Abstract

An increase in power quality issues in power systems has led to the development and utilization of Active Power Filters (APFs). Unified Power Quality Conditioner (UPQC) is a universal power quality compensator, which compensates for most of the power quality issues. It is a combination of series and shunt APF connected in back to back fashion. Series APF of UPQC is responsible for compensating source voltage based power quality issues such as voltage sag, swell, unbalance, and harmonics and thus maintaining ideal load voltage. Shunt APF of UPQC compensates for load current based power quality issues such as reactive power, harmonics, and unbalance, and thus keeps source current sinusoidal and in phase with source voltage.

Alarming climate situations have directed electricity generation toward renewable sources such as solar Photovoltaic (PV) and wind turbines, which are integrated into the grid as Distributed Generators (DGs). UPQC-DG, a unique configuration of UPQC with DG connected to DC link, offers a simultaneous solution to power quality issues and integration of DGs, avoiding costly grid-tie inverters.

Effective utilization of series and shunt APFs of UPQC is a challenge, and therefore Power Angle Control (PAC) methods, which share VA burden between the two APFs, have been proposed. PAC methods are particularly important in the case of UPQC-DG, in which shunt APF tends to be loaded heavily due to the additional task of feeding DG power to the grid. Existing PAC methods are complex and lack robustness and effectiveness in different operating conditions of UPQC-DG, such as unbalance in load. Thorough analysis of power angle and VA sharing in different operating conditions is necessary for field application, and has gained attention of researchers worldwide.

Therefore, in the present thesis, simple and effective PAC methods based on Synchronous Reference Frame Theory (SRFT) are developed, which give improved performance in different operating conditions of UPQC-DG. A solar PV based DG has been used for simplicity. Developed PAC methods help avoid the circulation of reactive power during compensation of unbalanced loads and reduce overall VA burden on UPQC-DG. Further, a modified SRFT based PAC (termed as SRF-PAC) method has been proposed, which supports larger values of power angle and enhances VA sharing between series and shunt APFs of UPQC-DG. Modified SRF-PAC doesn't put an additional burden on the controller because it estimates the power angle using

pre-calculated parameters.

Finally, an optimum VA sizing method of UPQC-DG based on the PAC approach is proposed, which gives a reduction in overall size and cost of UPQC-DG in comparison to existing methods. Modified SRF-PAC ensures that UPQC-DG operates withing designed VA ratings under all operating conditions. Proposed control techniques have been simulated, analyzed and validated using real-time simulations, controller hardware in loop simulations, and laboratory prototype of UPQC-DG. Controller performance has been tested for steady state as well as transient situations such as voltage sag, voltage swell, change in load and variation in solar irradiation. Analysis of results consolidates superiority of proposed techniques over existing ones.