

Abstract of PhD Thesis
Investigations on Utility Synchronized Microgrids with Solar-Wind-Hydro Generation
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Resilience and reliability of the microgrids are a vital issue, as it not only decreases the power outage, but it allows high penetration of various distributed energy resources such as renewables (solar, wind, hydro) and battery energy storage. Microgrid (MG) is a small-scale power network that functions either in the grid-connected (GC) mode or an islanding (IS) mode. In both these modes of operation and transition from an IS mode to the GC mode and vice-versa, the distributed energy resources (DER) in microgrid (MG) are controlled by using various control techniques. Therefore, this thesis deals with the design, control and implementation of various configurations integrating solar PV, pico-hydro generation, wind energy conversion system, battery storage, grid/DG set and local loads. These configurations are segregated on the basis number of energy sources (one or multiple), the configuration of each source (single stage or double stage) and types of loads (single-phase, three-phase, dynamic loads). The solar and wind generations are intermittent and thus used in conjunction with pico-hydro generation to guarantee that the baseload is supplied at all times. This MG operates in multiple modes like islanded mode, grid-connected mode and DG set connected mode to facilitate uninterrupted power to local loads. Moreover, few configurations have DG set, irrespective of the fact that the DG set utilizes diesel, which is not clean. Diesel power provides reliability that supports critical loads (hospitals) when renewable energy and battery power are insufficient. However, the DG set operates in the fuel-efficient zone under load unbalance conditions as it is supported through a battery storage. The core objective of the system is to deliver power to critical loads even at the grid outage.

A prime research feature for a microgrid is its appropriate control, which assures uniform power as well as current allocation between distributed generation units while operating in different operating conditions. A single voltage source converter achieves significant roles like frequency and voltage regulation (in islanded and DG set connected mode), energy management between generating units and loads, compensating the harmonics current demand of local nonlinear load and dynamic reactive power demand of dynamic loads (Induction Motor). Therefore, the VSC control is the eminent part of the MG and for the satisfactory operation, it should be fast and robust. In this thesis, various control algorithms are implemented and these controls provide reduced steady-state error, enhanced convergence rate, DC offset rejection capability to achieve accurate extraction of the fundamental component of nonlinear load currents.

The satisfactory performance of these microgrids and their control algorithms are replicated through simulated results, which are modelled in MATLAB/Simulink platform using Simpower toolbox and test results on the developed hardware prototype. Simulated and test results are presented for adverse conditions like solar intensity change, wind speed change and unbalanced load conditions.