CHAPTER 9

CONCLUSION

This chapter reviews the significant contributions made in this research and presented in this report. The contributions include new solution approaches developed for solving the following distribution system problems using Genetic Algorithm (GA) and Simulated Annealing (SA) algorithm:

- Optimal siting and sizing of substations and network routing.
- Optimal grading of conductor sizes in the radial distribution feeder mains.
- Optimal Allocation of fixed as well as switched capacitor banks in the radial distribution feeders.

The proposed solution procedures, the system studies carried out and the conclusions arrived at there from are summarized below:

Chapter-3

A Genetic Algorithmic approach for solving the substation siting, sizing and network routing problem is developed. An efficient coding method and crossover and mutation operations are devised. The method provides for reducing the production of infeasible solutions during the GA process. Diversifications of the populations at intermediate stages help to avoid convergence to local optimal solutions. Determination of the best values for the crossover and mutation operators using a graphical study approach has been demonstrated. The proposed GA approach is applied on two 33kV test systems, a small system with 2 substation nodes, 9 consumer nodes and 18 feeder route alternatives and a large system with 8 substation nodes (2 existing), 47 consumer nodes and 69 feeder route alternatives (10 existing). Studies were conducted on these networks using the proposed algorithms. The results presented highlight the efficiency of the algorithm developed with diversification strategy. The solution for the large system was obtained in 88 seconds. The proposed GA approach has been found to be faster, resulting in solution times lesser than about three times as that reported in the literature.
Chapter-4

A Simulated Annealing (SA) algorithmic procedure has been developed for solving the substation siting, sizing and network routing problem. Best values of the SA parameters, the number of iterations at a temperature and the temperature reduction factor are obtained. The transition mechanisms for the generation of neighborhood solutions are guided by heuristics to avoid infeasibilities and to direct the search towards optimum. The same coding, tree search and decoding mechanisms as that used in the GA based solution procedure presented in chapter 3 are adopted.

The solution procedure developed is applied for solving both the small and large systems of chapter-3. Stepwise procedure of the solution approach is presented in detail for the small system of chapter-3. It is observed that the SA based algorithm gives the same optimum solution as that obtained using GA approach but at a higher solution time (more than 350 seconds for the large system). Also the algorithm has to be run several times at a very slow cooling rate (temperature reduction rate) to get consistent results. This increases the solution time. Thus, for this type of problems GA based approach proves to be more efficient.

Chapter-5

A Genetic Algorithmic approach for solving the problem of grading of conductor sizes in the Distribution System feeder mains is developed. The devised coding method is presented. An efficient coding method and crossover and mutation operations are devised to generate feasible solutions only. The proposed approach is tested on a 14-bus main feeder and the results are presented. Best values of the crossover and mutation probabilities are obtained using a graphical study approach. The proposed approach can also be used to study feeders with branches.

Chapter-6

A Simulated Annealing (SA) algorithmic approach for solving the problem of grading of conductor sizes of feeder mains is developed. The same coding and decoding mechanisms devised in chapter-5 for the problem has been used. The feeder input is given with the parent - children relationship of each node. A transition to a neighbor
solution at a particular node is accomplished by verifying either its parent or children nodes. Thus a transition, though stochastic in nature, is guided to avoid infeasibilities. Best values of the SA parameters, the number of iterations at a temperature and the temperature reduction factor are obtained. The procedure gives the same optimum as that obtained using GA approach but taking more solution times.

Chapter-7

A Genetic Algorithmic procedure for solving the capacitor placement problem of radial distribution feeders has been developed in this chapter. The coding method is devised to map all possible regions of the solution space while reducing the complexity and memory requirement. The codification takes into consideration the discrete nature of the decision variables (capacitor location and sizes) of the problem. A power flow is conducted to determine the inductive current flows in the feeder sections. The reactive current flows are transformed into equivalent capacitor bank units and used as a template. Random allocations of each of the solutions are guided by this template to avoid overcompensation. The crossover and mutation operations are performed by verifying the reactive flow in the feeder sections. Mutation operation is designed to bring in new structures into the chromosome. A 35-bus 11kV radial distribution feeder is studied using the proposed approach. The optimum solution has been obtained in lesser solution time (43 seconds) than that reported in the literature for solving the problems of comparable size. The procedure developed is used for allocating both fixed and switched capacitors with appropriate changes in the data. The optimum fixed and switched capacitor allocations obtained for the system studied are presented.

Chapter-8

A Simulated Annealing (SA) based solution procedure for solving the capacitor placement problem of radial distribution feeders has been developed in this chapter. The same coding and decoding procedures used for the GA Approach is adopted for the SA based solution procedure. The proposed SA approach is tested on the same feeder used for testing the GA procedure. Best values of SA parameters are obtained through a graphical study. The transition mechanisms used for the generation of neighborhood
solutions are specifically manipulated to direct the search towards optimum. Adequate numbers of iterations are performed at each temperature to carry out satisfactory investigation at that state. The procedure produces the same optimum solution for both the fixed and switched capacitor allocations as that obtained using GA approach but at a higher solution times (145 seconds). Also the algorithm has to be run several times with different initial solution to get consistent results. As expected, consistent results are obtained for larger values of temperature reduction factor β but at the cost of increased solution times. The stepwise procedure developed to apply the SA algorithm on the feeder studied, are presented in detail.

**General Conclusion**

As discussed above this research work aimed at developing new solution procedures using GA and SA approaches. Among the two approaches developed for solving the distribution system problems studied GA seems to be better compared to the SA approach in terms of solution time and complexity of problem formulation. As a whole the solution procedures developed addresses the problem more efficiently than the earlier works.