ABSTRACT

Generation and overload contingencies in a power system lead to underfrequency and low voltages owing to real and reactive power deficiencies. Under these circumstances, load shedding is necessary to prevent a blackout in the power system by relieving overload in some parts of the system. Load shedding is resorted to cope with transmission line overloading conditions. Minimization of the load to be shed is essential to prevent the system from excessive load shedding. Load shedding carried out in all the buses of the test system is called as decentralized load shedding, whereas if it is carried out only in some buses, selected on the basis of certain criteria, it is known as centralized load shedding. Both centralized and decentralized load shedding are considered in this research work.

Three different load shedding strategies are solved here using various meta-heuristic optimization algorithms and tested on the standard test systems. These strategies are as follows:

(i) Optimization of steady state load shedding considering both real and reactive power load to be shed (decentralized)

(ii) Optimization of line voltage stability index based load shedding (centralized)

(iii) Optimization of load shedding (decentralized) in radial distribution systems without and with Distributed Generations (DGs).

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. For this strategy a new music inspired harmony based optimization algorithm known as Improved Harmony Search (IHS) algorithm, a new nature inspired optimization algorithm known as Glowworm Swarm Optimization (GSO) algorithm and another meta-heuristic optimization algorithm known as Artificial Bee Colony (ABC) Algorithm were implemented for the minimization of steady state load shedding. The performance of the proposed algorithms for generation loss contingency, generation
deficits and overload contingencies are analyzed and reported in this strategy. The proposed algorithms were tested on IEEE 14, 30, 57, 118 and Northern Regional Power Grid (NRPG)-(India) 246 - bus test systems.

The applicability of the proposed algorithms for this load shedding strategy in terms of solution quality and convergence properties is demonstrated by comparison with the other conventional methods, namely, Projected Augmented Lagrangian Method (PALM), Gradient Technique Based on Kuhn-Tucker Theorem (GTBKTT) and Second Order Gradient Technique (SOGT). The comparison shows that the proposed IHS algorithm gives better solutions as compared to those obtained by the other proposed algorithms and conventional methods. 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.

Modern power systems have been operated close to their limits for reasons of economic viability. 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, the second strategy of load shedding can be applied, where the buses for load shedding have been selected based on line voltage stability index and its sensitivities at the operating point. This avoids voltage collapse and improves the system stability. Hence, the optimization of line voltage stability index based load shedding strategy have been developed and considered as the second strategy of load shedding. IHS algorithm, Shuffled Frog Leaping Algorithm (SFLA) and ABC algorithm are the meta-heuristic algorithms used for the optimization of the second strategy of load shedding. 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. From the obtained results, in this case also IHS algorithm provides better convergence characteristics and gives a minimum amount of load shedding with better voltage profile as compared to those obtained with the other proposed algorithms used here. 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. In this strategy the objective is to minimize the total load shed based on the given degree of importance and system losses. Here, a new meta-heuristic optimization algorithm based on Newton’s law of gravity and mass interaction known as Improved Gravitational Search Algorithm (IGSA) and IHS algorithm have been implemented to solve this load shedding problem 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 electrical distribution systems are locally looped and have bidirectional power flows with distributed generation.

The proposed methods were tested on IEEE 12, 33 and 69-bus radial distribution systems. The feasibility of the proposed algorithms has been established by its comparison with the results presented in the earlier research using Genetic Algorithm (GA) in terms of solution quality over realistic test systems considered. In this case also IHS approach provides better results when compared with those obtained using the proposed IGSA 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.

So far in the literature, conventional methods and old heuristic methods were used to solve these strategies. However, in this research work recent meta-heuristic algorithms are implemented to solve these strategies. Moreover, for any test system subjected to generation and / or overload contingencies, the optimal amount of load shedding obtained when any one of the three load shedding strategy is solved by the meta-heuristic algorithms used in this research work is lower than those obtained by the other conventional and old heuristic methods reported. This is due to the better performance of the recent meta-heuristic algorithms in searching for a feasible solution. The performance of a meta-heuristic algorithm is determined by its two important characteristics, intensification and diversification. These characteristics of
the algorithm can be improved by tuning the control parameters of the algorithm. Particularly, in IHS algorithm, there is an interaction between the two characteristics that develops the performance of the algorithm far better than the other meta-heuristic algorithms.

Finally for the three load shedding strategies presented in this thesis, the applicability and the competence of the IHS algorithm 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.