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 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. Unfortunately, power system models are not very accurate in quantifying oscillation risks, or in cases of control failures, cannot predict them at all. Therefore, we need a comprehensive portfolio of tools to anticipate, detect, analyze and control oscillations.

Description

This project develops a portfolio of solutions to detect, analyze and control power oscillations in the grid. It was an outcome from the brainstorming meeting held at California Independent System Operator (CAISO) in February 2007 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?

This solutions developed 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 the 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 break-up of the power system, such as the August 10, 1996 blackout event. Following the outage, the operational rating of California-Oregon Intertie (COI) was derated for several months from 4,800 to 3,200 MW, and Pacific DC Intertie (PDCI) from 3,100 to 2,000 MW.

Large oscillations and resonance conditions can lead to catastrophic damages of generating and transmission equipment.

Power system models have been unreliable in representing the damping of oscillations.

Goals and Objectives

The objectives is to research and develop a portfolio of solutions to address oscillation damping issues. The solutions are grouped in the operational and control solutions.

Operational solutions will provide power system operators with the greater situational awareness of power oscillations and their risks:

- Tools to alert the operators when oscillation is occuring (reactive)
- Tools to provide early warning to operators when oscillation is at risk (pro-active)

These efforts are leveraged with DOE, WECC, and NASPI. 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 preffered option.

With federal hydro projects starting their hydro-governor replacement program, one of the project goals is to develop hydro-turbine governor controls that can provide faster controllable response without excessive oscillations.

The project also looks how larger use of electronic loads affects the oscillations, and what can be done at the end-use side to dampen the oscillation.

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Project Start Date: October 2008

Project End Date: September 2013

Reports & References

- Oscillation Damping Roadmap
- NERC OC Meeting, June 2011
- BPA dispatcher training, Fall 2011
- PMU Performance requirements
- Report on using active power modulation for oscillation damping

Key Results/Conclusions

The 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 GMShrum, 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 is very effective. The energy source can be either concentrated (e.g. at Chief Joseph) or distributed (e.g. across Puget Sound area). The further north we go, the more effective control are. PDCI power modulation will also work, but we may be asking DC to do too much.

b) 10 Ohms of controllable series compensation in each COI line is also very effective.

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.

Funding

Total Project Cost:	$1,309,065
BPA Share:	$1,309,065
External Share:	None
BPA FY2012 Budget:	$225,000

Participating Organizations

US Bureau of Reclamation
US Dept. of Energy (DOE)
Western Electricity Coordinating Council (WECC)
North American Synchro-Phasor Initiative (NASPI)
Lawrence Livermore National Laboratory (LLNL)
University of Wisconsin

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