GRID PERFORMANCE ASSESSMENT USING SYNCHROPHASOR DATA ANALYTICS

Presentation for NASPI Workgroup Meeting
Salt Lake City

NASPI – NERC Synchrophasor Data Analytics Workshop

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April 17, 2024

OUTLINE

- Introduction
- Use Cases from Utilities and Grid Operators
  - IBR Performance Assessment
  - Oscillations – Natural Modes, Forced Oscillations
  - Frequency Response and Inertia Assessment
  - Equipment Failure and Device Issues
- Data Analytics Tools
- Value of Synchrophasor Data Analytics

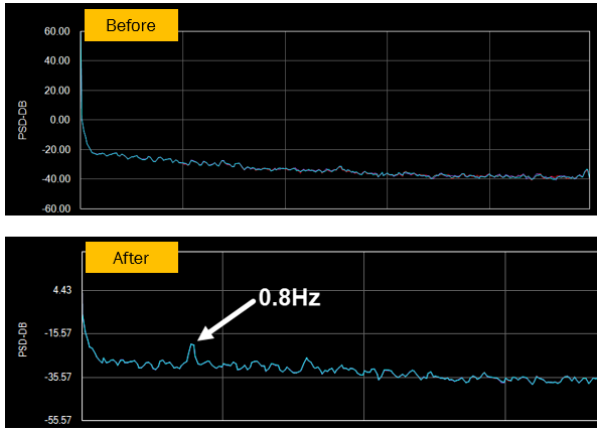
INTRODUCTION

Why Synchrophasor Data Analytics?

- Large deployment of PMUs
- Utilities, ISOs and RCs have Terabytes of Synchrophasor data being archived
- High-resolution (30 frames/second or higher) and time-synchronized data from PMUs provides unprecedented visibility into grid dynamics
- Need for PMU Data Analysis
  - ❑ Extract value from large archives to guide planning and operations
  - ❑ Assess Grid Performance
    - ➢ How Many Events: Where, When, How Severe?
    - ➢ Identify weak spots in the grid to guide capital investments and update operating procedures
    - ➢ Identify indicators of potential equipment failure and device malfunctions
  - ❑ Validate and Set Alarm Thresholds for Real-Time Operations

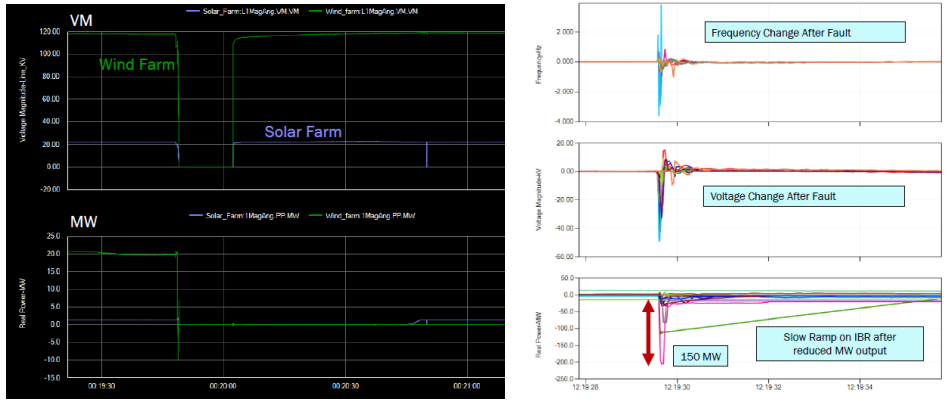
USE CASE EXAMPLES

Natural System Modes

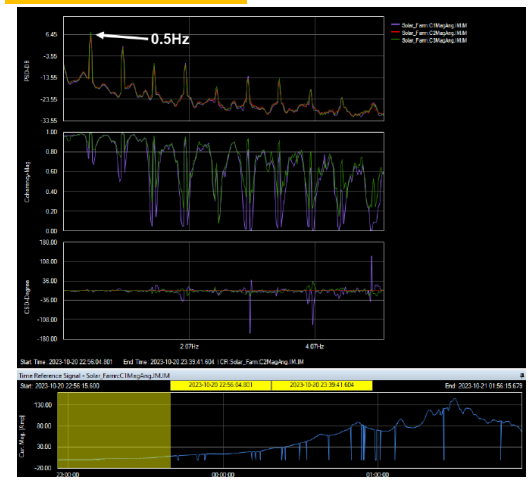


IBR Performance Assessment

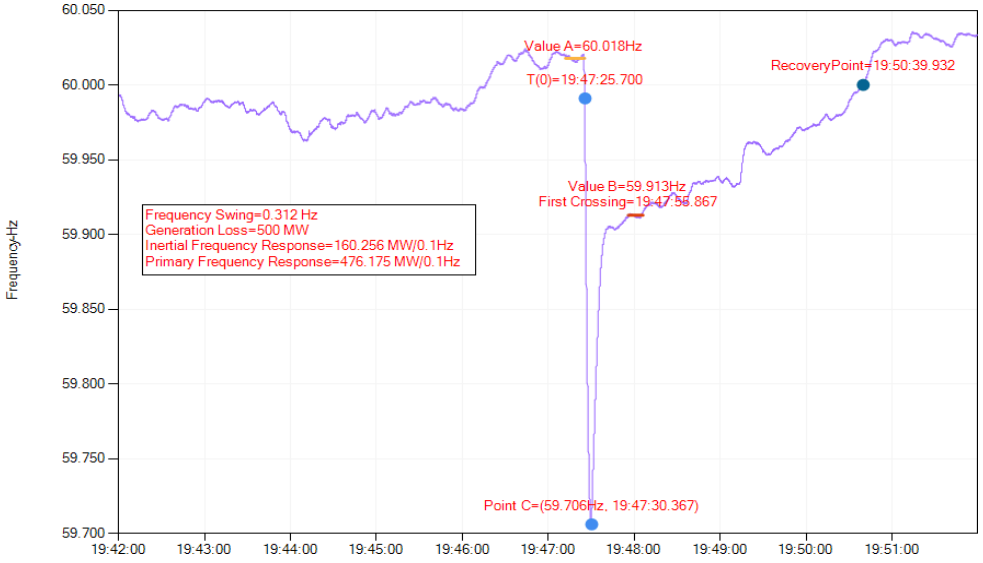
Ride Through



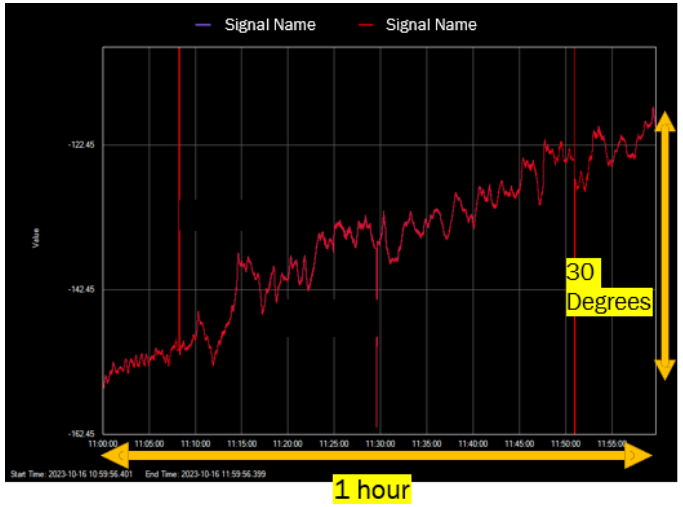
Oscillations

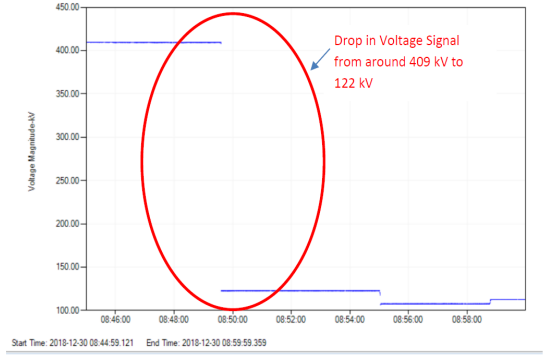


Frequency Response and Inertia



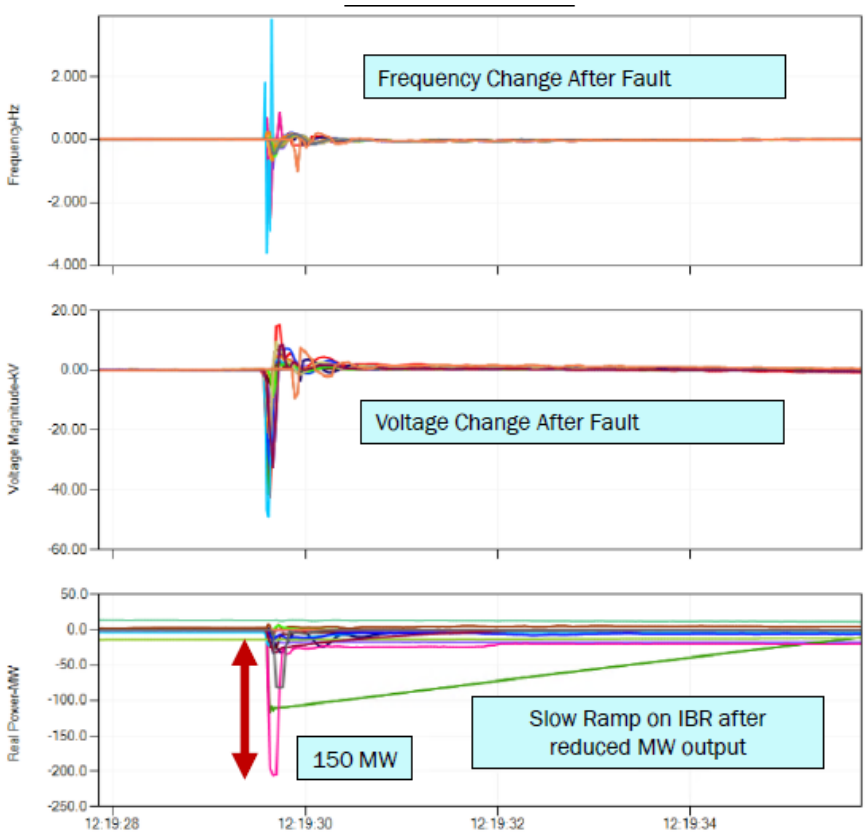
Equipment/Device Issues and Failure

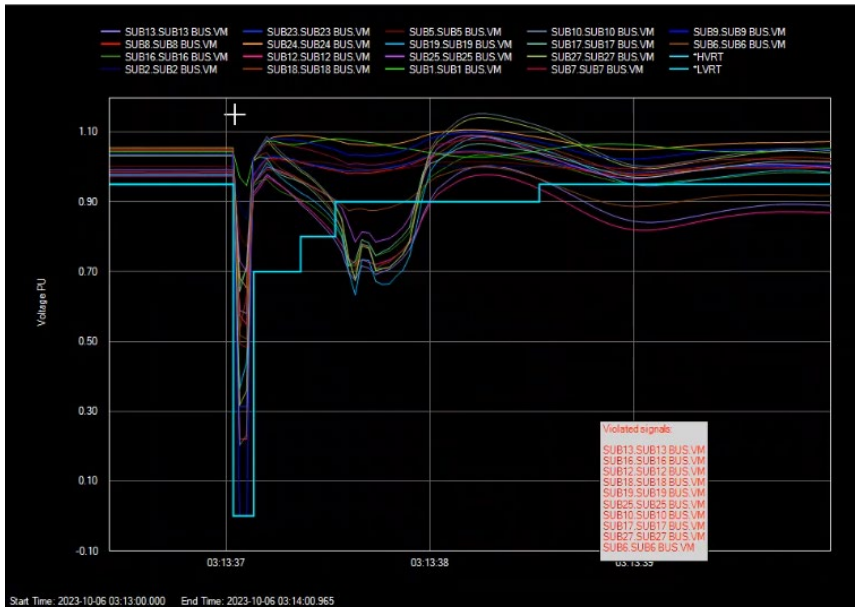




Potential Transformer (PT) Failure

IBR PERFORMANCE ASSESSMENT

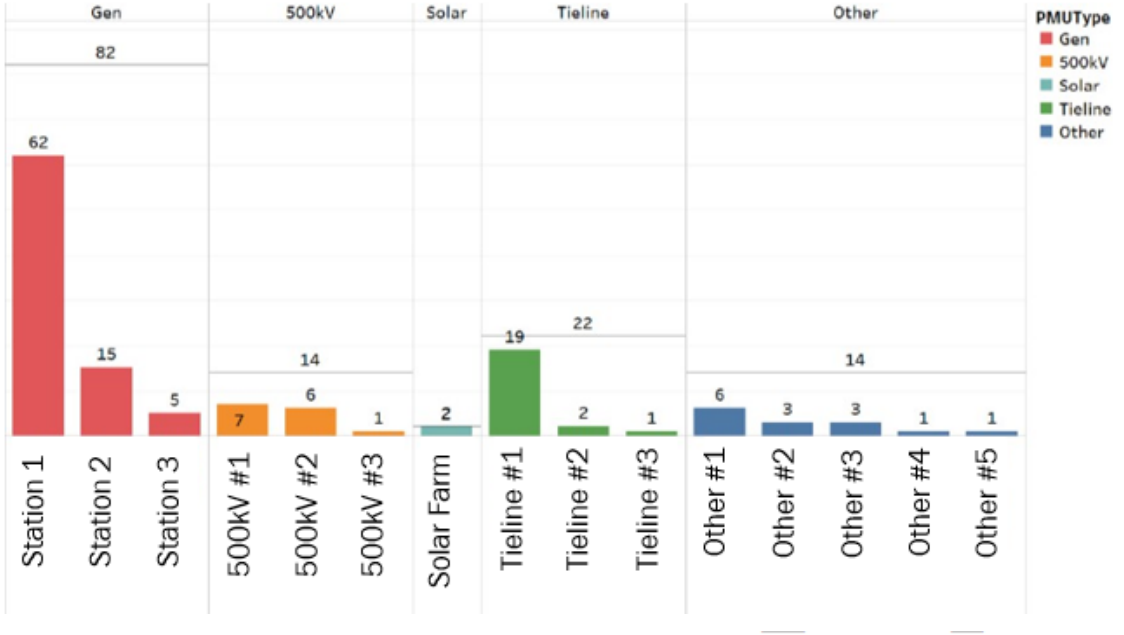




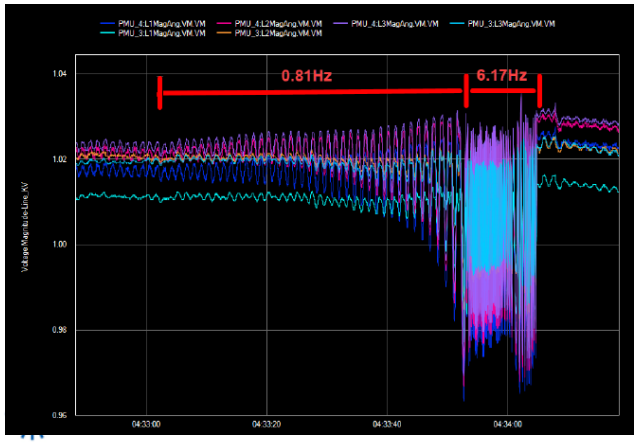
FORCED OSCILLATIONS

- Identify Issues in the Grid
- Unknown Forced Oscillations
  - Power Plants
  - IBRs
  - Equipment Failure
- Identify Weak/Spots for Monitoring in Real-time
- Identify oscillations that may have impact on system reliability
- Identify Oscillation Source
  - Dissipating Energy Flows
  - Harmonics Assessment

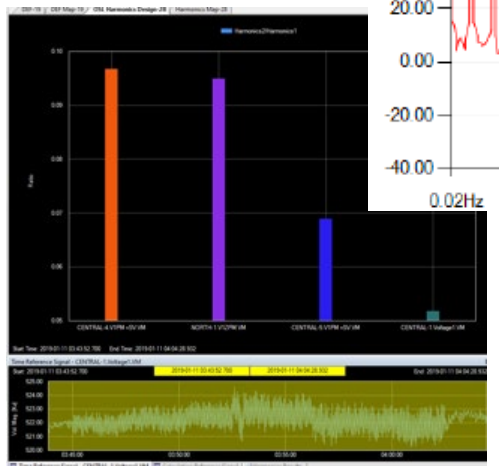
Oscillation Results by Location

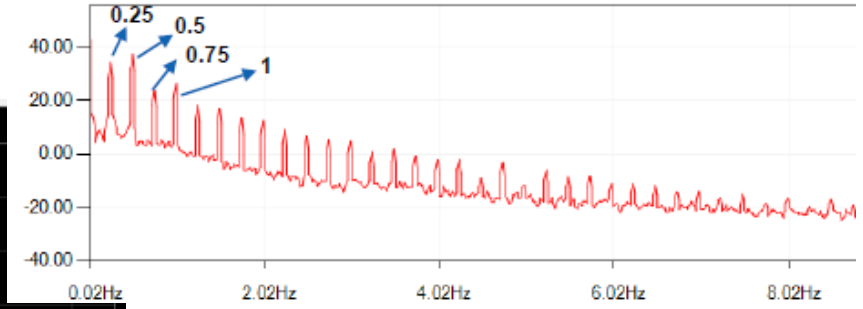


DEF



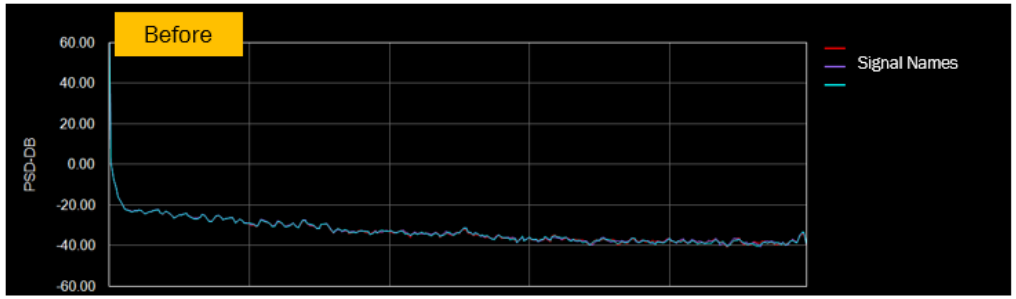
Harmonics

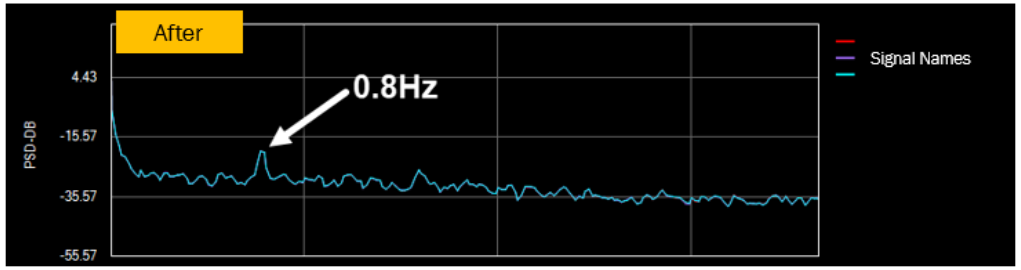




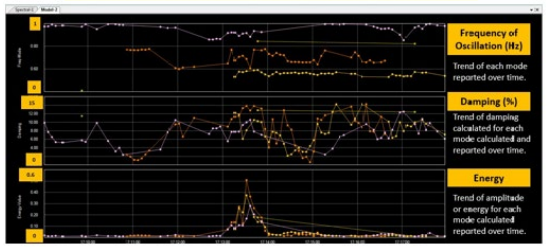
NATURAL SYSTEM MODES

- Identify Natural System Modes
- Characterize Modes
  - Frequency
  - Oscillation
  - Damping
  - Shape
  - Participating Signals
- Track Dynamics with Time – Changing Topology, Resource Mix, IBR Penetration
- Identify low damping/high energy time periods

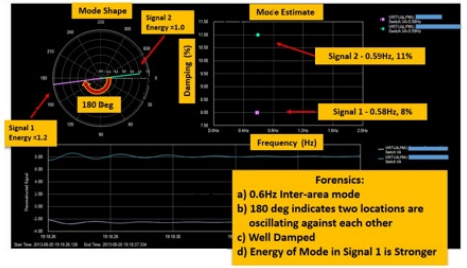




Modal Analysis – Natural System Modes

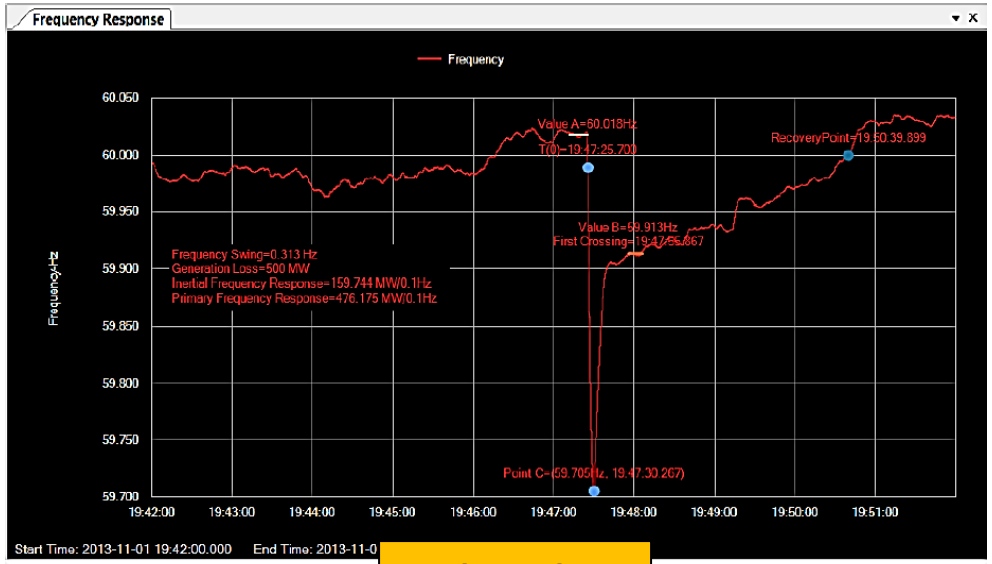


Ringdown Analysis – Response to Grid Disturbances

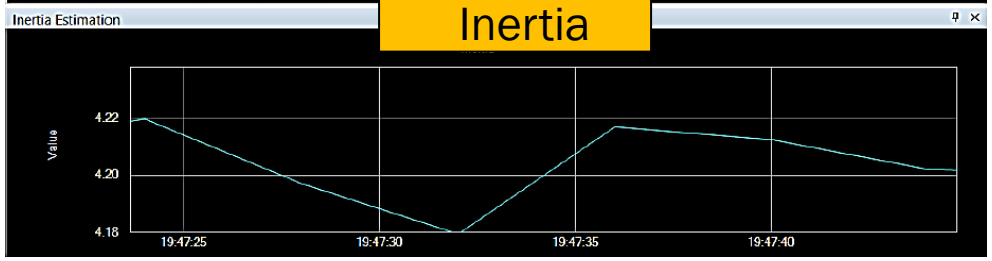


FREQUENCY RESPONSE AND INERTIA ASSESSMENT

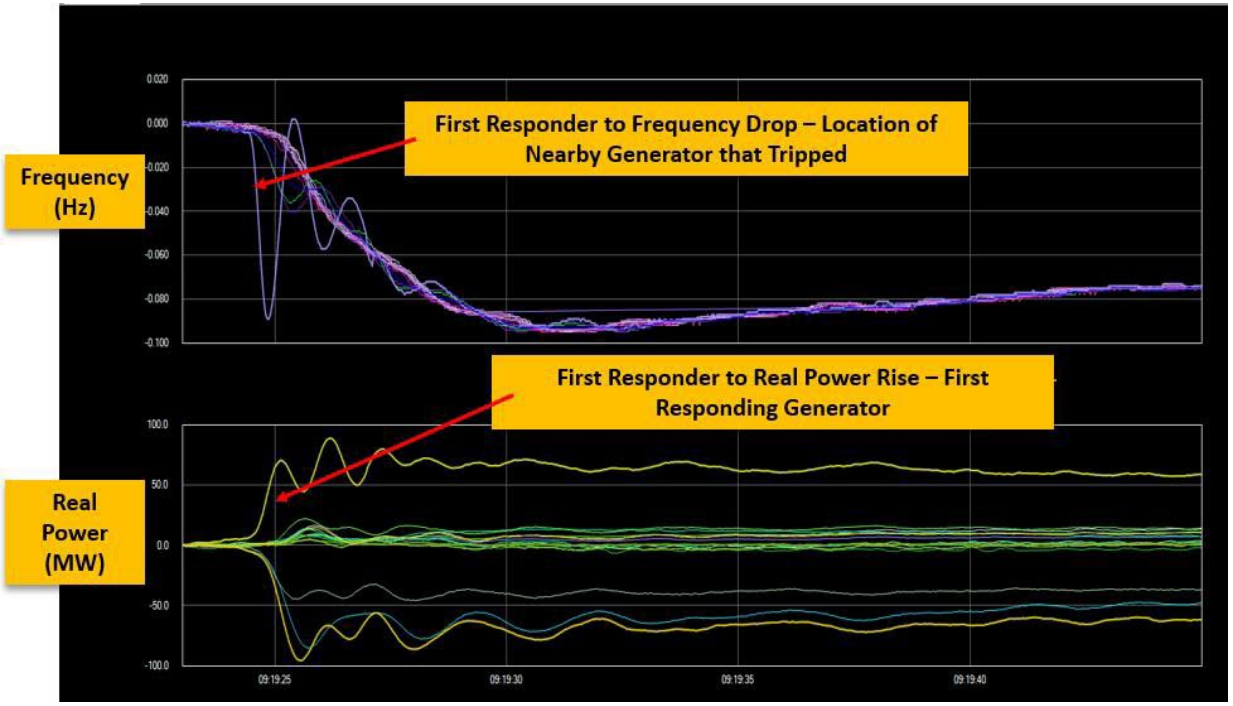
Frequency Response



Inertia

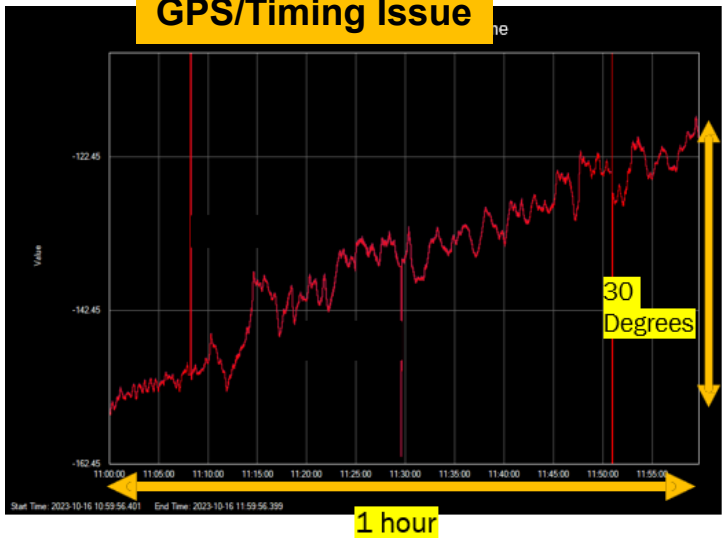


Plant Response



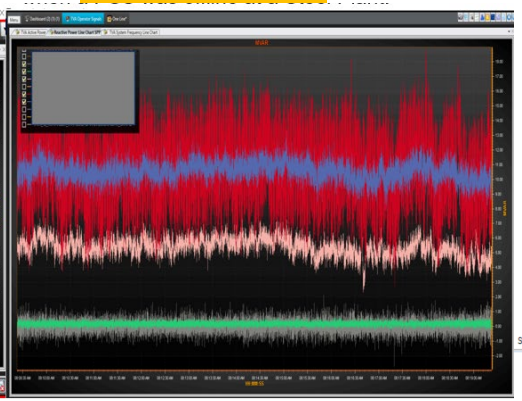
EQUIPMENT FAILURE AND DEVICE ISSUES

GPS/Timing Issue

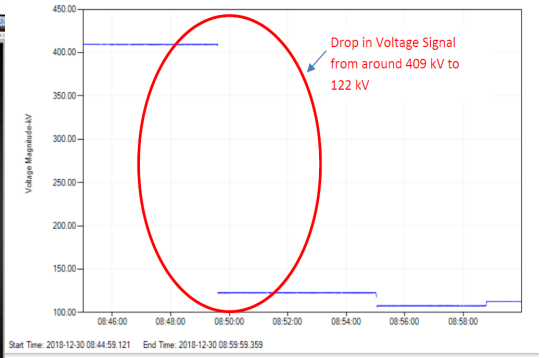


PT Failure

PSS Issue

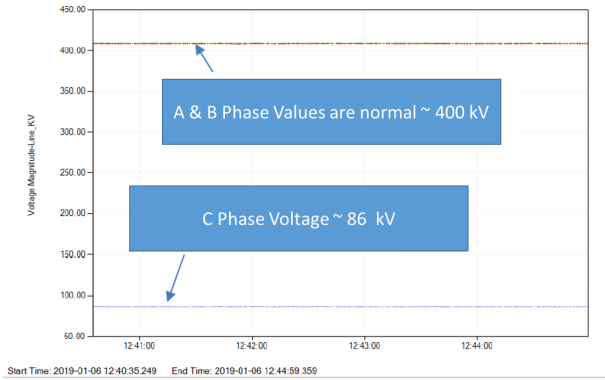


Potential Transformer (PT) Failure

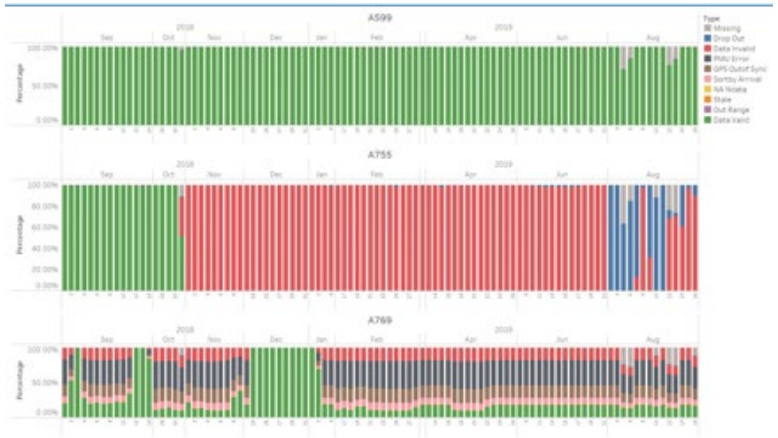


Source: Jonathan Sides, TVA, April 2024

Device (PT, CCVT) Calibration Issue



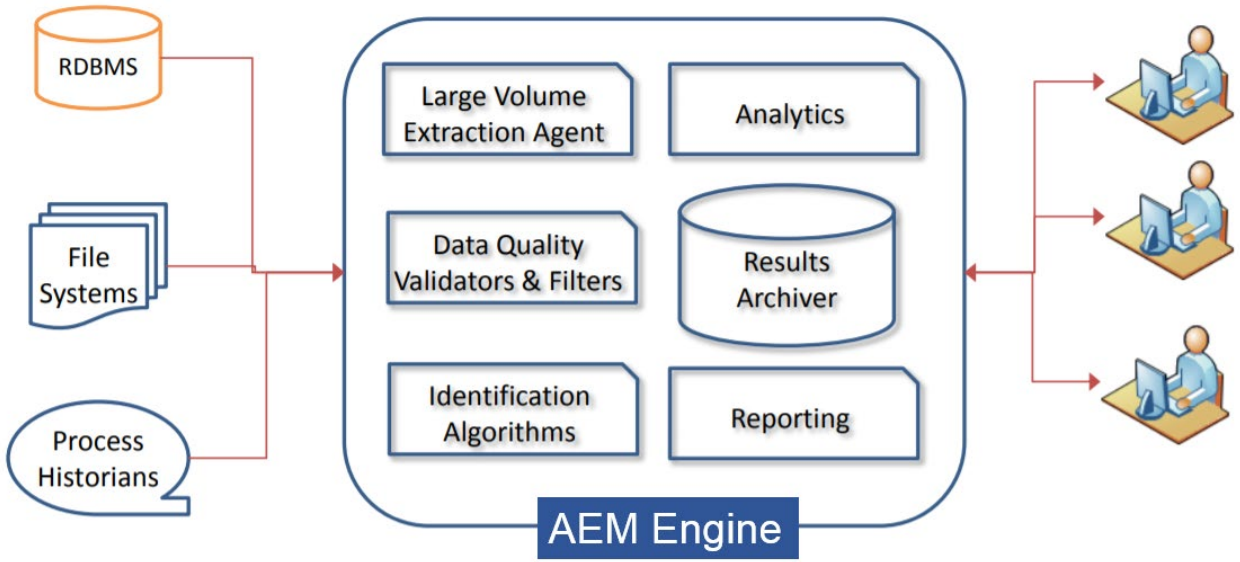
Data Quality Assessment



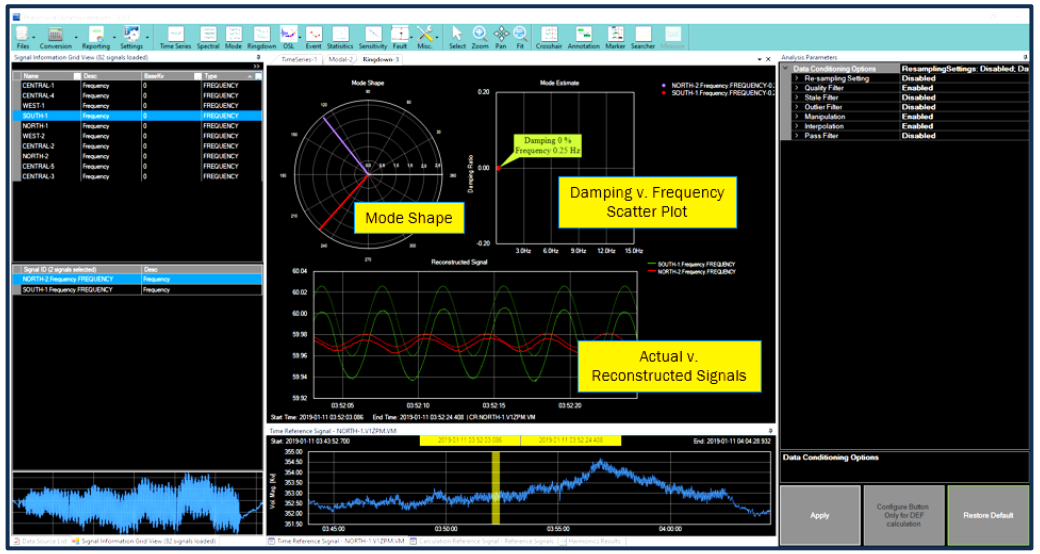
PMU level	Signal Level
• Data Invalid	• Out of Range
• GPS Out of Synch	• Stale
• PMU Error	• NaN
• Sort by Arrival	• Data Invalid
• Drop Out	• GPS Out of Synch
• Missing Data	• PMU Error
• Data Valid	• Sort by Arrival
	• Drop Out
	• Missing Data
	• Data Valid

DATA ANALYTICS TOOLS AND METHODOLOGY

Automated Event Miner (AEM)



Phasor Grid Dynamics Analyzer (PGDA)



Data Sources

PMUs, DFRs, Point-on-wave, Simulations, SCADA

Visualization

- ***Automated Process*** *to mine through large amounts of Synchrophasor data for Grid Performance Assessment*
- ***Integrated Platform*** *for Detailed Analysis and Root Cause Diagnostics*
- ***Automated Reports –*** *By Location, Time, Severity*

BENEFITS OF SYNCHROPHASOR DATA ANALYTICS

- Planning & Operation Management
  - System dynamic performance assessment
  - Identify emerging problem areas that threaten reliability
  - Actionable Information to guide goals and programs
- Operations Support & Analysis
  - Assessment of Events using multiple perspectives such as time-of-day, season, severity, etc.
  - Identification and Analysis of Oscillations for improved monitoring and mitigation
  - Event Library for Training
- Planning & Modeling
  - Identify Weak Spots in the system to guide capital investments
  - Support Model Validation using PMU data
- PMU Engineering
  - Verify Event detection and Alarm operation, fine tune Alarm thresholds
  - Identify unreliable Equipment and measurement system problem areas

Extract Value from large archives of Synchrophasor data to guide planning and operations

Q&A, DISCUSSION

Thank you!

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