

Abstract of PhD Thesis

“Design and Control of PV-Wind Energy Based Microgrids with Islanding and Resynchronization” Mrs. Farheen Chishti (2016EEZ8058), Research Scholar, Department of Electrical Engineering

This thesis presents the design and control of solar photovoltaic array and wind energy generation based microgrids with seamless transfer of operating modes for the electrification of rural communities as the prime motive. The combination of solar energy and wind energy generation increases the power reliability and provides energy surety as both the resources complement each other and cut down the reserve or storage requirements. The challenge is imposed as the renewable resources are dominated by their intermittency and geographic location availability. The variability of the energy supply is overcome by the use of energy storage systems, like battery energy storage (BES) or utility interconnection of the microgrid. The rural electrification is carried out either by grid interconnection or by incorporating the storage battery with the renewables to fulfill the community load demand. The first option is not viable for rural areas as site affordability acts as the key barrier. Secondly, the battery energy storage (BES) is worthwhile when specific conditions are fulfilled, which in return makes the value proposition of storage greater than the cost of installing it. BES is an expensive option but it meets all the aspects of integration challenges such as the uncertainty during demand rise and power sufficiency.

Here, in this work, BES control is deployed either connected directly at the DC link or through a bidirectional DC-DC converter. It controls the discharging and charging of the battery. The wind conversion systems also suffer from harmonics injection, degradation of minimum fault current and sudden voltage disruptions due to wind speed intermittency. These encountered challenges are resolved by utilizing full rated voltage source converters (VSCs) as an interface between the machine and the utility grid. Two back-to-back connected VSCs, i.e., AC/DC converter, named as machine side VSC (MSC), a DC link, and a DC/AC inverter named as load side VSC (LSC) are implemented for variable speed operation of the system. The MSC regulates the synchronous generator (SG) output power. It adjusts the current and torque of the SG. The LSC upholds the DC link voltage and synchronizes the AC generated power by the wind turbine driven SG with the power of the utility grid. The encoder-less field oriented control (FOC) with speed and position estimation is utilized for the SG. Depending upon the requirement, the solar PV array is configured as single stage or two stage configurations utilizing a boost converter. This work focuses upon the development and implementation of the advance control techniques for the successful operation of the microgrids during grid-connected mode or standalone operating mode. Even under adverse grid conditions, these improved approaches assess the amplitude, frequency, and phase of grid phase voltages quickly and accurately. All of the microgrid configurations have efficient control algorithms for the load side converter, which improve power quality at the PCC while maintaining unity power factor, provides harmonics elimination, grid currents balancing, reactive power compensation, neutral current compensation and power factor correction. The continuity of supply to the local consumer loads is ensured. The solar PV array and wind energy feed-forward terms express the power sharing mechanism to the utility and provides fast tracking under dynamic condition. The maximum power point extraction schemes for wind generation and solar PV array track the optimal power even under adverse solar insolation and wind speed conditions. The core objective is also to provide continuous supply to the critical loads even under grid outage scenarios. However, renewable generation loss and battery with low state of charge are also the conditions that need to be addressed for the continuity of supply during standalone operating mode. To overcome this shortcoming, the diesel generator set is brought into action for a short period of time and operated under maximum fuel efficiency zone to cater to the emergency load demand. All microgrid configurations are categorized in accordance to single phase, three phase three wire and three phase four wire distribution networks. The consumer requirement decides the type of the microgrid to be selected for specific applications. For investigating the performance, these microgrids are modelled and simulated using the MATLAB®/ Simulink platform, and experimental validations are carried out using developed laboratory prototypes. This study is intended to contribute significantly to existing knowledge on the design, development, and control of PV-wind energy based microgrids with islanding and resynchronization capabilities.