OPTIMAL PLACEMENT AND SIZING OF DISTRIBUTED GENERATION BASED ON MVMO-SH

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Abstract

This paper proposes a hybrid variant mean-variance mapping optimization (MVMO-SH) algorithm to optimize distributed generation (DG) sites and sizes in the grid network. The objective function is to minimize power loss. The proposed MVMO-SH algorithm is applied on standard IEEE-30 bus test system to examine the usefulness and effectiveness of the method in solving problems related to sitting and sizing of distributed generation in transmission system. A reduction in transmission system's total power loss and improvement in voltage profiles have been shown with appropriate sizes and sites of DG in power system network.

1 Introduction

According to T. Ackermann [1] DG is the electric power generation connected directly to the customer's meter or near to the load on the distribution network. This definition refers to the DG installation's site. The DG definition refers to size is based on the rating of generation source which falls into four categories. The categories suggested by Ackermann are micro, small, medium and large DG. The sizes of micro DGs are between 1W to 5kW. Small DGs range between 5kW to 5MW. Medium and large DGs range between 5MW to 50MW and 50 to 300MW respectively. DG can be categorized into two which are traditional and non-traditional. The traditional DGs are powered by non-renewable resources such as fossil and fuel while the non-traditional DGs are powered by renewable energy resources such as solar photovoltaic (PV), wind turbine (WT), mini hydro (MH) and so on. Their resources are sustainable; thus, reduced the negative impacts to the environment [2].

There are numerous advantages of implementing DG at optimal sites and sizes which includes reduce power losses, increased reliability and improve voltage profiles. However, the technology also has its disadvantages such as reverse power flow, voltage fluctuations due to source uncertainty, harmonic propagations and the need for suitable protection scheme [3]–[5]. Based on the drawbacks, it is important to optimize the sizes and sites of DGs in the grid network. It can be solved by analytical methods, numerical, stochastics or by using heuristics optimization techniques. Variety of techniques have been explored by researchers to optimize sites and sizes of DG for voltage profile improvement, system reliability, power quality and reduce system losses. Recent studies have also explored multi-objective approaches and hybrid method to optimize DG site and size to emphasize the benefits of connecting DG to the grid system [6]–[9].

Heuristics optimization methods are employed to optimize DG operation, control and planning for integration into the grid system. The methodology based on genetic algorithm (GA) is presented in [10]–[17]. Alternatively, particle swarm optimization (PSO) algorithm has widely been used to solve optimization problem related to sitting and sizing of DG. In [18] and [19], particle swarm optimization (PSO) algorithm was applied to minimize power loss and improve voltage profiles. The multi-objective particle swarm optimization (MOPSO) has been examined in [20] and [21] for loss minimization and reliability enhancement. Several other works which employed metaheuristics and AI techniques for optimal sitting and sizing of DG such as alternating direction method of multipliers (ADMM) [22], firefly algorithm (FA) [23], backtracking search algorithm (BSA) [24], [25], artificial neural network (ANN) [26], artificial bee colony (ABC) [27], gravitational search algorithm (GSA) [9], ant-lion optimization algorithm (ALOA) [28].

Based on the literature reviews, implementing the MVMO-SH algorithm to optimize the performance of DG integration in system network has not yet conducted in any investigation. Thus, this paper will encounter this novel algorithm to optimize DG sizes and sites in the transmission system. The remaining sections are elaborated as follows. Section 2 describes the MVMO-SH algorithm. Section 3 provides the problem formulations; which include the objective functions, equality and inequality constraints, and the flowchart of the proposed algorithm. Finally, in section 4, the results are discussed using IEEE 30-bus mesh system as a case study. Finally, the discussions and conclusions are presented.

2 MVMO-SH

The optimal sitting and sizing of DGs are evaluated by employing the hybrid variant mean-variance mapping optimization (MVMO-SH) algorithm and the fitness evaluation is generated by optimal power flow (OPF) based on Newton-Raphson method. The MVMO-SH algorithm is invented by Istvan Erlich [29]. The development of MVMO-SH algorithm is based on population-based stochastic optimization technique that constructed on mean and variance of the n-best population. The strategic transformation of