TIP 50: Inter-area Oscillation Damping

Context

Power oscillations are an inherent feature of inter-connected AC power systems. As a water drop creates ripples on a water surface, small load-generation imbalances create constant power oscillations across an interconnection. Of concern are conditions when oscillations are growing in magnitude, often due to high system stress (e.g., Aug. 10, 1996), equipment failures (e.g., CGS oscillation in 2005), or resonance conditions. Oscillations are one of the factors affecting transfer capabilities. Growing oscillations can result in damage to power system equipment. Therefore, it is necessary to understand the oscillation risks, being able to model them in system studies, and to develop mitigation strategies to address the issues.

Description

This project develops a portfolio of solutions to detect, analyze and control power oscillations in the grid. Further, it advances studies in hydro-governor tuning to coincide with federal upgrades. An outcome of the brainstorming meeting held at California Independent System Operator (CAISO) in February 2007 was to address the following questions:

- What is the risk of oscillations in the Western Interconnection?
- How well do our models represent oscillation damping?
- What can operators do to detect oscillations and what corrective actions can be taken?
- What control solutions can be deployed to dampen the oscillations?

Needed solutions to address oscillation issues are grouped into two categories:

- Operational solutions – what tools operators need to detect oscillations and anticipate their risk, and what actions can be taken to mitigate the risk.
- Control solutions – evaluate various controls based on their effectiveness, robustness and cost. These include options of what can be done at grid level, supply side, as well changes to end-use loads.

The project also includes activities to gain better understanding of the power oscillations in the West, including oscillation baselining and regular system tests, such as Pacific DC Intertie probing.

Why It Matters

Unstable oscillations can result in the breakup of the power system, such as the August 10, 1996 blackout event. Following that outage, the operational rating of the California-Oregon Intertie (COI) was derated for several months from 4,800 to 3,200 MW, and the Pacific DC Intertie (PDCI) from 3,100 to 2,000 MW. Large oscillations and resonance conditions can also lead to catastrophic damage of generating and transmission equipment. Power system models have been unreliable in representing oscillation damping.

Goals and Objectives

The objective is to research and develop a portfolio of solutions to address oscillation damping issues. Solutions are grouped into operational and control approaches.

Operational solutions will provide power system operators with greater situational awareness skills in dealng with power oscillations and their risks:

- Tools to alert operators when oscillation is occuring (reactive)
- Tools to provide early warnings to operators when oscillation is at risk (proactive)

These efforts are leveraged with DOE, WECC, and NASPI efforts, with BPA is providing a test environment.

Various osciallation dampening control solutions will be evaluated for effectiveness and robustness. A cost and feasibility analysis will also be done to move forward with a preferred option.

The project assesses oscillation damping risks in the Western Interconnection. Aa roadmap of solutions to address the oscillation damping risks will also be developed.

Currently, the project has three main focus areas: (i) activities to improve modeling and analysis of power oscillations, (ii) applications to give system dispatchers an awareness of oscillations and low damping conditions, (iii) controls to dampen inter-area power oscillations either on transmission. The project supports BPA capital investment in the synchro-phasor technology.

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Project Start Date: October 1, 2007

Project End Date: September 30, 2015

Key Results/Conclusions

- A roadmap of solutions is developed, considering planning, operational and controls related to oscillations.
- The most effective operator action is to reduce BC imports, particularly from generating stations at GM Shrum, Mica and Revelstoke dams.
- Grid-level control solutions to dampen COI power oscillations:
  a) 50 MW to 100 MW of active power modulation by energy/capacity storage. The energy source can be either concentrated (e.g. at Chief Joseph) or distributed (e.g. across Puget Sound area). The further north, the more effective are the controls. PDCI power modulation will also work, with careful attention to DC workload.
  b) 10 Ohms of controllable series compensation in each COI line.
  c) Relative frequency difference between North and South provides the best input.
- Supply-side solutions are most cost-effective. Significant dampening improvements can be achieved with better hydro-governor design and tuning.
- Electronic loads have negative effects on dampening because of their constant power nature. Changing the electronic load characteristic from constant power to constant current can dramatically improve dampening.

Reports & References

› Oscillation Damping Roadmap

› NERC OC Meeting, June 2011

› BPA dispatcher training, Fall 2011 and Spring 2013

› PMU Performance requirements

› Report on using active power modulation for oscillation damping

Funding

Total Project Cost:	$1,246,741
BPA FY2015 Budget:	$100,000

Participating Organizations

US Bureau of Reclamation
US Army Corps of Engineers
US Dept. of Energy (DOE)
Western Electricity Coordinating Council (WECC)
North American Synchro-Phasor Initiative (NASPI)
University of Wisconsin

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