

Abstract of Ph.D. Thesis
**“Control and Implementation of Single-Phase Grid Interfaced Solar PV-Wind and BES
Based Microgrid with Grid Synchronization”**
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This research work focuses on the development of a grid-interactive, multifunctional single-phase PV-BES (Photovoltaic-Battery Energy Storage) system for residential and rooftop applications. To enhance system reliability, configurations integrating battery energy storage (BES) at the DC link are presented, both with and without a bidirectional converter. The functionality of the microgrid in various operating modes is thoroughly discussed. A seamless transition logic, combined with an islanding detection technique, enables smooth transitions between off-grid and grid-interactive modes. In grid-interactive mode, the system effectively provides power quality (PQ) solutions, including harmonics elimination, power factor correction and reactive power compensation. In off-grid mode, the control objectives shift to maintaining voltage and frequency regulation at the point of common coupling (PCC). The primary goal of this system is to ensure uninterrupted power delivery to local critical loads, even during grid outages.

The primary aim of integrating battery energy storage (BES) into the microgrid is to enhance coordination with distributed generation, ensuring a reliable supply of electricity. By integrating BES, the reliability of peak load management is improved, along with the power quality of renewable energy production and the management of distributed and off-grid power systems.

This research work also includes on the development of a grid-interactive multifunctional wind energy generation system (WEGS), objective even during grid outages. Owing to the complementary profiles of renewable sources like wind and solar, this work emphasizes the development of a multifunctional microgrid employing a wind turbine based permanent magnet brushless DC generator (PMBLDCG) and a solar photovoltaic (PV) array. The functionality of the microgrid during various operating modes is discussed. A seamless transition logic, combined with an islanding detection technique, is incorporated for transitioning between off-grid and grid-interactive modes.

This study explores various topologies for parallel solar PV inverter-based microgrids, both with and without BES, aimed at enhancing reliability and accessibility in remote areas. These topologies consist of DG units, BES, and local loads, with each DG unit incorporating inverters connected to a PV array through an output interfacing inductor and coupling lines linked in parallel at the PCC. A microgrid is deemed efficient if it performs effectively in both standalone and grid-tied modes, ensuring a smooth power transition. When a PV inverter operates in islanding mode, the PV power should not exceed the load demand to maintain system stability. However, this can lead to either wasted PV power or underutilization of available PV power. To address this, additional solar panels are connected to other energy sources, such as batteries, to create a parallel PV inverter-based system, making it feasible to effectively harness power from each source.

The microgrid structures and control algorithms are used in microgrid and these are modelled and simulated with MATLAB/Simulink toolbox. Following satisfactory simulation results, a prototype microgrid incorporating a solar PV array, wind turbine driven PMBLDCG, and BES is developed. Test performances of multiple parallel PV inverter-based microgrids are validated on the RT-LAB platform using a real-time controller OP4510. The simulation and testing results are presented under various challenging conditions, including variations in solar insolation, loads, voltage distortion, and mode transition. Notably, the wind and solar power systems track the maximum power point. Finally, performance of the microgrid in both off-grid and grid-interactive modes, with seamless transitions between these modes, is demonstrated in detail.