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Optimal placement of distributed generator for power loss minimization and voltage stability improvement

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Abstract

This paper presents a solution to a problem of optimal allocation of distributed generator (DG) for multi objective minimization of real power loss, reactive power loss, reactive power generation and voltage deviation. The four objective functions are formulated and combined to form a single objective function using weighting factors. The problem is solved by using a technique formed by a combination of Particle Swarm Optimization (PSO) and Newton Raphson Power Flow (NRPF) methods. This hybrid strategy utilizes the global searching capability of PSO and its derivative free nature and the ability of NRPF method to find optimal solution when initial points are efficiently chosen to reach global optimal solution. The method is tested on IEEE 14-bus power system. To minimize cost one DG is considered for installation. The proposed method iteratively moves DG in each load bus of the test system, find optimal transformers' taps settings and compute objective function value. The DG is assumed to generate 2.5 MW. The bus that gives the minimum value of the objective function is considered as the best candidate for DG installation. In this work, it is bus number nine. Distributed generator used is from wind energy technology.

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Keywords: Renewable energy, wind turbine generator, optimal placement, energy loss minimization, power system.

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1. Introduction

In many power systems the majority of power is generated by conventional generators located very far from load centers. This accounts for the additional power loss in the transmission and distribution systems. Utilities are working tirelessly to implement several measures for power loss reduction. Some of these measures are reconfiguring the existing network topology, installing fixed / switched shunt capacitor banks, the use of flexible alternating current transmission devices (FACTS) and distributed generation units in close proximity to the consumer loads in transmission and distribution systems. These actions have brought positive effects to the utilities and customers. Some of those benefits are postponement for investing new transmission and distribution network construction, reduction in power loss, bus voltage profile enhancement and power system stability improvement. Prior to the implementation of those measures detailed study should be done to investigate their consequences.

Nomenclature

w_i	weighting factors for the objective functions	P_{Gi}	active power generation at bus i
N_{obj}	number of objective functions	Q_{Gi}	reactive power generation at bus i
g	equality constraints	Y_{ij}	admittance between bus i and j
J_i	i^{th} objective function	B_{ij}	susceptance between bus i and j
h	system operation constraints	G_{ij}	conductance between bus i and j
V_{ref}	system reference voltage	T_k	transformer tap setting at line k
V_i	voltage at bus i	N_{PV}	number of generator buses
V_j	voltage at bus j	N_{PQ}	number of load buses
δ_i	voltage angle at bus i	N_L	number of transmission lines
δ_j	voltage angle at bus j	n	total number of buses
θ_{ij}	admittance angle between bus i and j	P_i	net active power
Q_i	net reactive power		
v	wind speed.	Q_{Lk}	reactive power loss at line k
P_r	rated output power	V_{ci}	cut-in wind speed
V_r	the rated wind speed	V_{co}	cut-out wind speed

Distributed generation (DG) is a small-scale power generation that is usually connected to distribution system. Distributed generation is playing a big role in minimizing losses and improving voltage stability in power systems. This can be achieved when they are optimally placed and/or sized. This has made the problem of optimal allocation of distributed generation to be an interesting research topic for many researchers.

This paper presents the application of a method which combines particle swarm optimization (PSO) and Newton-Raphson power flow solution to find optimal placement of one DG in IEEE 14-bus [1] power system that minimizes losses, reactive power generation and voltage deviation. In addition to DG placement transformers' taps of the system are also set. The DG is assumed to generate 2.5 MW. Therefore, the problem becomes to find optimal placement only.