PhD Public Defence

Title: Stability Analysis and Performance Optimization for the Multi-Parallel Grid Inverters System

Location: Pontoppidanstræde 111, auditorium

Time: Friday 18 August 2017 at 13.00

PhD defendant: Minghui Lu

Supervisor: Professor Frede Blaabjerg

Moderator: Professor Francesco Iannuzzo

Opponents: Associate Professor Weihao Hu, Dept. of Energy Technology, Aalborg University (Chairman)
Assistant Professor Maryam Saeedifard, Georgia Tech, US
Associate Professor Robert S. Balog, Texas A&M, Qatar

All are welcome. The defence will be in English.

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

With the development of highly penetrated renewable energy generation systems, power electronics converters have been widely employed in the modern power system. Although these power converters are able to realize efficient power conversion between renewables and the grid, they bring the resonance and instability problems at the same time. Hence, many advanced schemes have been developed to attenuate the undesirable resonances and to avoid the system instability. However, it is still a challenge for the manufacturers and research institutes to maintain high performance of power converters in the complex grid conditions, for instance the power grid is weak or contains background voltage harmonics.

Fortunately, thanks to the development of the power semiconductor devices and more advanced digital microprocessors, many innovative control strategies and system optimization design guidelines are proposed, which will promote the product development of future power converters. In this context, this thesis presents several technical chapters on the stability analysis and performance optimization of grid-connected voltage source inverters with LCL-filter. Firstly, in order to mitigate the influence of grid voltage background harmonics, Grid Voltage Feedforward Regulator (GVFR) is commonly adopted in the grid-connected applications. This thesis analyzes the impacts of the GVFR on system stability when the power grid is weak. Meanwhile, a robust design guideline for the LCL-filter is proposed to adapt the inverters to the weak grid condition. On the other hand, to optimize the output performance and dynamics of the grid-connected inverters using digital microprocessor as the controller, the digital time delays need to be compensated. The origin of these digital delays is clearly revealed in the thesis, moreover, the basic principle for existing time delay compensation schemes are explained using a unified graphical evaluation method. Besides, an improved delay compensation scheme is proposed based on the comparison of various compensation schemes in this thesis.

Finally, the parallel operation of multiple parallel grid-connected inverters has been addressed. It has been reported that the interactions between these parallel inverters may excite resonance in the distributed power system. This thesis has developed a current separation model to analyze the system stability using two separate stability criterion. Apart from the resonant current injected into the power grid, the current circulating between these parallel inverters also may excite the resonance.

All the theoretical analysis in this thesis have been verified by simulation or/and experimental results. These contributions have been published/submitted through 3 journal papers and 7 conference papers.