DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Three-level (TL) based Isolated DC/DC Converters with Improved Performances

Location: Pontoppidanstræde 105, room 4.127

Time: Monday 26 March at 13.00

PhD defendant: Dong Liu

Supervisor: Professor Zhe Chen

Moderator: Associate Professor Yongheng Yang

Opponents: Professor Stig Munk-Nielsen, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Brad Lehman, Northeastern University, Boston, US
Researcher and Professor Mauro Cappelli, ENEA, Frascati Res. Center, Rome, Italy

All are welcome. The defence will be in English.

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Abstract:

Currently, the AC power transmission system is widely used for the electrical power transmission. However, the DC power transmission system is becoming the promising solution for the future electrical power transmission due to the advantages of no reactive power, no frequency stability, high conversion efficiency, and easy system control in comparison with the conventional AC power transmission system. In the DC power transmission system, the DC/DC converters are one of most important components because they are responsible for the voltage conversion and power transmission. Normally, a high DC bus voltage is required to reduce the transmission power losses, which can reduce the transmission power losses and thus improve the transmission efficiency of the whole power transmission system. The three-level based (TL-based) isolated converters are one of most attractive choices for the DC transmission systems with the high DC bus voltage because the voltage stress on the power switches in the TL-based isolated DC/DC converters are only half of the input voltage. Accordingly, this project mainly focuses on investigating the isolated TL-based DC/DC converters.

The current studies about the isolated TL-based DC/DC converters mainly pay attention on the topics of 1) reducing the switching noises; 2) increasing the efficiency of the converter; and 3) increasing the power density of the converter. However, there are few papers discussing about improving the performances of the isolated TL-based DC/DC converters in aspects of the capacitor, power switch, and transformer. Accordingly, this project focuses on investigating the methods to enhance the performances of the capacitor, power switch, and transformer in the isolated TL-based DC/DC converters, which can thus improve the reliability of the isolated TL-based DC/DC converters.

For improving the performance of the capacitor, this project proposes the input-parallel output-parallel three-level (TL) DC/DC converters with the interleaving control strategy for minimizing and balancing the currents on the input capacitors, which can reduce the size of the capacitors or prolong the lifetime of the capacitors. In addition, a zero-voltage switching PWM strategy is proposed in this project to balance the currents through the two input capacitors for the half-bridge TL DC/DC converter, which can balance the thermal stresses among the input capacitors and thus prolong the lifetime of the capacitors.

For improving the performance of the power switch, a periodically swapping modulation (PSM) strategy is proposed in this project for kinds of TL-based isolated DC/DC converter to balance the currents flowing through the power switches. Through balancing the currents flowing through the power switches, the power losses and thermal stresses on the power switches would be balanced.

For improving the performance of the transformer, a double phase-shift control strategy is proposed in this project for the full-bridge (FB) TL DC/DC converter to reduce the high voltage change rate (dv/dt) on the transformer by producing the multi-level voltage.

Finally, in order to verify the effectiveness and validity of the proposed topology and control strategies, the simulation and experimental studies are both conducted.