Technology Innovation Project

Closing Project Brief

TIP 349: Demonstration of Applications for Baselining Power Oscillations

Context

Power oscillations are always present in electric power systems. Most of time, oscillations do not represent reliability, safety of power quality risks. However, growing or large magnitude oscillations can lead to large scale power outages, equipment damage, or power quality concerns.

Under TIP 50 and the synchrophasor program, BPA has greatly advanced our understanding of power oscillations and oscillation damping controls; as well as increased our capabilities in oscillation detection and analysis.

But more work is needed to further enhance and mature the comprehensive package of applications developed in the previous projects.

Description

One of the areas identified in TIP 50 for future work is developing applications for baselining power oscillations. This requires developing baseline analysis tools for three categories of oscillations, and then using them to flag abnormalities.

BPA uses the following categories to describe power oscillations:

- Oscillation Ringdown (a.k.a. transient response) – an oscillation that occurs after a sudden disturbance such as a fault, line tripping, generator trip, or load tripping. Small-scale oscillation ringdown is characterized by the Oscillatory Modes of the system.
- Forced Oscillations – an oscillation caused by an external system component or malfunctioning apparatus (e.g. a failed control valve, rough zone operation of a hydro-generator, etc.) Forced oscillations may include harmonics resulting from the periodicity of the external inputs.
- Ambient Oscillations – an oscillation in response to the small random changes within the system. These changes are typically characterized by small random load changes.

The specific tasks and task components in this project include:

Task 1: Oscillation Ringdown Baseline
- Enhancements to the existing ringdown analysis tools
- Developing an application for baselining these oscillations

Task 2: Ambient Oscillation Baseline
- Evaluate enhancements of ambient data analysis
- Integrate ambient data analysis in the oscillation baselining tool

Task 3: Using oscillation baseline for model validation
The developed baseline will be very useful in model validation, particularly as state estimator models become available, and model validation can be performed more routinely, including studies of brake tests and low damping system conditions.

Task 4: Low-level oscillation detector
- Evaluate existing low-level oscillation detection algorithms
- Develop oscillation detection engineering interface

This application's purpose is to alarm dispatchers when an oscillation develops that puts power system reliability at risk or may cause a catastrophic damage to generation or transmission equipment.

Benefits

Baselining power oscillations allows enhancement and refinement of existing applications for oscillation detection and analysis, as well as the development of other advanced applications.

The applications developed in this project will be integrated into the engineering analysis packages, in model validation studies, and in control room operations.

Accomplishments

The goal is to develop a suite of applications that can detect, identify and characterize oscillations against a baseline of oscillation occurrences correlated with other power system measurements – e.g. generator statuses, generator loading, system strength, line outages, etc. The applications will enable early detection of control problems and system conditions when such problems can surface.

Deliverables

Actual system applications will be completed and "mission qualified" through test and demonstration in an operational environment.

- Baselining tools will be developed and integrated with the enhanced ringdown and ambient data analysis tools.
- Baseline will be linked with model validation applications.
- Detective tools will be developed to identify sources, causes and conditions of sustained low level system oscillations.

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Project Start Date: October 1, 2015

Project End Date: September 30, 2018

Funding

Total Project Cost: $750,000

Reports, References, Links

Technical Papers

1. Modes of Inter-Area Power Oscillations in Western Interconnection, https://www.wecc.biz/Reliability/WECC%20JSIS%20Modes%20of%20Inter-Area%20Oscillations-2013-12-REV1.1.pdf
2. Dan Trudnowski, Dmitry Kosterev, John Undrill, "PDCI damping control analysis for the western North American power system," http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6672718, http://sites.ieee.org/pes-enews/2014/04/11/pes-technical-activities-update/
3. NASPI Oscillation Detection and Voltage Stability Tools Technical Workshop - Houston, TX October 2014 https://www.naspi.org/site/Module/Meeting/Forms/General.aspx?m_ID=MEETING&meetingid=347

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Related Projects

TIP 50: Oscillation Damping Controls
TIP 289: Wide-Area Damping Control Proof-of-Concept Demonstration
TIP 305: Data Integrity and Situational Awareness Tools

Participating Organizations

Pacific Northwest National Laboratory (PNNL)