Abstract of PhD Thesis

"Control and Implementation of Solar PV-DG Based Microgrids in Grid-Connected and Islanded Modes"

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The advent of distributed power generation using various renewable and nonrenewable sources has given rise to the concept of microgrids. Using solar photovoltaic (PV) array, wind mills, diesel generators (DG), hydro plants etc., have enabled power production at utility as well as residential or community levels. Though the initial microgrids started as AC microgrids, consisting of AC generators and loads, however, the majority of distributed energy sources and upcoming loads are DC, the trend is shifting towards DC microgrids, and hybrid AC-DC microgrids. The remote areas and mountain villages where grid is not accessible, can now create their own microgrid and operate it in standalone mode (SAM). The same distributed power generation plant can be synchronized with the grid as and when available, and operate in grid-connected mode (GCM). Thus, the convenience of having electricity supply has increased for remote, hilly, as well as utility fed communities. However, the reliability, safety, security, and quality of power need to be maintained, which need prior planning, design and complex control schemes. Additionally, the multimode operation of the microgrid is desired for it to smoothly transfer between SAM and GCM, without disturbing the system. The islanding & synchronization with grid are regulated as per IEEE standard 1547.

DGs have been used conventionally as main power source in the villages devoid of grid power, and as backup power source in residential communities and industries. Combining DG with solar PV array would help in saving fuel as well as environment, along with maintaining the reliability of power. In order to reduce the rating of DG, and store excess PV array power whenever available, BES becomes an important part of the microgrid. However, presence of multiple sources not only add to complexity, but also call for intelligent power management control schemes in order to coordinate between different sources under various scenarios. The control schemes need to be resilient to variations in load and solar PV array power, and also regulate the charging and discharging of battery within permissible limits. Additionally, the control should be robust to be applied to a variety of loads.

In today's world, the loads in residential as well industrial communities comprise of power electronics-based devices such as laptop chargers, mobile chargers, welding machines, variable speed drives, etc., apart from the lighting load. The nonlinear nature of the loads causes non sinusoidal current to be drawn from the source. Drawing nonlinear current from grid leads to nonlinearity in the voltage at point of connection (POC), thus, deteriorating the power quality factor. The total harmonic distortion (THD) in the grid current is regulated as per IEEE-519 standard, and must be kept below 5%. In the absence of grid, DG is used as auxiliary generator, and the manufacturers of DG advise to use it with linear loads only, as drawing nonlinear current from the DG leads to reduction in its loadability. Thus, the THD of DG current is also regulated to be below 5% to maximize the loading. Moreover, the fuel efficiency of DG is affected by the percentage loading also. At low loading, typically below 40% of the rated, the inefficient burning of fuel causes emission of soot, thick smoke, and toxic gases. Thus, the DG is operated within its fuel economy zone (FEZ), and with linear DG currents.

This research work aims at developing multi-objective control schemes for coordinated control of solar PV array power, BS power, and DG power for power management, along with maintaining the power quality at source end within given limits. The work discusses design, control, and implementation of a number of plausible system architectures which are opted for deployment in AC, DC, and AC-DC microgrids. The challenges associated with each system configuration are identified and addressed through design and control.