TIP 348: Measurement-Based Voltage Stability Assessment

Context

Voltage stability assessment methods can be classified into two categories; model-based methods and measurement-based methods. Model-based methods use a full-topology state estimator model to perform contingency analysis and to find real-time voltage stability limits. Model-based approaches, when applied correctly, are usually better for finding voltage stability limits, as demonstrated during the NASPI voltage stability workshop in October 2014.

BPA Technology Innovation funded TIP 325 by V&R Energy, demonstrating their ROSE application for model-based voltage stability assessment.

Measurement-based approaches have their place as well in voltage stability assessment. First, measurement-based approaches do not need a full-topology state estimator model. So, should the state estimator model be unavailable, (e.g. after a severe contingency) measurement-based approaches can serve as a back-up. Measurement-based approaches also work well in local networks.

Description

Boundaries of a voltage stability area can be approximated with Thevenin equivalent sources. Source impedance and voltage are estimated from real-time data. Then, voltage stability analysis, which could also include contingency analysis, is performed for the local area.

Voltage instability events are rare (fortunately). Therefore, it is difficult to verify the claims for a measurement-based algorithm performance on historic data. However, capacitor and reactor switching occur regularly on the system. A measurement-based application can be employed to calculate the expected change in voltage due to capacitor/reactor switching. The application can also be used to determine the bus voltage sensitivities and robustness, and to flag conditions when voltage sensitivity becomes excessive.

In developing this application, the following major tasks were accomplished:

Thevenin Equivalent Calculations
Simulation test cases for validating Thevenin equivalent calculations are developed. The cases are selected when the system impedance is known, and there are cases of shunt capacitor/reactor switching in the BPA system.

Further, we develop and prototype Thevenin equivalent calculations of several reduced-order models including: single Thevenin equivalent, multiple Thevenin equivalents and Kalman filter.

Measurement-Based Voltage Sensitivity Application

A "plug and play" environment to test voltage sensitivity applications is implemented -The intention is to make the application capable of performing self-assessment. We build intelligence for the application to detect actual reactive switching events and to compare actual voltage change against what was predicted by the application.

Applications are baselined against real-time switching events - The application is tested on streaming PMU data in the BPA synchrophasor lab. Because reactive switching events are frequent, there will be ample opportunities for validation of the application algorithm.

Measurement-Based Voltage Stability Analysis

- *A "plug and play" environment to test voltage stability apps is implemented.*
- *Measurement-based applications are base-lined against the model-based applications.* The application will be capable of performing self-assessment. Intelligence is built into the application to detect actual reactive switching events and to compare actual voltage change against what was predicted by the application
- *Develop displays and visualizations of the voltage stability analysis, active power margin.*

Displays

Finally, display capabilities are developed to convey the information to the users. We envision two options, display indicators of voltage robustness; and display indicators of voltage change due to BPA capacitor / reactor switching.

Benefits

Voltage stability can be a limiting factor for dynamic transfers – real-time tools will improve monitoring and managing dynamic transfer impacts. As the variety of system inputs increase, actual system conditions may vary more often and more rapidly. Additionally, real-time assessment helps ensure maintenance of system voltage stability margin during dynamic changes.

The project further develops the real-time monitoring and voltage stability assessment using BPA's installed synchrophasor network.

Accomplishments

This project validates real-time, measurement-based applications for voltage control and voltage stability, bringing them to near production technology readiness level.

Finally, it provides improved visualization of real-time voltage sensitivity/stability to dispatchers

Deliverables

- A qualified Voltage Assessment application that was tested to the BPA system;
- Technology Transfer plan to incorporate the final applications into professionally developed, commercial Tools and Applications

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Project Start Date: October, 2015

Project End Date: September, 2018

Funding

Total Project Cost: $575,000

Reports, References, Links

Related Projects

TIP 325: Real-Time System Operating Limits (SOL) Computation and Visualization for BPA

Participating Organizations

Pacific Northwest National Laboratory

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