



Nonlinear Analysis of Power System Oscillations Using Models and Measurements

Final Project Report

S-89G

Power Systems Engineering Research Center
*Empowering Minds to Engineer
the Future Electric Energy System*



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Power Systems Engineering Research Center

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Executive Summary

Hopf bifurcations can occur in power systems when a system mode experiences low damping because of changes in system operating conditions and they can lead to emergence of limit cycles and oscillations. There are two types of Hopf bifurcations, namely, supercritical and subcritical, and they are determined by the sign of a cubic normal form coefficient. This report discusses the two types of Hopf phenomena in test power system models where both types could be seen under changes in system and control parameters. The report proposes an efficient computational method for carrying out higher order center manifold and normal form calculations for a general power system model and discusses the implications of the normal form coefficients for power system dynamics. Distinguishing between subcritical versus supercritical is important since they lead to very different type of oscillatory phenomena related to unstable versus stable limit cycles respectively.

Project Publications:

- [1] Y. Zhi and V. Venkatasubramanian, "Interaction of Forced Oscillation With Multiple System Modes," in *IEEE Transactions on Power Systems*, vol. 36, no. 1, pp. 518-520, Jan. 2021, doi: 10.1109/TPWRS.2020.3024407.
- [2] Y. Zhi and V. Venkatasubramanian, "Analysis of Energy Flow Method for Oscillation Source Location," in *IEEE Transactions on Power Systems*, vol. 36, no. 2, pp. 1338-1349, March 2021, doi: 10.1109/TPWRS.2020.3024866.