Analysis of different techniques for optimal sizing and placement of DG resources

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Abstract

The process of generating electricity from many small energy sources and connecting it directly to the distribution network or on the customer's side of the meter is called Distributed generation (DG). It can also be called as onsite generation, dispersed generation, decentralized generation, decentralized energy or distributed energy. In this paper, the performance analysis of various techniques for optimal sizing and placement of Distributed Generators (DG) in distribution networks is done.

Keywords –Distributed generation (DG), optimization techniques

1. Introduction

The Electrical distribution system is normally radial without installed DG units [1]. Power flows in a single direction, from transmission line to the distribution system. Since in the recent past, there have been an increasing number of generation units being connected to the distribution system that is, a Generation unit at the customer side of the meter; such units are called Distribution Generation Units (DGU) [2-3]. The positioning and the magnitude of the generated power supplied to the distribution system by the DGU have an influence on the daily workings of the whole system. It can either make it more efficient or decrease the efficient operation of the system which could adversely affect the stability of the system [4]. Large power supplied by a DGU can even reverse the direction of flow of current. Therefore, finding a position for the DGU which is economically viable, through a suitable size and minimization of losses is of utmost importance. From the definition, the DG includes those generating units that cannot supply reactive power and are located close to the customer or the end user [5-6]. DGU kinds are based on the classification of the power resource available in the vicinity of the location such as biomass, biogas, solar and wind [7]. They can be micro-turbines, solar cells, fuel cells and Combined Heat and Power (CHP). Each of them is defined by a particular characteristic like producing only real or reactive power. Distributed Generation (DG) is a small generator spotted throughout a power system network, providing the electricity locally to load customers [8]. DG can be an alternative source of power supply for industrial, commercial and residential applications. DG makes use of the latest modern technology which is efficient, reliable, and simple enough so that it can compete with traditional large generators in some areas [9]. Distributed generation systems (such as fuel cells, combustion engines, micro turbines, etc) can reduce the system loss and defer investment on transmission and distribution expansion. Appropriate size and optimal locations are the keys to achieve it [10].

2. Optimal Sizing & Placement of DG

Optimum distributed generation location can pick up voltage profile and to minimize power loss. Voltage profile of a system can be improved by introducing DG unit because DG can provide a portion of real and reactive power to the load locally [11]. Power loss in a system depends on numerous factors such as system configuration, such as level of losses through transmission and distribution lines, transformers, capacitors, insulators etc. It is possible to transfer real power to customers through transmission and distribution lines. Optimum location of DG in a distribution network can provide several benefits such as voltage profile improvement, loss minimization, power quality improvement, contributing for frequency regulation and acting as spinning reserve in main system [12].

3. Optimization Techniques

- Analytical Technique: Analytical techniques represent the system by a mathematical model and evaluate it using direct numerical solution [13].
- Genetic Algorithm [14]: Genetic Algorithms (GA) has become increasingly popular in the recent times. Genetic algorithms belong to the larger class of evolutionary algorithms (EA), which generate solutions to optimization problems using techniques inspired by natural evolution, such as inheritance, mutation, selection, and crossover. In a genetic algorithm, a population of strings (called chromosomes or the genotype of the genome), which encode candidate solutions (called individuals, creatures, or phenotypes) to an optimization problem, evolves toward better solutions.
- Heuristic Techniques: A heuristic is an algorithm that locates optimal or near optimal solutions to a problem without concern for whether the solution can be proven to be correct [15].
- Meta-Heuristic Techniques [16]: A meta-heuristic is an iterative generation process which can act as a guide for its subordinate heuristics to efficiently find the optimal or near optimal solutions of the optimization problem.

a. Tabu Search [17]: Tabu search is a meta-heuristic approach which has dramatically changed the ability to solve a host of optimization problems.
b. Particle Swarm Optimization [18]: Particle swarm optimization (PSO) is a population based stochastic optimization technique developed by social behavior of bird flocking or fish schooling. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles.
c. Ant Colony Optimization [19]: Ant colony algorithms are based on the behavior of social insects with an exceptional ability to find the shortest paths from the nest to the food sources using a chemical substance called pheromone.
d. Simulated Annealing [20]: Simulated Annealing (SA) is a generic probabilistic meta-heuristic for the global optimization problem which locates a good approximation to the global optimum of a given function in a large search space. It is often used when the search space is discrete.

- Genetic Algorithm Hybrid Approach [21]: Genetic Algorithm has been found to be very effective in area of DG allocation; however it is not very efficient in determining the absolute optimum. Therefore it is not the obvious choice when the high quality solutions are desired. To overcome this drawback, GA is combined with other techniques in order to improve its efficiency.

4. Conclusion

As DG technologies improve and cost decrease, their use is expected to rise. However, this may lead to a compromise in solution quality and computational time. In this paper, performance analysis of various techniques available for the optimal placement of distributed generation resources is done. The DG of different kinds of energy systems allows for the integration of renewable and nonconventional energy resources.

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