



INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: MODELLING AND ALLOCATION PLANNING FOR OPEN UNIFIED POWER QUALITY CONDITIONER TO IMPROVE OPERATIONAL PERFORMANCE OF RADIAL DISTRIBUTION NETWORKS

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SHORT ABSTRACT

The compensators are widely used in the distribution networks to improve their steady-state operational performance, such as energy efficiency and bus voltage. The capacitor bank, voltage regulator, on-load tap changer etc., are traditionally used as compensators. However, the optimal placement of these does not ensure desired power quality (PQ) level. The custom power devices are group of compensators which can mitigate PQ issues and provide reactive power compensation. Thus, their optimal allocation in distribution networks can ensure desired PQ level and improve energy efficiency. UPQC is a versatile custom power device, which can simultaneously inject a series voltage and a shunt compensating current by using its series and shunt inverters, respectively to provide reactive power compensation and to mitigate PQ problems. In UPQC, the series and shunt inverters are connected to a common DC-link. An open UPQC (UPQC-O) topology, in which, the series and shunt inverters can be placed in different locations and they do not share a common DC-link, is used in this thesis to improve the operational performance of distribution networks. This needs the modelling of UPQC-O and the formulation of planning approach to optimally allocate in distribution networks.

In this thesis, the modelling and allocation of UPQC-O without and with active power injection are presented to improve the energy efficiency of distribution networks keeping a desired PQ level intact in terms of voltage sag mitigation and harmonic elimination. A new technical constraint, i.e., percentage of voltage sag mitigated load is formulated to optimally allocate the series inverter for voltage sag mitigation. The performances of UPQC and UPQC-O models without and with active power injection are compared in view of energy efficiency improvement. The optimal allocation of UPQC-O in

distribution networks significantly reduces energy loss and improves bus voltage. The modelling and allocation planning of UPQC-O integrated PV generation system are provided to improve the energy efficiency and PQ of distribution networks. The particle swarm optimization (PSO)-based solution approach is used.

The modelling and allocation planning of inverters of UPQC-O are provided to maximize the photovoltaic hosting capacity (PVHC) of a distribution network. PVHC is defined as the maximum amount of PV capacity that a network can accommodate without deteriorating its operational performance in terms of network power loss. PSO is used to optimally allocate the inverters of UPQC-O and to determine the PV generation capacity of each load bus. The simulation results show that appropriate placement of the inverters of UPQC-O increases the PVHC of a network. Since the maximization of PVHC and minimization of energy loss conflict with each other, a multi-objective planning approach is also developed for the simultaneous optimization of these two objectives. The Strength Pareto Evolutionary Algorithm-2 (SPEA2)-based multi-objective PSO (MOPSO) is used as the solution approach. This provides a set of solutions, from which a utility can choose one for the implementation according to its preference.

The proposed PV integrated UPQC-O model is used for the peak load shaving of distribution networks keeping a desired PQ level intact. For this, a multi-objective planning approach is developed to optimally allocate the UPQC-O in distribution networks. SPEA2-based MOPSO is used as the solution approach. This also provides a set of solutions, from which one solution can be selected.

An operational optimization approach is proposed to determine the time-varying reactive power injection set points for UPQC-O for time varying load and generation. This is a type of on-line optimization approach. The simulation results show that the allocation of UPQC-O with time-varying reactive power set points provides higher energy loss reduction of distribution networks for the areas where load factor is low. The CONOPT solver of General Algebraic Modelling System software is used as the solution tool.

The 33-bus and 69-bus radial distribution networks are used to validate all the proposed planning models.