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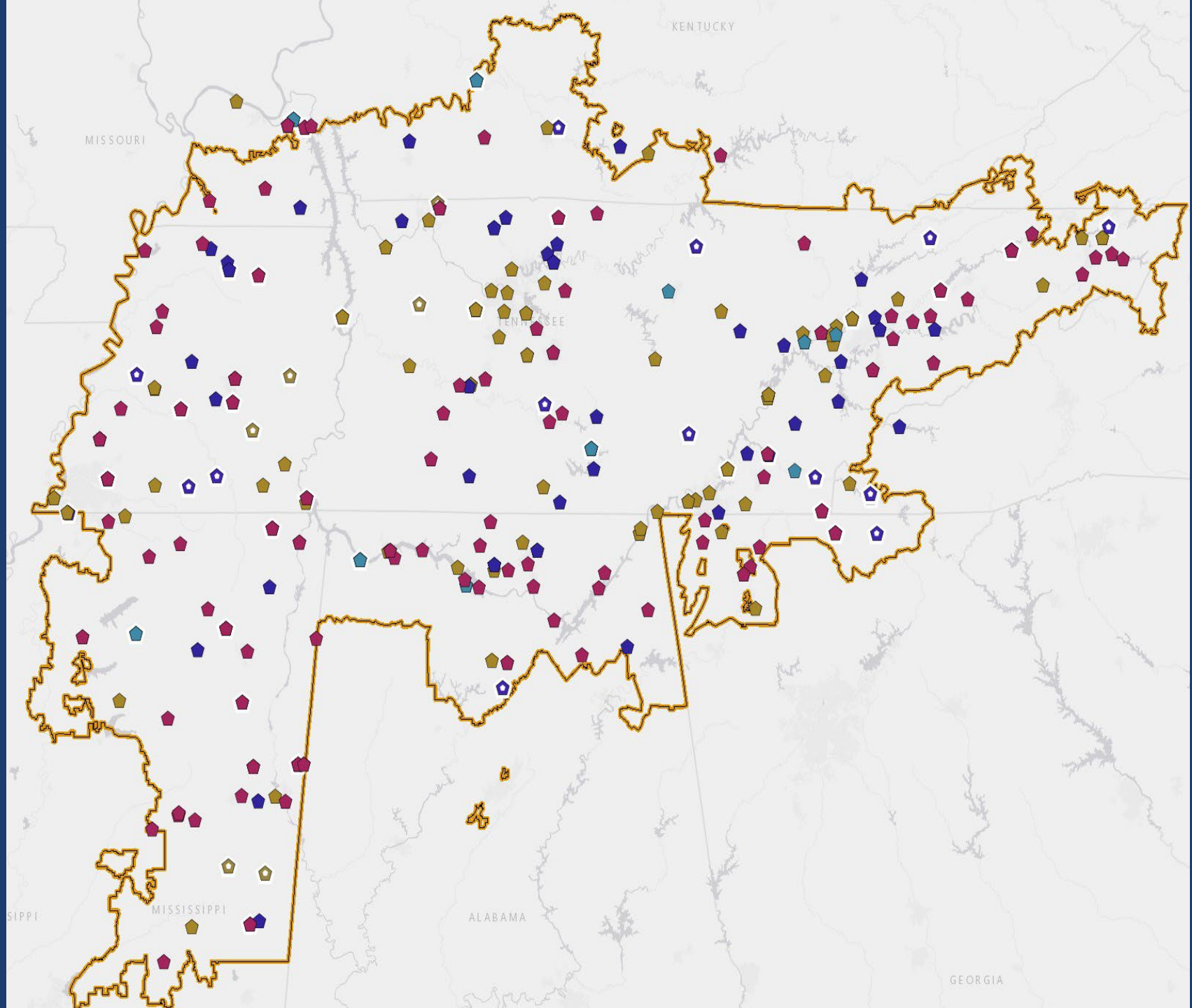
TVA Real Time PMU One Lines

Jonathan Hayden, Power Quality - TVA

TVA PMU Locations in PDC (as of 7/2024)

1038 PMUs located across 137 sites including:

- DFR
- GE N60
- GE D90
- SEL 311C
- SEL 411L
- SEL 787
- SEL 735



TVA PMU Program Overview

- PMU functionality and channels are enabled, when possible, in all new DFR and new line and transformer relays installations
- Priority of PMU installation to is given in the following order
    1. Generating Stations(Nuclear, Fossil, Hydro, Any BES Generator, Solar and Wind)
    2. Major Transmission Interfaces(Locations with at least one intertie with another utility greater than 100-kV
    3. Potential Voltage instability areas
    4. Opportunity locations on portions of system with low visibility

Real Time PMU Applications

- Momentary cessation alarming for Solar Generation
- Inverter Based Resource commissioning activities
- Voltage Unbalance monitoring and testing
- Real Time one line diagrams
    - Hydro Generation Black Start diagrams
    - 500kV system diagram
- Oscillation detection
- Event Investigations
- Islanding detection (future)
- Current Unbalance monitoring (future)

IBR Monitoring and Commissioning

New IBR sites are commissioned and monitored through PMU visualizations in Grafana, oscillation and momentary cessation alarming in RTDMS, and trending through OpenHistorian applications.

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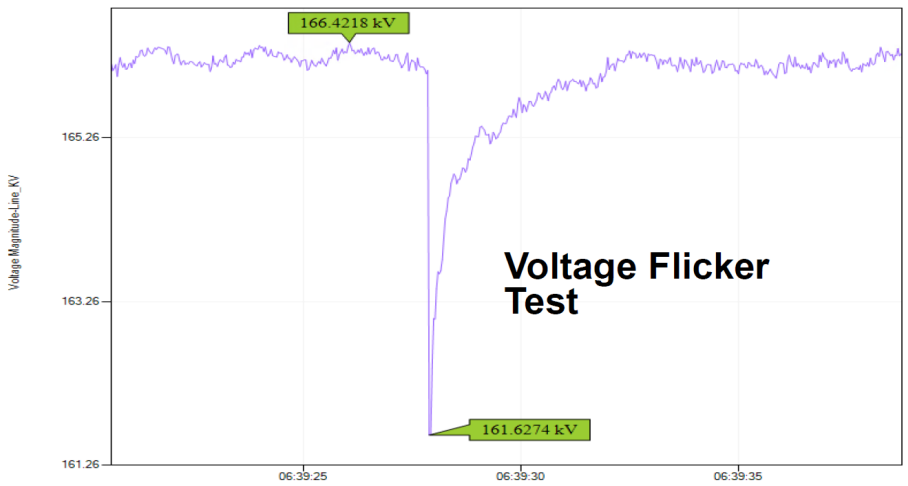
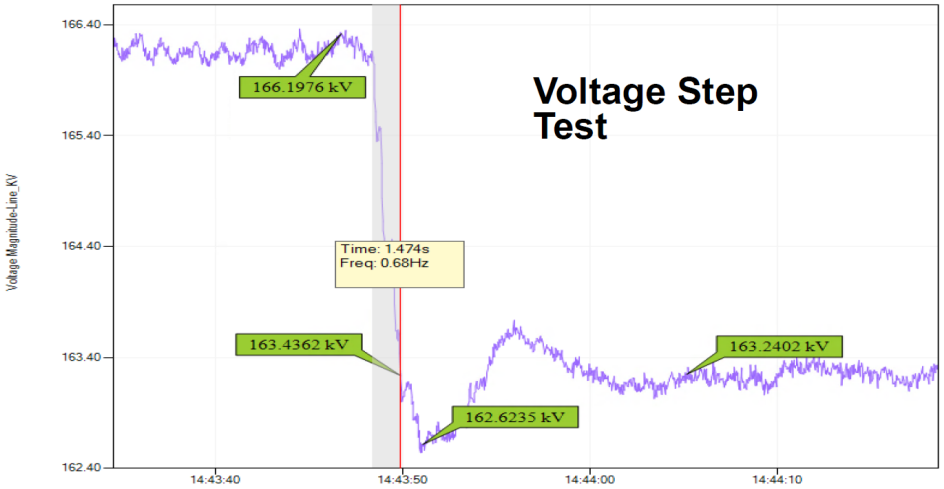
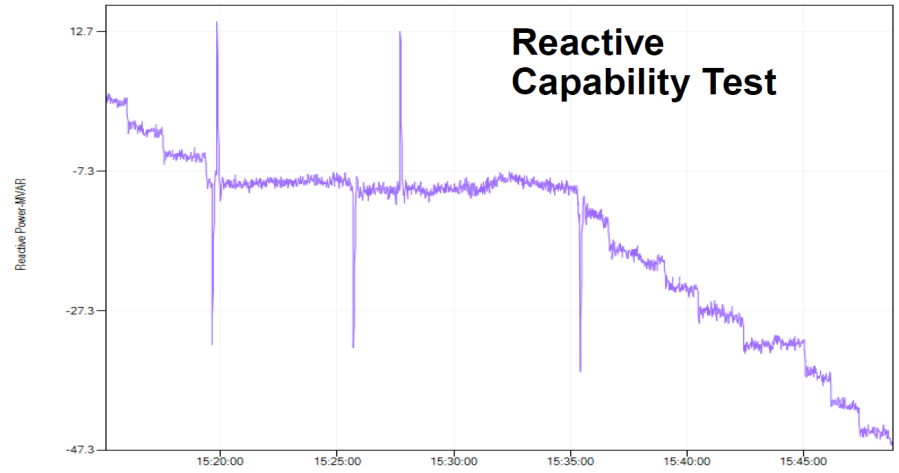
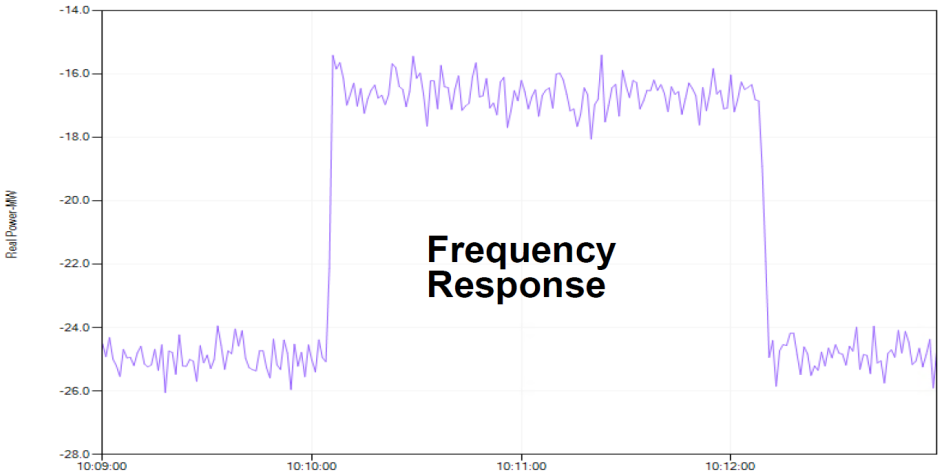
IBR Monitoring and Commissioning Cont'd

Through the use of PMU data we can remotely test functionality of new IBR sites where SCADA may not provide sufficient visibility requiring travel to the generation sites.









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Voltage Unbalance Monitoring and Testing

Customer inquiries and complaints in the TVA service area led to a pilot program to address the issue of voltage unbalance. Grafana and OpenHistorian were utilized to build the visualizations while implementing the pilot in real time. Since the main concern was high neutral currents in this pilot, graphs with relaying limits were created prior to testing to give visibility if the currents were approaching the trip settings.

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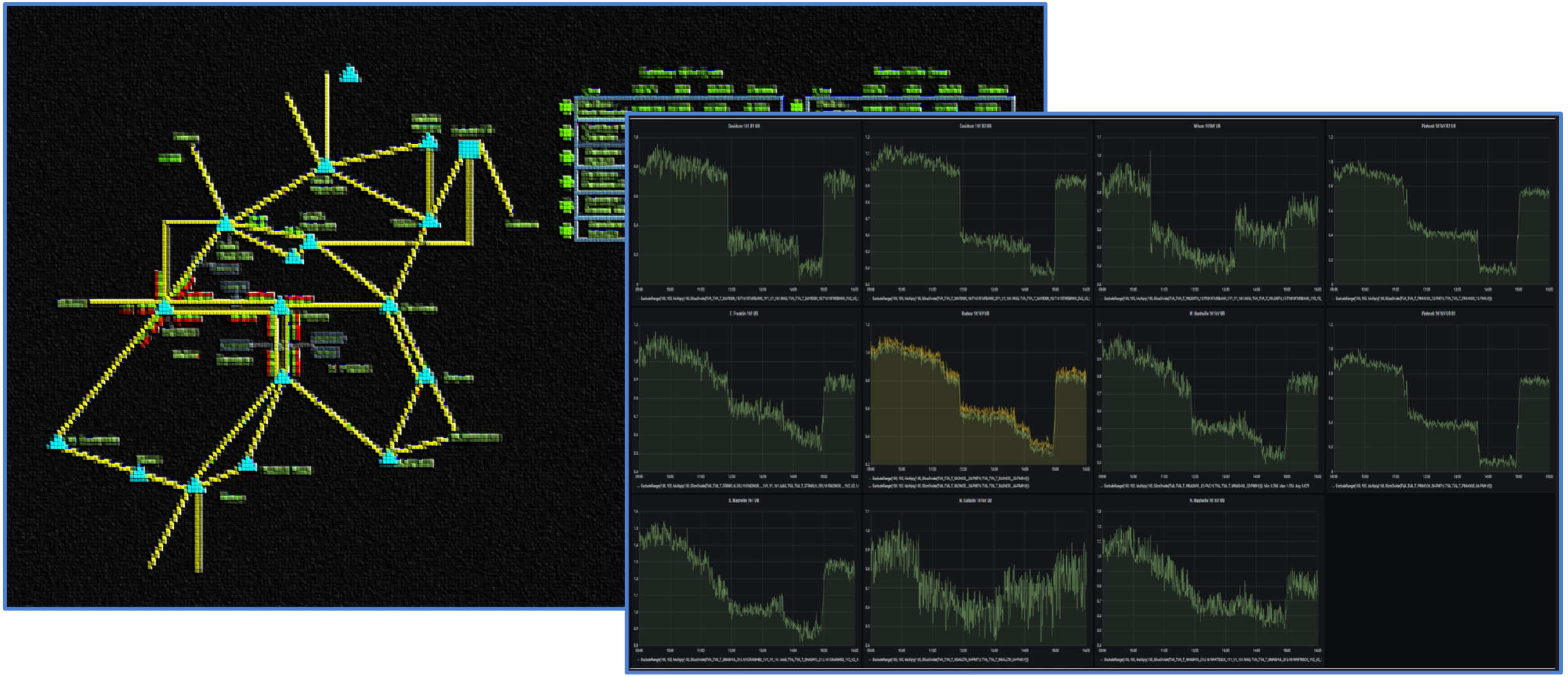
Voltage Unbalance Monitoring and Testing



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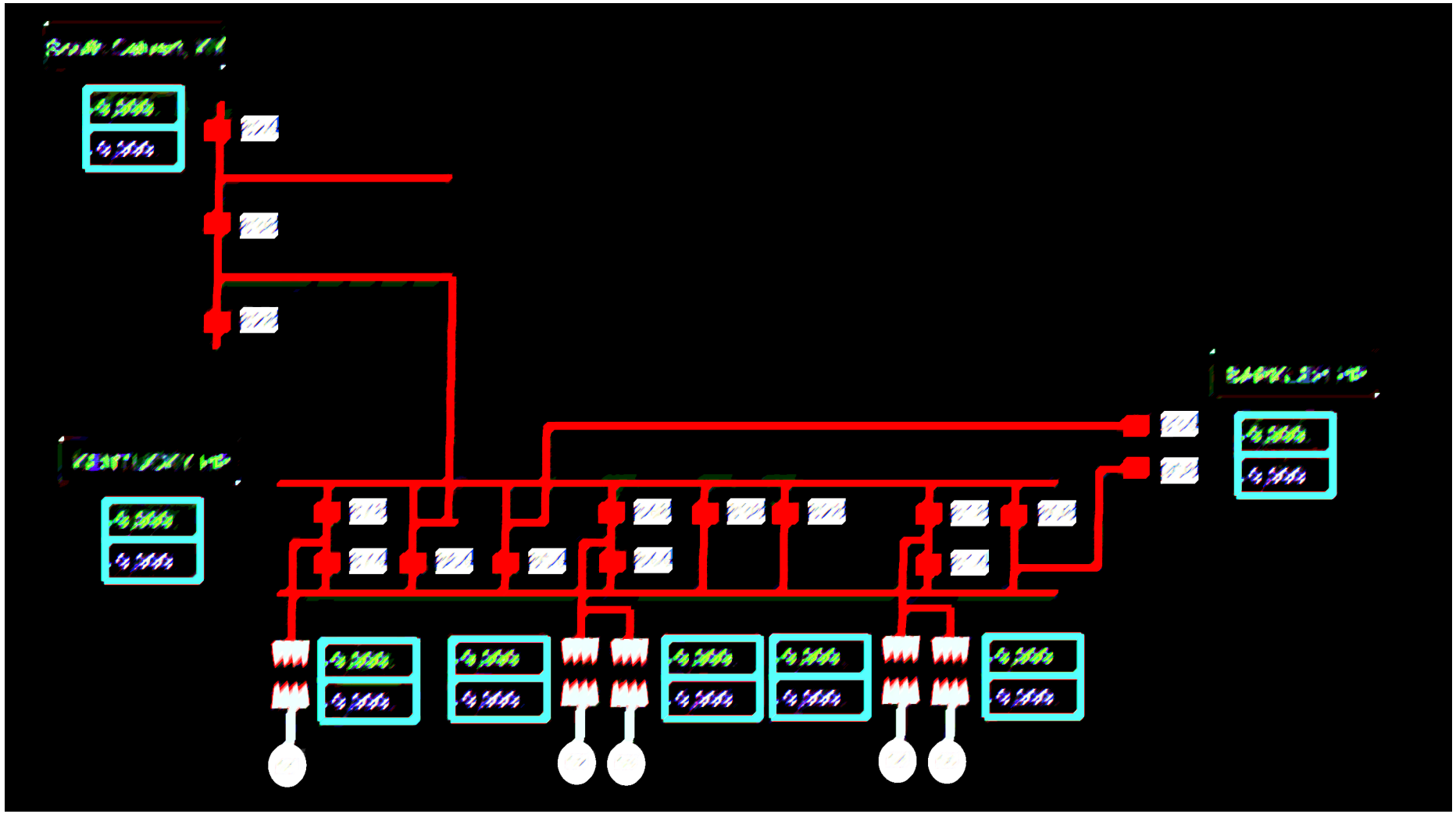
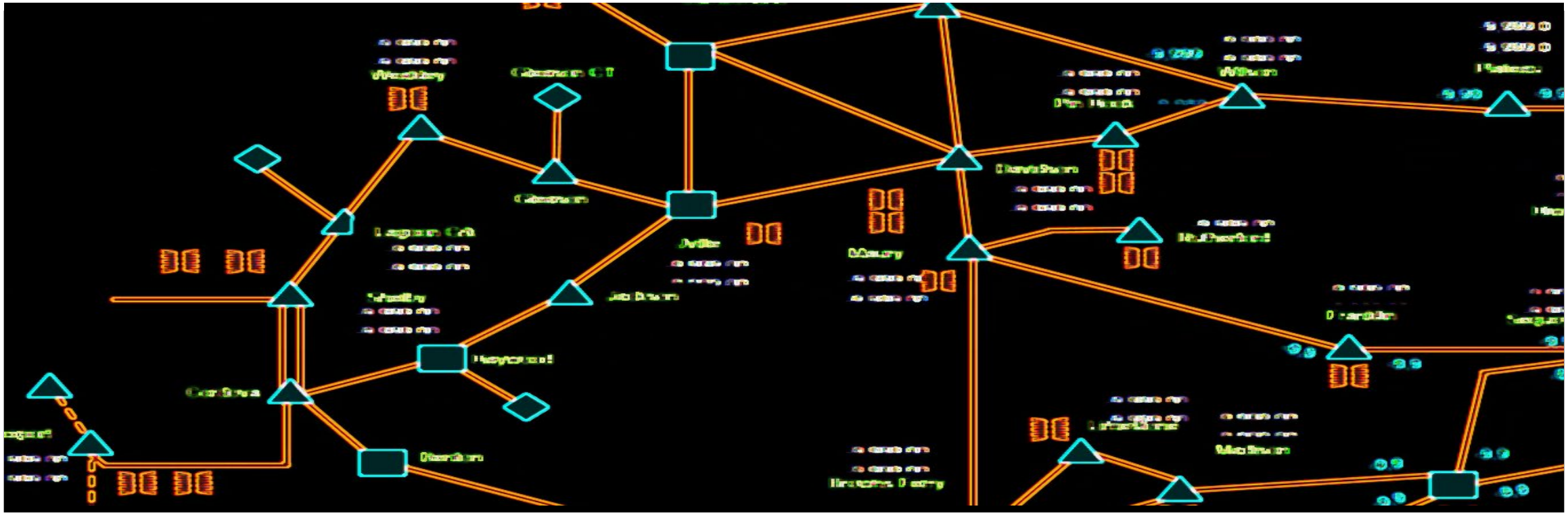
Real Time Single Lines – Black Start

- Developed to compliment SCADA data for designated black start units across TVA's system.
- Additional channels increase visibility for black start islands and cranking paths during large scale outage events.



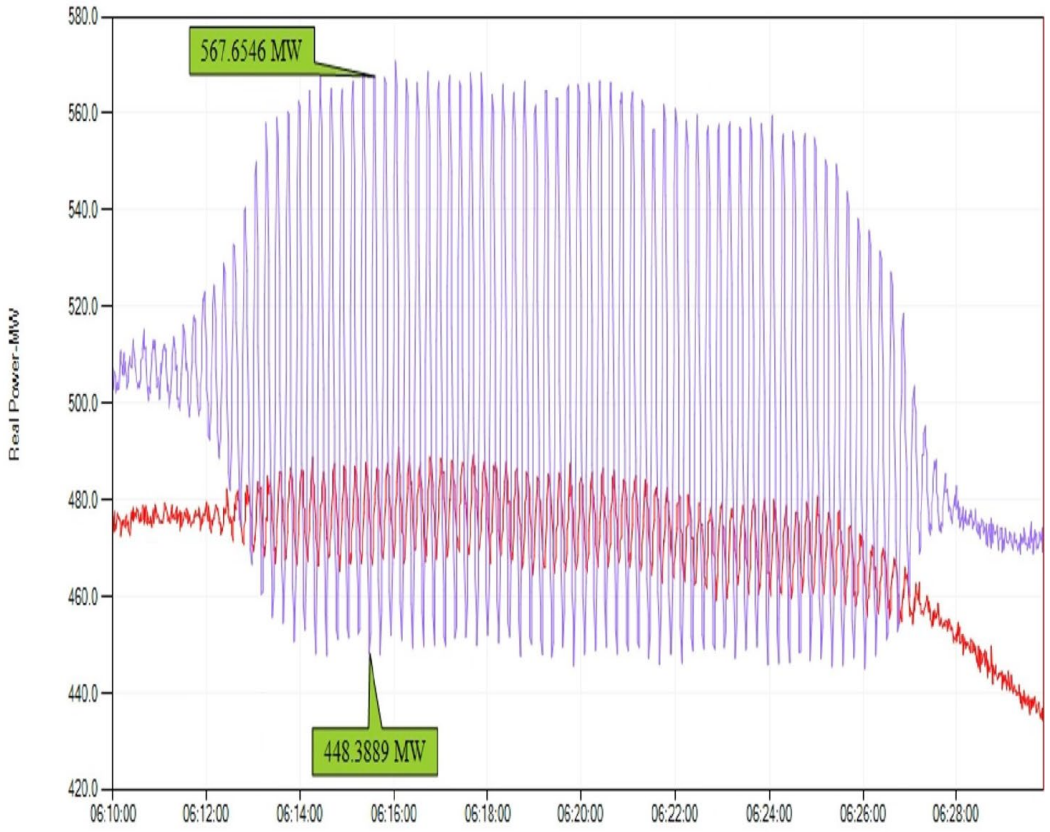
Real Time Single Lines – 500kV System Overview

The 500kV system overview was developed as contingency for central operations visibility in the event of primary SCADA outage. These single lines have also supplemented operations in local area SCADA issues.

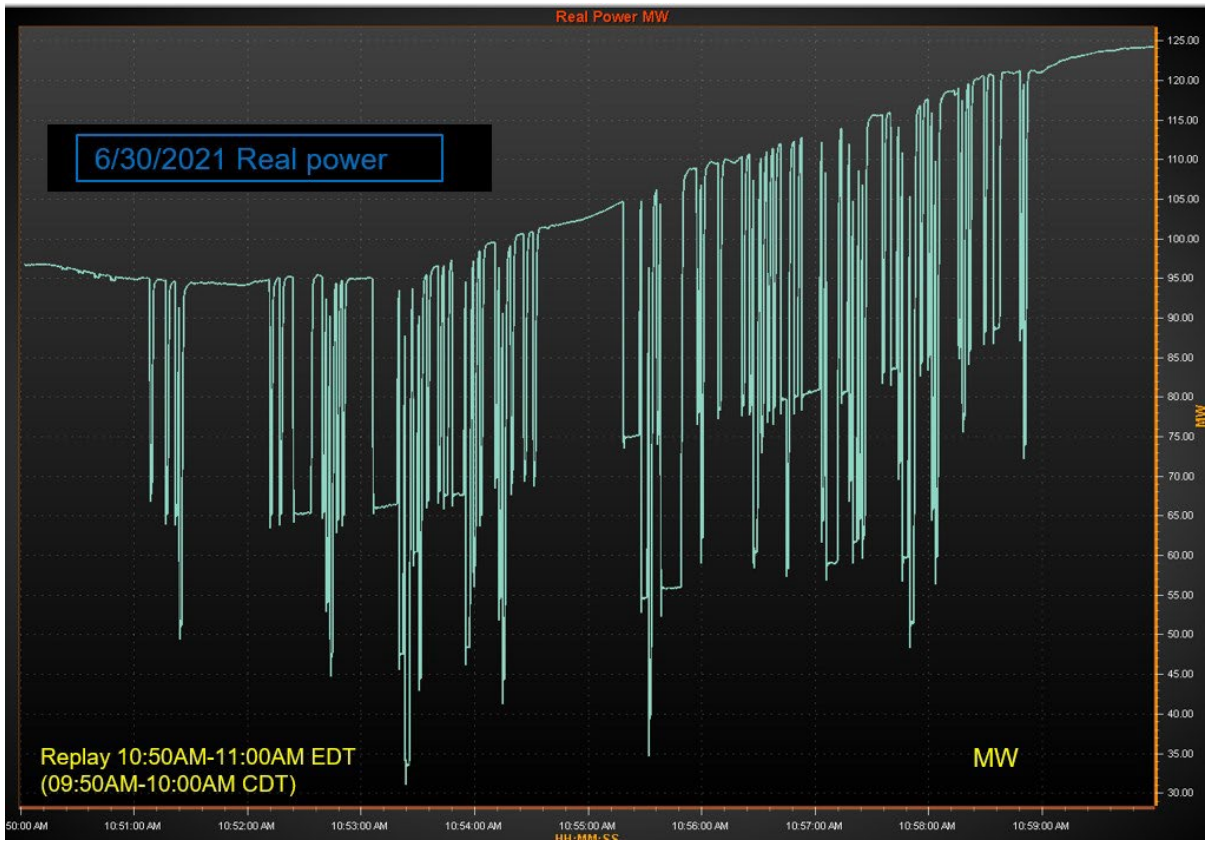


Oscillation Detection

Unit megawatt oscillation due to steam control valve issues. Similar oscillations seen during steam valve or flow gate failures.



Solar Generation site swinging 60-70 megawatts due to IBR controller design. Commonly seen during commissioning activities.



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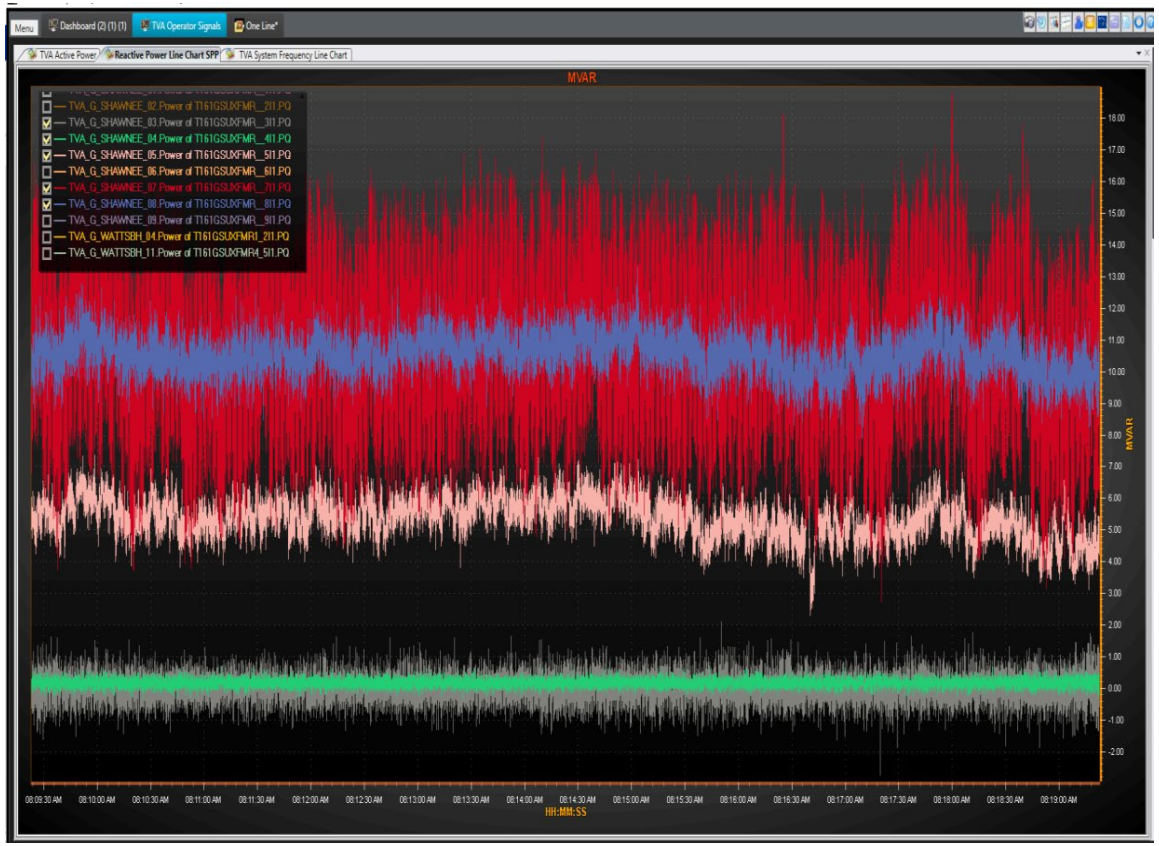
Oscillation Detection

A failing PT supplying the AVR caused large reactive power swings on a generator.

High frequency oscillation due to power system stabilizer on a generator. Swings of this nature also seen on the system when a PSS was offline at a steel mill.



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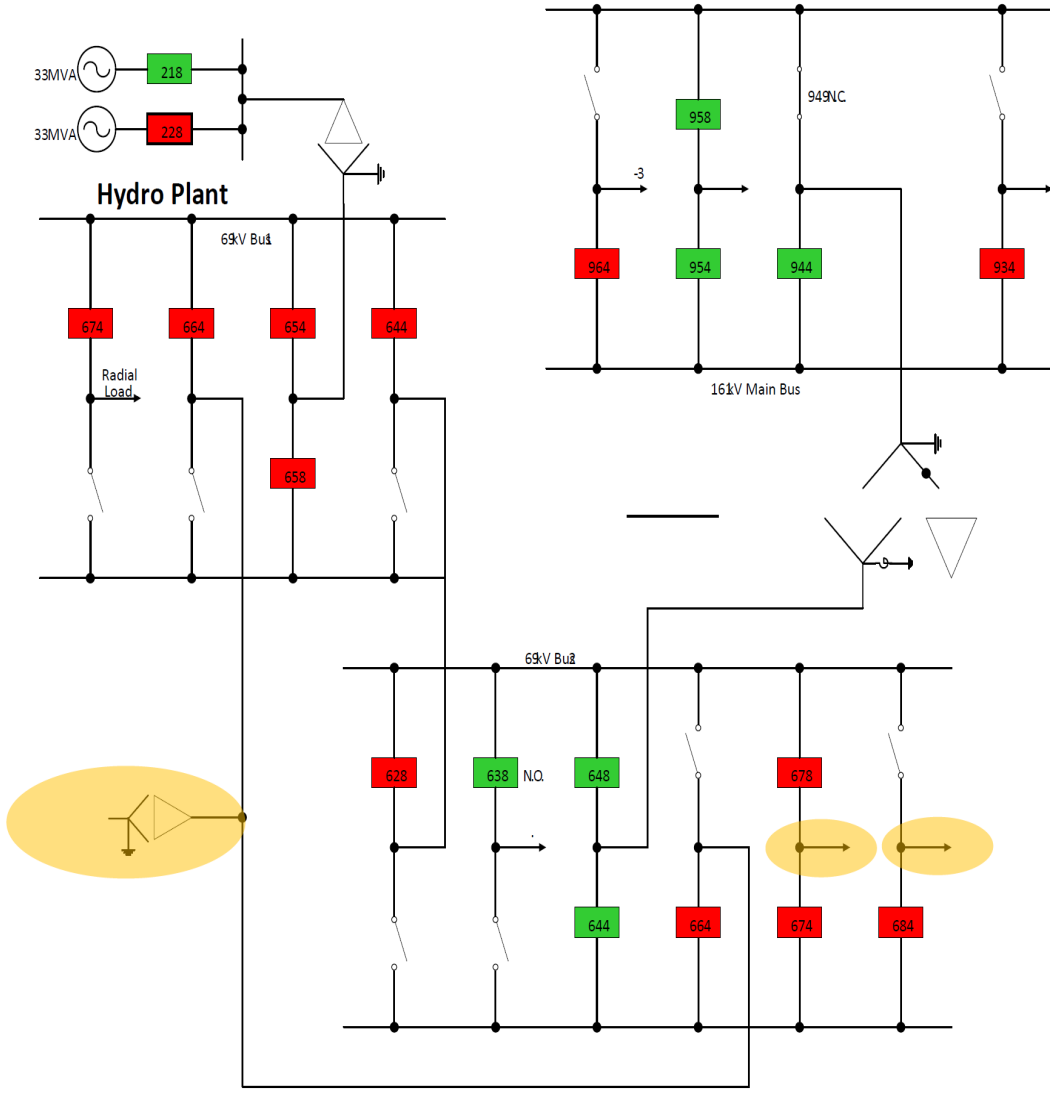
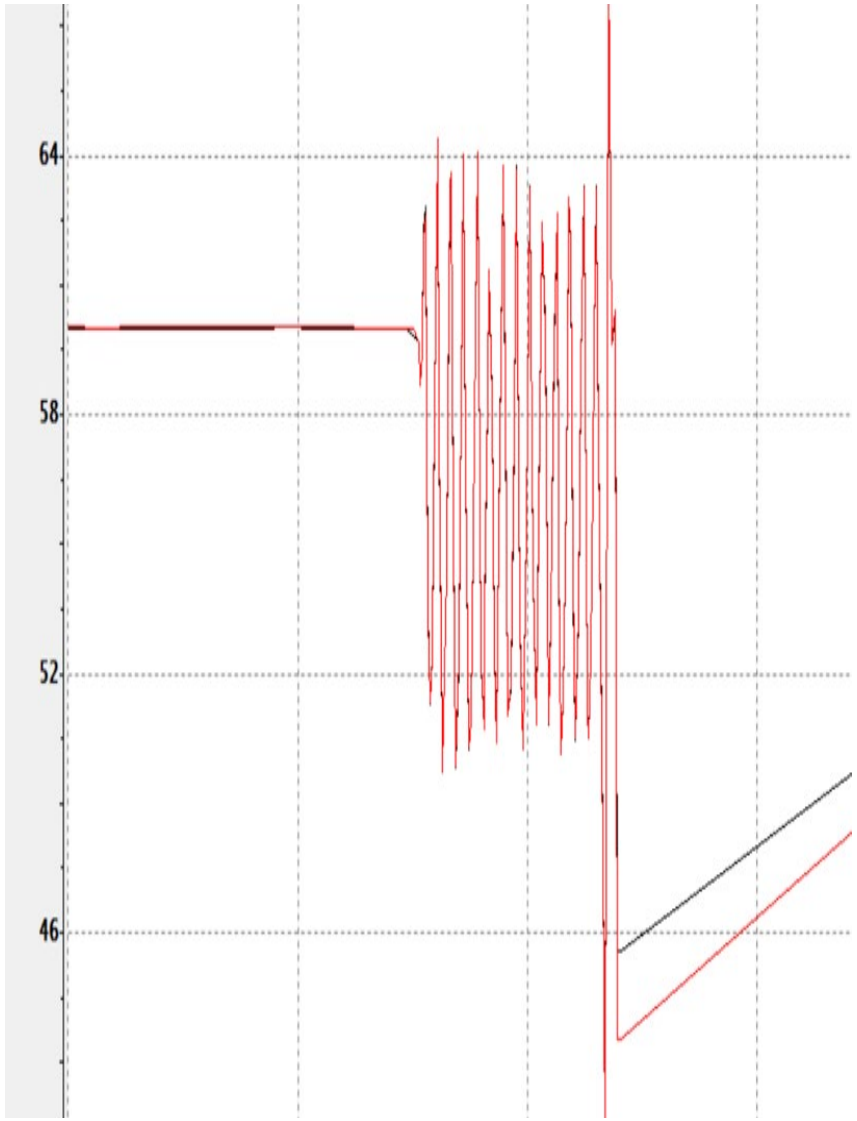
Future Applications

- Islanding Detection for remote areas of hydro generating facilities
- Current unbalance monitoring to assist with broken conductor detection and equipment failures, i.e. high impedance connections on substation devices.





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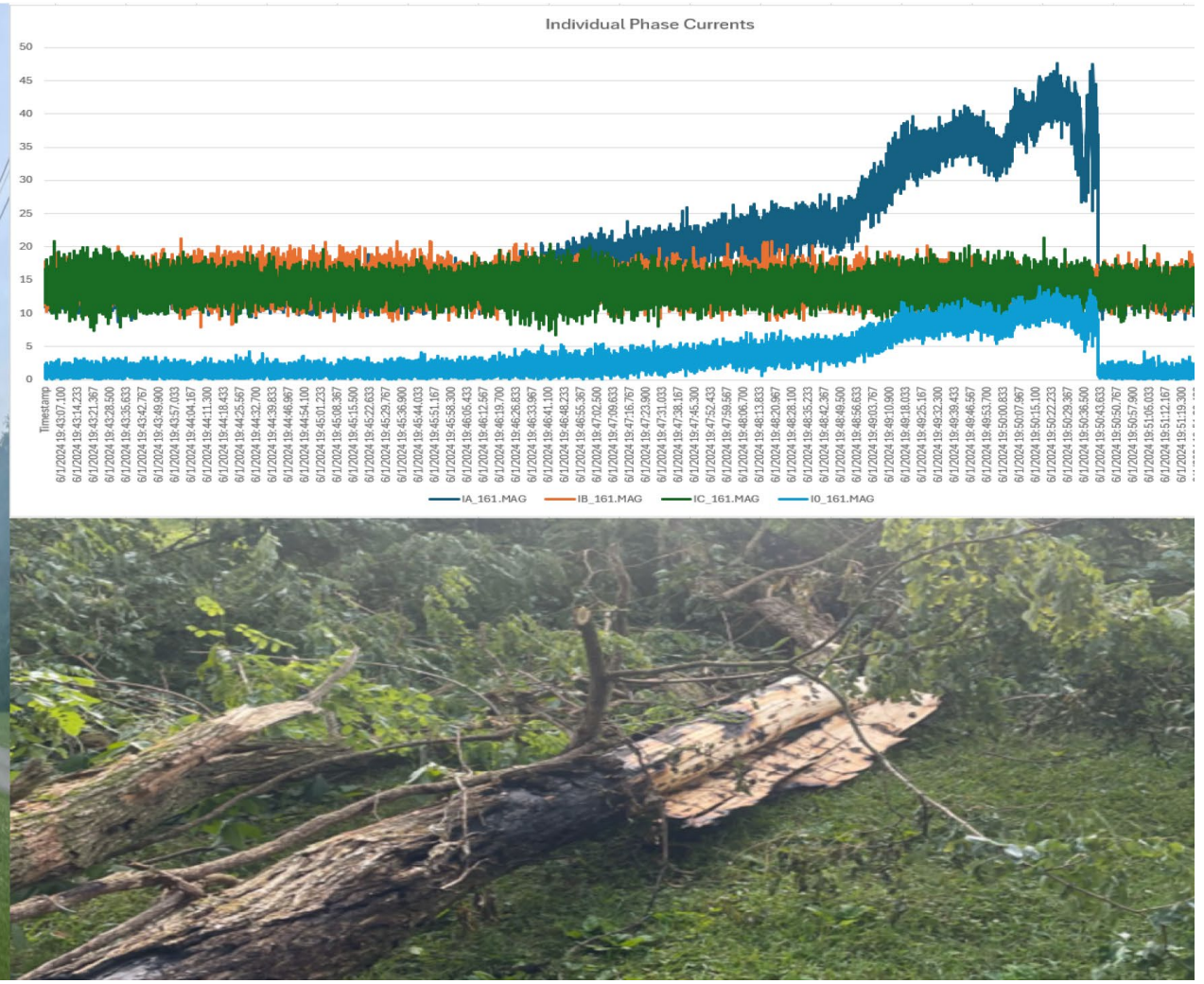
Post Event Investigations

- Assist in generation troubleshooting and power system fault analysis.
- Collaboration using pre-fault data to research equipment failure signatures.
- Validation of relay action.



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