Chapter 6
Conclusion

In this thesis three different voltage based load shedding strategies are considered. They are as follows:

(i) Optimization of steady state load shedding considering both real and reactive power load to be shed
(ii) Optimization of line voltage stability index based load shedding
(iii) Optimization of load shedding in radial distribution system without and with DGs.

These strategies are solved using various meta-heuristic optimization algorithms and tested on the standard test systems.

In the first strategy, the optimal solution of steady state load shedding is carried out by squaring the difference between the connected and supplied power (active and reactive). The supplied active and reactive powers are treated as dependent variables modeled as functions of bus voltages only. The meta-heuristic algorithms namely, IHS, GSO and ABC approaches are used in the first strategy for the minimization of steady state load shedding. The performance of the proposed algorithms for the generation loss contingency, generation deficits and overload contingencies are analyzed and presented in this thesis. The proposed algorithms are tested on IEEE 14, 30, 57, 118 and Northern Regional Power Grid (India) 246-bus test systems. The viability of the proposed algorithms for this load shedding strategy is demonstrated by comparison with the other conventional methods reported earlier in terms of solution quality and convergence properties. The analysis of the results obtained for this strategy shows that the proposed IHS approach gives better solutions as compared to those of the other proposed GSO and ABC approaches and the conventional methods, GTBKTT, SOGT and PALM reported earlier. As an example, from the result obtained for IEEE 30 bus system, when subjected to generation loss contingency, it can be observed that the proposed IHS approach has yielded a load shedding improvement of 5.258%, 4.334%, 2.623% and 9.892% than the
proposed GSO, ABC approaches and conventional methods GTBKTT and PALM respectively.

For reasons of economic viability, modern power systems have been operated close to their limits. Consequently, a small increase in the load may lead to the Maximum Loading Point (MLP) of the system resulting in voltage collapse. Under such circumstances in order to avoid the voltage collapse, the buses for load shedding have been selected based on line voltage stability index and its sensitivities at the operating point. On this basis, the optimization of line voltage stability index based load shedding strategy have been developed here and considered as the second strategy of load shedding. IHS, SFLA and ABC approaches were used for the optimization of the line voltage stability index based load shedding strategy. These algorithms are implemented on the standard IEEE 14 and 25-bus test systems to obtain the optimal load shedding at the selected buses when the systems are operated at their MLP. The effectiveness and efficiency of the proposed approaches are established by improvements in the line voltage stability index and the bus voltages. In this strategy also IHS approach provides better convergence characteristics and obtains a minimum amount of load shedding with better voltage profile as compared to those obtained with the other proposed SFLA and ABC approaches. From the results obtained, for IEEE 14-bus test system, operated at its MLP, the proposed IHS approach has yielded a load shedding improvement of 18.129 % and 14.056 % than the proposed SFLA and ABC approaches respectively.

The last strategy presented in this thesis is the optimization of load shedding in radial distribution systems without and with DGs. The meta-heuristic algorithms, IHS and IGSA have been implemented to solve this load shedding strategy during an overload contingency in the radial distribution systems. Overload contingency in the radial distribution systems without and with DGs are the two cases considered here. The main objective of the proposed algorithms is to minimize the sum of load shed based on their assigned degree of importance and the system losses subject to operational and security constraints of the system. The proposed approaches were tested on IEEE 12, 33 and 69-
bus radial distribution systems. The feasibility of the proposed approaches have been established and compared with those of the results presented in the earlier research using GA in terms of solution quality over realistic test systems considered. In this case also IHS approach provides better results as compared with those of the other proposed IGSA approach and GA reported earlier. From the results obtained, for IEEE 33-bus radial distribution systems under overload contingency without DGs, the proposed IHS approach has yielded a load shedding improvement of 7.359 % and 13.08 % than the proposed IGSA and GA respectively.

Finally for the three load shedding strategies presented in this thesis, the applicability and the competence of the IHS approach have been well established in comparison with the other meta-heuristic algorithms used in this work and also with the other methods reported in the earlier research works. The way of handling the intensification and diversification characteristics is the key factor of IHS algorithm for its success. The diversification is controlled by the PAR and randomization. Generating new solutions, via randomization is similar to the randomization done in other algorithms. Whereas, the pitch adjustment which is carried out by adjusting the pitch in the given bandwidth by a small random amount relative to the excising pitch (or) solution from the harmony memory is a refinement process of local solutions.

Both the pitch adjustment and harmony memory considering rate ensures that the good local solutions are retained and the global search space is explored efficiently by randomization and pitch adjustment thereby the exploration is carried out around good solutions. The intensification of the algorithm is controlled by HMCR. Good solutions from the memory are likely to be selected for a high harmony memory consideration rate. If this consideration rate is too low, the rate of convergence will be reduced. Also the intensification is enhanced by the controlled pitch adjustment. Such interaction between various components of the algorithm is another important factor for the better performance and success of the IHS algorithm over other algorithms.

Finally it can be concluded that the proposed IHS algorithm provides a better performance as compared to the other proposed approaches and conventional methods
reported and can be considered as an alternative technique in solving the optimal load shedding problem.

The research work presented in this thesis suggests IHS as one of the best meta-heuristic algorithm to solve the load shedding (forced outages) strategies described here. The future scope of the work is as follows,

(i) These load shedding strategies can be implemented on the real time systems and can be solved by the proposed IHS algorithm

(ii) The IHS algorithm can be implemented to optimize the scheduled outages, which is necessary to regain the balance between generation and demand in the developing countries

(iii) Instead of one algorithm a hybrid of more than one algorithm can be used to solve the load shedding problem. As the advantages of all the algorithms in the hybrid structure is fully utilised, the overall performance of the algorithm will be improved and the computational time of the algorithm in finding the optimal solution will be reduced.