



NASPI/NERC SMWG Joint Workshop Viewpoint from Academia

September 27, 2023

Joe H. Chow

Electrical, Computer, and Systems Engineering

Rensselaer Polytechnic Institute

Troy, NY, USA



Northeastern



Rensselaer

TUSKEGEE

Background

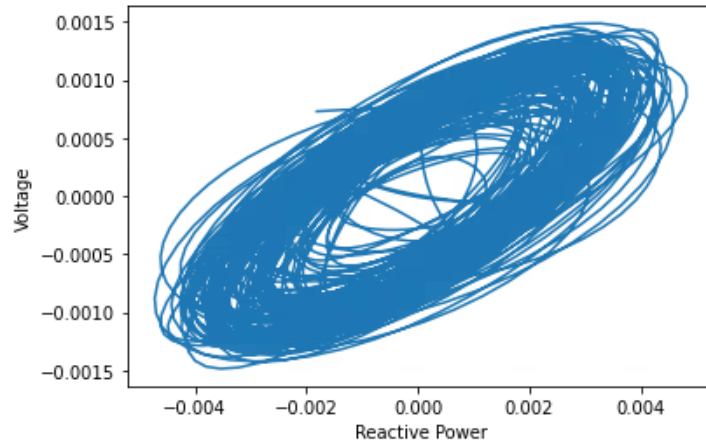
- Most PMU applications developed so far are for transmission grid operations, such as angle separation across control regions, disturbance analysis, model parameter identification, damping monitoring, oscillation source identification, ...
- The main issue for this panel is how dynamic data measurement can be useful for distributed energy resource (DER) integration, to check whether the DER controllers are operating properly with traditional distribution system controls and with each other
- Thus we need to install PMUs (or IEDs as appropriate) on subtransmission/distribution system, particularly at point-of-connection (POC) with sizable solar PV units (possibly multiple plants)

IBR Performance Monitoring

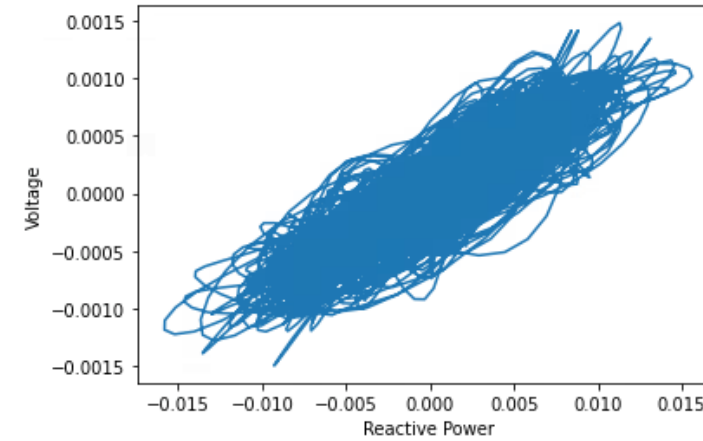
- Opportunity to analyze reactive power and voltage regulation for Inverter-based resources (IBRs) in subtransmission/distribution systems, preferably on a continuous basis, i.e., under ambient conditions
- On Day 1 of this NASPI meeting, C. Lackner had presented a Variational Mode Decomposition (VMD) method of separating an ambient signal into band-limited Intrinsic Mode Functions (IMFs), allowing the removal of the quasi-steady state.
- How do we know that we can get some meaningful results, given that most of the time, these IBR controllers came with a black-box model?

PV Plant/STATCOM Regulation Response

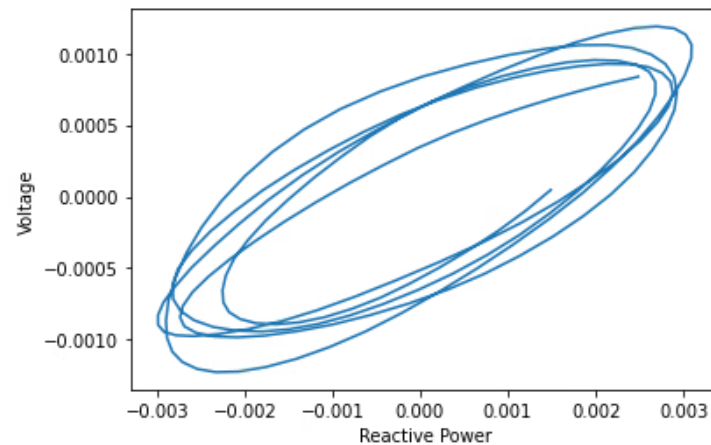
PV Plant (20%) 3-minute window



STATCOM (10%) 3-minute window



3-second window

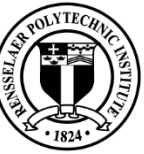


- From the regulation response, one can compute the effective droop and equivalent time constant for voltage regulation for the equipment.
- The analysis shows that PV Plant and the STATCOM are functioning well in their respectively operating conditions.

Note: Plots from DOE Digitizing Utilities Prize Competition video of the Red Hawk team (Christoph Lackner, Denis Osipov) based on Dominion Energy PMU Data.

DER Controller Operational Issues

- What if the regulation response curve from PMU data shows undesirable behaviors?
- Possible causes:
 - Controller gain not tuned properly – either too high or too low
 - An operating condition that accounted for in the controller design – such as losing a line, changing the short-circuit ratio of the DER looking into the network
 - Interactions with conventional voltage regulators and shunt capacitors which tend to have time delays.
- Manifestation:
 - Bang-bang voltage/reactive power response if the controller gain is set high
 - Sustained oscillations emanating from an DER



Concluding Remarks

- A strong case for installing PMUs on subtransmission/distribution systems
- Appropriate signal processing techniques are needed for ambient operating condition analysis
- PMU data can be used to check control coordination between active controllers (DERs) and passive controllers (voltage regulators, switched capacitor banks) on distribution systems
- Community collaboration is critical, particularly, data availability
 - The sustained oscillation test cases set up by Drs./Profs. Slava Melenikov, Bin Wang, and Kai Sun, available on Prof. Sun's University of Tennessee website, are instrumental in advancing the state-of-art in this research topic.
 - The IEEE PES Subcommittee on Big Data & Analytics for Power System also has a website <https://bigdata.seas.gwu.edu/data-sets/> with (limited) PMU data sets for distribution systems.

General Discussion:

Next Generation Measurement-Based Reliability Tools



Questions and Answers