SEMINAR NOTICE:

Robust Stability of Multivariable Systems and its Application in Smart Grids

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Abstract:

Robust stability theory investigates how the system remains stable under uncertainties and/or external disturbances. The problem gets much complicated for multivariable systems due to the interactions among loops. My major contribution to this area is to successfully extend the concept of gain and phase margins (from single variable systems) to multivariable systems. The loop gain and phase margins are defined, respectively, as the allowable perturbation ranges of gains and phase for each loop such that the closed-loop system remains stable. To get these ranges, Lyapunov Stability Theorem is utilized as the criteria to check the system stability, while different Lyapunov functions are constructed for loop gain and phase margins, respectively. By equivalently converting the Lyapunov functions into the linear matrix inequalities (LMI), numerical solutions are obtained by MATLAB LMI Toolbox. Besides the LMI-based methods in time domain, frequency domain method is also proposed for loop phase margins. Since the loop phase variations is actually the unitary mapping between frequency responses of the system output and input, the loop phase margins can be solved equivalently within a framework of constrained optimization.

The smart grid is quite similar to the multivariable system in the following aspects:

- As a decentralized network, smart grid contains multiple inputs (generation sources) and multiple outputs (consumers).
- As the high penetration of renewable energy into the grid, the intermittency of the wind or solar can be regarded as the uncertainties and/or disturbances to the system. The allowed perturbation ranges of these uncertainties and/or disturbances can be defined as the gain margins of the grid.
- Both real and reactive powers are transmitted in the grid where the phase angles between them vary with the load changes. The allowed perturbation ranges of the phase angle can be defined as the phase margins of the grid.

Therefore, the above robust stability analysis for multivariable systems can be easily extended to smart grids, and the achievements in robust stability of multivariable systems should be applicable to the robust stability analysis of smart grids.

Biosketch:

Ye Zhen received the B.E. and M.E. degree in control engineering from Wuhan University, China, in 2000, and 2003, respectively. In 2008, he received the Ph.D. degree in control engineering from the National University of Singapore (NUS). During his Ph.D. study, Ye Zhen got the NUS president's Graduate Fellowship for his outstanding research in 2006 and won IEEE Region 10 Postgraduate Student Paper Competition in 2007. After graduation, he was a research fellow of NUS and NTU and senior engineer at Seagate Technology.

At present he is a research scientist with the Solar Energy Research Institute of Singapore (SERIS). His research concentrates on the monitoring and control of photovoltaic systems, PV system modelling, solar irradiance forecast, and solar power integration to the grid. His current projects include "High-performance photovoltaic systems for tropical regions – optimization of system performance" (1 May 2009 – 31 October 2012, S$ 1.275m) and "Novel monitoring and control unit for enhanced availability and reliability of solar PV systems – optimization of photovoltaic electricity generation in tropical power grids through radiation forecasting and system monitoring" (9 May 2011 – 08 May 2013, S$ 1.6 m).