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Allocation and Sizing of Distributed Generation (DG) using EP, AIS and PSO

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Abstract

Recent changes in the electric utility infrastructure has created opportunity for many technological innovations including application of Distributed Generation (DG) in order to obtain a maximum benefits. To achieve the benefits, factors such as the sizing and the best location have to be considered. This paper focuses on to determine the optimal allocation and sizing of the DG in order to minimize the losses and improve voltage stability in the system using Evolutionary Programming (EP), Artificial Immune System (AIS) and Particle Swarm Optimization (PSO) technique. The Static Voltage Stability Index (*SVSI*) was used as the objective function for the developed optimization technique and able to minimize total transmission losses, improved voltage stability and increase voltage profile of the system. The effectiveness of the proposed technique was validated on standard IEEE 30-bus Reliability Test System (RTS).

1. Introduction

Nowadays, the distributed generation has used extensively in the power sector. Due to the wide spread use of distributed generation, several system operating issues have come into sight. These issues include both advantages and disadvantages of using distributed generation associated with the implementation of DG units at a well-established system perennially. The concept of implementation of DG has been practice as standby, backup and stand-alone generation [Lasseter, 1998].

The effects on voltage profile and transmission line losses must be evaluated separately before installed the DG. The planning of the electric system with the presence of DG requires the best technology to be used, the number and the capacity of the units, the optimum location and the type of network connection. The impact of DG in system operating characteristics such as the electrical losses, voltage profile and stability needs to evaluate properly. The allocation and sizing of DG is the most importance problem as the installation of DG units at non-optimal places can result in increased system losses. The used of an optimization technique is capable to indicate the best solution for distribution network in loss reduction and voltage profile improvement for the system planning engineer [Sedighizadeh and Rezazadeh, 2008].

2. Objective Function and Optimization Technique

SVSI is a line-based voltage stability index used to find the location of DG installation [Qi, 2004]. Then the locations are determined in term of maximum loadability and voltage stability index. Voltage stability index has been chosen as the objective function which utilized the fitness in the load flow calculation which needs to be minimized. The mathematical formulation for *SVSI* is given as in equation (1):

$$SVSI_{ji} = \frac{2\sqrt{\left(X_{ji}^{2} + R_{ji}^{2}\right)\left(P_{ji}^{2} + Q_{ji}^{2}\right)}}{\left|\left|V_i\right|^2 - 2X_{ji}Q_{ji} - 2R_{ji}P_{ji}\right|} \quad (1)$$

This paper presents the Evolutionary Programming (EP), Artificial Immune System (AIS) and Particle Swarm Optimization (PSO) as the optimization technique to solve the DG problems.

3. Result and Discussion

The analysis involved three optimization techniques such as EP, AIS and PSO. The comparison is made in terms of total transmission loss reduction, voltage stability improvement and increment of voltage profile in the system. Table 1 tabulate the results of DG at Q_{30}=34MVAr using EP, AIS and PSO. From the table, it is observed that AIS and PSO similarly manage to reduce losses from 27.47MW to 24.10MW while EP managed to reduce 24.11MW.The difference is very close using these three techniques. Based on the results, both PSO and AIS give equally performance in terms of total losses. Besides, lowest reduction in *SVSI* performed by PSO indicating the highest voltage stability index improvement from 0.6797 to 0.5274.From the same table, EP and AIS managed to reduce *SVSI* to 0.5360 and 0.5362 respectively. PSO also obtain the highest voltage profile improvement. It can be observed that PSO improved voltage profile from 0.6105p.u. to 0.7162p.u..In other hand, EP and AIS improve to 0.7093 and 0.7092 p.u. respectively. From the results of comparative studies, it is observed that PSO has outperformed EP and AIS in terms of voltage stability improvement and voltage profile minimization. For total losses reduction, AIS and PSO have equally performance.

Table 1: Results of comparative studies for optimization of DG

Criteria	pre- DG	post-DG at Q_{30}=34 MVAr		
		EP	AIS	PSO
Total loss (MW)	27.47	24.11	24.1	24.1
SVSI	0.6797	0.536	0.5362	0.5274
Voltage (p.u.)	0.6105	0.7093	0.7092	0.7162

4. Conclusion

The three techniques have been successfully tested on the IEEE 30-bus RTS. The result indicated that these techniques had improved the result for all cases. The result shows that PSO technique outperformed EP and AIS in terms of voltage stability improvement and voltage profile minimization. For total losses reduction, AIS and PSO have equally performance. For future work, the larger test system can be incorporated together to achieve similar task.

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