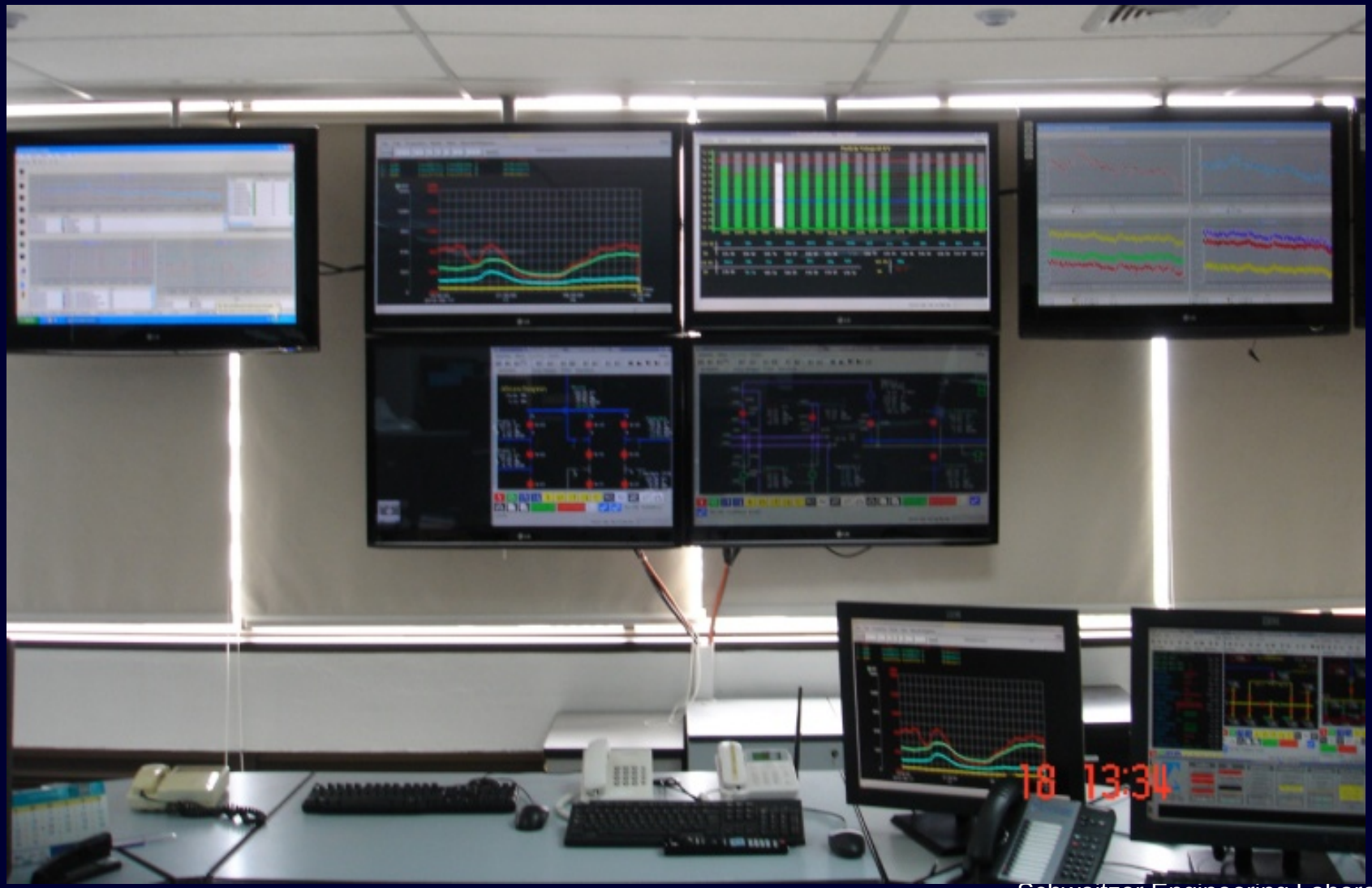
WAPS Architecture



PMCUs Receive Control Commands and Provide Synchronized Measurements

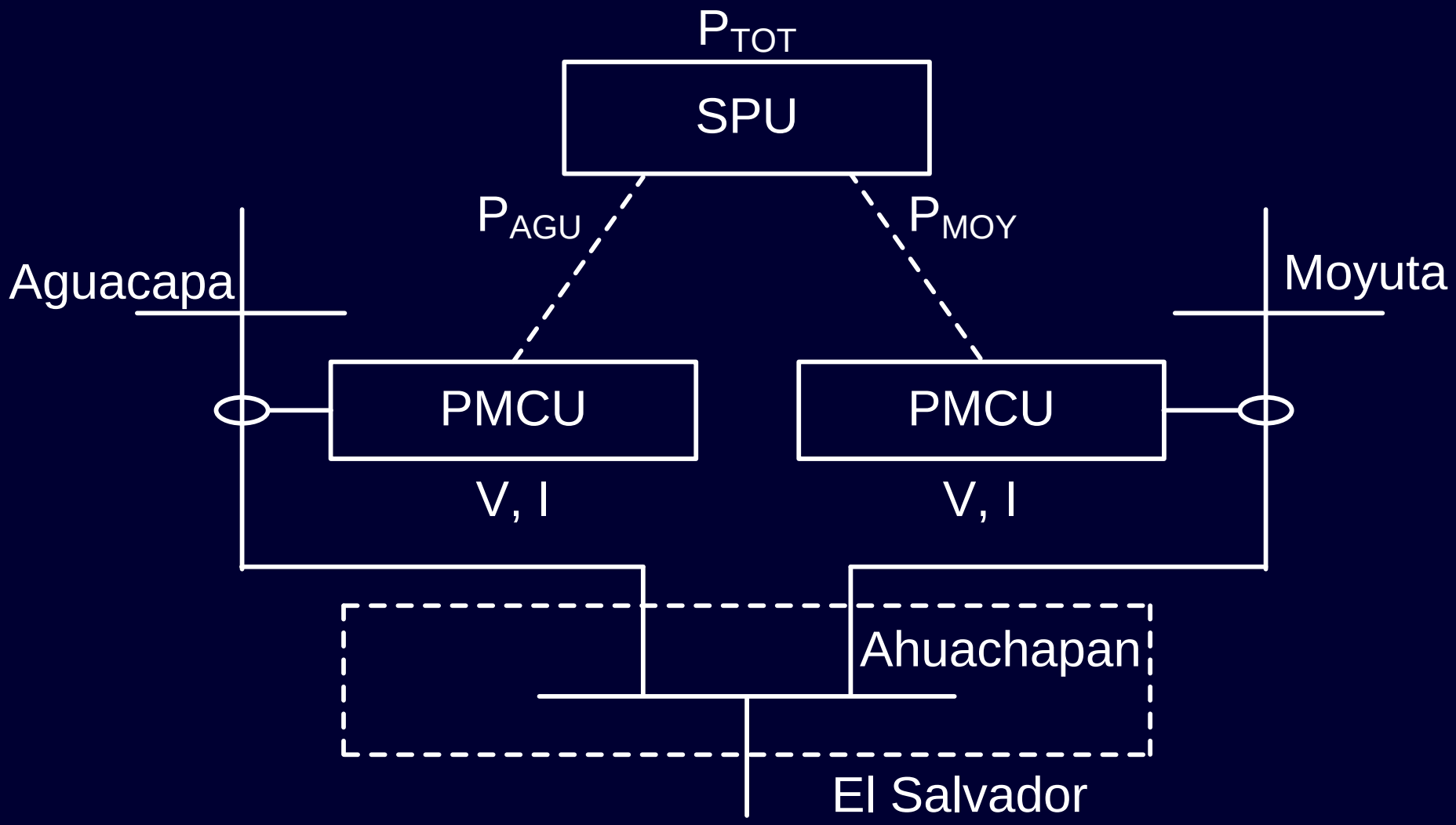


Synchrophasors Complement Traditional SCADA

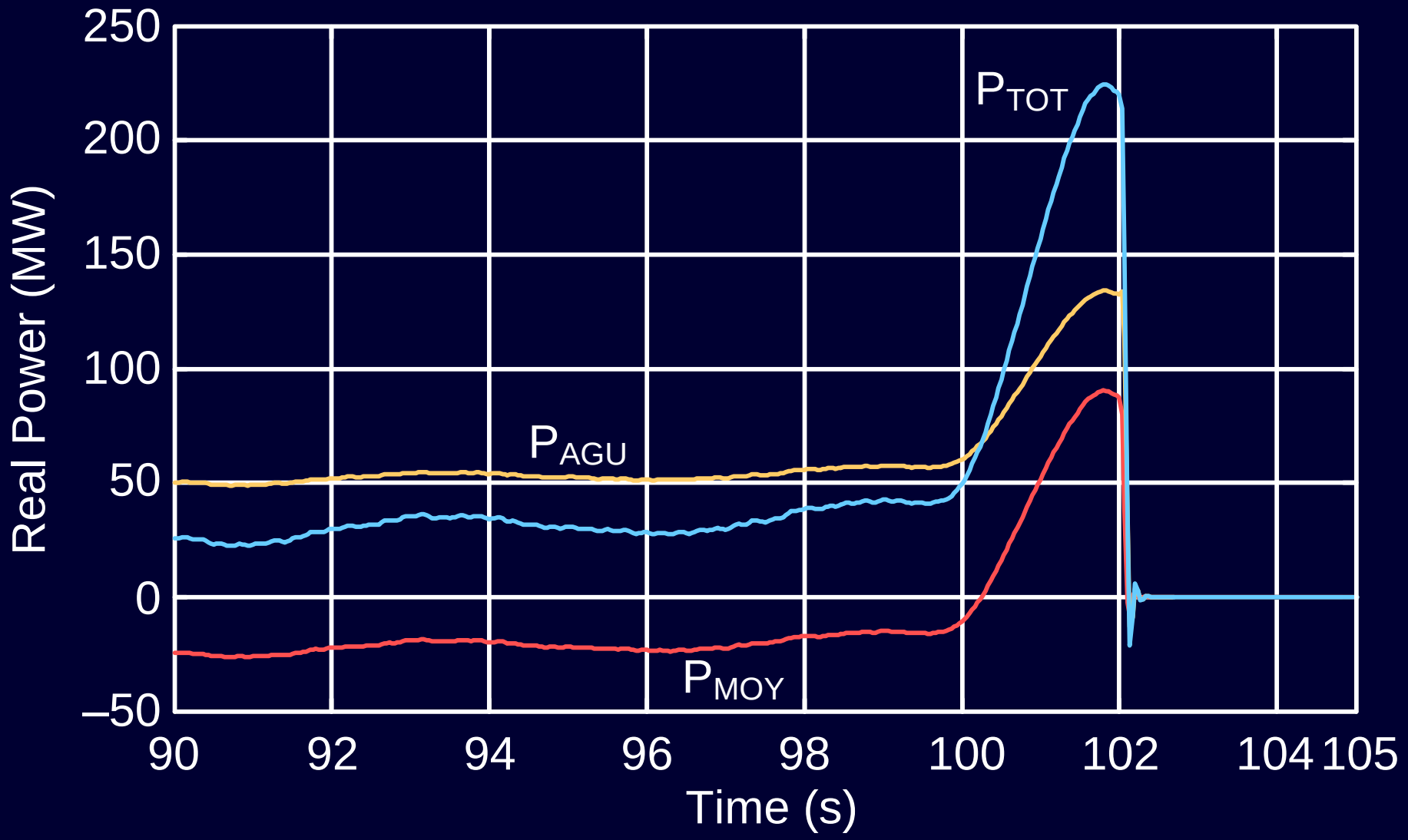


Another Synchrophasor Display View

Supplementary Control Scheme (SCS) Trips Interconnection to El Salvador



Scheme 1 – Synchronized Power



Synchronized Power Levels

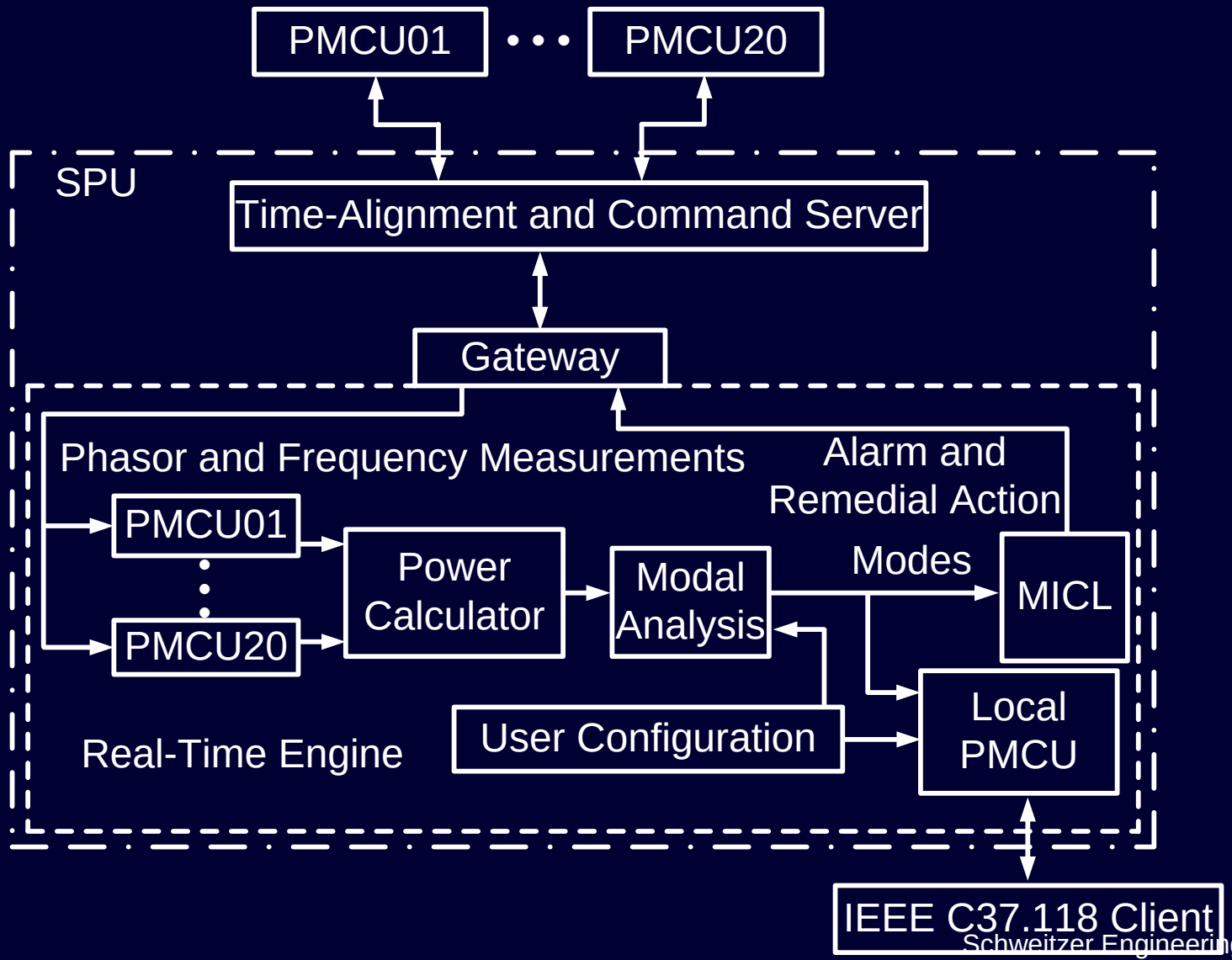
Total Power (AGU+MOY)	Delay (ms)
200	1200
245	600
297	300

Not possible with 4 second asynchronous SCADA rate

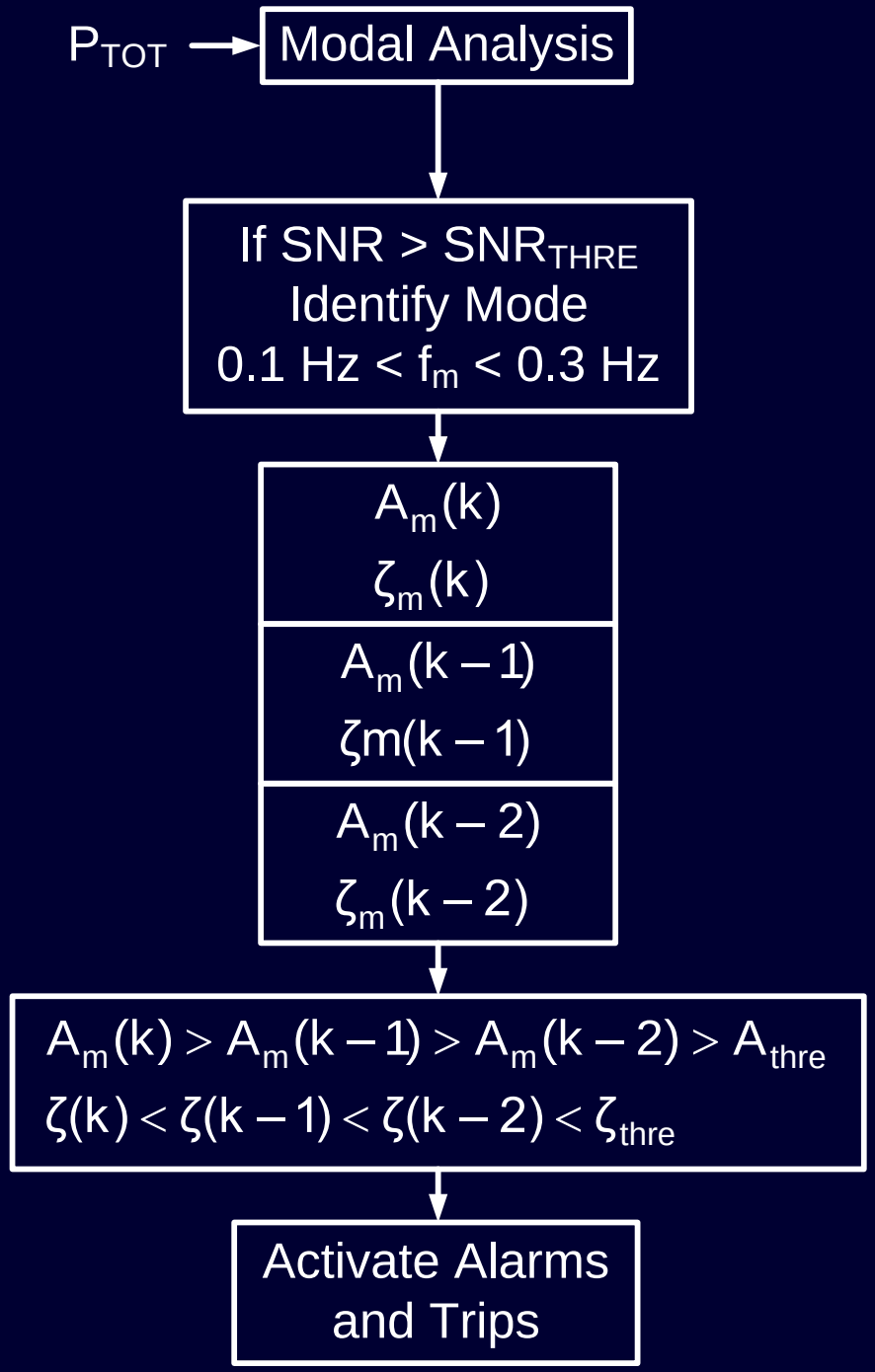
Scheme 2 – Modal Analysis

- Central American interconnection shows possible 0.17 Hz unstable mode
- 20-second observation window
- 2 bands are defined
  - 0.1 to 0.3 Hz unstable band
  - 0.5 to 0.9 Hz steady-state oscillations

Real-Time Modal Analysis Detects Unstable Oscillations



Real-Time Modal Analysis Decision Logic



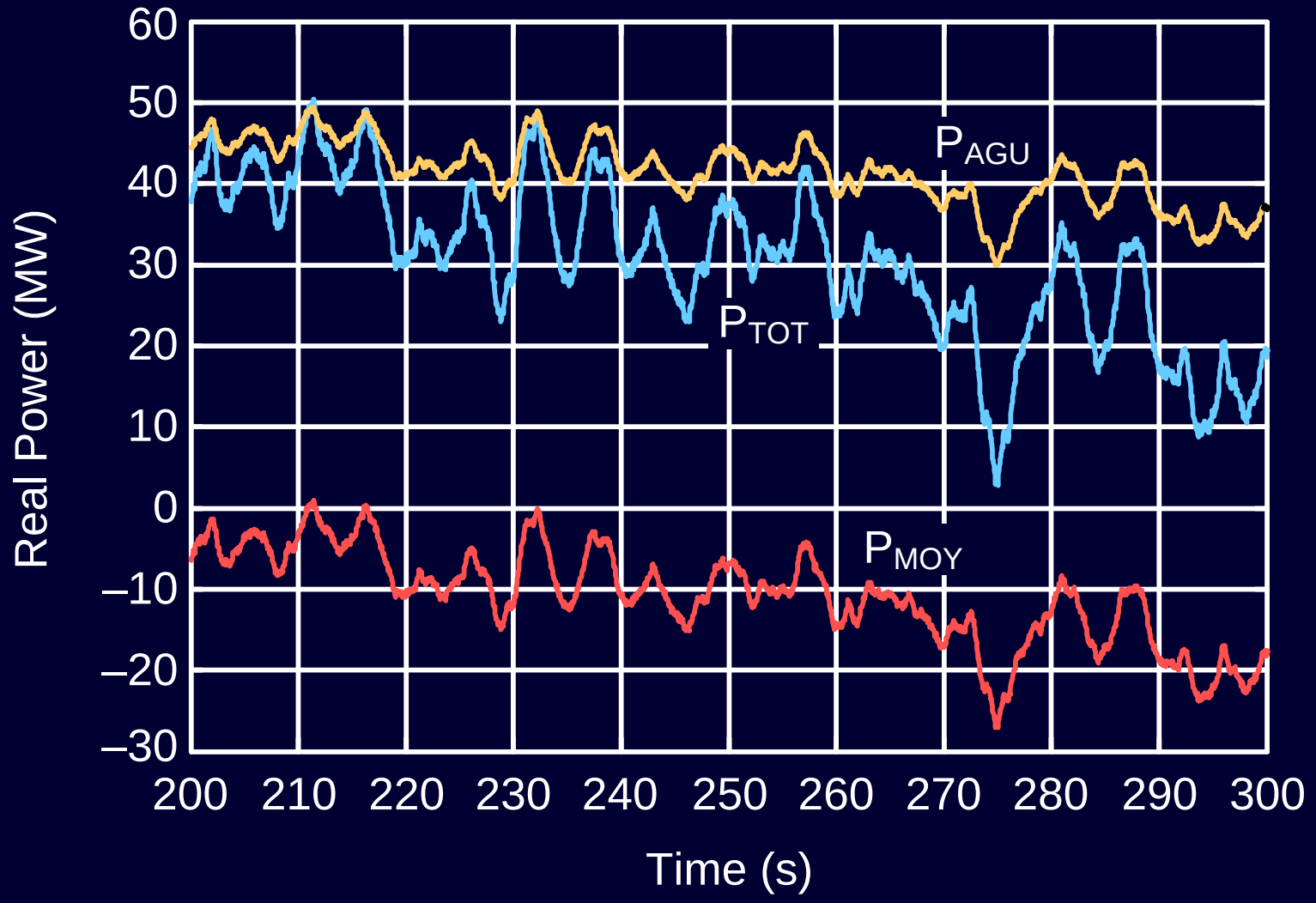
Signal-to-Noise Ratio (SNR)

Mode Frequency(f_m)

Mode Amplitude (ζ_m)

Mode Damping Ratio (A_m)

Normal Operational Experience

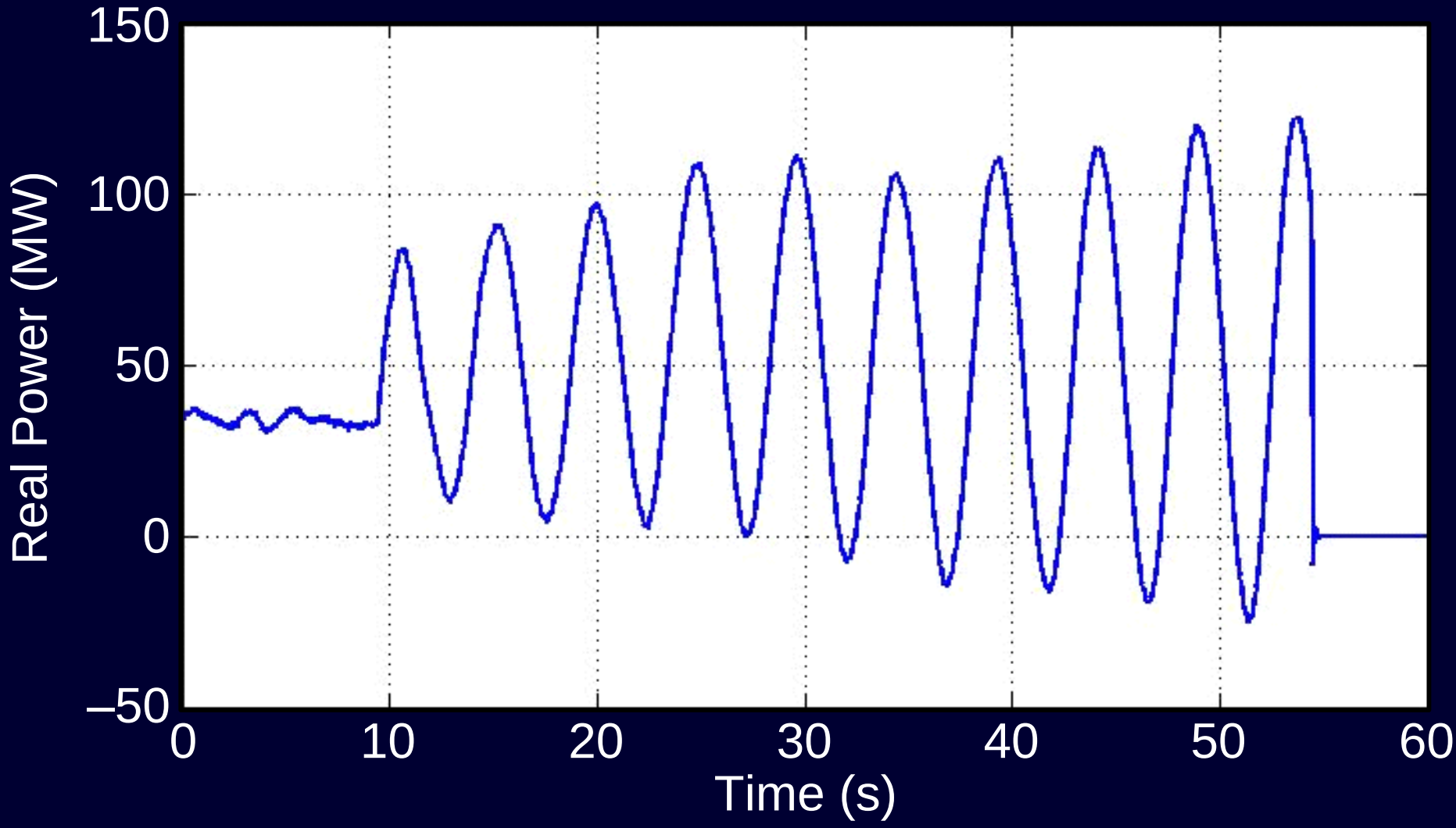


MA Scheme Mitigates Unstable Oscillation – July 28, 2012

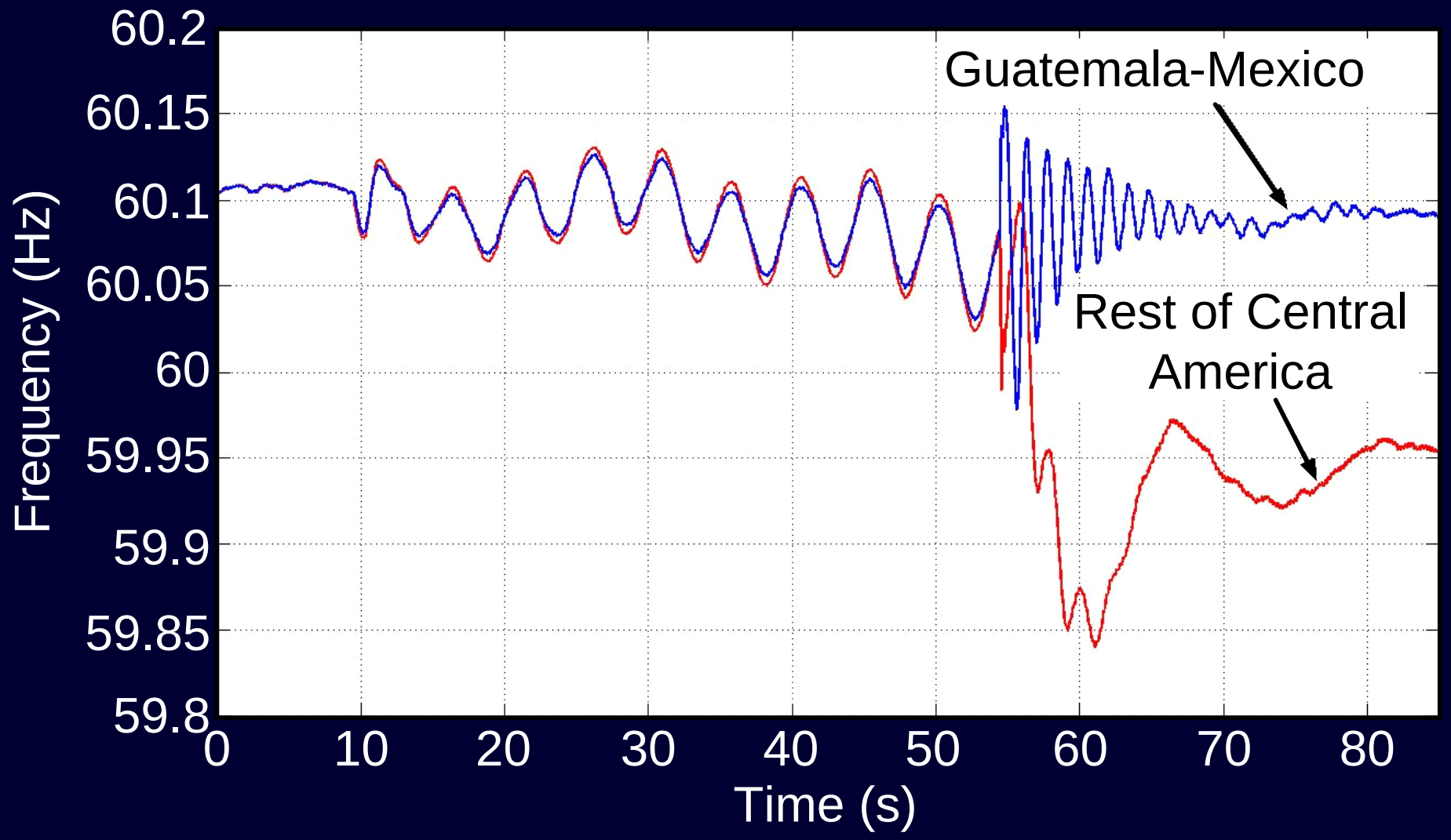
- MA scheme enabled in mid-June 2012
- Unstable mode shows after synchronizing two parts of Central American power system

Event Happens After Synchronization

MA Scheme Mitigates Unstable Oscillation – July 28, 2012

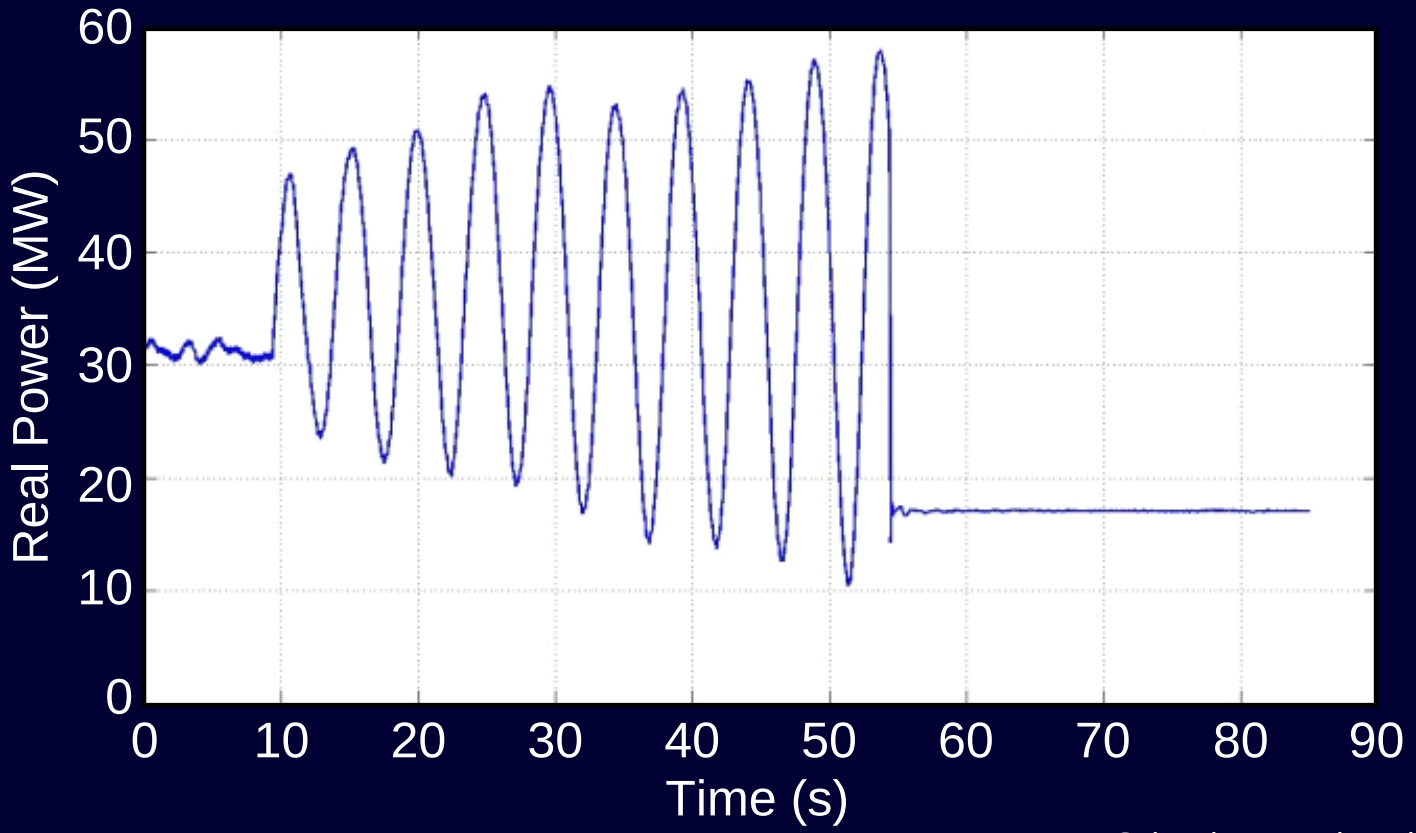


Synchrophasor-Based Control Successfully Stabilizes System



Guatemala Remains Stable

- Guatemala reaches new steady state
- Mexican power system largely contributes



Wide-Area Visualization, Analysis, and Control Summary

- Synchronized power measurements
- Real-time modal analysis
- System visualization displays
- Archived data analytics
- Operational experience

Questions?