INVESTIGATIONS ON STANDALONE SOLAR PHOTOVOLTAIC AND WIND ENERGY CONVERSION SYSTEMS

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by

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INSTRUMENT DESIGN DEVELOPMENT CENTRE

Submitted

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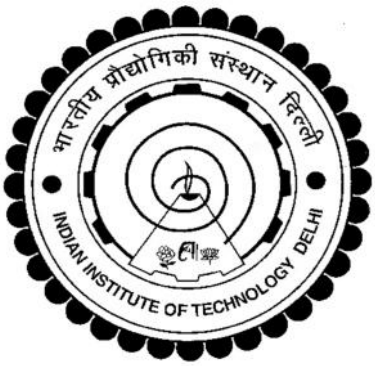

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Certificate

This is to certify that the thesis entitled, "**Investigations on Standalone Solar Photovoltaic and Wind Energy Conversion Systems,"** being submitted by **Ms. Neha Adhikari** for the award of degree of **Doctor of Philosophy (Ph.D.)** to the Indian Institute of Technology Delhi, New Delhi is a record of bonafide research work carried out by her under our guidance and supervision.

In our opinion, the thesis has the standard of fulfilling the requirements of all the regulations related to the degree. The results contained in this thesis have not been submitted in part or full, to any other University or Institute for the award of any degree or diploma.

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ABSTRACT

The fossil fuels based energy resources are diminishing and their adverse affects on the environment are raising the need to look for alternative sources of energy. Renewable energy sources are achieving high attention as an energy alternative due to factors like environment friendly and inexhaustible in nature. The recent incidents like, 'The Great Indian Outage,' world's largest power blackout occurred (2012) due to failure of the northern power grid in India, caused nearly 700 million people - twice the population of the United States -to be without electricity. A grid failure of such magnitude has thrown light onto massive demand for electricity, together with the struggle to generate as much power as India need.Thus for economic as well as environmental reasons there is a need to shift to non-polluting renewable sources of energy to meet future demand for electricity. This thesis is in line with such global concerns. Renewable energy resources mainly comprising solar, wind, small hydro, geothermal, bio fuels etc. are inexhaustible and natural resources. All these sources are being explored and the research is carried out to optimize their application in wider fields. Amongst these sources, the solar energy and wind energy conversion systems (WECS) in standalone generation as well as in grid integration are achieving the most optimistic estimates worldwide. Standalone solar-PV and WECS are prominently being studied due to their advantage of easily availability for electricity generation in rural areas. However, the solar and wind energy systems both have their own drawbacks as they immensely depend on the weather conditions, while solar energy can be tapped only during daylight. Integration of these renewable energy sources with a competent system has immense potential to furnish a reliable energy source for the consumers in distributed generation than a system based only on solar or wind energy. These systems are expected to play a significant role for meeting the

future energy demand in a sustainable way. Thus in case of a hybrid energy generating system, an immense potential is there to improve quality and reliability of power supply to consumers.

There are large numbers of human terrains on the earth, where grid-fed electrification is not being accomplished due to technical and economical issues. Such areas require an autonomous system to provide power of desired power quality to various consumer loads, such as linear loads, nonlinear loads etc. Typical use of electricity in a rural or a far-flung area is for daily uses such as lighting, water pumping, heating, and specific services such as a network communication center. Electricity not only is a basic human need for quality of life but it constraintsgeneration of productive activities and incomes andemployment in rural areas which has itself become acritical factor in India's future development process.Further, the little supply that comes in such areas is fromthe use of kerosene for lighting and diesel for poweringirrigation pumps and small enterprises. Both these areimposing further financial burdens on the economybecause of high levels of subsidy and add to the problemsof energy security.

In this thesis, the investigations are carried out on various configurations of autonomous distributed energy generating systems. These system configurations include the solar-PV (PhotoVoltaic) and WECS (Wind Energy Conversion system) in isolated as well as hybrid configuration with the BESS (Battery Energy Storage System). Typical range of power rating of these systems is few kW to 5kW. The general outlining philosophy for these systems is based on the use of different dc-dc converters, PMBLDC (Permanent magnet brushless DC) generator, with the battery for power management and dc load leveling.

The standalone system configurations with solar-PV and WECS are designed using non-isolated and isolated dc-dc converters, BESS, PMBLDC generators and single phase VSI (Voltage Source Inverter). The MPPT (Maximum Power Point Control) techniques are proposed and designed to analyze the system performance under various input and output conditions. The proposed MPPT controller for WECS is based on the mechanical sensor-less control mechanism and its performance is demonstrated under varying wind speeds. A comparison of various MPPT control strategies is presented considering the system complexity, response time, required sensing method, cost etc. The power quality at the consumer load end is maintained using output voltage and current regulators. The control strategies are implemented using DSP (Digital Signal Processor dSPACE1104 controller)along with the laboratory prototype for proposed configurations. The simulation and experimental results are presented to evaluate the performance of the system andto measure power quality in case of load variations. Thus the investigations are carried out on new configurations for autonomous solar-PV and WECS and hybrid energy systems.

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