INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: **MODELLING AND ECONOMIC ASSESSMENT OF MULTIPLE POWER ELECTRONIC BASED COMPENSATORS ALLOCATION IN ACTIVE POWER DISTRIBUTION NETWORKS**

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SHORT ABSTRACT

The integration of photovoltaic (PV) systems into distribution networks has been increased due to government policies promoting renewable energy schemes. However, this increased integration presents challenges, such as over-voltage, current harmonics, and voltage instability. The thesis explores the strategic placement of power electronic (PE) based compensators in PV-rich power distribution networks to address these issues and enhance overall system performance.

The optimal placement of these compensators significantly reduces energy losses and improves the voltage profile of the network. The modeling and allocation planning of Series Compensators (SECs) and Shunt Compensators (SHCs) are presented to mitigate voltage sag/swell and current harmonics, respectively. In addition to the technical aspects, the thesis conducts a comprehensive economic evaluation of multiple SHC allocations in highly PV-integrated networks. The solution strategy chosen is Particle Swarm Optimization (PSO), meta-heuristics-based optimization algorithm. Over a 20-year planning horizon, profit maximization is performed by considering factors, such as PV integration, load growth, seasonal load variations, and intermittent PV generation profiles.

An operational optimization approach is proposed to determine the time-varying reactive power injection set-points for SHCs, considering varying load and PV generation scenarios. This approach shows that injecting time-varying reactive power into the networks reduces the annual energy loss costs. Due to the time-varying nature of load and PV generation, the objective function for annual energy loss costs involves many variables. A novel multi-swarm surrogate-assisted PSO algorithm has been developed to address this high-dimensional optimization problem. This

new PSO variant combines the Gaussian Process Regression (GPR) technique with PSO in a multi-swarm framework, utilizing parallel computing. This approach demonstrates substantial capability in solving high-dimensional optimization problems.

An optimization approach is proposed to maximize PV hosting capacity (PVHC) and minimize energy losses. PVHC is defined as the maximum PV capacity a network can accommodate without degrading its operational performance. This process involves optimizing the time-varying reactive power injection set-points for SHCs and the time-varying charging and discharging set points for Battery Energy Storage Systems (BESS) in response to time-varying load and PV generation. A multi-objective planning approach is developed to address the conflicting objectives of maximizing PVHC and minimizing energy loss. This approach simultaneously optimizes these two objectives using the Strength Pareto Evolutionary Algorithm-2 (SPEA2)-based Multi-Objective GPR assisted PSO (SPEA2-MO-GPRS PSO). The solution provides a set of options from which utilities can choose based on their preferences. Additionally, the proposed SEC and PV-integrated SHC (PV-SHC) allocation aims to minimize network power losses, the rating of compensators, and the number of undervoltage nodes. A multi-objective planning approach is also developed to optimally allocate SEC and PV-SHCs in distribution networks using the SPEA2-MO-GPRS-PSO.

The proposed planning models are validated using the 33-bus and 69-bus test distribution networks.