Chapter 6
Conclusions and Future Work

6.1 Conclusions

Several benefits can be captured by optimizing the photovoltage distributed generation (PV-DG) and the distributed static compensator (D-STATCOM), where the PV-DG can provide active power to the load. In contrast, D-STATCOM can provide reactive power to the connected load. However, the inclusion of the PV-DG and the D-STATCOM is a strenuous task due to the continuous variations in the load and the solar irradiance.

This book deals with the integration of the PV-DG and the D-STATCOM in radial distribution networks (RDN) to improve the system performance and reduce costs. The optimal sites and sizes of the PV-DGs and the D-STATCOMs have been determined using developed optimizers such as marine predators algorithm (MPA), equilibrium optimizer (EO), lightning attachment procedure optimization (LAPO), sine cosine algorithm (SCA), ant lion optimizer (ALO), whale optimization algorithm (WOA), and slime mold algorithm (SMA). In this work, the forward backward method is used for solving the power flow in RDN, and the candidate buses for optimal allocation of the PV-DG and the D-STATCOM have been determined using the sensitivity analysis. The assessment of integration of the PV-DGs and the D-STATCOMs has been studied for several objective functions, including the power losses, the voltage profile improvement, stability enhancement, and the total annual cost, which is comprised of the installation and operation cost of the PV-DGs and the D-STATCOMs, the purchased power from the grid, and the cost of the power loss. The effectiveness of the PV-DGs and the D-STATCOMs and the validity of the proposed algorithms have been tested and verified on different standard IEEE test systems such as IEEE-33, IEEE-69, IEEE-94, and IEEE-118 bus test systems and real test systems such as the 30-bus of the East Delta Network (EDN) and the 94-bus practical distribution system situated in Portugal.

A. M. A. El-Hameid et al., *Enhancement of Grid-Connected Photovoltaic Systems Using Artificial Intelligence*, https://doi.org/10.1007/978-3-031-29692-5_6

The allocation problem has been solved under deterministic and probabilistic conditions, i.e., considering the variations and uncertainties of the load demands and seasonal solar irradiances. From the study, the following conclusions are drawn:

- The developed algorithms are effective in interpreting the allocation of PV-DGs and the D-STATCOMs.
- In the case of optimal integration, a single PV-DG and the D-STATCOMs in IEEE-118 are at 20%, 30%, and 40% penetration levels; the annual cost reductions are 3.4%, 4.47%, and 5.72%, respectively, when compared to the base case. In the case of optimal integration of two hybrid PV-DGs and D-STATCOMs, the reductions in annual costs are 4.12%, 5.55%, and 6.69% under 20%, 30%, and 40% penetration levels, respectively.
- In the case of optimal integration of a single PV-DG and the D-STATCOMs in IEEE-94 under deterministic conditions, the cost is decreased by 14.88%, the total voltage deviation (TVD) is reduced by 73.36%, and the total voltage stability index (TVSI) is enhanced by 21.71% compared to the base case. In the case of including two hybrid systems, the reduction in cost and TVD are 15.68% and 77.96%, respectively, and TVSI is enhanced by 24.016%.
- In the case of optimal integration of a single PV-DG and the D-STATCOMs in IEEE-94 under probabilistic conditions, the cost is reduced by 10.917%, the time is minimized by 72.53%, and the enhancement is enhanced by 24.016% compared to the base case, while in the case of including two hybrid systems, the reduction in cost is 17.16% and 86.64%, respectively, and the enhancement is enhanced by 34.96%.
- Under the uncertainty condition, the PV-DGs and D-STATCOMs in IEEE-69 reduce total annual cost by 7.59% and 51.35%, respectively, in the case of optimal integration. Furthermore, voltage stability is improved by 5.05% when compared to the base case, and the optimal incorporation of two hybrid PV-DG and D-STATCOM can reduce total annual cost and voltage deviations by 10.78% and 57.55%, respectively. Also, the voltage stability is enhanced by 5.82% compared with the base case.
- In the case of optimal integration, the PV-DGs and the D-STATCOMs in IEEE-118 under the uncertainty condition of the expected cost, the voltage deviations are reduced by 8.25% and 27.34%, respectively. Furthermore, voltage stability is improved by 4.6% when compared to the base case, and the optimal incorporation of two hybrid PV-DGs and D-STATCOMs can reduce total annual cost and voltage deviations by 9.151% and 40.33%, respectively. Also, the voltage stability is enhanced by 6.57% compared with the base case.