

Duke Energy's Experience with Oscillation Monitoring and Analysis

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Duke Energy

NASPI Work Group Meeting

September 24, 2025

11:00 – 11:20 am

Outline

Duke Energy Overview

Duke Energy PMUs Across the Carolinas

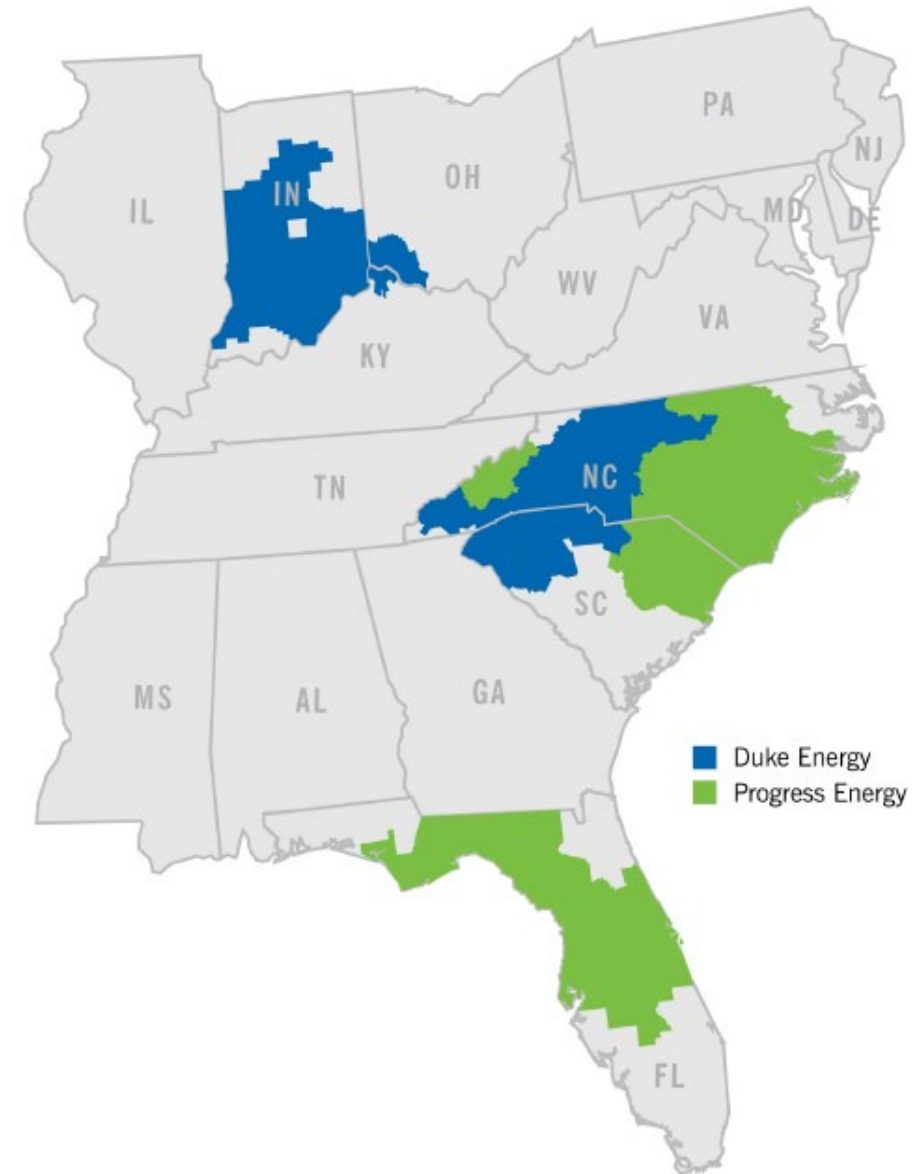
Past Oscillation Events

Recent Oscillation Events

Oscillation Detection Pilot

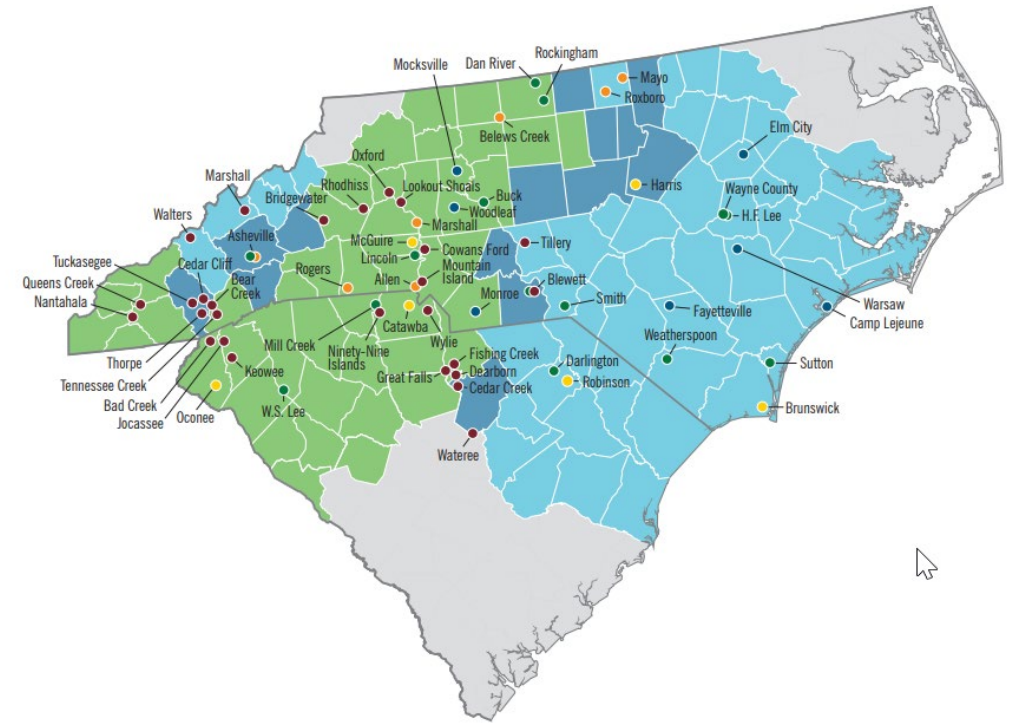
Future Work

Duke Energy U.S. Service Territories



DEC and DEP Footprint and Generation

*Approximately 40 Transmission
Connected Solar Sites in DEC and
DEP*



Plant Locations Generation Type

- Nuclear
- Hydro
- Coal
- CC/CT
- Solar

Service Territory Counties Served*

- Duke Energy Progress
- Duke Energy Carolinas
- Overlapping Territory

**Portions may be served by other utilities.*

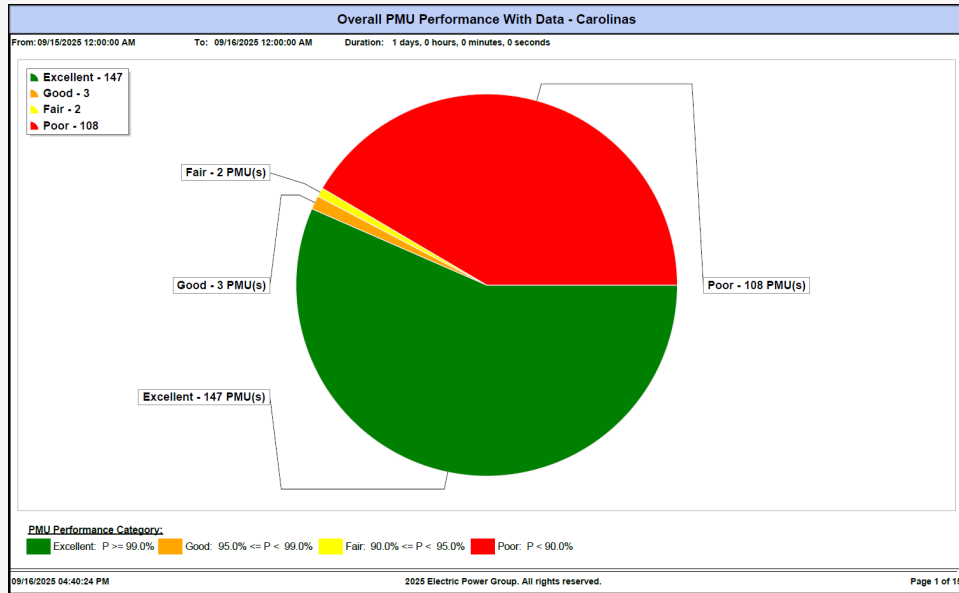
Duke Energy – the Carolinas at a Glance

- Energy Control Centers in Raleigh (Duke Energy Progress) and Charlotte (Duke Energy Carolinas) operate and serve customers in both North and South Carolina
- North Carolina
 - 3.7 million retail customers, representing a population of more than 7 million people
 - 13,403 miles of high voltage transmission lines
- South Carolina
 - 820,000 retail customers
 - 6,000 miles of high voltage transmission lines
- Duke Energy Progress' service area covers approximately 32,000 square miles, supplies electric service to approximately 1.5 million residential, commercial and industrial customers, owns 13,600 MW of generation capacity (winter) and 6,300 miles of transmission lines



6

Garner Energy Control Center

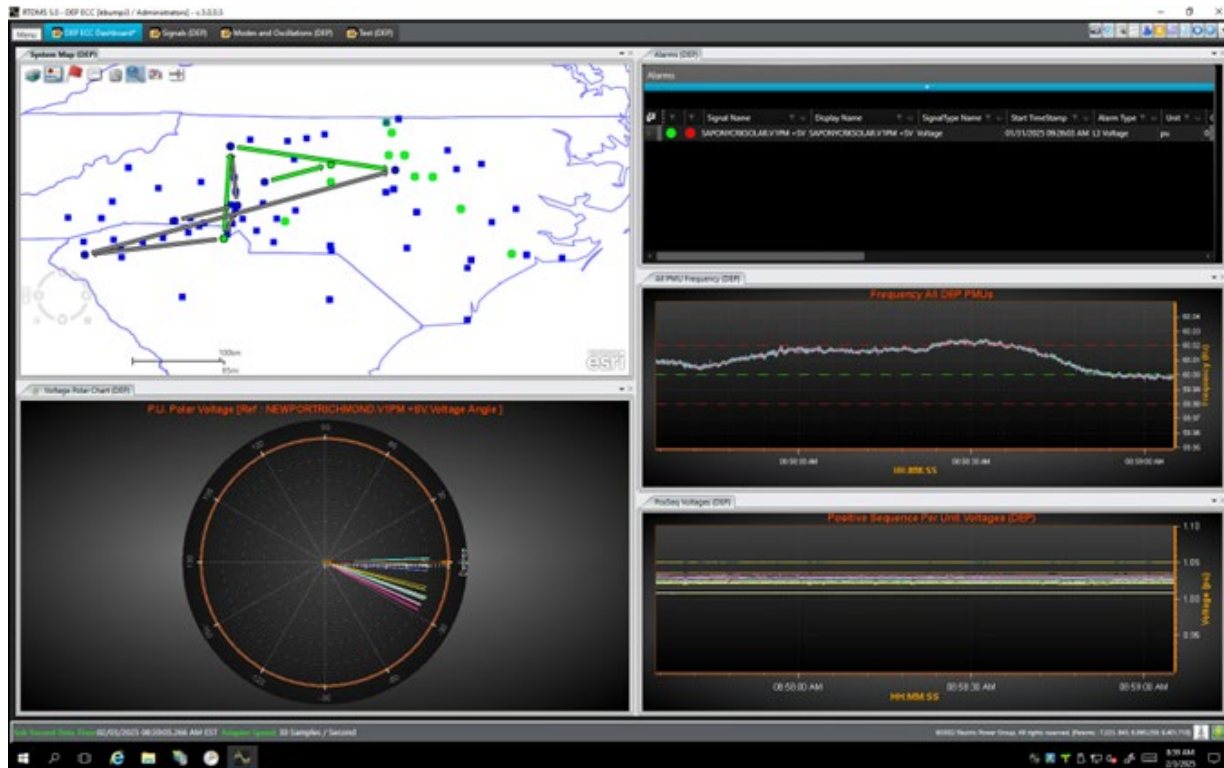


Duke Energy PMU Data in the Carolinas

- Approximately 450 PMUs installed across the Duke Energy Carolinas Territory
 - Devices
 - SEL 351
 - USI DFR
 - SEL 735
 - Locations
 - Initial selected transmission lines
 - Solar and Battery Interconnections
- 260 PMUs Sending Data to EPG's RTDMS
- Approximately 147 PMUs sending good data.

Storage and Visualization Tools

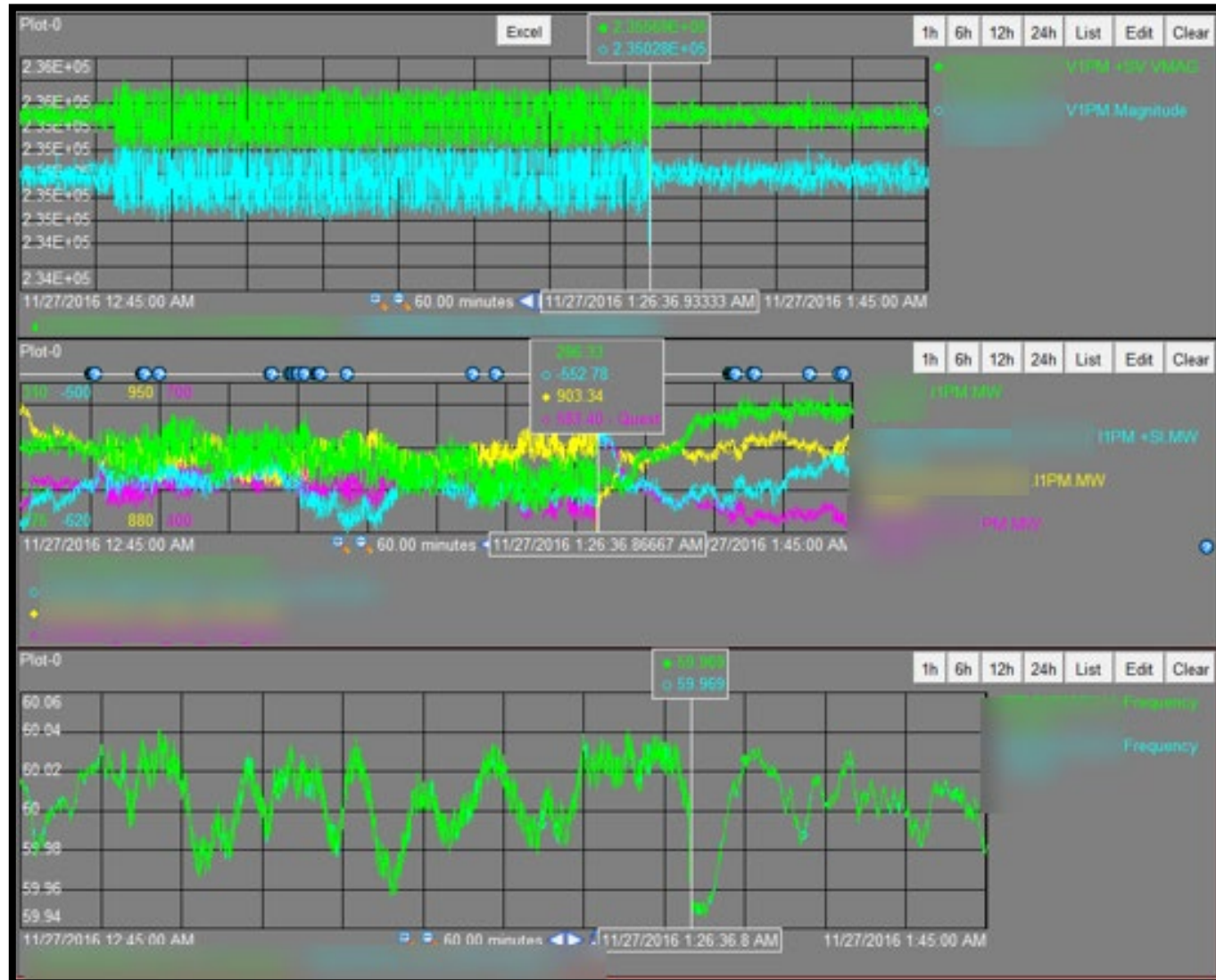
RTDMS - ~260 PMUs



PI - All PMUs



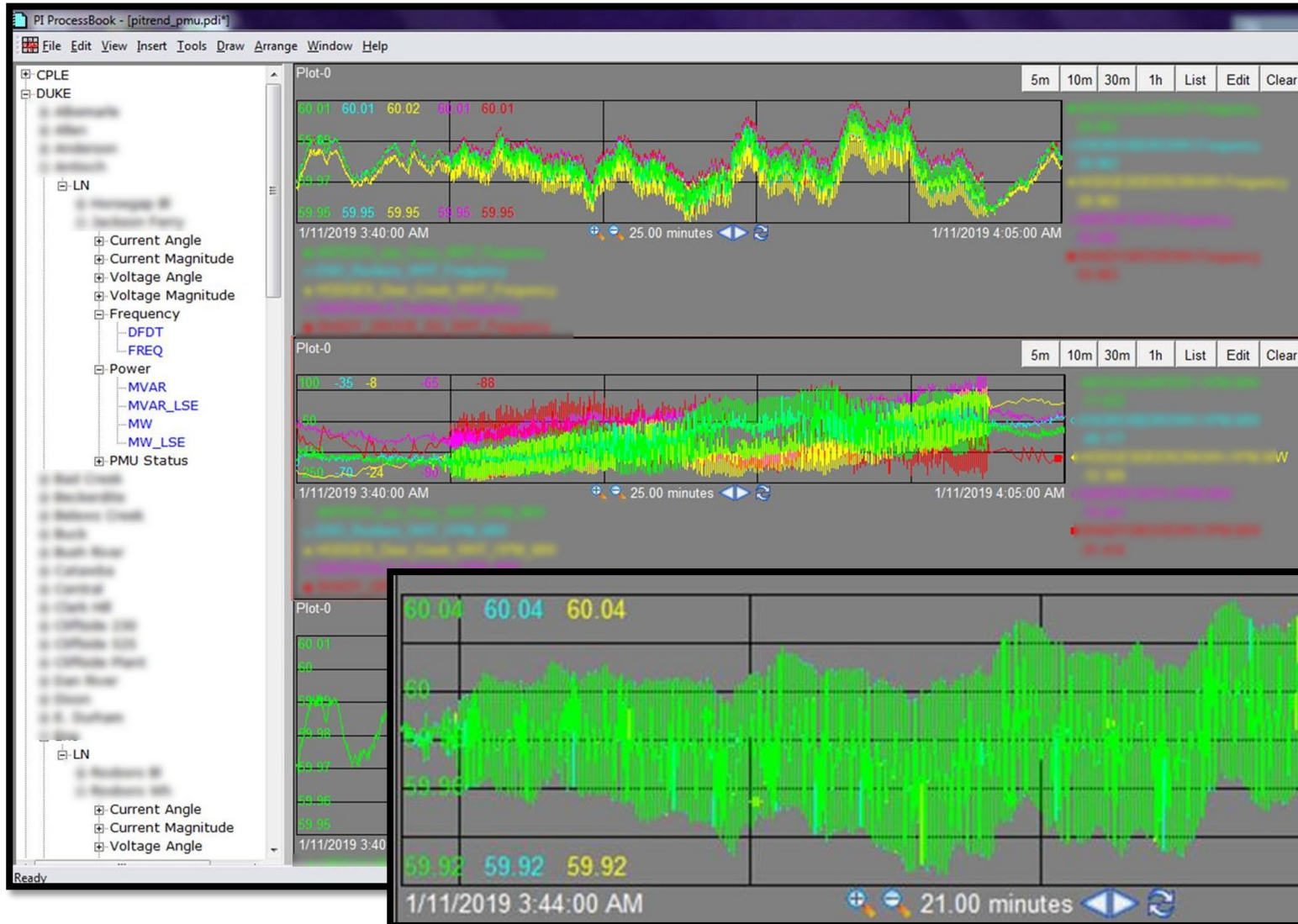
Forced Oscillations – Farley Unit 2016



Email Communication:

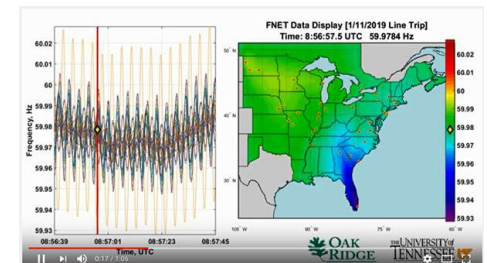
- On Sunday morning 11/27/2016 One of the Duke Nuclear Plant Operations noticed irregular swings on their generator field voltage and generator output voltage on Unit 1 and similar swings (but less pronounced) on Unit 2.
- The ECC was unable to see the voltage oscillations from the SCADA data.
- It appears that the oscillations started around ~00:51 and lasted until ~01:26 for a duration of approximately 35 minutes.
- Looking at Plant data and PMU data we noticed oscillations throughout the system. We also noticed a drop in frequency of ~0.05 Hz at the exact time that the oscillations stopped.
- We discovered that during the time of the oscillations the SOCO RC reported a problem near the “Georgia-Florida Line” and the oscillations stopped when an approximately 900 MW Nuclear Unit (Farley Unit 1) in the Southeastern corner of Alabama tripped offline.

2019 Forced Oscillation



Email Communication:

- Early this morning we experienced some pretty big frequency oscillations across the Eastern Interconnection from about 3:44 AM to 4:03 AM.
- Based on what little information I have, I am speculating that the oscillations were centered somewhere in Florida, but am not sure of that.
- I sent an email to Dr. Yilu Liu at Univ of Tenn to ask if she could make a video of this event from FNET. Don't know if she is in today, so not sure when I might get anything. Will share it with you when I do.



0.25 Hz Oscillation
Frequency in Band-2
detected



Frequency
Voltage Magnitude
Angle Difference
MW
MVAR
Sensitivity
Oscillation
Damping

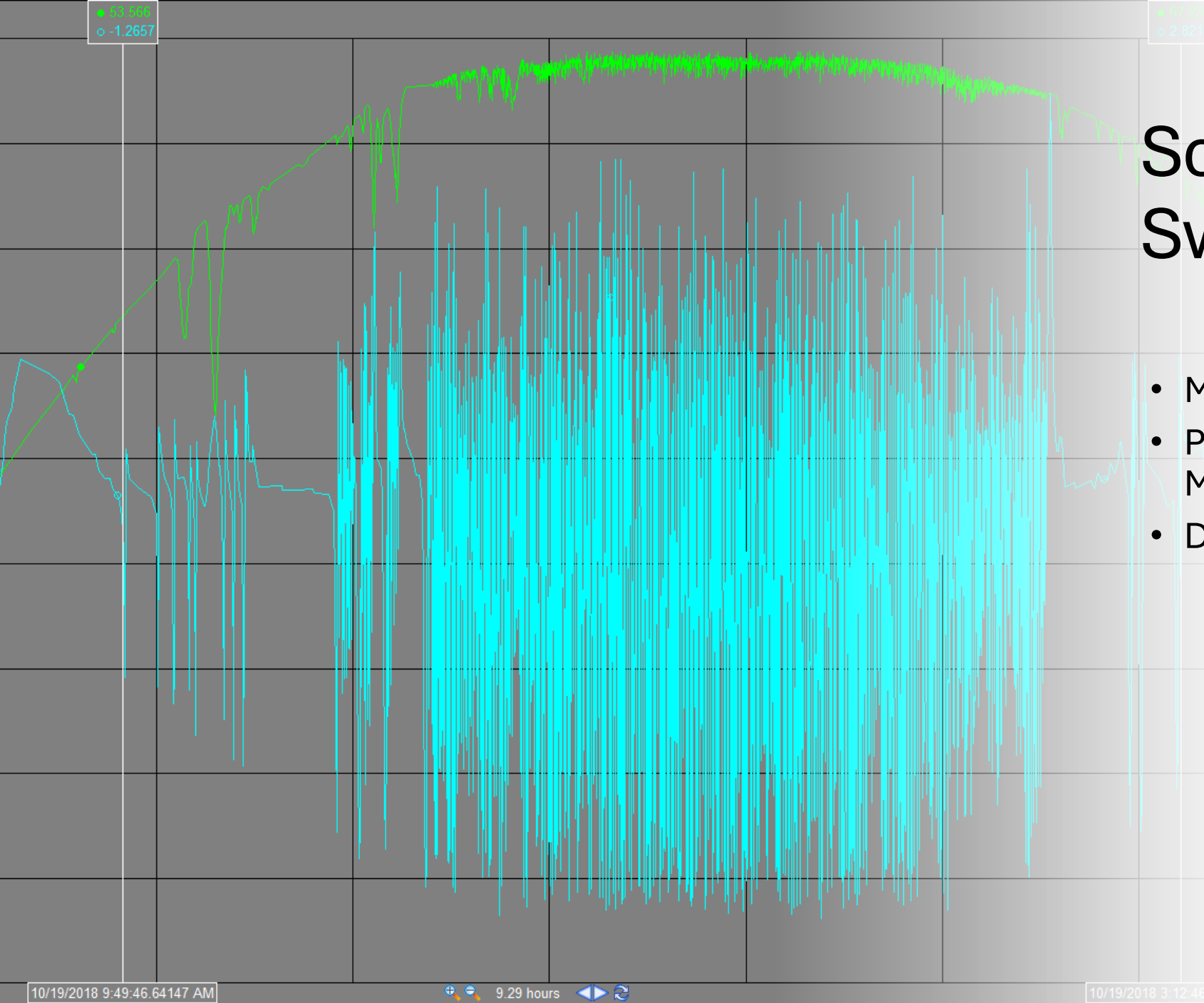
Oscillation Alarm
Indication

Signal Name	Display Name	SignalType Name	Start Time/Stamp	Alarm Type	Unit	Cum
		Oscillation	01/15/2019 06:34:45 PM	H3 Value 2 Band2 Oscillation %	%	01/15
		Oscillation	01/15/2019 06:33:30 PM	H4 Value 1 Band2 Oscillation %	%	01/15
		Oscillation	01/15/2019 06:32:15 PM	H4 Value 1 Band2 Oscillation %	%	01/15
		Oscillation	01/15/2019 06:31:30 PM	H3 Value 1 Band2 Oscillation %	%	01/15
		Oscillation	01/15/2019 06:31:30 PM	H3 Value 1 Band2 Oscillation %	%	01/15



2019 Forced Oscillation

- EPG played back the DEF PMU data using the RTDMS configuration provided in our test system , and RTDMS detected the 0.25 Hz oscillation with the **existing** DEF configuration.



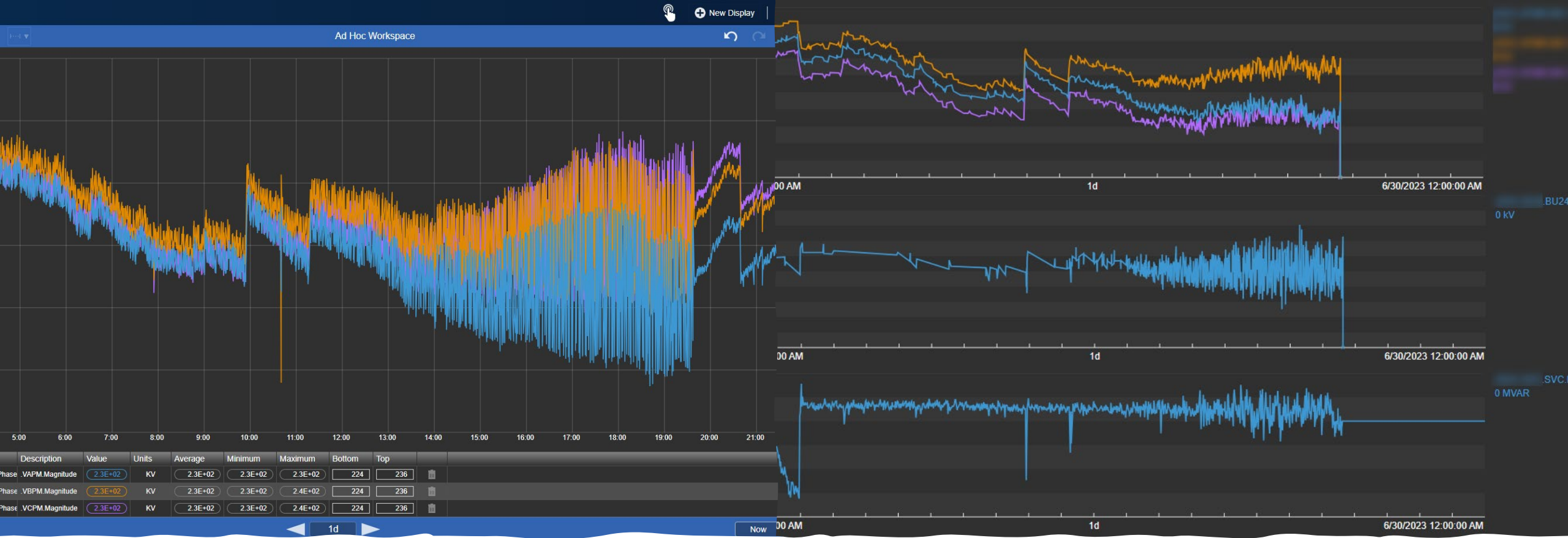
Solar Site MVAR Swing 2018

- MVAR plot (cyan)
- Plot scale -15 MVAR to 15 MVAR
- Detected via SCADA Data

10/19/2018 9:49:46.64147 AM

9.29 hours

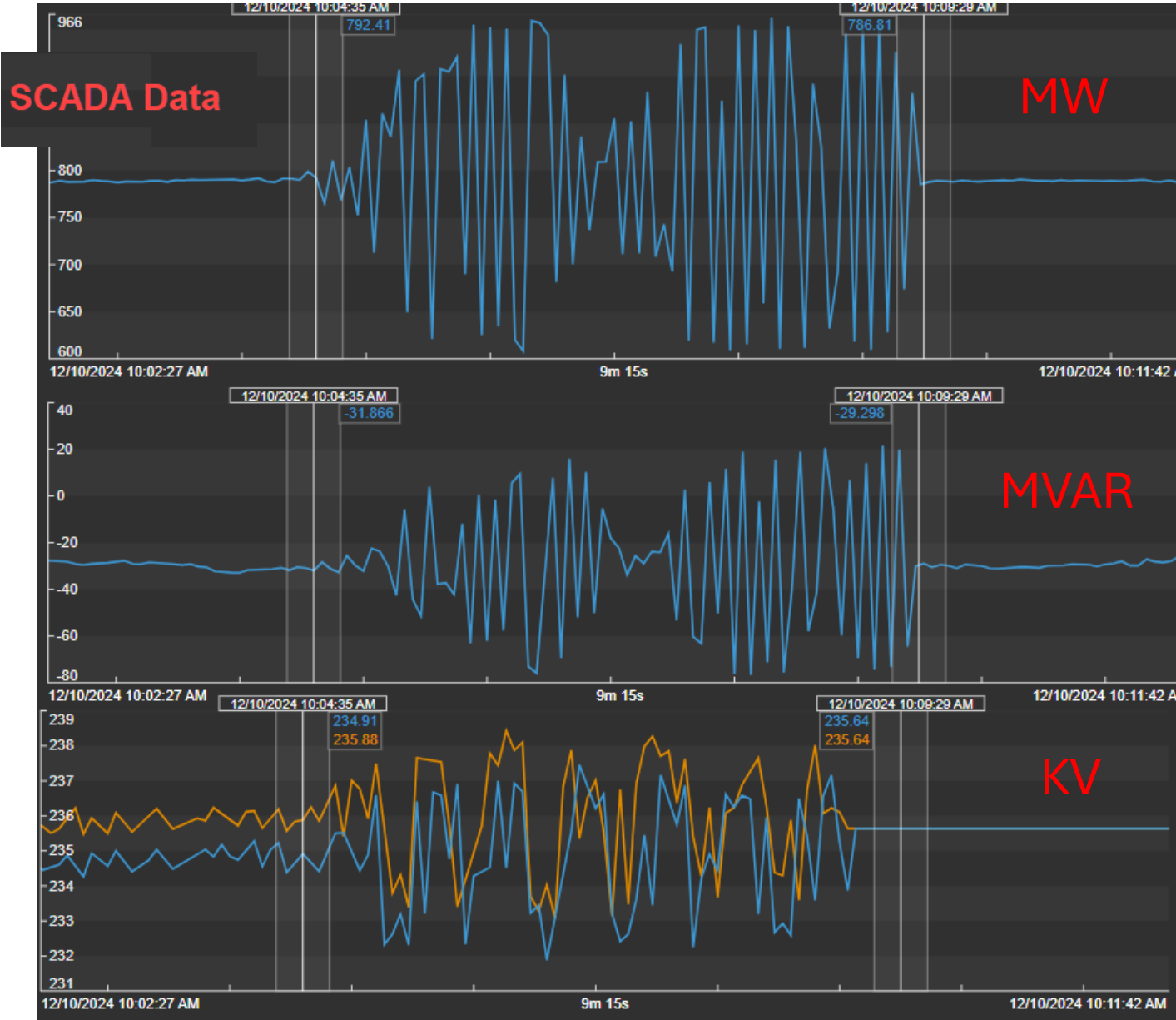
10/19/2018 3:12:46.47136 PM



SVC Induced Oscillation

- Received call from account representative regarding customer voltage problems.
- LED lighting; customers seeing flickering lights; voltage at the [home] meter is within tolerance. It's been noticed sporadically.
- PMU data shows voltage oscillation. Largest magnitude is largest close to one of the SVC locations.
- Verified issue via SCADA data in EMS and de-energized SVC.

2024 Forced Oscillation Duke Energy

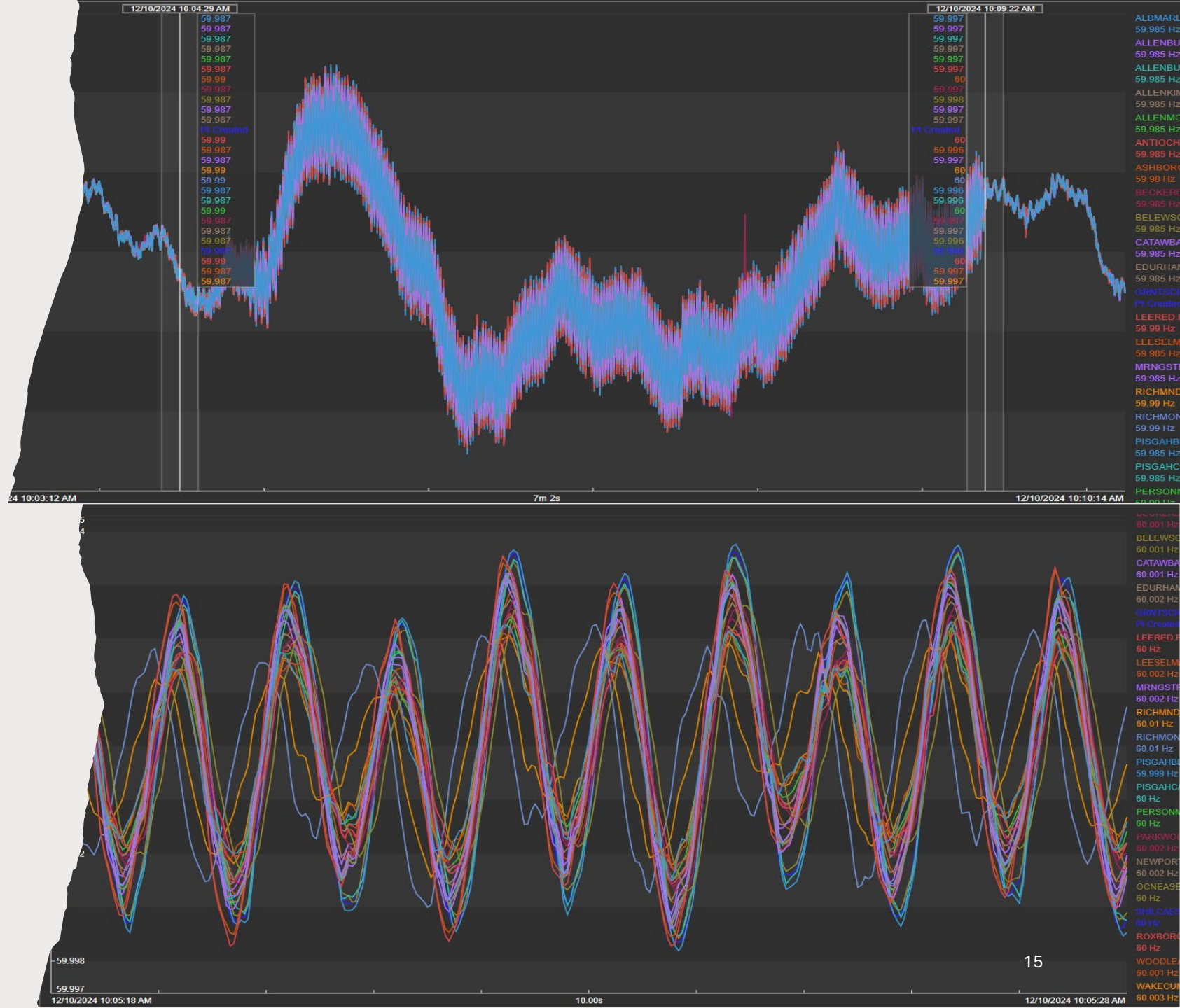


- Recent oscillation Event that occurred during generator PSS testing.
- This oscillation event was able to be detected by the system operator through the SCADA data and voltage alarms.
- System Operator was aware the testing and quickly notified the Plant

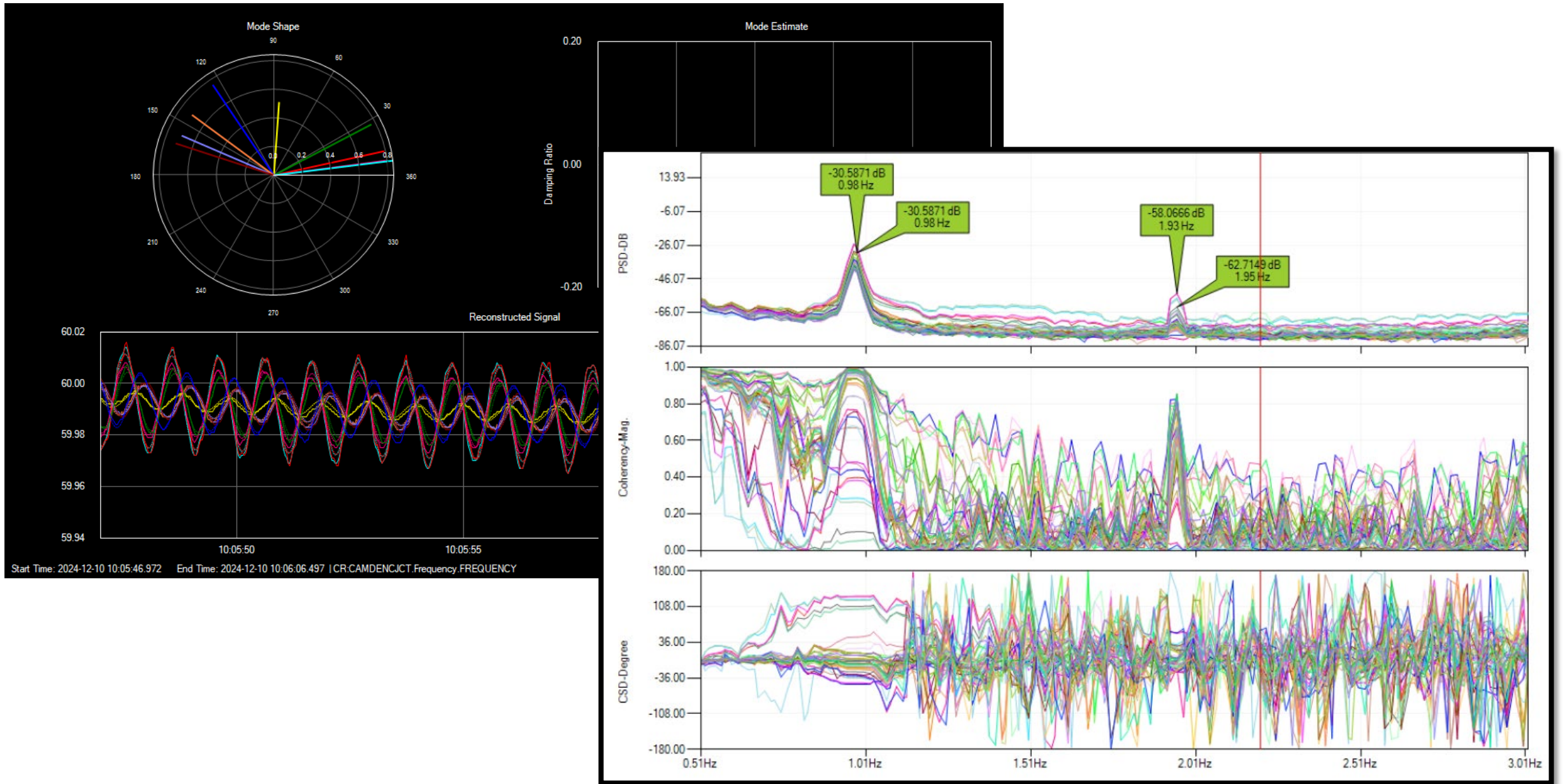
Timestamp	Al	Al	Message
10:04:51	1	1	EXCEED MINOR LIM 236.00
10:04:53	1	1	WITHIN MINOR LIM 236.00 current value : 234.57 high limit : 236.00
10:04:55	1	1	WITHIN MINOR LIM 236.00 current value : 233.79 high limit : 236.00
10:04:57	1	1	V_A EXCEED MINOR LIM 236.00
10:04:57	1	1	EXCEED MINOR LIM 236.00
10:04:57	1	1	EXCEED MINOR LIM 236.00
10:05:01	1	1	V_A WITHIN MINOR LIM 236.00 current value : 233.35 high limit : 236.00
10:05:01	1	1	WITHIN MINOR LIM 236.00 current value : 233.95 high limit : 236.00
10:05:01	1	1	EXCEED MINOR LIM 236.00
10:05:03	1	1	V_A EXCEED MINOR LIM 236.00
10:05:03	1	1	234.71 KV_A WITHIN MINOR LIM 236.00 current value : 234.71 high limit : 236.00
10:05:03	1	1	WITHIN MINOR LIM 236.00 current value : 234.44 high limit : 236.00
10:05:05	1	1	237.06 KV_A EXCEED MINOR LIM 236.00
10:05:07	1	1	234.74 KV_A WITHIN MINOR LIM 236.00 current value : 234.74 high limit : 236.00
10:05:09	1	1	234.92 KV_A WITHIN MINOR LIM 236.00 current value : 234.92 high limit : 236.00
10:05:09	1	1	WITHIN MINOR LIM 236.00 current value : 234.68 high limit : 236.00
10:05:11	1	1	V_A WITHIN MINOR LIM 236.00 current value : 233.86 high limit : 236.00
10:05:11	1	1	236.20 KV_A EXCEED MINOR LIM 236.00
10:05:11	1	1	236.86 KV_A EXCEED MINOR LIM 236.00
10:05:11	1	1	EXCEED MINOR LIM 236.00
10:05:11	1	1	EXCEED MINOR LIM 236.00
10:05:13	1	1	.93 KV_A WITHIN MINOR LIM 236.00 current value : 234.93 high limit : 236.00
10:05:13	1	1	V_A EXCEED MINOR LIM 236.00
10:05:13	1	1	WITHIN MINOR LIM 236.00 current value : 233.30 high limit : 236.00
10:05:15	1	1	V_A WITHIN MINOR LIM 236.00 current value : 234.43 high limit : 236.00
10:05:17	1	1	234.49 KV_A WITHIN MINOR LIM 236.00 current value : 234.49 high limit : 236.00

2024 Forced Oscillation Across Several PMUs

- High resolution PMU data showed the oscillation across several Duke Energy PMUs system wide.
- Zooming into the PMU data it was easy to identify the frequency of the oscillation at approximately 1 Hz.



2024 Forced Oscillation PGDA Analysis



Oscillation Detection EPGs RTDMS

FileConfigurationsMonitoringAccountToolsHelp

RTDMS Server Configuration

PMU Input

PDC

PMU/Signal

Signal Aggregation

Advanced Data Process

Mode

Sensitivity

Oscillation Detection

Islanding Detection

Generation Trip Detec...

Load Trip Detection

Voltage Stability Index

Area Angle

Alarm Event

Data Buffer

Output Configuration

Logging System

Oscillation Configuration

Oscillation Names

Oscillation

Voltage

Angle

Angle

Power

Power

: Voltage Magnitude:0

: Individual Angle Derivative:0

: Angle Difference Derivative:0

: Power Flow Path:9

: Individual Power Flow:606

Selected Power Signals

Property Editor

Overall Configuration

Enable

☒ True

Invalid Data Threshold

30 %

Overall Spectral Analysis Configuration

Oscillation Alarm Threshold

Band1

Level A0

10.00 MW

☐ NAN

Time TD0

300 Seconds

Level A1

20.00 MW

☒ NAN

Time TD1

1200 Seconds

Level A2

40.00 MW

☐ NAN

Time TD2

600 Seconds

Band2

Level A0

5.00 MW

☐ NAN

Time TD0

30 Seconds

Level A1

6.00 MW

☒ NAN

Time TD1

120 Seconds

Level A2

7.00 MW

☐ NAN

Time TD2

45 Seconds

Band3

Level A0

5.00 MW

☐ NAN

Time TD0

30 Seconds

Level A1

6.00 MW

☒ NAN

Time TD1

120 Seconds

Level A2

7.00 MW

☐ NAN

Time TD2

45 Seconds

Band4

High 3

Alert

Message

High 3 Message Test

High 4

Warning

Message

High 4 Message Test

Shortcut

Apply to All Selected Signals ...

Alarms

From: 12/10/2024 12:00:00 AM

To: 12/11/2024 12:00:00 AM

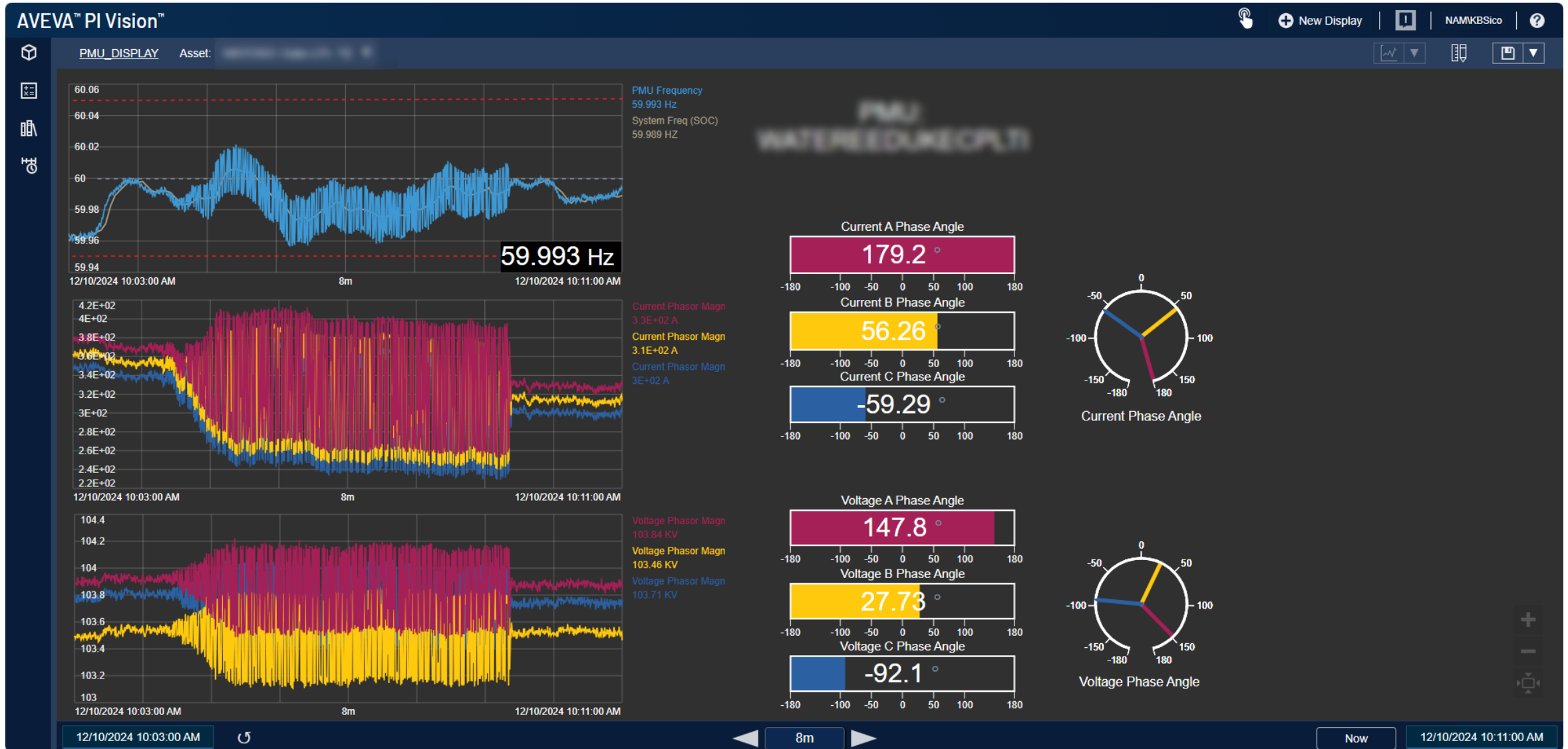
Duration: 1 days, 0 hours, 0 minutes, 0 seconds

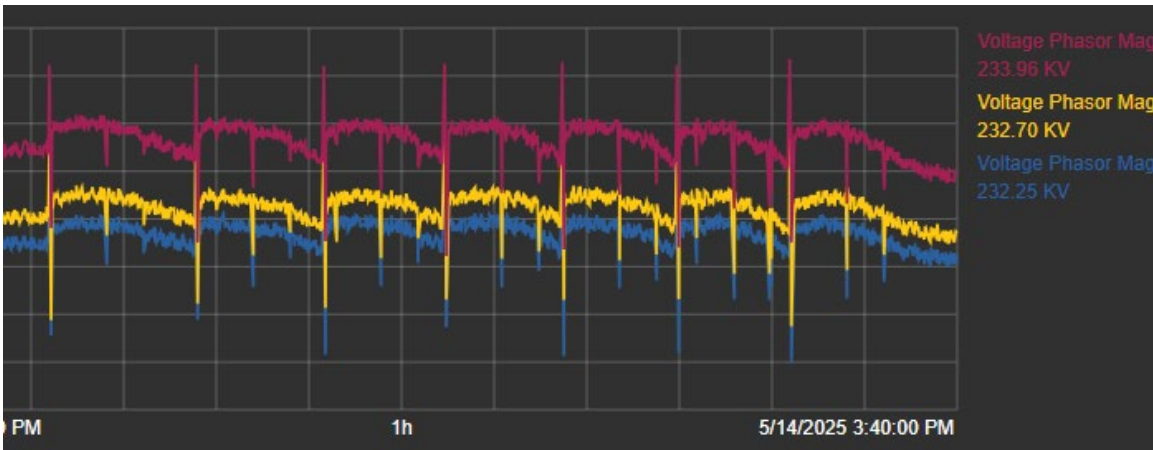
Count: 710

InternalName	Gen Trip	Osc	StartTimeStamp	EndTimeStamp	PeakTimeStamp	AlarmTypeName	Threshold	Duration	Unit	CurrentValue	PeakValue
			12/10/2024 10:05:45 AM	12/10/2024 10:09:15 AM	12/10/2024 10:07:30 AM	H3 Value 1 Band3 Oscillation	5	210	%	6.192897	6.347057

1/30/2025 8:02:19 AM> Ready...

2024 Forced Oscillation PI Display





Load driven MVAR Swings near Plant

- Received a call from a nearby generating plant complaining of MVAR swings.
- Used PMU and SCADA Data to pinpoint the source of the oscillation to a particular load.
- This was not detected by the pilot oscillation detection in place.

Future Work and Industry Involvement

[Home](#) > [Committees](#) > [Reliability and Security Technical Committee \(RSTC\)](#) > [Synchronized Measurement](#)

Synchronized Measurement Working Group (SMWG)

All previous documents under the Planning Committee can be found here: [SMS Documents](#).

The purpose of the SMWG is to provide technical guidance and support for the use of synchronized and high-resolution measurements to enhance the reliability and resilience of the bulk power system (BPS) across North America.

Recent Activity

Working Group Resources

Name

[SMWG Meeting Schedule](#)

[SMWG Oscillation Reporting Document](#)

[SMWG Roster](#)

[SMWG Scope](#)

[SMWG Work Plan](#)

The screenshot displays the RTDMS Server Configuration application. The left sidebar contains a tree view with the following items: PMU Input, PDC, PMU/Signal, Signal Aggregation, Advanced Data Process, Mode, Sensitivity, Oscillation Detection (highlighted), Islanding Detection, Generation Trip Detec..., Load Trip Detection, Voltage Stability Index, Area Angle, Alarm Event, Data Buffer, Output Configuration, and Logging System. The main window is titled 'Oscillation Configuration' and shows a list of 'Oscillation Names' with columns for Name, Voltage, Angle, Power, and Time. The 'Oscillation' entry is selected, showing details: Voltage: Voltage Magnitude:0, Angle: Individual Angle Derivative:0, Power: Power Flow Path:9, and Time: Individual Power Flow:606. The bottom status bar indicates the date and time: 1/30/2025 8:02:19 AM, and the version: RTDMS Server Version 5.0.2 Copyright (c) Electric Power Group.



Questions