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Application of flower pollination algorithm for optimal placement and sizing of distributed generation in Distribution systems

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Abstract

Distributed generator (DG) resources are small, self contained electric generating plants that can provide power to homes, businesses or industrial facilities in distribution feeders. By optimal placement of DG we can reduce power loss and improve the voltage profile. However, the values of DGs are largely dependent on their types, sizes and locations as they were installed in distribution feeders. The main contribution of the paper is to find the optimal locations of DG units and sizes. Index vector method is used for optimal DG locations. In this paper new optimization algorithm i.e. flower pollination algorithm is proposed to determine the optimal DG size. This paper uses three different types of DG units for compensation. The proposed methods have been tested on 15-bus, 34-bus, and 69-bus radial distribution systems. MATLAB, version 8.3 software is used for simulation.

Keywords: Flower pollination algorithm; Index vector method; Distributed generation placement; Radial distribution system

Introduction

Distribution system is that part of the power system which connects the high voltage transmission system to low voltage consumers. 70% of the total losses are occurring in the primary and secondary distribution system, while the remaining 30% in transmission and sub transmission lines. Distribution losses are 15.5% of the generation capacity whereas the target level is 7.5%. Therefore the primary and secondary distribution system must be properly planned to ensure losses within the tolerable limits.

Distribution systems have more losses and poor voltage regulation. Almost 13% of the generated power is wasted as I^2R losses. Loss reduction in distribution systems by applying the optimization methods is the current potential area of research. The basic requirements of a good distribution system are good voltage profile, availability of power on

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demand and reliability. The efficiency of the distribution system can be improved by adopting reactive power compensation, network reconfiguration, distributed generation and hybrid methods. Each method has its own advantages and disadvantages.

Distributed generators are commonly used to provide the real and reactive power compensation in distribution systems. However, DG unit installation in distribution networks requires an appropriate location and size. Thus, optimal placement plays an important role in minimizing the losses through proper installation and sizing which can be achieved by using optimization techniques.

Hung et al. (2014) presented a methodology for the integration of dispatchable and non-dispatchable renewable distributed generation (DG) units for minimizing annual energy losses. Jalali et al. (2014) presented a new multi-stage model, based on the mixed integer nonlinear programming (MINLP) approach, to determine the optimal sub-transmission system expansion planning (SSEP). This model considers the placement of distributed generation (DG) units in distribution networks over the planning periods.

Gopiya Naik et al. (2013) proposed sensitivity based simultaneous optimal placement of capacitors and DG. In this paper analytical approach is used for sizing. Injeti and Prema Kumar (2013) developed simulating algorithm for optimal placement of DG units. Kansal et al. (2013) in this paper uses particle swarm optimization algorithm is used for DG allocation. The results obtained are promising when capered to analytical method. Kayal and Chanda (2013) proposed a new constrained multi-objective particle swarm optimization (PSO) based wind turbine generation unit (WTGU) and photovoltaic (PV) array placement approach for power loss reduction and voltage stability improvement of radial distribution system.

Alonso et al. (2012) proposed a generalized optimization formulation is introduced to determine the optimal location of distributed generators to offer reactive power capability. Junjie et al. (2012) proposed a dynamic model of distributed generation in the smart grid, based on environmental compensation costs, traditional DG capacity cost, DG operation and maintenance costs, purchased power cost and network loss cost. Aman et al. (2012) proposed a golden section search (GSS) algorithm for distributed generator (DG) placement and sizing for distribution systems based on a novel index. A novel combined genetic algorithm (GA)/particle swarm optimization (PSO) is presented in Moradi and Abedini (2012) for optimal location and sizing of DG on distribution systems. Improved group search optimizer (iGSO) is proposed in this paper (Kang et al., 2012) by incorporating particle swarm optimization (PSO) into group search optimizer (GSO) for optimal setting of DGs.

Singh and Goswami (2010) presented new methodology based on nodal pricing for optimally allocating distributed generation for profit, loss reduction, and voltage improvement including voltage rise phenomenon. A value-based method is proposed in Teng et al. (2007) to enhance the reliability and obtain the benefits for DG placement. An analytical approach based on exact loss formula has been presented in Acharya et al. (2006) to find the optimal size and location of DG however voltage constraint has not been considered.

Different types of the DG's can be characterized as

Type I DG capable of injecting real power only. For instance, photovoltaic, micro turbines, fuel cells which are integrated to the main grid with the help of converters/inverters are good examples of type I, if they are running at unity power factor.

Type II DG capable of injecting reactive power only to improve the voltage profile fall in type-II DG, e.g. kvar compensator, synchronous compensator, capacitors, etc.

Type III DG capable of injecting both real and reactive power, e.g. synchronous machines (cogeneration, gas turbine, etc.).

Type IV DG capable of injecting real but consuming reactive power, e.g. induction generators used in the wind farms.

In this paper new optimization algorithm i.e. flower pollination algorithm (FPA) is used for sizing of DGs. In this paper type-I, type-II and type-III DG's are considered for optimal placement. Optimal placement problem has been solved using flower pollination algorithm (FPA) approach by taking the exact loss formula as objective function. As the FPA technique is a heuristic global optimization method which is based on flower pollination process.

The algorithm is new and rapidly developed for its easy implementation and few particles required to be tuned as compared to other heuristic approaches. The proposed technique has been tested on 15 bus, 34-bus and 69- bus systems. The results obtained from the technique have also been compared on the basis of different types of DG units.