Abstract of Ph.D. Thesis

"Design, Development and Control of Region-Specific Solar PV/ Wind Driven DFIG Based Microgrids"

Mr. Sandeep Kumar Sahoo (2017EEZ8190), Research Scholar

The objective of this research is to design, control, and implement microgrid systems integrating solar photovoltaic (PV) array with battery energy storage (BES) and wind energy with BES. Double stage three phase three wire and three phase four wire solar PV-BES based microgrids are implemented in this work. Three-phase four-wire microgrids offer neutral current compensation in addition to the functionalities of three-phase three-wire PV-BES microgrids. Doubly fed induction generator (DFIG) is preferred in wind energy conversion system (WECS) due to its variable speed operation, partial-scale power converter (reducing cost), independent active/reactive power control and higher efficiency compared to full-converter systems. So, in this work, wind driven DFIG-BES based DG set/grid interactive microgrids are explored.

This work investigates a cost-effective mechanical speed and position sensorless control for DFIG-wind energy conversion system (WECS). A sensorless technique based on an adaptive notch filter (ANF) with a position compensation unit (PCU) is proposed for DFIG. It operates efficiently under varying wind speeds and load imbalances. Despite the presence of harmonics in rotor currents, proposed scheme ensures precise rotor speed estimation. Additionally, PCU corrects position errors, ensuring accurate rotor position estimation.

Frequent power outages in rural areas demand reliable and efficient energy solutions. To tackle this, autonomous and intelligent control strategies are developed for grid-interactive PV-BES and wind-BES microgrids. These systems ensure uninterrupted power during grid failures and subsequent restorations while managing renewable power fluctuations. The microgrid operates seamlessly across different modes, with smooth transition logic and islanding detection enabling shifts between off-grid and grid-connected modes. In off-grid operation, the grid-forming converter (GFC) maintains voltage and frequency stability at the point of common interconnection (PCI). During grid/DG-connected mode, advanced GFC control techniques improve power quality by extracting fundamental positive-sequence currents from nonlinear loads. These systems also provide power quality enhancements-such as harmonic elimination, power factor correction, reactive power compensation, and grid currents balancing-while ensuring continuous power to critical loads, even during grid outages.