University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

NAGENDRAPPA HARISCHANDRAPPA

MTech (National Institute of Technology Karnataka, 2002)
BE (National Institute of Technology Karnataka, 1999)

“High-Frequency Transformer Isolated Fixed Frequency DC-DC Resonant Power Converters for Alternative Energy Applications”

Department of Electrical & Computer Engineering

Friday, July 31, 2015
2:00PM
Engineering/Computer Science Building
Room 468

Supervisory Committee:
Dr. Ashoka Bhat, Department of Electrical & Computer Engineering, University of Victoria (Supervisor)
Dr. Adam Zielinski, Department of Electrical & Computer Engineering, UVic (Member)
Dr. Rustom Bhiladvala, Department of Mechanical Engineering, UVic (Outside Member)

External Examiner:
Dr. William Dunford, Department of Electrical & Computer Engineering, University of British Columbia

Chair of Oral Examination:
Dr. Michelle Wiebe, Department of Curriculum & Instruction, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The demand for power converters is on the rise due to their ability to achieve high power conversion efficiency, small size, light weight and reduced cost. DC-DC converters are used in many applications where, the output voltage needs to be regulated for wide variations in the input voltage and the load. They are also used in applications where electrical isolation is required. Power generation from renewable energy sources suffers from highly fluctuating output voltages. Electrical isolation of renewable energy sources from the grid is essential. Therefore, DC-DC converters are used as an integral part of the power electronic interface required for grid integration of renewable energy sources such as wave energy power conversion.

In this dissertation as a first step, the power converters used in wave energy applications are classified and compared. Analysis, design, simulation and experimental results of fixed frequency controlled HF transformer isolated DC-DC resonant converters are presented. The first converter topology presented in Chapter 3 is a ‘fixed frequency controlled single-phase high frequency (HF) transformer isolated DC-DC LCL-type series resonant converter (SRC) with capacitive output filter using a modified gating scheme’. Working of this converter has been explained. Modeling and steady-state analysis of the converter using approximate complex ac circuit analysis method has been done. Various design curves have been obtained. A step-by-step design procedure has been illustrated with an example of a 200 W converter. PSIM simulation results for different operating conditions are presented. Experimental model of the designed converter has been built and the test results are given. Power loss breakdown analysis of the converter has been made. Zero-voltage switching (ZVS) is achieved for different input voltages, and load. This converter cell can be used in interleaved operation to realize higher power converters.

The second topology presented in Chapter 4 is ‘a fixed-frequency controlled, 3-phase HF transformer isolated, integrated boost dual 3-phase bridge DC-DC LCL-type SRC with capacitive output filter’. Detailed modeling of the boost section and one of the two identical 3-phase inverter modules is presented. Analysis of the inverter module using approximate complex ac circuit analysis method is presented. Various design curves have been obtained. A step-by-step design procedure has been illustrated with an example of a 600 W converter. Detailed PSIM simulation results for different operating conditions are presented. Experimental model of the designed converter has been built and the test results are given. Power loss breakdown analysis has been made. Major advantage of this converter has been its ability to regulate the output voltage for wide variations in the input voltage and load, while maintaining ZVS for all the switches. Also, due to the parallel connection of the inverter modules the component stresses are significantly reduced. This encourages the converter to be used in high power applications such as wave energy.

A 10 kW DC-DC converter cell of the second topology mentioned above has been designed to illustrate the design and working of a high power converter. Performance of the designed converter has been verified by PSIM simulations. This converter operates with ZVS for all the switches for a wide variation in the input voltage and the loading conditions. Power loss breakdown analysis has been performed.