Abstract of Ph.D. Thesis

"Control of Renewable Energy based Grid Interactive Microgrids with Squirrel Cage Induction Generator"

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There are still many villages in India, which are not yet electrified, and the residents of those villages are not getting the electricity even for the lighting loads. This is due to the fact that commissioning new transmission lines to those places are very difficult and costly too. Therefore, one comes up with next obvious solution that the renewable energy sources such as solar PV array, wind energy and hydro as the best option for the electrification. However, each of the renewable energy source has their own limitations. For example, the solar PV array generation is not available in night, when it is most needed. The wind energy generation is also uncertain due to the varying wind speeds. On the contrary, the hydro based power generation is always available, however, the large land mass requirement, huge initial investment and their suitability for only hilly areas are the limiting factors for the rural electrification.

To solve the aforementioned problems and to ensure the electricity to the far flung homes, in this thesis, a number of configurations of microgrids are designed for integrating the renewable sources such as solar, wind and hydro, storage battery, the grid and DG (Diesel Generator) set. These configurations are segregated on the basis of number of energy sources, and configurations of every energy sources in the microgrid. Moreover, the application of these microgrids (farming, lighting, small industries or critical loads such as hospitals), and types of loads (single phase, three phase and dynamic loads etc.), are also considered for designing the microgrid. For example, the pico-hydro in conjunction with solar, wind and battery based configurations are presented for the areas where canal small tributaries or the river are available. Therefore, the proposed configurations solve the huge space and massive investment requirement of the hydro generator. Moreover, due to the continuous power generation using the pico-hydro generator, the proposed microgrid configurations ensure that the base load always gets supply, which means the proposed microgrid configurations solve the problem of complete black out in night when the solar power and wind generation are not available. Moreover, with the use of storage battery and the coordinated control, the proposed model also solves the problem of intermittent renewable generation. Few configurations are also dedicated to operate the microgrid without storage battery yet supplying power to the loads instead of completely shutting down the microgrid under fault in the battery. Similarly, for ensuring the continuous supply to the critical loads such as hospitals, some microgrid configurations have used DG set, despite knowing the fact that the DG set does not use the power from the clean sources of energy. However, it is guaranteed through the control and the storage battery that the DG set is always utilized optimally by operating into the fuel efficient zone irrespective of the variation in the load demand.

Apart from various configurations of the microgrids, the control of the microgrid is also designed to operate in multimode such as islanded, grid connected and DG (Diesel Generator) set connected mode, so that the utilization of energy source increases and the probability of continuous supply to the loads increases. Another major contribution in this thesis is that, only a single voltage source converter is controlled for achieving various tasks such as delivering continuous power to the loads, injecting the surplus renewable generation into the grid, voltage and frequency regulation at PCC (in islanded and DG set connected modes), compensating the harmonics current demand of nonlinear loads and dynamic reactive power demand of the dynamic loads (Induction Motor), and maintaining the active power balance during the disturbances using the storage battery and the voltage sources converter. Therefore, the VSC control should be fast and robust, which contributes to achieve the above-mentioned tasks.

Hence, in this thesis, various robust and fast VSC control algorithms are implemented. The presented algorithms offer DC-offset rejection, fast convergence and low steady state oscillations for fast tracking of reference signals. In these designed microgrids, the control requires the local parameters such as PCC voltages, load currents, grid currents, PV voltage and current, to monitor the status of generation and loads. According to the situation of the real parameters, the controller takes the decision and controls the power flow within the microgrid.