Abstract of Ph.D. Thesis

"Control of Small Hydro-PV-Wind Based Hybrid Microgrids with Synchronization"

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Abstract

This research work investigates different configurations of hydro-solar-wind based microgrids, aiming to offer a sustainable solution for decentralized power generation, especially in remote or off-grid areas and in grid connected areas. It focusses on developing control strategies for these inverter-based distributed energy resources, addressing on achieving synchronization of doubly fed induction generator-based wind energy conversion system with small hydro turbine driven permanent synchronous generator to enhance reliability of developed microgrid configurations. This is achieved by formulating a systematic methodology and devising control objectives for the rotor side converter and stator side converter of doubly fed induction generator-based wind energy conversion system. Additionally, to attain seamless transition between grid-connected and standalone modes and vice-versa, control objectives for the grid side converter are formulated in detail. Moreover, the synchronization is carried out using stator side static transfer switch (SSSTS) and grid side static transfer switch (GSSTS), respectively. Advanced control techniques for the grid side converter are also implemented to mitigate harmonics and unbalance currents due to single phase and three phase nonlinear loads. Besides, control scheme also facilitates the suppression of neutral current in the three phase four wire microgrid configuration. Furthermore, a sensorless scheme for the estimation of rotor speed and rotor position of doubly fed induction generator is devised based on notch filter thus, eliminating the use of sensor and reducing the cost. The effectiveness of developed hydro-PV-wind based microgrid configurations and their respective control methodologies is assessed through comprehensive simulations conducted on MATLAB/Simulink platform. Various simulation scenarios, encompassing steady state, transition mode and dynamic responses are analysed, with detailed simulated results provided for each system configuration. Furthermore, experimental validation of all developed microgrid configurations is conducted using a laboratory prototype. The detailed test results are reported providing empirical evidence to complement the simulation findings.