**Abstract of Ph.D. Thesis**
**"Analysis, Design and Control of Single Phase Microgrid"**
**Mr. Tripurari Nath Gupta (2015EEZ8112)**

Technical advancement, continuously improving living standard and dependency on the electrical power on daily life have increased the demand of electricity exponentially. The availability of fossil fuels is limited in nature and may deplete soon. Moreover, the deteriorating environmental conditions have grabbed the attention of the world towards the nonconventional energy sources, which are freely available in nature and do not pollute the environment. The solar PV (Photovoltaic) generation system and WEGS (Wind Energy Generation System) are gaining popularity. The SPV generation systems require low maintenance and have modular structure with possibility of installation on roof tops as small generation system. The WEGS has gained great interest in recent years to improve its behaviour and response. Unlike fossil fuels, with the fact that it emits no air pollution or greenhouse gas, also its ability to generate high amount of power with no fuel consumption, the wind power is becoming much more reliable and promising to the number one source for clean energy in very near future. One of the most important aspect is MPPT (Maximum Power Point Tracking), which is important to extract maximum power at different wind speeds, which increases the efficiency of the variable speed turbine system when the rotational speed is below rated speed. The evolution of generator technology and power electronic devices has made it available to control it at variable wind speeds, and have made it much more reliable to design large and small scale WEGS. Different types of generators are used in variable speed WEGS, some of them are DFIG (Doubly Fed Induction Generator), SCIG (Squirrel Cage Induction Generator) and PMSG (Permanent Magnet Synchronous Generator). With the advancement in power converters, the use of the direct driven PMSG has increased as a much reliable method for power generation. PMSG is characterized by its high efficiency with no need for additional power supply.

This work presents multi-objective PV-BES (Battery Energy Storage), wind-BES and PV-wind-BES microgrid systems, which address the problems related to remote places, where system is dependent on diesel generators for supporting the loads under outage of utility grid. It reduces the consumption of conventional fuels and also supplies the load continuously under outage of the utility grid or under deficit generation. Moreover, conventional energy conversion systems are shut down at loss of utility grid for protection reasons. However, presented microgrid are operated 24x7, the load is supported by BES. The same converter is operated in the grid connected mode and islanded mode, which increases the utilization of the system. This results in saving of substantial capital investment, and maintenance cost on behalf of multi-functional features. However, under islanded mode of operation, BES and renewable energy resources (RESs) must supply the load uninterruptedly. These microgrids are installed for dedicated local loads, thereby reduce the losses by avoiding the long transmission line and, therefore, reduce the overall cost. It has capability to transfer the mode of operation from grid connected to islanded and vice versa seamlessly, without disturbing the load power supply. The voltage and frequency are decided by the utility grid under grid connected mode operation. The load side voltage source converter (LSC) performs multiple objectives, such as, it supplies the harmonics current required by the loads, compensates the reactive power demand of the nonlinear loads and maintains unity power factor. Under islanded mode, the same converter operates in voltage control mode and maintains the voltage and frequency across the loads, which is supported by BES. The BES increases the reliability and utilization of the microgrid, as it absorbs the excess power in case of excess generation and discharges to maintain the load demand in case of deficit generation or utility outage.

This research work aims at the design, control and implementation of various single-phase PV-BES, wind-BES and PV-wind-BES microgrids. These microgrids are further classified based on PV array connection (single-stage and two-stage) and the battery connection (with and without bidirectional converter) on the DC link. In two-stage PV based microgrid, the MPPT from the PV array is harvested by controlling the boost converter and second stage is LSC. However, in single-stage PV based microgrid, the bidirectional converter is utilized to extract the optimal power along with charging/discharging control of BES. The feed-forwards terms for wind and solar energies are incorporated in current control scheme for injection of active power to the grid, which also improve the dynamics of the microgrid. All the presented microgrids are simulated in MATLAB/Simulink platform. Their topology, control techniques and developed simulation models are validated on the developed laboratory prototype. The problem of utility grid outage is common issue in the rural areas. Therefore, the simple, autonomous and intelligent control techniques for microgrids, are developed such that they are capable of operating under grid connected mode and islanded mode and maintains continuous supply across the load.