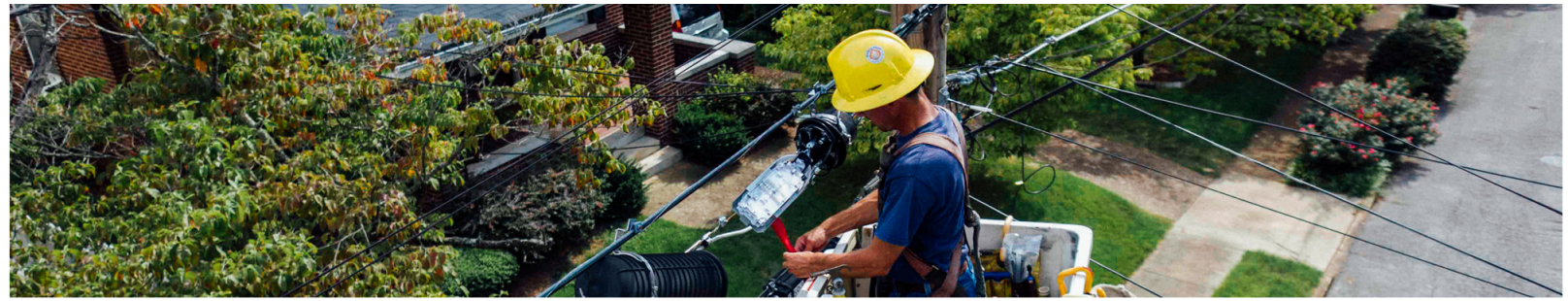
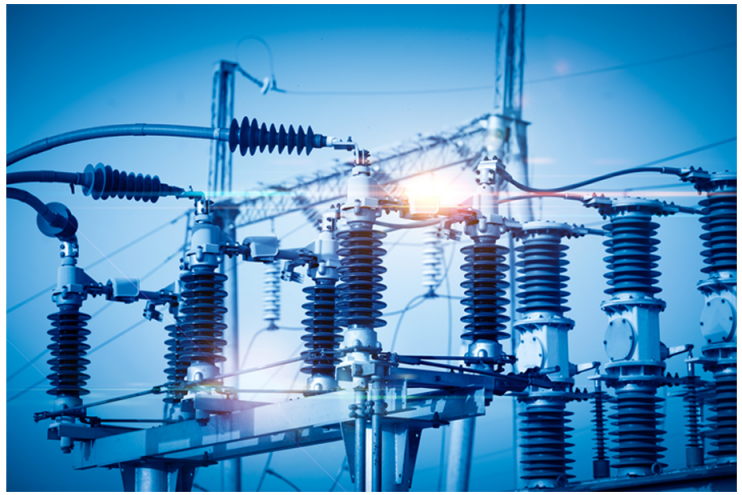


AUTOMATED

EVENT MINER

Electric Power Group



Contents

Industry Need
Platform
Architecture
AEM Process - 6 steps
User defined Criteria for Mining Events
Setting Alarm Thresholds
Mining Summary
Event Mining and Root Cause
Event Mining at Utilities and ISO's
Reports
Summary

Industry Need

- Utilities have Terabytes of Synchrophasor data
- Synchrophasor data provides unprecedented visibility into grid dynamics and oscillations
- Need
  - > 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

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AEM Platform

- **Design Goal**: AEM is designed to mine through archived data (Days to Years) to identify events based on default criteria or user defined mining parameters
- **Event Types**:
  - Frequency excursion – Gen trip, Line fault, Load Loss
  - Oscillation – Sustained oscillations, forced oscillations, control system issues, low damping
  - Low Voltage - Faults/Metering Problem, Low Voltage, Delayed Voltage Recovery
  - Grid Stress: Increased Angle Differences
  - User-defined events (Composite events, Customized algorithm)
- **Detailed Offline Analysis**: Integrated with Phasor Grid Dynamics Analyzer (PGDA) for offline data analysis
- **Data Sources:** Flat Files (*.csv, COMTRADE), Databases (MySQL, MSSQL, PI, OpenHistorian)
- **User Interface**: AEM provides GUIs to setup mining parameters, select mining engines, visualize mining results and generate mining report
- **Reports**: Mined events are reported by location, severity, duration and count to provide engineers an event library to select significant events for analysis

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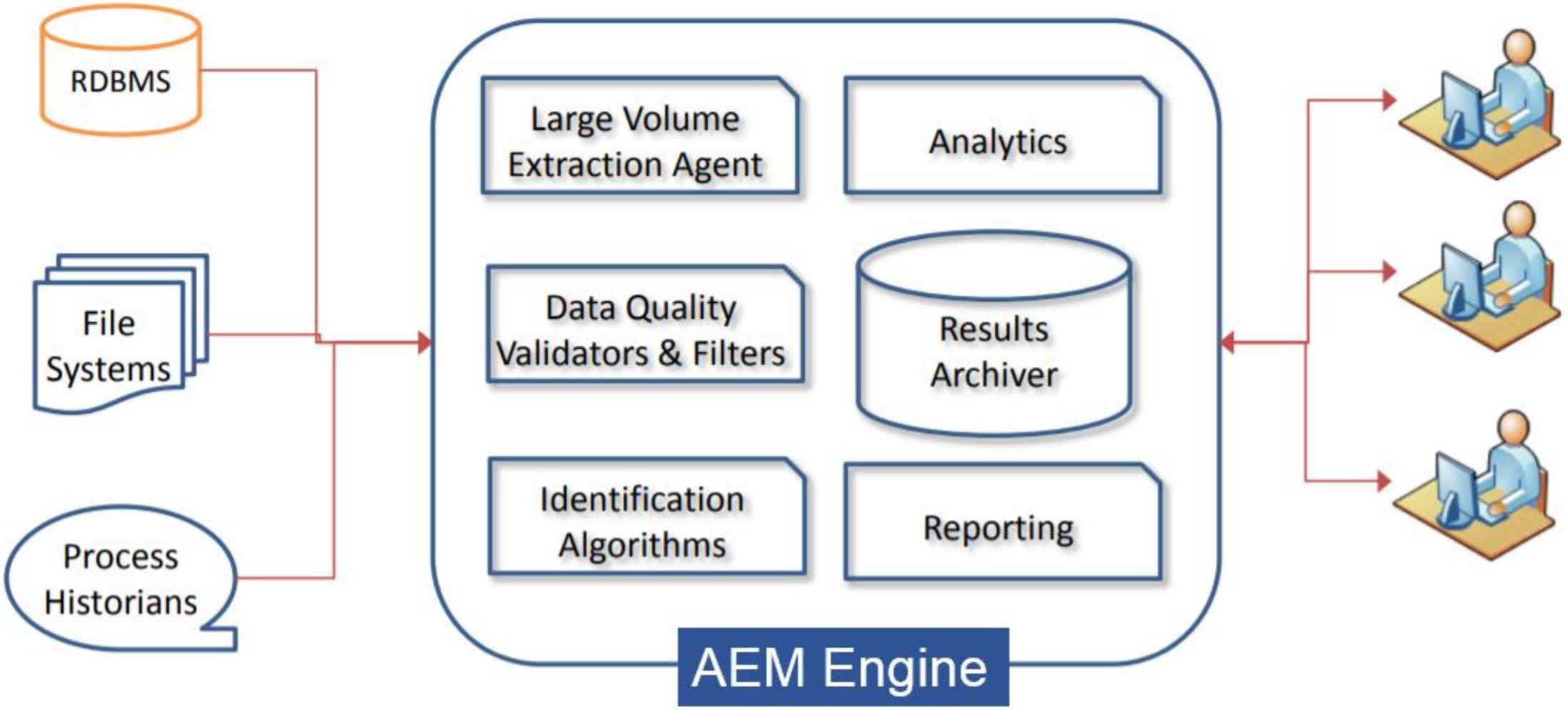
Architecture - Overview



Data Sources

Visualization

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AEM Process - 6 Steps

1. Load Input Data
2. Select Signals and Preprocessing Options
3. Select Types of Events for Mining
4. Start Mining Process
5. Analyze Results
6. Generate Report

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User-Defined Criteria for Mining Events

- AEM can mine for events using default criteria or user-defined criteria such as:
  - > Faults with voltage below 0.9 per unit for less than 1 second
  - > Low voltage events with voltage below 0.9 per unit for more than 1 second
  - > Extended low voltage events with voltage below 0.9 per unit for more than 15 minutes
  - > Generation and Load trip events with frequency change greater than 30 mHz over a time window of 15 seconds
  - > Oscillation Energy exceeding 3 standard deviations of RMS energy in voltage, real and reactive power flows
  - > Phase Angle Differences exceeding 10 standard deviations
  - > Composite Events with combination of the above criteria

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Setting Alarm Thresholds using AEM

- Perform Mining Using Wider Thresholds, Narrow Down using post processing filters
- Oscillation Events
  - > RMS Energy is calculated and saved for each signal
  - > Threshold: Use a multiple of average RMS energy for each signal based on mining results
- Frequency Events
  - > Use Frequency Change (mHz/sec) and time window (sec) settings based on mining results
- Voltage Events
  - > Use upper and lower voltage thresholds based on mining results

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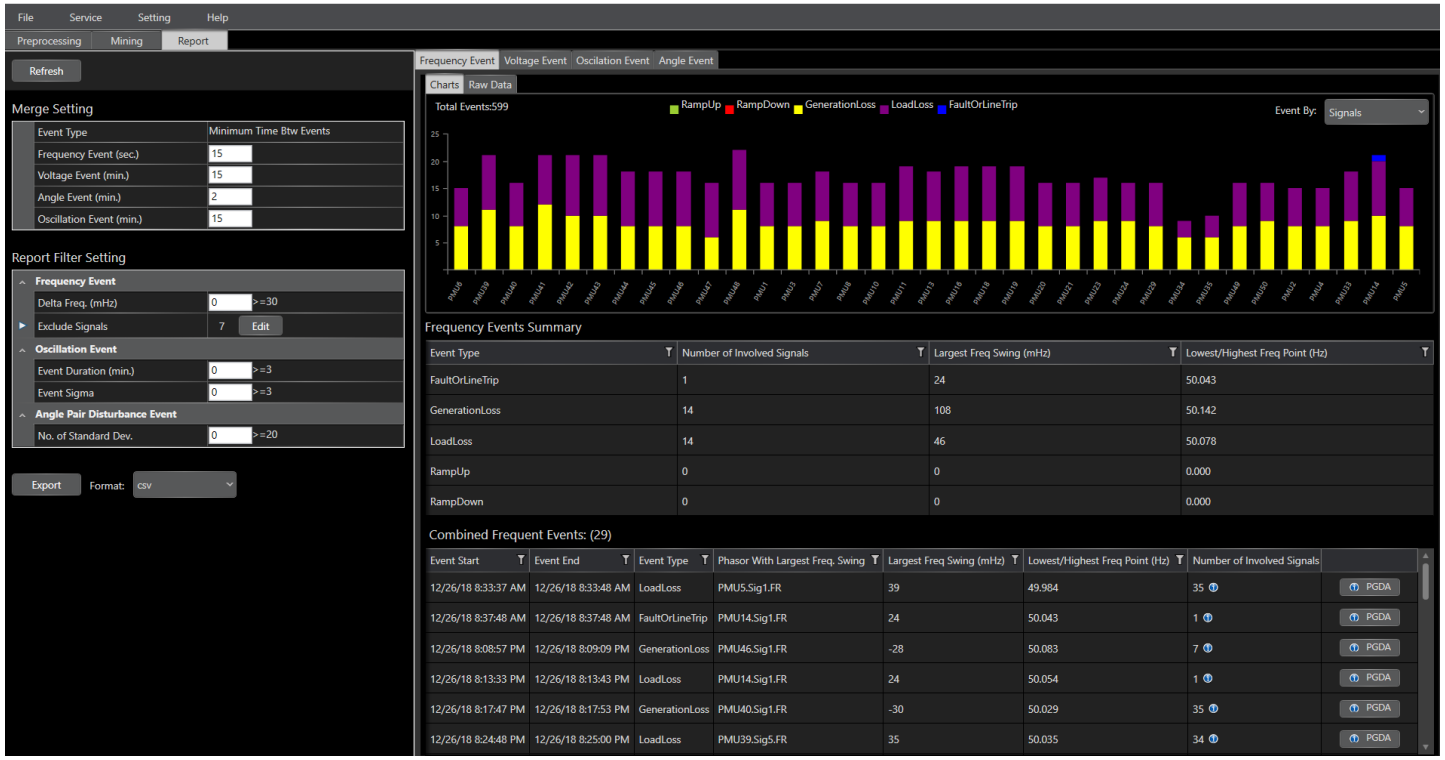
Mining Summary

- **Data Duration: 3 Months**
- **PMUs: 50**
- **Signals: 1500**
- **Events Identified: 30**
  - > Frequency Events – 16 (Threshold: 30 mHz/sec)
  - > Voltage Events – 10 (Threshold: 0.9 and 1.1 pu)
  - > Oscillations – 4 (Threshold: 3 times Standard Deviation of RMS Energy)



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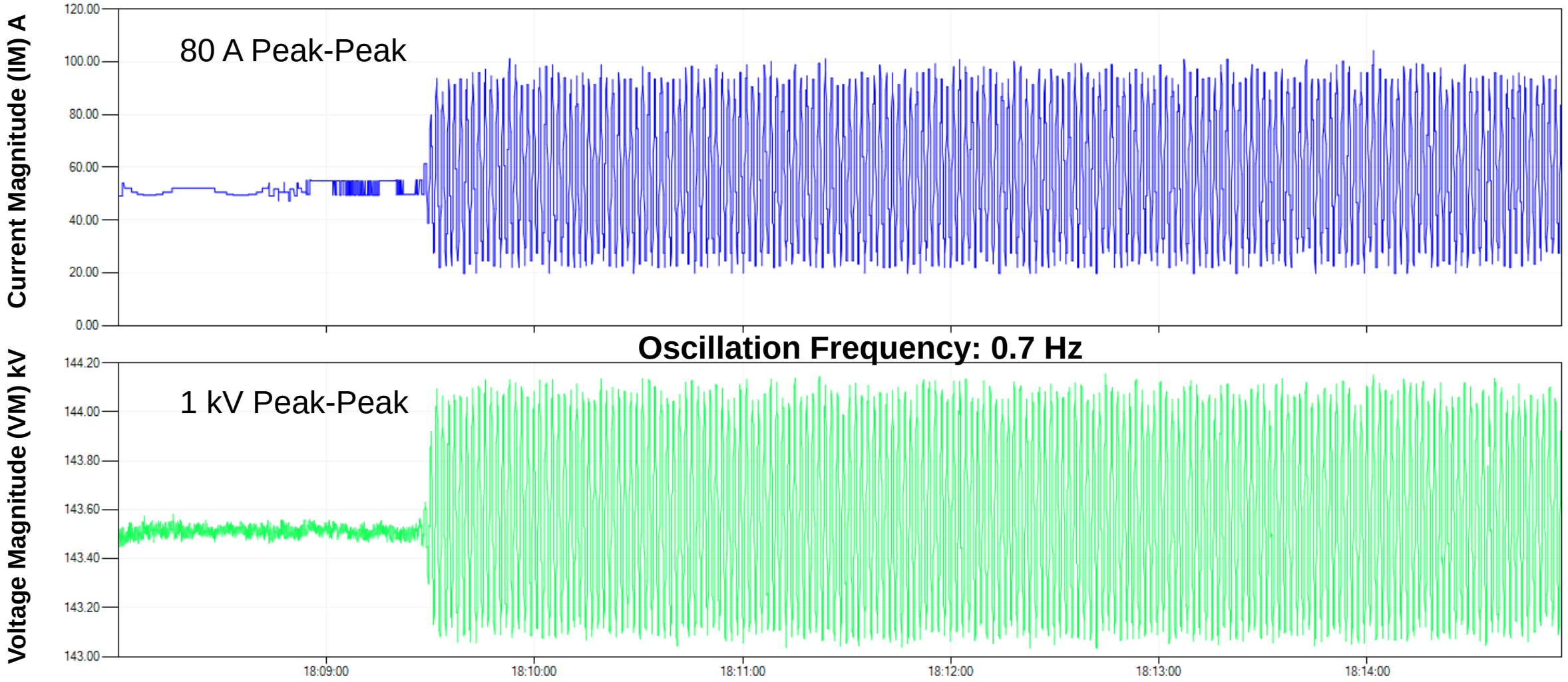
Event Mining and Root Cause

Oscillation Event Caused By Voltage Controller Issue



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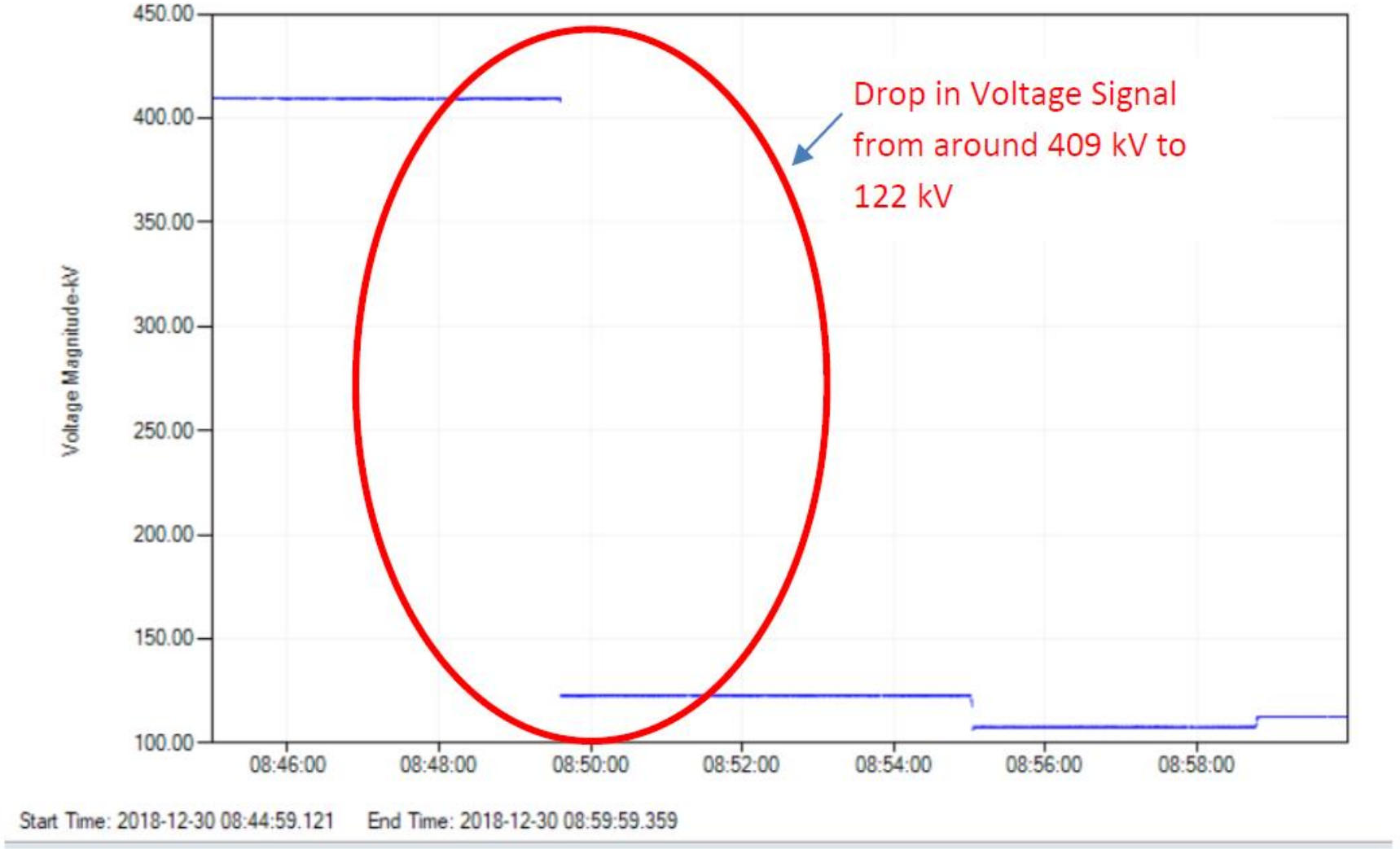
Event Mining and Root Cause

Voltage Event caused by PT Failure



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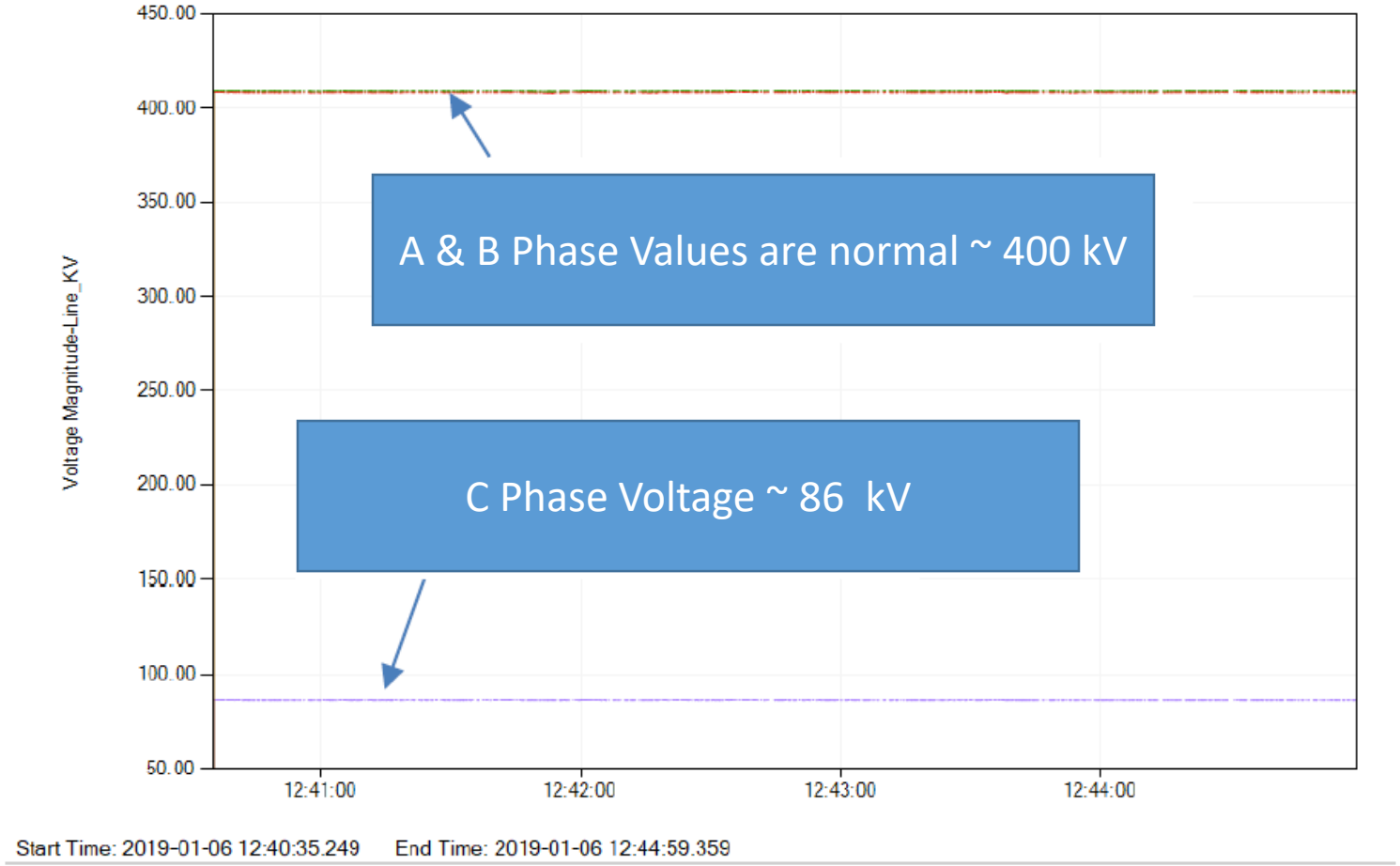
Event Mining and Root Cause

Voltage Event Caused By CCVT Calibration/Scaling Issue



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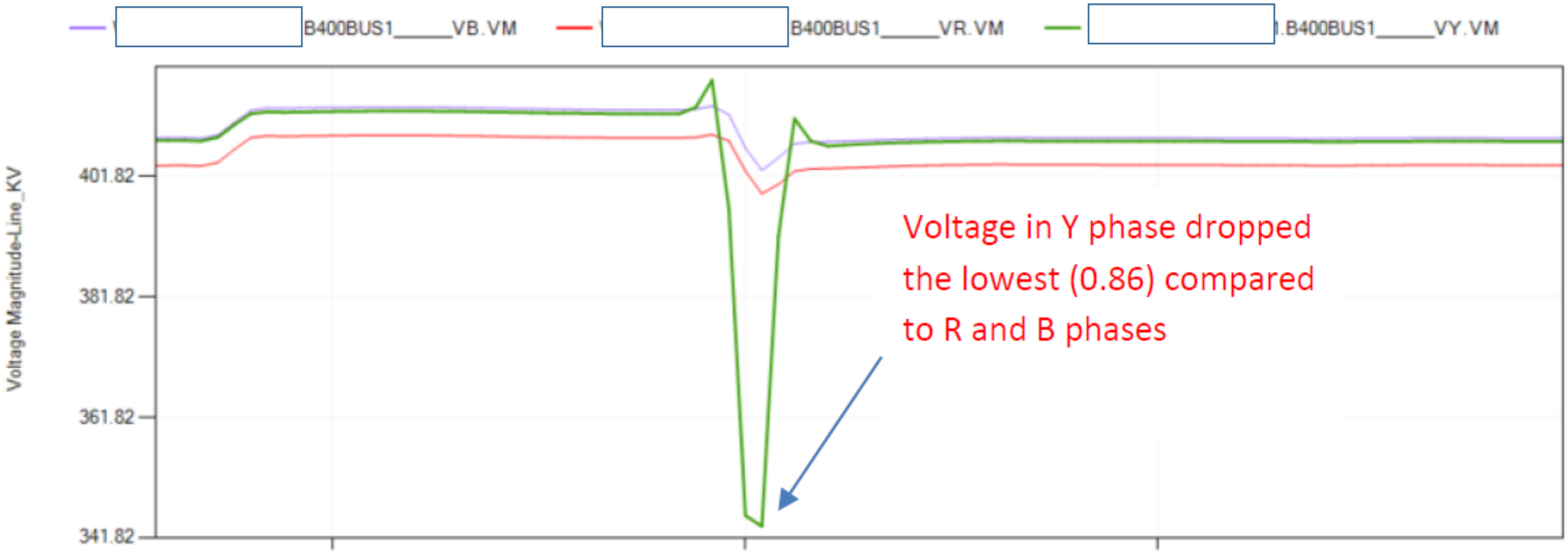
Event Mining and Root Cause

Voltage Event Caused By Single-Line to Ground Fault



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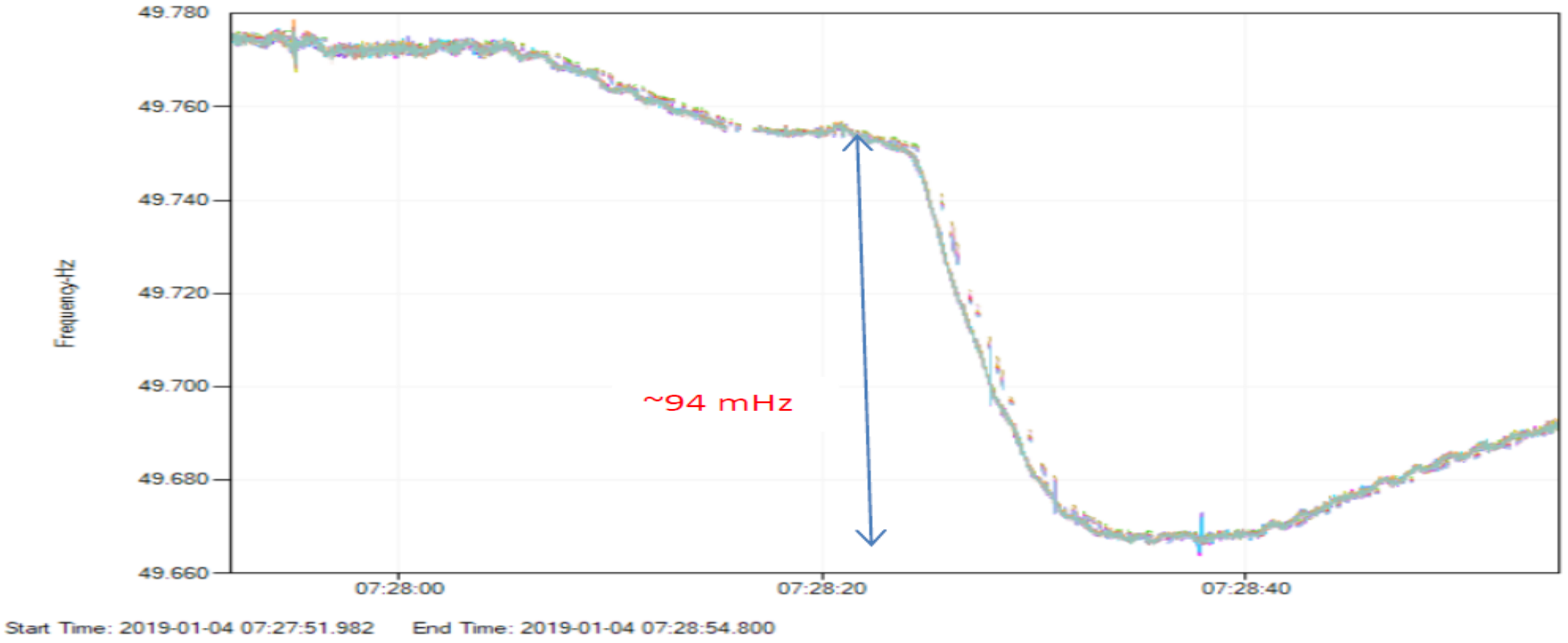
Event Mining and Root Cause

Frequency Event Caused By Generation Trip



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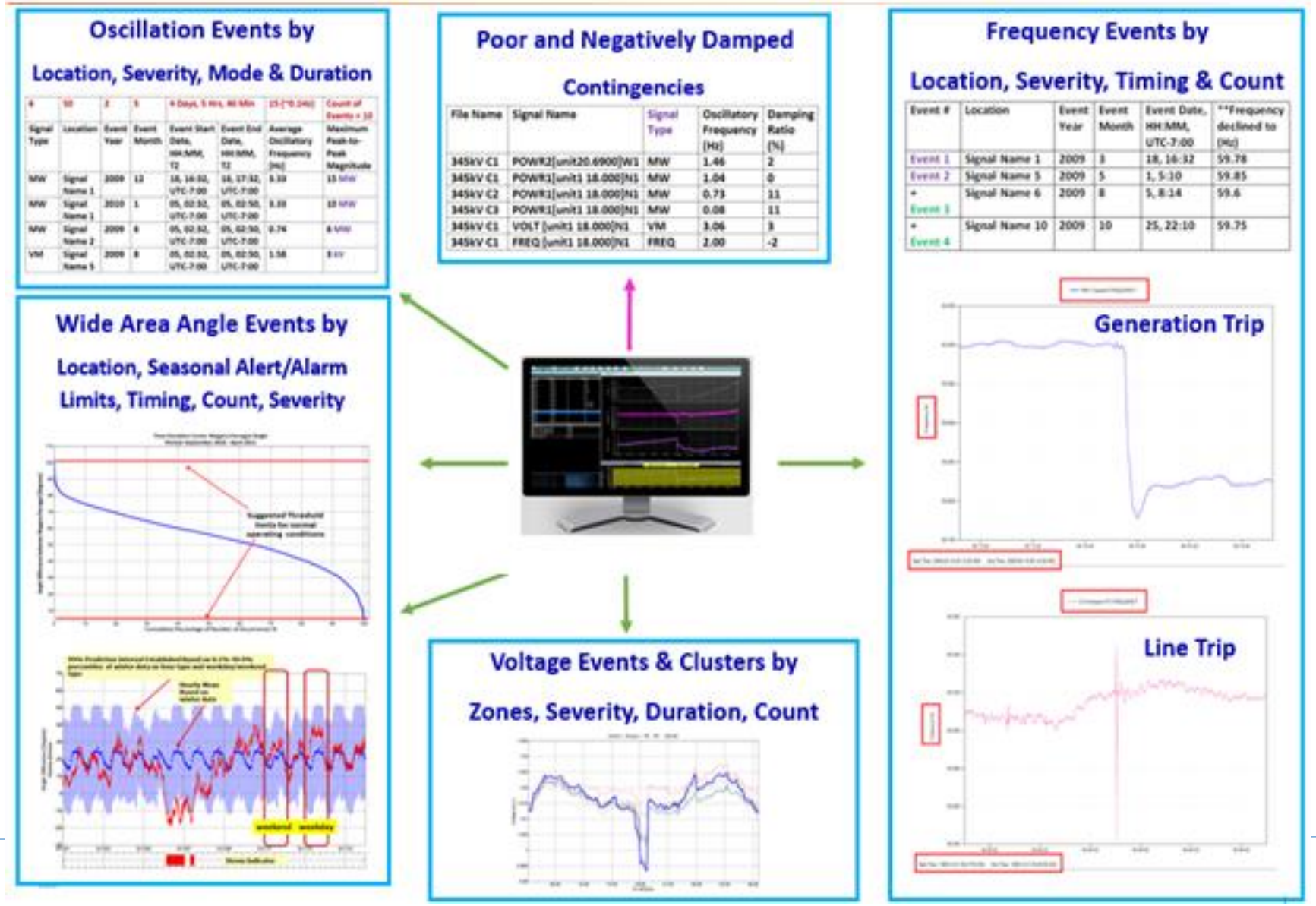
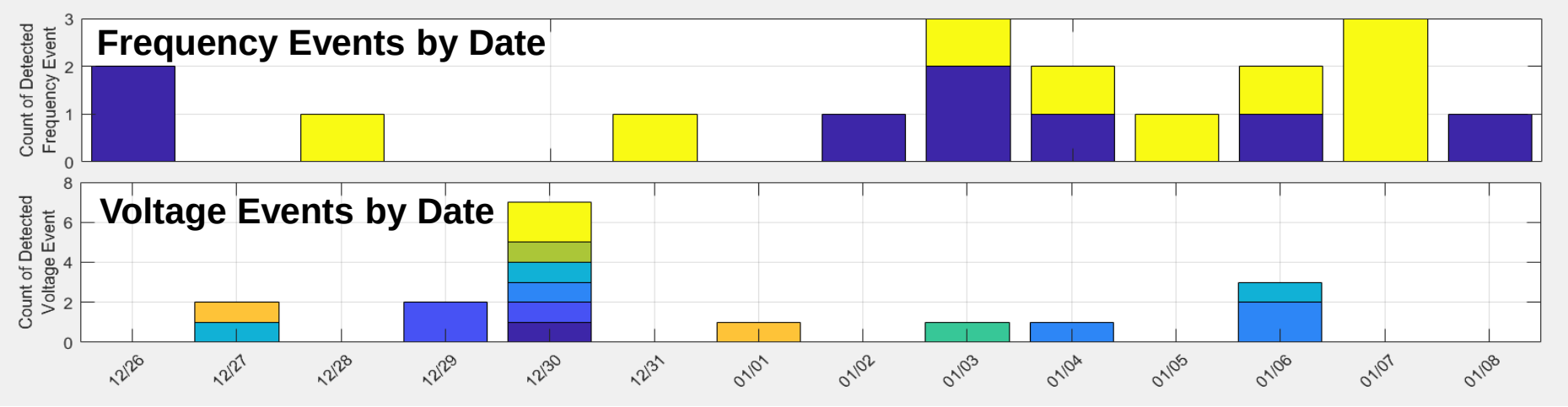
Event Mining at Utilities & ISOs

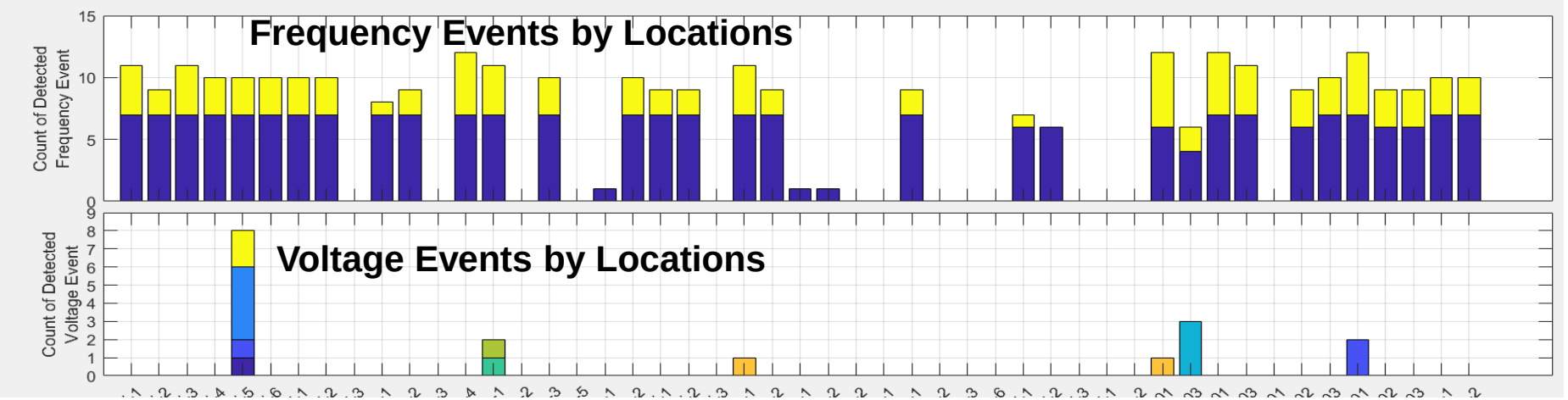
Examples from CAISO, SPP, ERCOT, OETC & GETCO

- AEM was used for the following
  - > Oscillations
  - > Generation & Load Trip
  - > Faults
  - > Line Trips
  - > Extended Low voltage events
  - > Device Calibration Issues
  - > Equipment Failure
  - > Alarm Thresholds

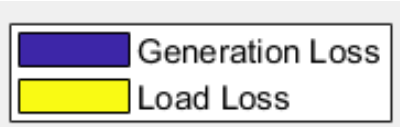


Report - Examples

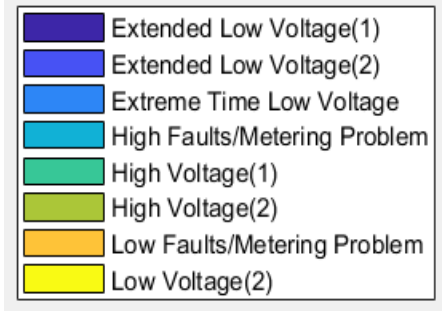




Frequency Events



Voltage Events



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AEM Summary

- Comprehensive Platform for Event Mining
- Used AEM extensively for generating reports for CAISO, SPP, ERCOT, GETCO, SRLDC, OETC
- Key Functionality and Capabilities
  - > Automated Mining and Identification of Oscillations, Generation trip and load trip, faults and low voltage events
  - > Measurement Anomalies and Device Calibration Issues
  - > Data Quality Assessment Summary
  - > Automated Report Generation
  - > Easy to use Interface
- EPG offers AEM as a service package

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