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CORDOVA ELECTRIC COOPERATIVE, INC

Identification and Evaluation of Oscillations in the Cordova, Alaska Microgrid

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***PNNL, +Cordova Electric Cooperative**

U.S. DEPARTMENT OF ENERGY BATTELLE

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RADIANCE
Project Overview

Image Source: https://www.cordovaelectric.com/cordova/radiance-project/

Project Objectives & Expected Outcomes

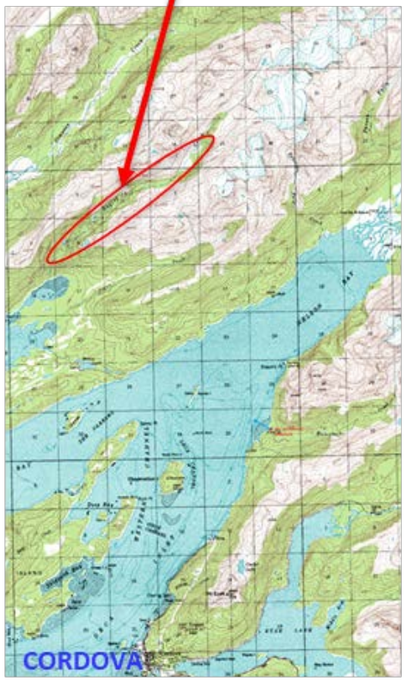
- **RADIANCE** - Resilient Alaskan Distribution system Improvements using Automation, Network analysis, Control, and Energy storage
- Three-year GMLC project started in December 2017
- Resilience enhancement in Cordova against physical threats (tsunami, avalanche, volcano) and cyber threats
- Resilience by design – using zonal approach in multiple loosely- and tightly-networked microgrids
- Multiple networked microgrids, energy storage, early-stage grid technologies such as distribution-PMUs

Demonstration site: City of Cordova, AK

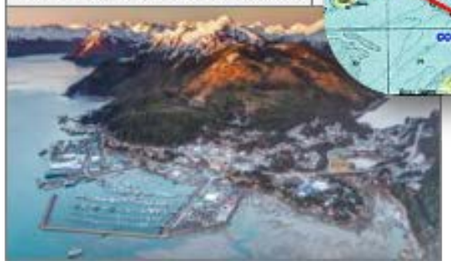
Humpback Creek Hydroelectric Plant
1250kW (2 x 500 kW + 1 x 250 kW)
17,000 foot UG and submarine transmission line

Power Creek Hydroelectric
6278kW (2 x 3124 kW)
25 kV transmission ties to Eyak Substation, Inflatable dams

Location: Raging Creek
Potential site for another hydro ~2 to 5MW



City of Cordova
1,566 customers, 18MW
One Substation
78mi UG distribution lines



Orca Power Plant
10.8 MW Diesel
Control Center, CEC

Crater Lake Dam Storage
may offset 25% Diesel consumption

- Population of 2600
- Total load demand of about 18MW
- Generation:
  - primarily hydroelectric plants (total 7.5MW), and 10.8MW diesel generation.
  - three generation stations (one diesel - ORCA, and two hydroelectric – Power Creek and Humpback Creek (HBC) plants).

Project Team

NREL / INL	Sandia National Laboratories	Pacific Northwest National Laboratory
Digital Real-time Simulation, HIL, Rapid prototyping, cyber-vulnerability and security analysis testbed, virtual rotational inertia controls, batteries	Microgrid design (MDT – Microgrid Design Toolkit) and control testbed, PHIL Inverter testbed, Stability, energy storage, protection systems, field deployment	Micro-PMUs and sensor placement, fault propagation, communication networks testbed and protocols, IEC 61850, IEC 62351, GridLAB-D integration

City of Cordova, Alaska
Demonstration site, Engineering and deployment

AVEC – Alaska Village Electric Cooperative
58 remote village communities in AK

SIEMENS
Energy Storage Management System

Microgrid Design Toolkit
Microgrid design, controls vendor for networked architecture, protection

NRECA – America's Electric Cooperatives
Rural electrification leadership, outreach

ACEP – Alaska Center for Energy and Power
University partner, rural microgrid research, microgrid and communication design, field deployment, utility interaction

CEC
Utility partner, engineering support, field deployment

Washington State University
Resilience metrics, valuation analysis, baseline

NM State University
Microgrid design, stability analysis

Clemson University
Protection design and testing

Highlights

- 1MW/1MWh ABB-Saft BESS installed and commissioned in August 2019
- A new fiber optic network has been installed and commissioned between all generating stations and Eyak substation
- Dispatchable Electric Boiler that captures excess hydro and offsets an estimated $10,000 of diesel installed 2019
- Advanced Metering Infrastructure (to be installed and commissioned in FY21)
- Cybersecure Network buildout (to be commissioned in FY21)
- Four micro (distribution) Phasor Measurement Units (uPMUs) were installed in the substations, plus one was installed directly at the BESS

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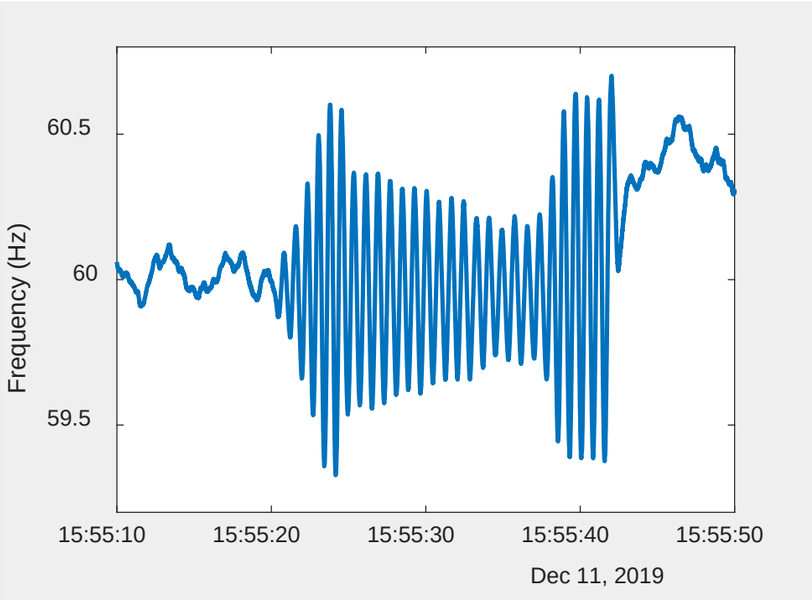
Synchrophasor Analysis



Analysis Setup

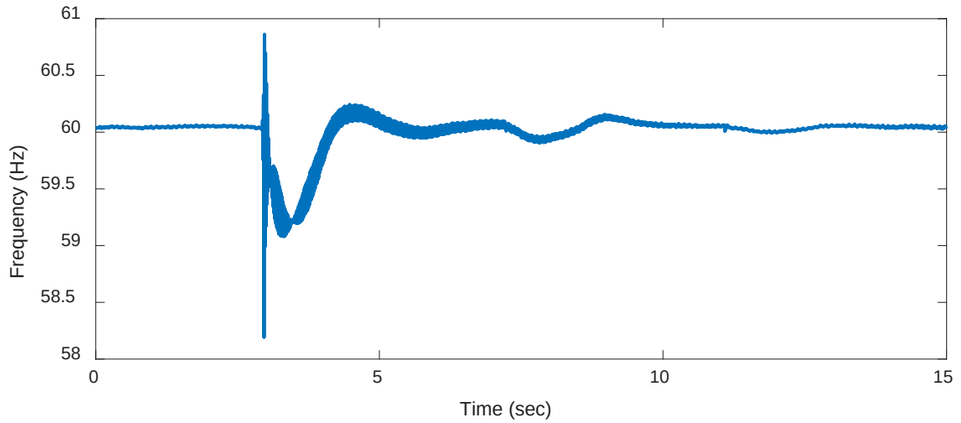
Power Standards Lab (PSL)
microPMU

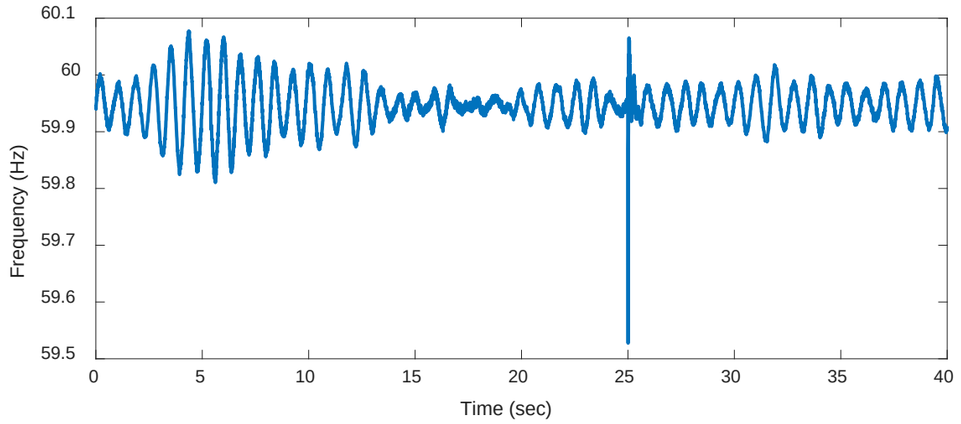
Grid Protection Alliance (GPA)
openHistorian

PNNL Archive Walker

Initial Oscillation Identification

- Data ingestion
- Quality checks
- Signal processing
- Event detection
- Data export

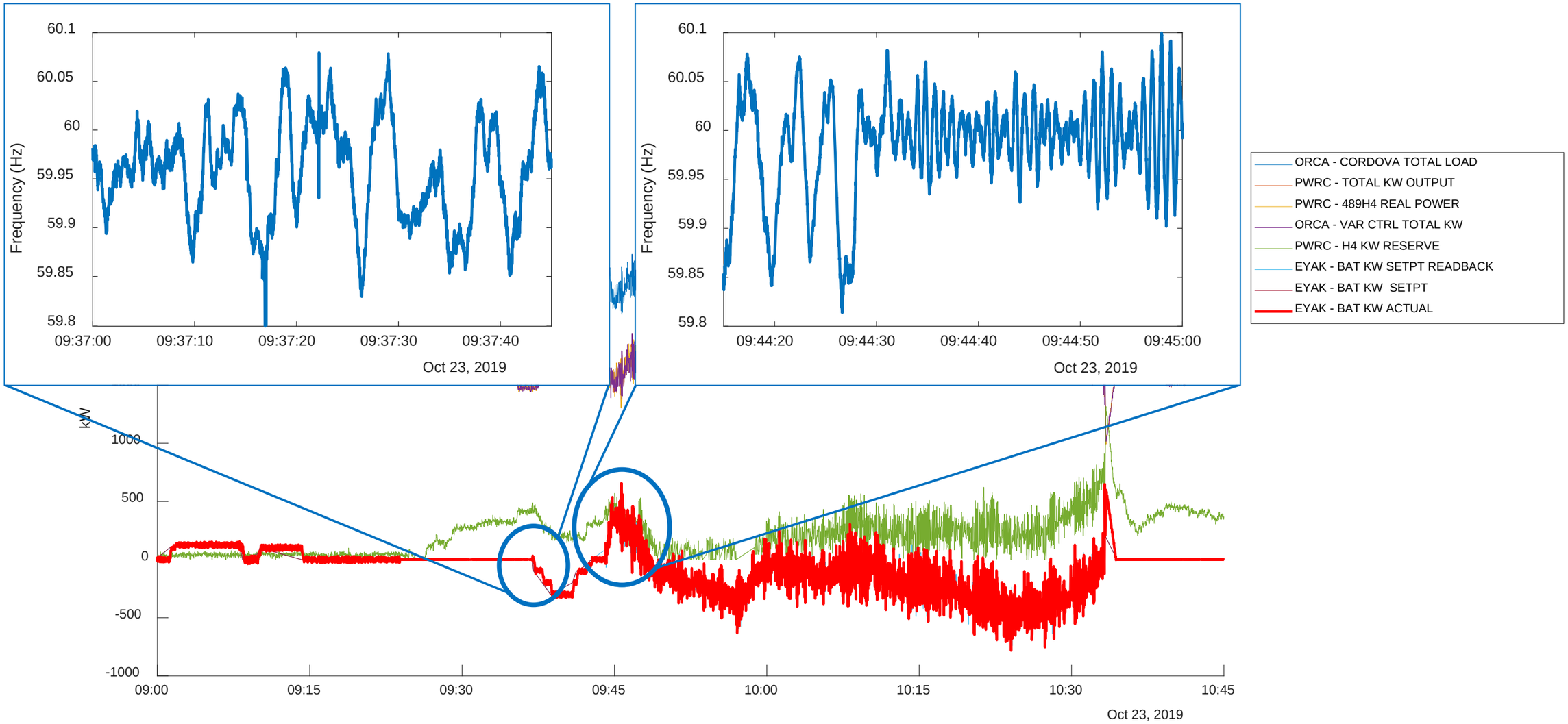




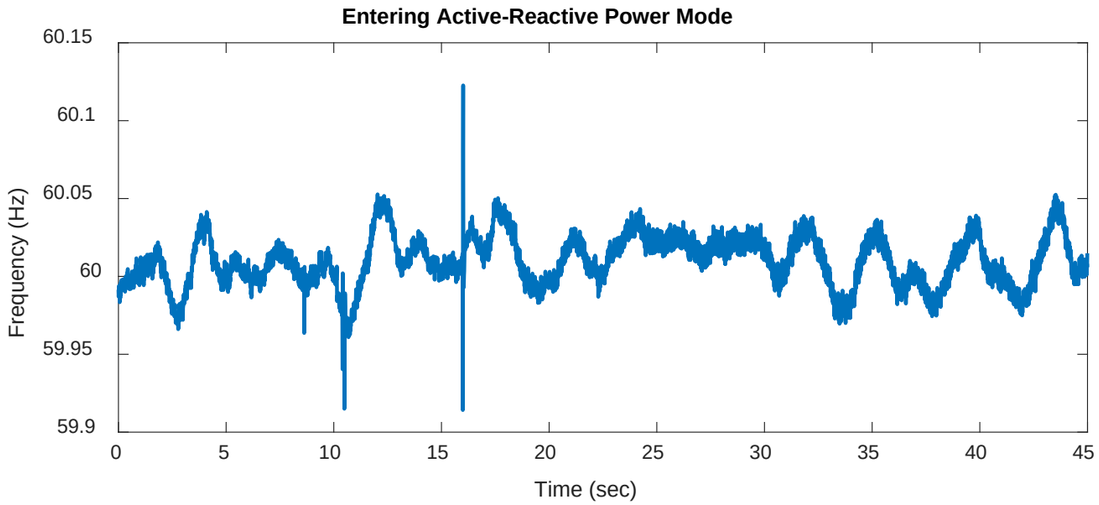
Oscillation frequency ~ 1.2 Hz

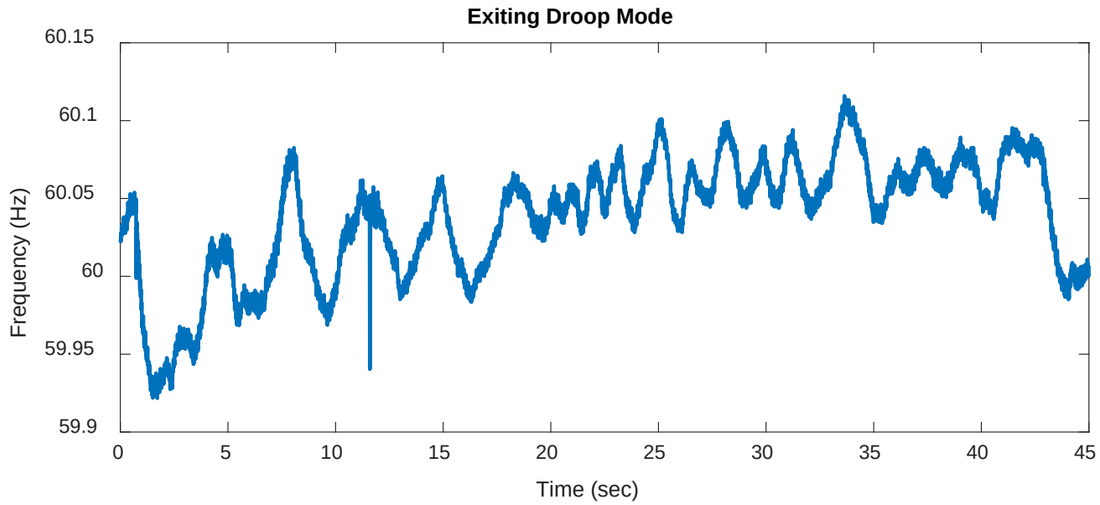
Model Validation

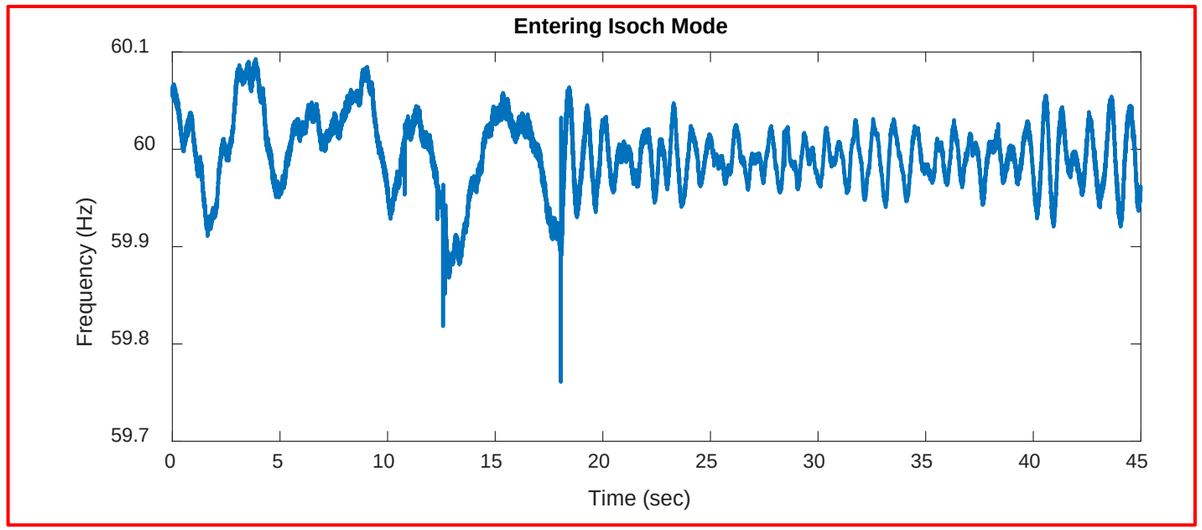
Identifying the Oscillation's Source



BESS Operating Modes

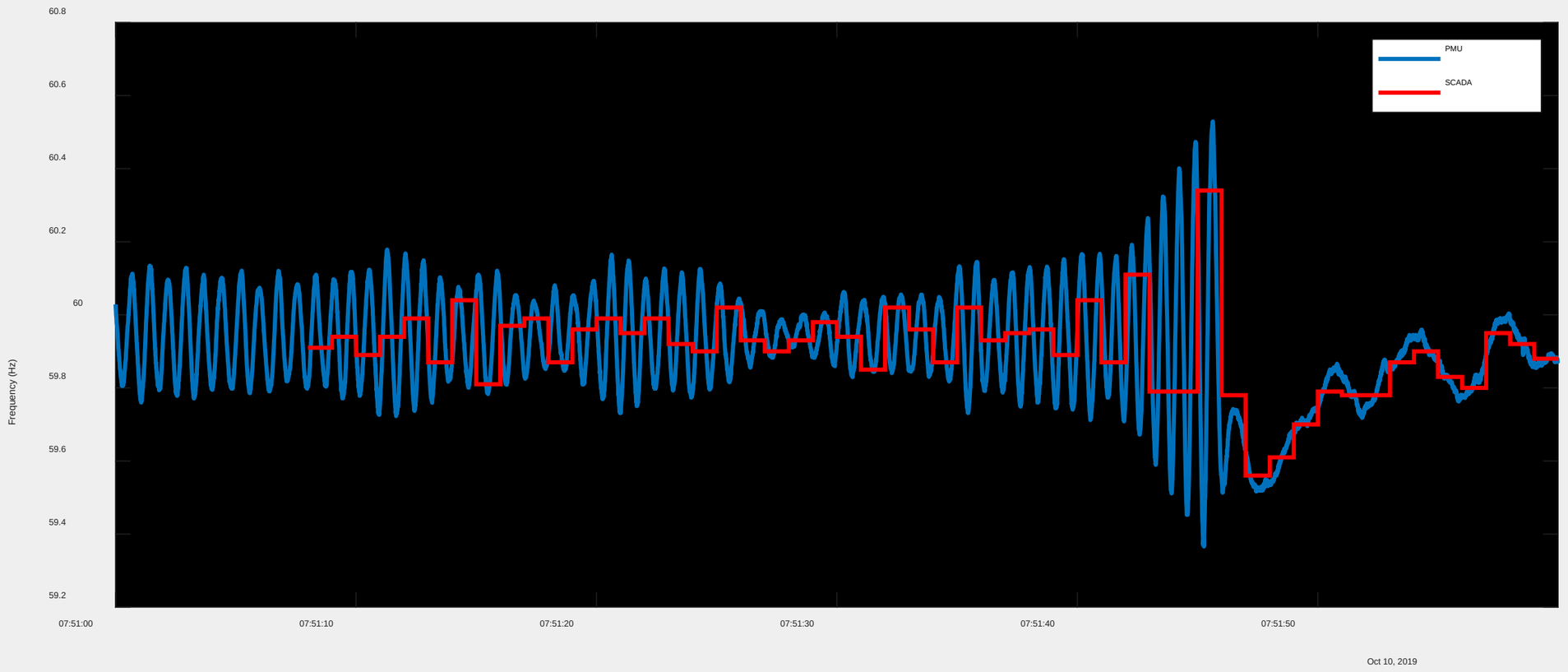






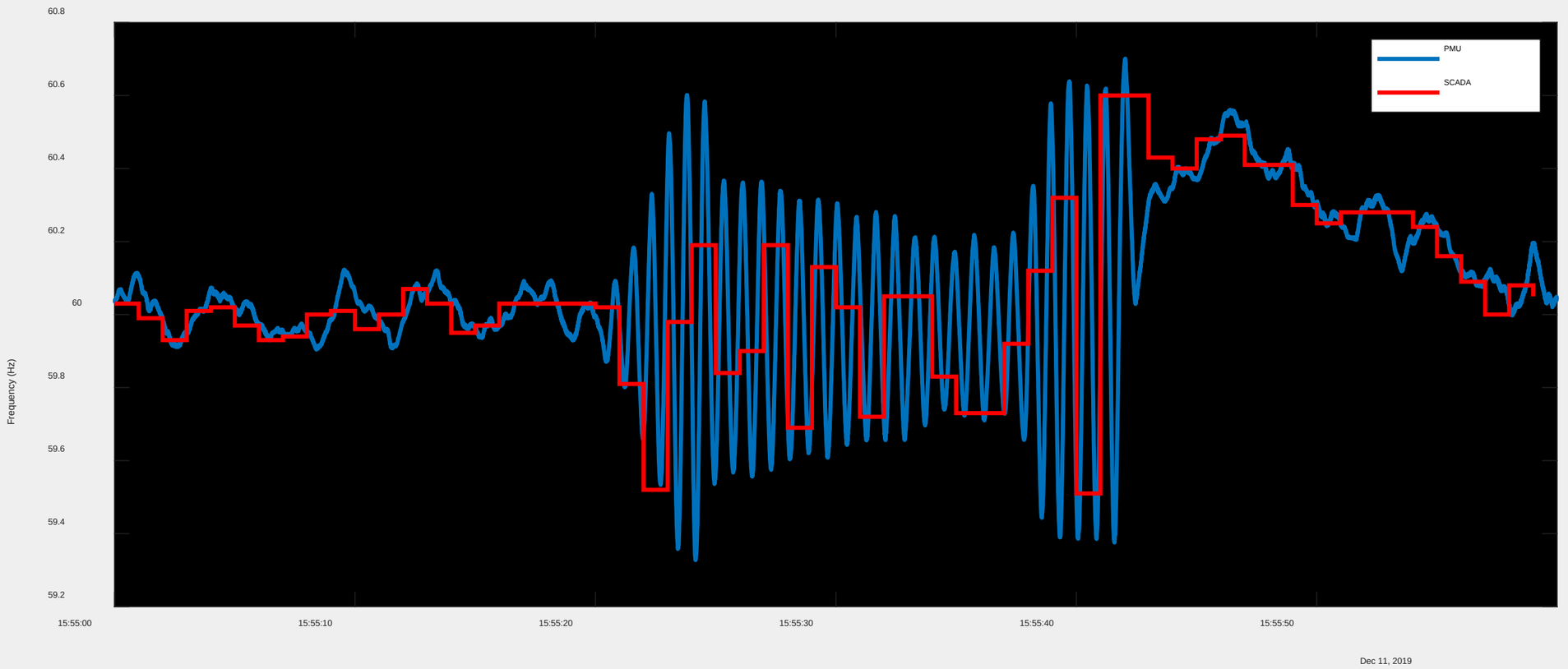
SCADA-Based Tuning

Before tuning: synthetic inertia set to 1000 ms



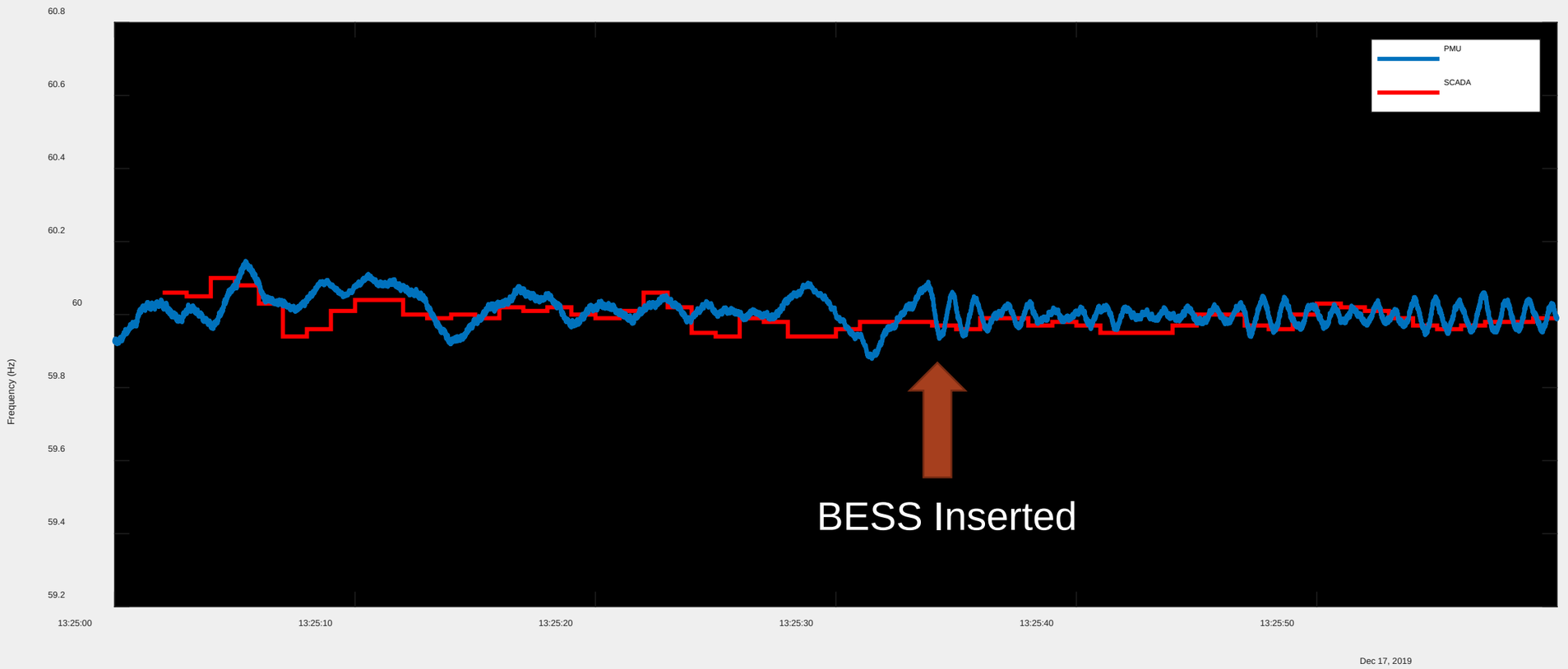
SCADA-Based Tuning

Initial tuning: synthetic inertia changed from 1000 to 2000 ms



SCADA-Based Tuning

Final tuning: synthetic inertia changed to 500 ms



Success?

After SCADA-based tuning, the oscillation was no longer visible in SCADA measurements

PMU measurements still revealed the oscillation, particularly in the frequency domain

Does an oscillation's unobservability in (SCADA) measurements indicate that it is not a threat?

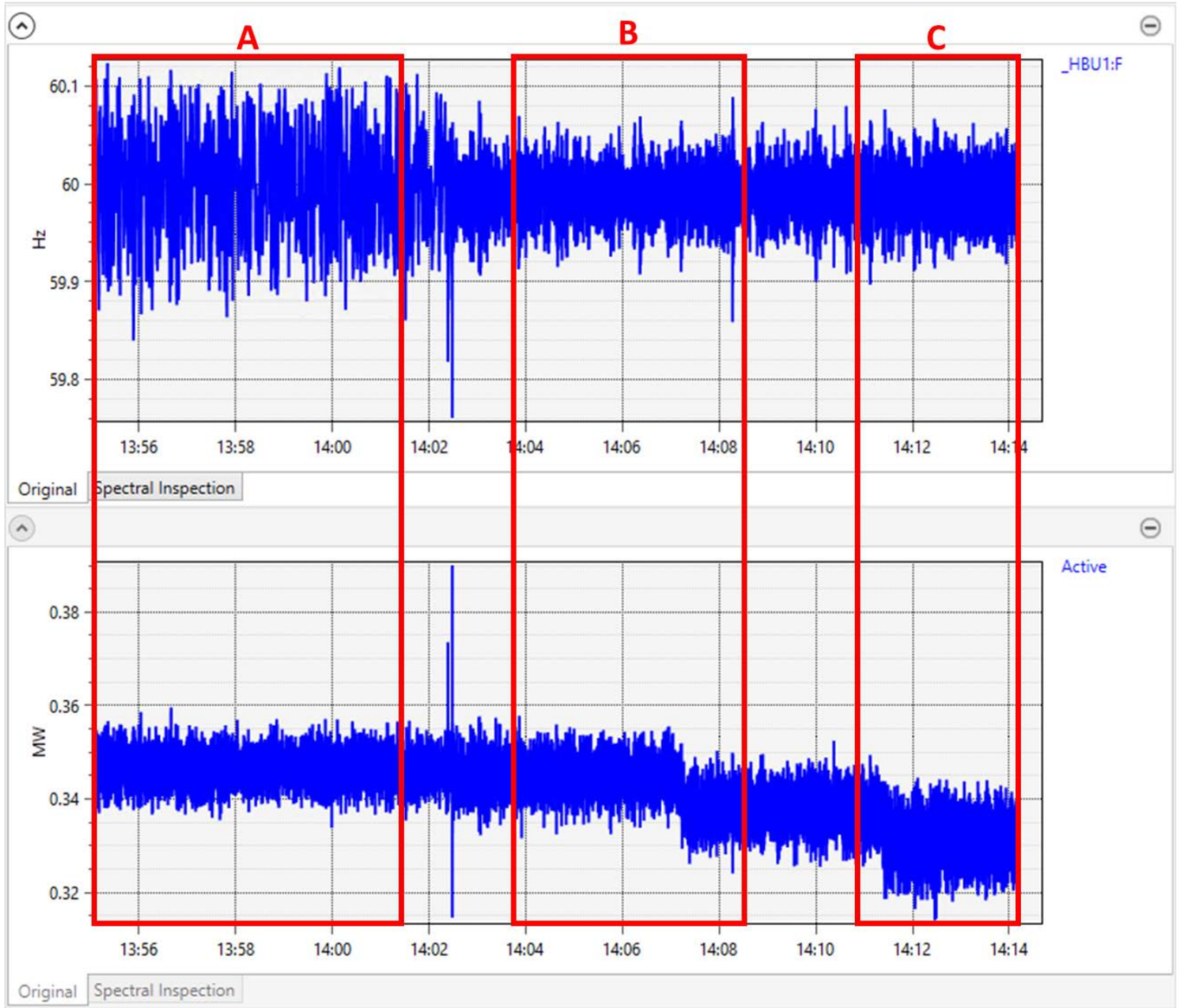
No

The RADIANCE team continued investigation and discussion based on PMU measurements

PMU-Based Investigation

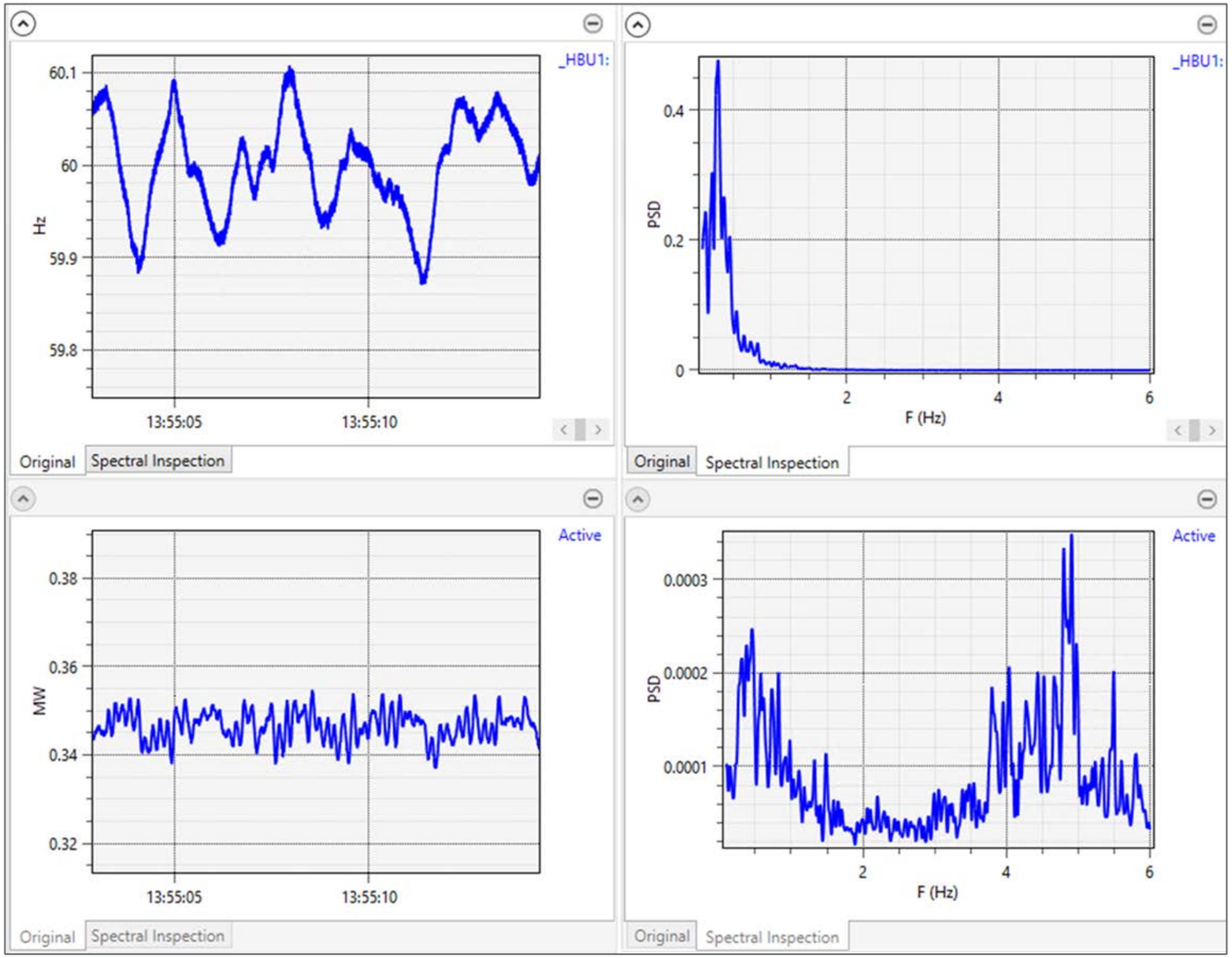
A. BESS disconnected
B. BESS in isoch
C. BESS in isoch

Measurements are from a PMU monitoring a hydro unit



A. BESS Disconnected

Time-domain frequency measurements



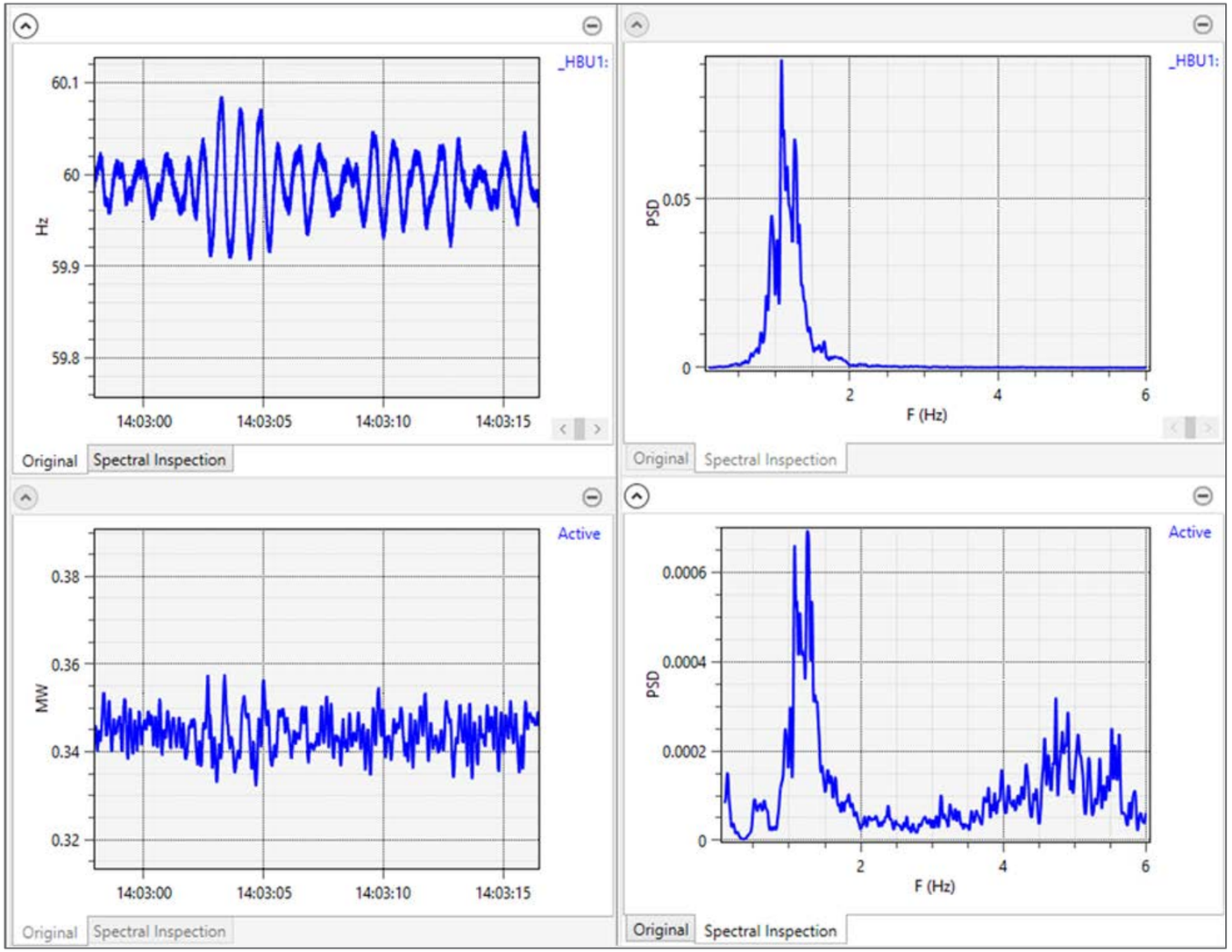
Spectrum of frequency measurements

Time-domain power measurements

Spectrum of power measurements

B. BESS in Isoch

Time-domain frequency measurements



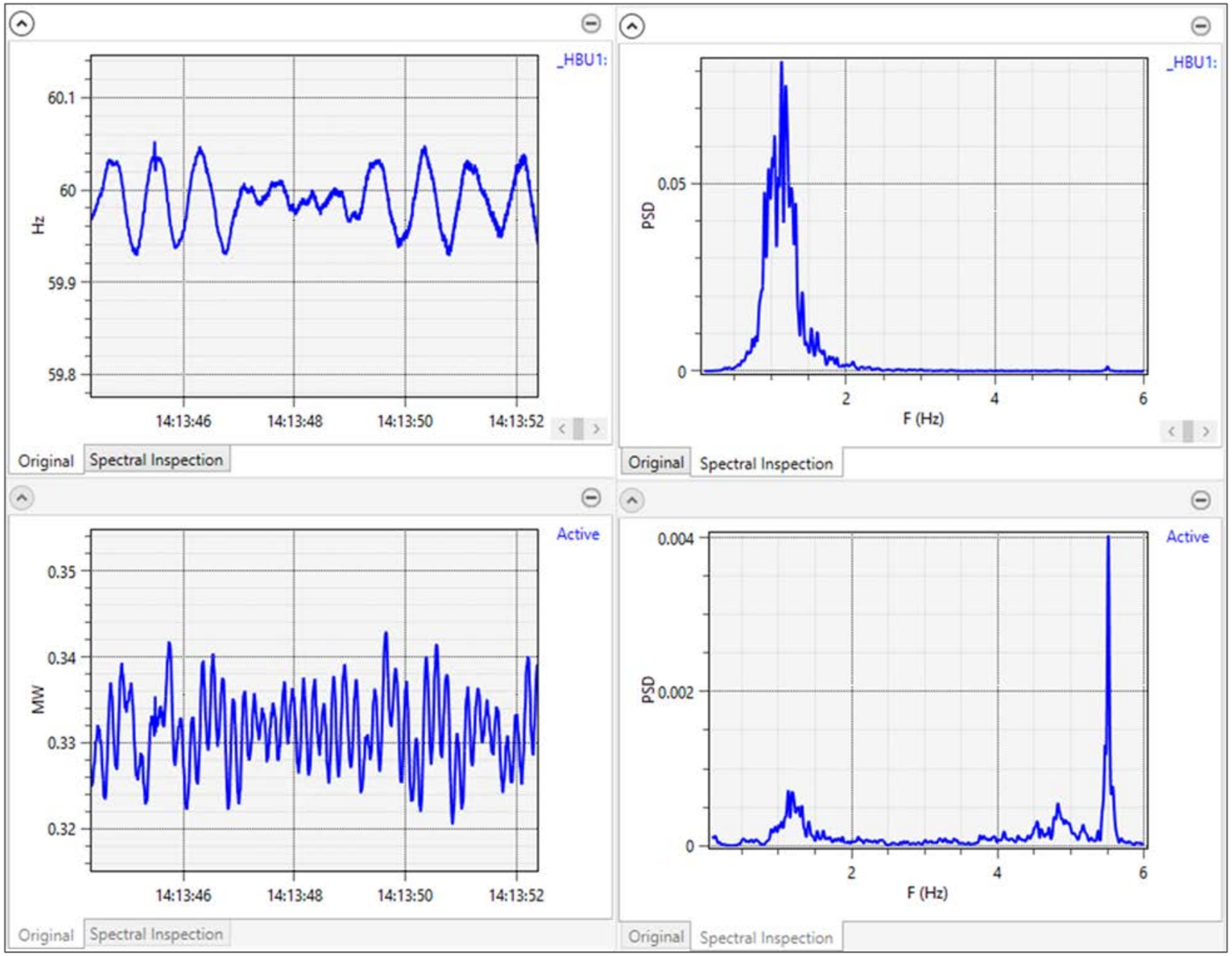
Spectrum of frequency measurements

Time-domain power measurements

Spectrum of power measurements

C. BESS in Isoch

Time-domain frequency measurements



Spectrum of frequency measurements

Time-domain power measurements

Spectrum of power measurements

Outcomes

- PMUs
  - Enabled a thorough investigation of the oscillations
  - Improved the team's understanding of the BESS control modes
- Low-level oscillations are still present near 1.2 Hz and 5 Hz
- Valuable insight from other BESS installations in Alaskan microgrids
  - Oscillations are not viewed as an immediate threat
  - Primary concern: reduced BESS life
  - Secondary concern: long-term wear on equipment
- Cordova Electric Cooperative is coordinating with vendor to ensure BESS control system is properly tuned

Cordova Electric Cooperative Energy Storage Integration (CECESI)

Project Overview

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Project Objective & Expected Outcomes

- Cordova Electric Cooperative installed a 1MW/1MWh battery energy storage system (BESS) in 2019 with a primary objective of reducing diesel fuel consumption
- To support the BESS's primary objective, the CECESI project will:
  - further improve integration of the BESS into CEC's utility monitoring and controls environment,
  - support CEC's use of recorded operating data to verify the benefits from BESS operation, and
  - inform CEC's continued improvement to the BESS's dispatch algorithms

CECESI Scope Update, Add microPMU

- In 2020, the CECESI project scope was updated
- Addition of a microPMU at the Cordova Community Medical Center with the following goals:
  - Provide additional information on the interrelationships between grid operations and major load operations
  - Expand the CECESI optimization solution
  - Help to further reduce diesel fuel use
  - Explore extending load service reliability through better visibility

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Thank you