CHAPTER VII

CONCLUSIONS

7.1 Conclusions

Optimal power flow (OPF) is a large dimension nonlinear, nonconvex and highly constrained optimization problem that has been used widely for power system planning and operation. The main purpose of this dissertation is to develop an enhanced version of the conventional differential evolution (DE) called self-adaptive differential evolution with augmented lagrange multiplier method (SADE_ALM) for solving the OPF and SCOPF problems. In addition, a parallel version of SADE_ALM called pSADE_ALM is also developed for these implementations to increase the search capability of the sequential algorithm. The performance of developed algorithms have been illustrated by their application to solve the OPF and SCOPF problems based on the standard IEEE 30, 57, and 118 bus test systems.

In the OPF problems, the developed SADE_ALM and pSADE_ALM have been tested on the IEEE 30-bus system with four types of fuel cost characteristics. Numerical results show that both algorithms are successfully and effectively implemented to find the best total generator fuel cost of the OPF problems compared with other approaches. However, for higher test system, i.e. 57 and 118 bus system, the pSADE_ALM provides the best generator fuel cost without violating any constraints. In addition, the robustness of the optimal results determined from each trial for all test cases of pSADE_ALM is significantly better than SADE_ALM. Therefore, the pSADE_ALM shows promising capability for solving the OPF problems especially for larger system.

In the SCOPF problems, the effectiveness of both algorithms have been tested based on the IEEE 30, 57, and 118 bus test systems. Numerical results show that both algorithms are successfully and effectively implemented to find the best secure generation cost compared with the conventional gradient method and evolutionary programming (EP) for the IEEE 30 bus test system. Considering between the SADE_ALM and pSADE_ALM, it has been found from for all test cases that the pSADE_ALM provides the best secure optimal solution without violating any constraints. In addition, the robustness of the pSADE_ALM is also better than others. The pSADE_ALM shows higher capability for solving the SCOPF problems than the sequential SADE_ALM.

However, the main drawback of the pSADE_ALM is its computational time compared with the sequential SADE_ALM. The average computational time of pSADE_ALM for all test cases is higher than SADE_ALM. The main reason is that there may be bottle necks in the inner loop iteration of pSADE_ALM. The computational time of every inner loop iteration of pSADE_ALM is higher than SADE_ALM since the master node has to wait for the elite members from every nodes, including the master node, before proceeding to the outer loop iteration, whereas the SADE_ALM can proceed to the outer loop iteration immediately without wasting idle time. This drawback should be improved for the next future research.

In addition, the mixed-integer SADE_ALM called MISADE_ALM is also proposed in this dissertation. Since, in practice optimal settings of the control variables, e.g. shunt capacitors/reactors, and transformer tap-settings, are discrete in nature. The SADE_ALM may possibly provide the local optimal solutions after the continuous control variables are modified to the nearest discrete control variables. The effectiveness of MISADE_ALM has been implemented to solve the OPF problems with a mixture of continuous and discrete control variables. The IEEE 30-bus system with three fuel cost characteristics is considered in this case. Numerical results show that MISADE_ALM is successfully and effectively implemented to find the feasible global or quasi-global optimum of the OPF problems compared with other approaches. The proposed MISADE_ALM shows promising capability for the OPF problems where the optimal settings of discrete control variables are taken into account.

7.2 Recommendations for Future Works

Based on the present study, recommendations for the future research can be made as presented below.

1) The pSADE_ALM should be implemented on a PC Cluster with more nodes to reduce the average computation time of the inner loop iteration by performing power flow calculation simultaneously. Moreover, the pSADE_ALM should be integrated with other DE's strategies (i.e., DE/best/1/bin, and DE/rand/2/bin) to enhance the search capability of the algorithm.
2) Nonlinear electronic based devices, e.g. FACTS devices, can be incorporated into the system of which its impact can be evaluated.

3) The environment constraints, e.g. emission control limit can be taken into account with the OPF and/or SCOPF problems.
4) The multi-objective OPF and/or SCOPF problems can be formulated in order to optimize multiple objective simultaneously.