Toward the Development of a Real-Time Monitoring System for a Transmission Operator based on High-Sampling-Rate Data

Team: Red Hawk

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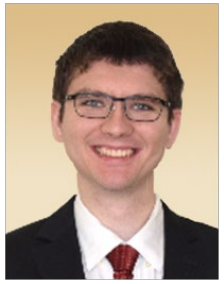

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- ❑ 30+ total years of experience working with synchrophasor data. Accomplishments include:
- ❑ Cross power spectral density method for locating and characterizing power oscillation sources (first place in 2021 IEEE-NASPI Oscillation Source Location Contest)
- ❑ Power control equipment performance analysis from disturbance and ambient PMU data
- ❑ PMU missing data recovery using matrix and tensor completion methods
- ❑ Automated analysis of power system equipment via tracking real-time performance characteristics
- ❑ Development of production-grade tools, SciSync, for online and offline analysis of synchrophasor data

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Proposal

Goal: develop data analytics functions using PMU and point-on-wave data for asset diagnostics and performance evaluation system
1. Methods applicable to synchronous machines and inverter-based resources (wind turbines and solar PV)
2. Resolve oscillations due to equipment malfunctions
3. Monitor frequency and voltage regulation performance of controlled equipment
4. Impact positively on utility asset management and maintenance

Background: Previous NYSERDA funded work has shown offline ambient analysis of synchophasor measurements from
1. Synchronous Generators
2. STATCOM
can estimate droop and controller performance.

Proposed Approach

Further develop our methods for analyzing synchrophasor data to provide transmission system operators diagnostic and dynamic performance evaluation tools, with the following tasks:

1. Oscillation detection, location, and characterization for internal or external oscillation sources due to synchronous generators or inverter-based resources
2. Control equipment performance analysis for voltage and frequency regulation by generators and inverter-based resources using disturbance and ambient PMU data
3. System frequency response analysis to capture aggregate frequency response parameters of the control region
4. Exploratory data analysis and diagnostics of PMU and point-on-wave data to track nonstationary higher frequency oscillations

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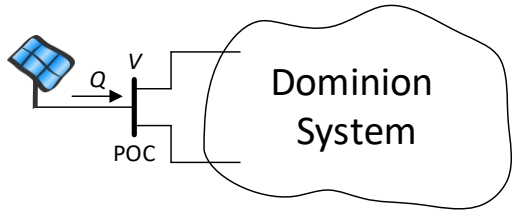
Challenges

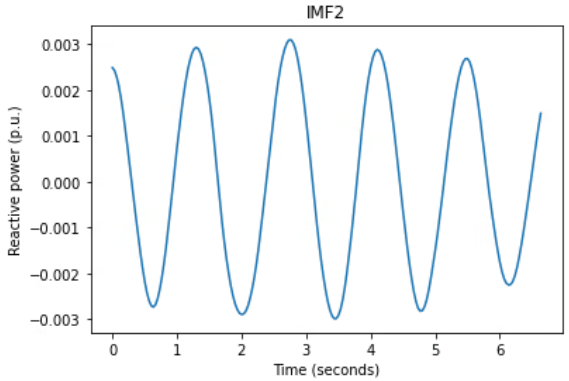
- Limited data availability: Dominion has one of the most comprehensive synchrophasor systems.
  - Missing Data
  - Missing measurements – not all equipment is monitored
- Limited Network Visibility:
  - One Line Diagrams don’t indicate location of PMU
  - Visibility ends at Dominion Substation – DER owners don’t supply information
- Forced local oscillations
  - Approach developed requires ambient data
  - Local oscillations may not impact dominion
  - DERs at same station can interact

Variational Mode Decomposition based Method

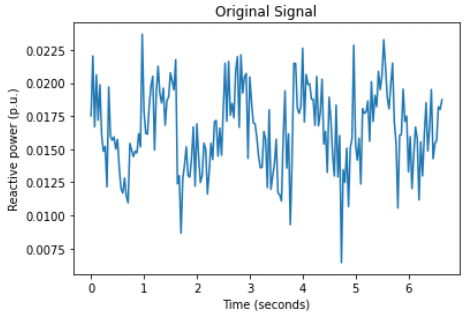
Select a PV plant or STATCOM with appropriate measurements



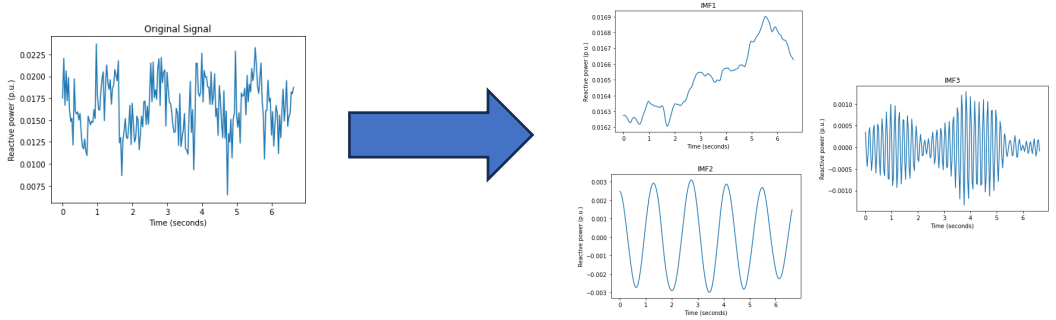
Select dynamic component



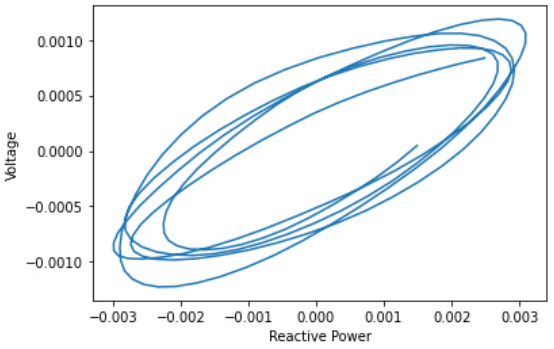
Obtain several minutes of ambient reactive power and voltage magnitude data measured at the point of connection.



Apply VMD to reactive power and voltage signals to remove quasi-steady state and high-frequency components



Estimate the droop and display regulation curve.



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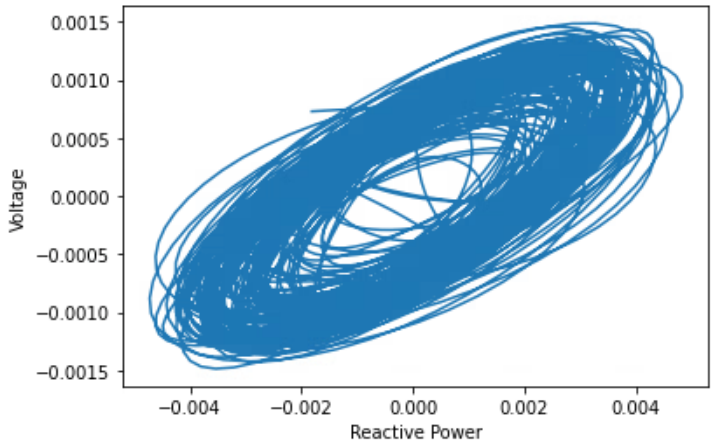
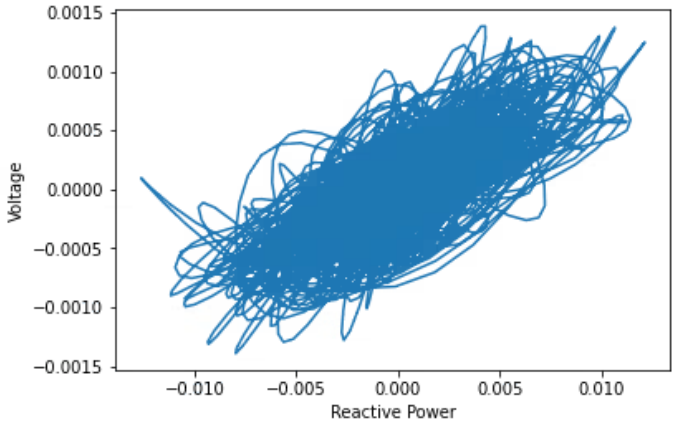
Dominion 2022 Data Study

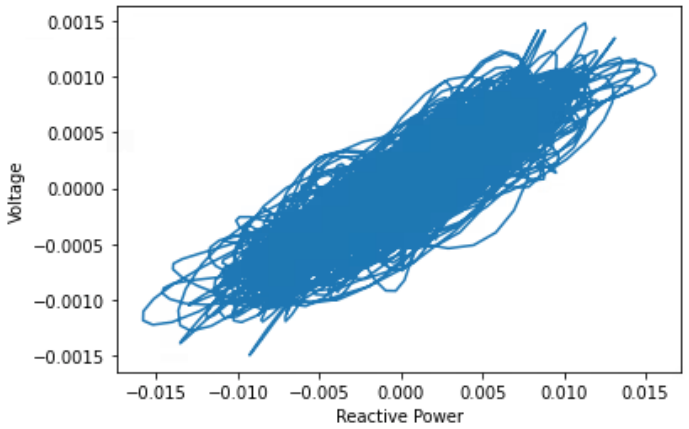
PV Plant (20%)



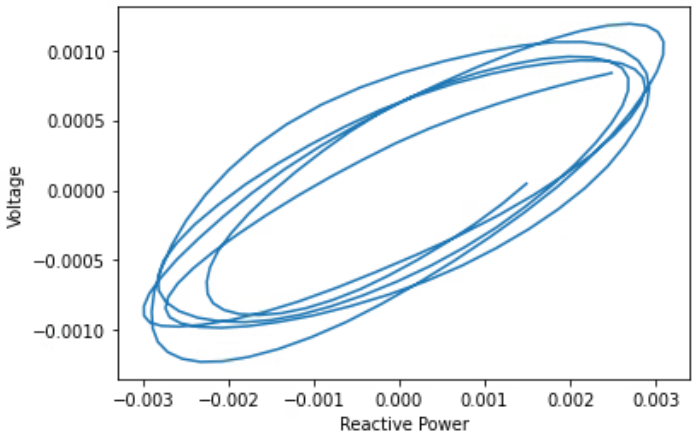
STATCOM I (10%)

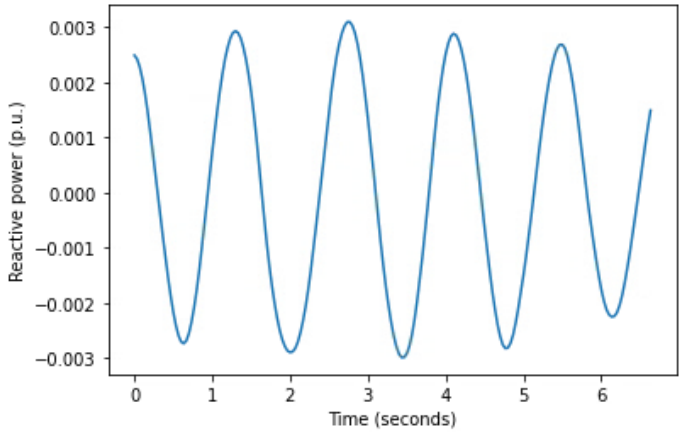


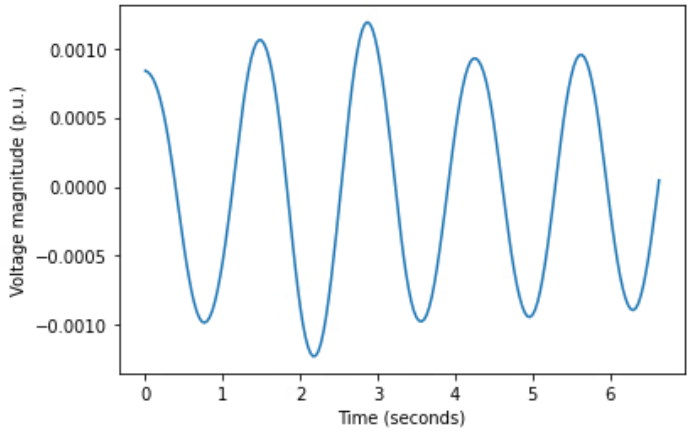
STATCOM II (10%)



Detailed Analysis of the PV plant shows general consistency around 20% Droop







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Impact and Future Plans

The team delivered a solution to assess control performance of the equipment connected to Dominion Energy system.

- Focus on control performance of PV plants and STATCOMs during ambient conditions
- A way to continuously estimate the droop value of voltage regulation of PV plants and STATCOMs

Potential Impact of Solution includes:

- Use for benchmarking for equipment
- Use as indicator for need of thorough analysis
- Use for preventive maintenance indication

Due to limited time the team has only analyzed a few solar PV locations, but provided Dominion Energy with the tools to apply analysis to a larger set.

The team developed the tools on PingThings Predictive Grid Platform

PingThings

The team will leverage their experience in open-source software development to include the developed tools in GPAs SciSync Tool.

SciSync

During the investigation a case in which the solar PV converter generated a sustained reactive power bang-bang oscillation was identified. Future work may show the use of the algorithms developed here under such conditions.

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Future Plans II

Synchrophasor Span Substation to Cloud

Multiple Vendors before we get to Analytics

PingThings +

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