PhD Public Defence

Title: Stability Assessment of Inverter-Fed Power System

Location: Pontoppidanstræde 111, auditorium

Time: Monday 28 August 2017 at 13.00

PhD defendant: Yanbo Wang

Supervisor: Professor Zhe Chen

Moderator: Associate Professor Kaiyuan Lu

Opponents: Professor Francesco Iannuzzo, Dept. of Energy Technology, Aalborg University (Chairman)
Professor for Electrical Drive Systems and Power Electronics Ralph M. Kennel, Technische Universität München, Germany
Senior Staff Manager, Dr. Don Tan, Northrop Grumman Corporation, USA

All are welcome. The defence will be in English.

After the defence there will be an informal reception in Pontoppidanstræde 111 (coffee room).
Abstract:

As the increase of renewable energy utilization, the power electronic-enabled power plants such as wind farm and Photovoltaic plant are becoming attractive architectures to integrate renewable energy sources. However, the emerging power electronic-fed power plants also pose new challenges. Stability issue is matter of concern. The low frequency oscillation phenomenon may be caused by droop-based power controller, constant power loads, and grid synchronization loop of grid-connected inverters. In addition, the interaction of the wideband control systems for power converters with passive components may results in harmonic-frequency oscillation phenomena. These phenomena are challenging the system stability and power quality. Hence, it is essential to develop the modeling and analytical technique for the stability assessment of power electronic-fed power system.

The aim of this project is to develop the stability assessment methods and reveal the oscillation mechanism of inverter-fed islanded power system as well as paralleled grid-connected inverters system. The main contents of the thesis are organized as following. The chapter 1 introduces the motivation and background of this project. Also, the problem statements and structure of the thesis is described. The chapter 2 presents a state-space-based harmonic instability assessment method for inverter-fed power system, where the effect of time delay is considered in details. Furthermore, the participation analysis is developed to evaluate and identify the contributions of different components on harmonic-frequency oscillation. The chapter 3 develops a component connection method-based stability analytical approach to assess low frequency oscillation and high-frequency resonance of inverter-fed power systems. The chapter 4 develops a state-space-based impedance stability analysis method for paralleled grid-connected inverters system, where the resonance mechanism of paralleled inverters with grid-current feedback and converter-current feedback is investigated. In addition, a frequency scanning-based impedance analysis for stability assessment of grid-connected inverters system is presented, which can be easily performed for stability assessment without using the detailed mathematical model. Main conclusions of this project are drawn and future research topics are explained in Chapter 5.

The main contributions and conclusions are summarized as following. (1) The influence of time delay of digital controller on harmonic instability is considered in proposed stability analysis. (2) Participation analysis is adopted to assess and identify the contributions of different components on harmonic-frequency oscillation phenomenon. (3) The CCM-based small signal model of voltage-source inverters with multiple control loops is proposed, where the frequency response and eigenvalue analysis explain the contributions of different control parameters on terminal characteristic in a wide frequency range. (4) A state-space-based impedance stability analysis for multiple paralleled grid-connected inverters system is presented, which establishes the bridge between the state-space-based modelling and impedance stability criterion, and combines the advanced merits of the two worlds. Finally, the application of these stability analysis methods in different situations is demonstrated.