A Novel Multi-Objective Bat Algorithm for Optimal Placement and Sizing of Distributed Generation in Radial Distributed Systems

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Abstract. *In the few last decades, Distribution Generation (DG) has drawn a great attention by researchers around the world in the field of Radial Distributed Systems (RDSs). Generally, the optimal placement is based on the maximization of the Voltage Stability Index (VSI) and the optimal sizing is based on the minimization of the Total Active Power Losses (TAPLs). Hence, a Multi-Objective Optimization Problem (MOOP) is proposed to achieve the both mentioned objectives. For this purpose, a new simple optimization algorithm known as Bat Algorithm (BA) based on Weight Sum Method (WSM) has been used to resolve the MOOP. Then, the Fuzzy Based (FB) technique is employed to find the Best Compromise Solution. This paper also provides a comparison between the proposed algorithm and other recently published methods. From the obtained results, the advantage of the proposed algorithm is clearly observed from multiple points of view such as enhancement of Voltage Profile (VP), decreasing of the TAPL, and the maximization of the VSI. The investigations have been carried out on a standard IEEE 12-bus, 33-bus, 69-bus, and 85-bus test feeders.*

Keywords

Bat Algorithm, Distributed Generation, Fuzzy Based, Multi-Objective, Power Losses, Radial Distributed System, Voltage Stability Index.

1. Introduction

Nowadays, the Distributed Generations (DGs) are becoming more important in radial distributed systems due to the increase of electrical energy demands [1]. Generally, the DG term refers to the small scale electric power generators (from 1 kW to 50 MW). Generally, the primary sources used in DG units are supplied by renewable energies such as combustion turbine, microturbines, fuel cells, micro-hydro turbines, photovoltaic, wind turbines, and other small power sources [2] and [3].

In fact, the radial distribution network has a high R/X ratio mainly in low and medium voltage cable networks. However, known power flow methods such as Gauss-Seidel (GS), Newton Raphson (NR), Fast Decoupled Load Flow (FDLF), etc., are not effective in this case, and may often fail to converge. For this purpose, other algorithms have been proposed to solve this problem. The mostly used algorithm is the Backward Forward Sweep (BFS) technique [4] and [5].

Recently, the employment of DG units in distributed radial networks has drawn a great attention by many researchers around the world due to their effectiveness in power losses reduction, enhancement of voltage stability index, low cost, and the exploitation of renewable energies [6]. For this purpose, different approaches based on classical and meta-heuristics algorithms have been described in the literature to solve the problem of placement and sizing of DG units. Analytical approach is one of the mostly used algorithms, which was presented in [7] and [8]. The authors in [9] proposed a Grid Search Algorithm (GSA) to reduce the total power losses. Other propositions have also been suggested by many authors [10], [11], [12], [13] and [14] based on meta-heuristics approaches such as Particle Swarm Optimization (PSO), Modified PSO (MPSO), Artificial Bee Colony (ABC), hybrid Ant Colony and Artificial Bee Colony (ACO-ABC) algorithm, and Flower Pollination Algorithm (FPA) in the aim to ensure a high performance of radial distribution networks by minimizing the total power losses and exploitation costs and maximizing VSI. Furthermore, the authors in [15]