TomKat Center for Sustainable Energy
Precourt Institute for Energy
SLAC National Accelerator Laboratory
Energy and Environment Affiliates Program
Civil and Environmental Engineering
Department of Electrical Engineering

Stanford University

Stanford SmartGrid Seminar

Modal Analysis of Power System Data

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1:00pm-2:00pm, Wednesday, Feb 25th, Y2E2 270

Abstract: Reliable operation of the power grid relies on the real-time stabilization of an interconnected continental-scale network of dynamic components. These include everything from central-station thermal and hydro power plants to end-use loads. The natural uncontrolled responses to disturbances are oscillatory, and swings in voltage and power flows are evident in data from disturbances. Specific control systems are used to damp these natural oscillations that otherwise can result in large-scale blackouts. In order to design and tune controllers it is imperative to understand and anticipate the oscillations, and to develop high fidelity models that can represent this behavior. In this seminar we focus on the modal analysis of power system data to study oscillations for three purposes:

1. Better the understanding of the oscillations actually present in the grid. (Off-line engineering analysis.)
2. Validation of models used to study the grid. (Operational Planning.)
3. Improve situational awareness by tracking system modes in real-time. (Operations.)

We will provide examples of oscillations observed in the grid in the context of these three objectives. We review the industry standard approaches for power system modal analysis and highlight their shortcomings in practice. They often require preprocessing the data, fine-tuning in model order, and give inconsistent results with related data sets. We suggest that the main attraction of these established methods is that they are computationally easy to use; the calculations require linear algebra. Based on our experience and dissatisfaction with these methods, we explore the use of nonlinear fitting techniques to estimate modes from data. With current computing power, computational barriers are low, and we show excellent results using a variable projection method.

Our method is currently in use by some power engineers to characterize observed oscillations in the West. We show results of using modal analysis to aid in power plant model validation. We discuss and present initial results for adapting our method to estimating modal behavior from ambient data in the grid, which is the focus of our on-going research in this area.

Bio: Bernie is a Professor of Electrical Engineering at the University of Wisconsin-Madison. He received his B.S., M.S., and Ph.D. degrees from the University of Illinois. His research interests include the modeling, monitoring, and analysis of electric power systems.