INVESTIGATION ON SOME ASPECTS OF BRUSHLESS GENERATION OF POWER USING MATRIX CONVERTER FROM VARIABLE SPEED WIND ENERGY SOURCES

SHANKAR S.

DEPARTMENT OF ELECTRICAL ENGINEERING

INDIAN INSTITUTE OF TECHNOLOGY DELHI

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by

SHANKAR S.

Department of Electrical Engineering

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CERTIFICATE

This is to certify that the thesis entitled, **"Investigation on Some Aspects of Brushless Generation of Power Using Matrix Converter from Variable Speed Wind Energy Sources",** being submitted by **Mr. Shankar S.** for the award of the degree of **Doctor of Philosophy,** is a record of bona fide research work carried out by him in the Department of Electrical Engineering, Indian Institute of Technology Delhi, New Delhi.

Mr. Shankar S. worked under my guidance and supervision and has fulfilled the requirements for the submission of this thesis, which to my knowledge has reached the requisite standard. The matter embodied in this thesis have not been submitted, in part or full, to any other university or institute for award of any degree or diploma.

(Prof. J. K. Chatterjee)
Department of Electrical Engineering,
Indian Institute of Technology Delhi,
New Delhi-110016

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Date: February 25, 2015 **Shankar S.**

ABSTRACT

Power generation technology is shifting from conventional fossil fuel based energy sources used in centralized bulk power generation to non conventional decentralized energy sources for small and medium scale power generation with wind energy being one of the most efficient renewable energy sources available. Squirrel Cage Induction Generator (SCIG) is emerging as a popular choice for small and medium scale distributed power generation to cater to the power demands of remote isolated locations due to its low cost, reliability and rugged construction. Integration of SCIG based Wind Energy Conversion System (WECS) to the grid with simple efficient means is of primary concern.

This thesis describes the work carried out on some important aspects of single stage power conversion based on Matrix Converter (MC) controlled gearless SCIG-WECS for providing a simple conversion scheme and its operation in a microgrid structure. The MC is a single stage AC-AC converter without any reactive elements in its basic structure for power conversion. Thesis mainly focuses on simple gearless operation of MC controlled SCIG-WECS using Cosinusoidal modulation and Pulse Width Modulation (PWM) techniques and reduction of total injected grid current harmonics in an environment having multiple MC-SCIG systems by paralleling individual systems using transformers having relative phase shift between them. In this way, the overall current injected into the grid contains lower harmonic content providing clean power to the grid.

A novel scheme for tracking maximum wind turbine power in a PWM controlled MC-SCIG based WECS by appropriate design of SCIG rotor resistance without having to use any complex control algorithms has been described. Maximum

Grid Power Injection (MGPI) technique for injecting maximum power into the grid rather than tracking maximum turbine power using the wind turbine parameters like optimum tip-speed ratio of wind turbine and generator slip condition has been carried out and described in detail. Operation of a PWM controlled MC-SCIG based WECS using feedforward MGPI technique in a dynamic wind velocity condition has also been presented. The overall system efficiency in this technique is better as the point of concern is the power into the grid rather than the maximum turbine power.

Operation of the PWM controlled MC-SCIG based WECS connected to a Generalized Impedance Controller (GIC) based Self Excited Induction Generator (SEIG) system forming an autonomous microgrid structure has been described, where GIC-SEIG system acts a voltage/frequency governor under all source or load perturbations. Integral feedback control for controlled active power injection into the microgrid from the MC-SCIG system has been presented. Controlled active power injection based on the feedforward MGPI technique from the MC-SCIG system into the microgrid formed by the GIC-SEIG system has been carried out. This type of controlled power injection is useful for systems having no battery backup facilities.

The comprehensive analytical and simulation work carried out on MC-SCIG system and MC-SCIG system with GIC-SEIG system has demonstrated that, this project has a very good prospect of integrating locally available renewable energy sources in autonomous microgrid applications for solving the energy crisis in remote locations thereby alleviating the social, economical and environmental aspects of the society.

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