ABSTRACT

Power distribution networks are built as interconnected systems. They are constructed by one of the three types: radial, loop and network system. They are usually arranged to be radial in operation to simplify over-current protection. In general, distribution systems are designed to be most efficient at peak load demand. Utilities are constantly looking for newer technologies that enhance power delivery performance. Amongst all, control of power loss and balancing the unbalanced loading at the feeder/ phases refer to phase balancing and these are the two most important issues which determine the power delivery performance of the distribution system. The increase in power loss and unbalanced loading at the feeder increase energy loss, risk of exceeding their branch currents and bus voltages capacity, deteriorate power quality and also increase electricity cost. To deal with this problem, several strategies are employed to minimize power loss and phase balancing at the feeder such as inclusion of capacitor banks, phase swapping and system and/or feeder level reconfiguration.

Network reconfiguration is the process of changing the topology of distribution systems by altering the open/close status of switches. The load at the feeder can be transferred as a result of altering the open/close status of the
switches. However, there are numerous switches in a typical distribution system and the number of possible switching operations is complicated. Considering this complexity, the capacitor placement has been carried out for loss reduction as an alternative practice. Various practices have been adopted for in finding the location of the capacitor banks and the amount of capacitor banks switched on / off to the identified location in the distribution systems.

The nature of the distribution system is normally dynamic and entails change in load conditions. Under varying load demand, maintaining the voltage magnitude within the limit also has great importance with power loss reduction. Therefore, for regulating capacitors in different loading conditions, their constructions are generally combined by fixed and switched capacitors. Yet they are not capable of continuously generating variable reactive power. Also, the oscillatory behavior of capacitors with inductive components sometimes results in the ferroresonance and / or self-excitation of induction machinery. Further, the continuous switching action of the regulator coupled with capacitors can cause power quality problems for customers.

With the improvements in current and voltage handling capabilities of the power electronic devices and quick response to the changes in network condition, Flexible AC Transmission System (FACTS) has been used in different types of controllers for efficient shunt and series compensation. The concept of FACTS devices was originally developed for transmission
systems, but a similar idea has been accepted and applied in distribution systems.

The discrete nature of the state variables and constraints prevents the use of classical optimization techniques that can solve the network optimization problem. Therefore, heuristic methods as well as modern optimization methods have been proposed for the problem under consideration. These are simpler and efficient, but they may not give the global optimum at all instances. They are also computationally expensive. Hence, there is a need to employ a robust optimization technique in order to achieve the loss reduction of distribution systems for economic operation. In addition, it is most essential and important to identify the suitable compensator with economic considerations.

The research work introduces three optimization algorithms, namely SaHDE, Fuzzy-SaHDE and Fuzzy-Bees, to address the reactive power compensation for volt / var regulation. Furthermore, the research work is aimed at identifying the most suitable compensator by means of economic considerations. The proposed work has been tested on 10, 34 and 85 bus radial distribution systems and then they are compared with other techniques addressed in the literature. The proposed algorithm outperforms the other techniques. The robustness of the algorithm has been validated by handling 24
hour load patterns of the test systems. Also, bus voltages and branch currents are maintained within the limits under dynamic load conditions.

The methodology adopted in the thesis can be extended to any real time system to solve efficient and economic operating conditions at a less computational effort. Additionally, a simulation package is developed using Java programming language to effectively accomplish the distribution system analysis for online application. The software package has the features such as open source, user friendliness, design of distribution system patterns, formation of report with necessary / expected fields in the report, robust optimization algorithm and software reusability.