

Abstract of PhD Thesis
“Design and Development of Renewable Energy Based Microgrids with Grid Synchronization and Their Applications to EV Charging Infrastructure”
Mrs. Pavitra Shukl (2016EEZ8087)

This work focuses on the utilization of hybrid distributed energy resources such as solar, wind, battery and fuel cell sources based microgrids with applications to the electric vehicles (EVs) charging infrastructure. The usage of microgrids addresses the problems related to the electrification of remote areas along with the ability to synchronize with the utility grid. Thus, with the utilization of renewable energy sources and energy storage devices, the problems to feed the remote locations along with reduction in fossil-fuels consumption can be resolved. In addition, the EVs connected to the microgrids for charging purposes, act as highly flexible loads, with additional storage capacity and offers the advantages of reduction in harmful emissions, thereby, guaranteeing environmental friendly transportation.

The microgrids consisting of renewable energy sources such as solar PV array, wind turbine and fuel cell stack are utilized here, which work in synchronicity with the utility grid along with power transfer to the local loads and charging of EVs. Moreover, the microgrid reliability is dependent upon the capability to operate both in the grid connected and grid disconnected modes of operation. Therefore, the smooth transition between the modes of operation is achieved here, with the utilization of static transfer switches and appropriate switching of the voltage source converter (VSC) during different modes of operation. The VSC works as a power conditioner unit for mitigating harmonics and providing the reactive power required by the loads. Moreover, power quality problems such as poor power factor, harmonics in the grid current, neutral current etc. are also observed in the distribution network, which pollutes the grid and causes mal-operation of the appliances, increased losses and deterioration in the power factor. Therefore, the control and coordination among various sources are presented here for the integrated system, thereby, complementing the variability of each, along with multifunctional and multimode operating capabilities for the charging of EVs.

This research work aims at the design, control and implementation of various renewable energy sources based microgrids with applications to EVs charging system. The microgrids structures and control algorithms are simulated in MATLAB platform and the simulation results are verified with the test results to be in compliance with the IEEE standards. In order to deal with the power quality issues along with charging of EVs, various configurations are developed, which are classified based on the type of distribution networks i.e. number of power stages, the functionalities of the microgrids and connection of the battery storage to the DC link along with DC/ AC charging capabilities of EVs. Moreover, the three-phase microgrids are further classified into the three-phase three-wire and three-phase four-wire configurations, where the three-phase four-wire microgrids are also capable of providing neutral current compensation abilities. Therefore, the selection of the type of microgrid, depends on the requirements of the consumers. Thus, the control techniques are developed for the renewable energy sources based microgrids with satisfactory operation under the grid connected and grid outage modes of operation along with the uninterrupted power supply to the critical local loads. Moreover, the participation of EVs in the microgrids, has the potential to enhance the system resilience along with the improvement in environmental conditions. Thus, the proficiency in the charging of EVs with the off-board and on-board chargers are tested during various conditions of grid disconnection, load perturbation, varying solar insolation and changing wind speed conditions.