



Non-Minimum-Phase Dynamics in the Electric Power Transmission Network: Identification, Analysis, and Preserving Model Reduction

Final Project Report

S-68G

Power Systems Engineering Research Center

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Non-Minimum-Phase Dynamics in the Electric Power Transmission Network: Identification, Analysis, and Preserving Model Reduction (S-68G)

Final Project Report

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Executive Summary

Several factors including higher penetration of intermittent renewables, changing operational paradigms, and new technology deployment (e.g., power-electronic controls) are necessitating a fresh look at the fast dynamics of the bulk power transmission network, which extends beyond the traditional modal perspective. The purpose of this PSERC project, supported by RTE-France, was to initiate a study of the fast dynamics of the bulk power network from an input-output perspective. The focus was particularly on characterizing nonminimum-phase zeros, which essentially determine response properties and place fundamental limits on control. Several results were obtained, including: 1) topological conditions for the presence/absence of nonminimum-phase zeros; 2) understanding of the dependence of zeros on operating conditions; 3) demonstration that nonminimum-phase dynamics may be missed when standard model-reduction techniques are used; 4) characterization of the role of HVDC modulation on zeros; and 5) preliminary algorithm development for estimation of nonminimum-phase zeros from synchrophasor data. As a whole, the project research demonstrates that the presence of nonminimum-phase behaviors in the power grid's fast dynamics may be a real concern, depending on the structure and operating point of the grid.

Project Publications:

- [1] Koorehdavoudi, Kasra, Mohammadreza Hatami, Sandip Roy, Vaithianathan Venkatasubramanian, Patrick Panciatici, Florent Xavier, and Jackeline Abad Torres. "Input-output characteristics of the power transmission network's swing dynamics." In Decision and Control (CDC), 2016 IEEE 55th Conference on, pp. 1846-1852., Las Vegas, Nevada, Dec. 2016.
- [2] Koorehdavoudi, Kasra, Sandip Roy, Thibault Prevost, Florent Xavier, Patrick Panciatici, Vaithianathan Venkatasubramanian, "Input-output properties of the swing dynamics for power transmission networks with HVDC modulation," to appear in the IFAC World Congress, Toulouse, France, June 2017.
- [3] Mohammadreza Hatami, Vaithianathan Venkatasubramanian, Sandip Roy, Patrick Panciatici, Thibault Prevost, Florent Xavier, "Study of nonminimum phase zeros in test power systems from wide-area control designs," to appear in the IREP 2017 Symposium, Espinho, Portugal, Aug.-Sep., 2017.

Student Theses: None completed (K. Koorehdavoudi and M. Hatami are pursuing research toward PhDs).