Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 142 (2017) 749–754

Energy Procedia

www.elsevier.com/locate/procedia

9th International Conference on Applied Energy, ICAE2017, 21-24 August 2017, Cardiff, UK

Optimally Allocation of Distributed Generators in Three-Phase Unbalanced Distribution Network

Manoj Kumawat[a], Nitin Gupta[a], Naveen Jain[b], R. C. Bansal[c]*

[a]Department of Electrical Engineering, MNIT Jaipur, 302017, India

[b]Department of Electrical Engineering, CTAE, MPUAT, Udaipur, 313001, India

[c]Department of Electrical, Electronics and Computer Engineering, University of Pretoria, South Africa

Abstract

Increasing energy demand can be compensated with integration of distributed energy resources in the three-phase distribution system. Load flow analysis of the unbalanced three-phase distribution system requires a tool and algorithm to manage the multiple sources. In this study, Jaya algorithm is applied and interfaced with open source software openDSS to solve the unbalanced three-phase optimal power flow. Further, co-simulation framework is used to obtain the optimal allocation of two types of multiple distributed generators in unbalanced radial distribution system. The effectiveness of the approach is validated on IEEE 123 node distribution system. For a realistic study, mixes of all type of loads and configuration of the actual distribution system are considered. The results are compared with already published results obtained from established particle swarm optimization.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.

Keywords: Distributed generator; Jaya algorithm; openDSS; multi- phase unbalanced distribution system; component object model server.

1. Introduction

The electric power system has witnessed many rectifications in the last two decades. The existing conventional power systems are causing several types of problems such as high amount of emissions, voltage deviations, static-, dynamic-, and transient-stability problems, overloaded lines, service interruptions, high capital cost, and high levels

* Corresponding author. Tel.: +27 12 4205446; fax: +27 12 3625000.
E-mail address: rcbansal@ieee.org (R. C. Bansal)

Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.
10.1016/j.egypro.2017.12.122

of resistive losses [1]. Moreover, regulatory commission addresses on global warming issues with the objective to reduce the pollutants contents in the environment by decreasing the percentage of fossil fuels from the power station and increase the penetration of distributed generator (DGs) in the distribution system [2]. Moreover, DGs has contributed in the diversification of energy resources to reduce the cost and losses of transmission and distribution, decrease the operating cost of peak load, supports for uncertainty in the electricity market and competitive policies, enhances the energy security, and increases the potential for service quality [3]. Therefore, it is required to increase the percentage contribution of the DGs into the radial distribution system. However, the non-optimal allocation (site and size) of the DGs may increase the power losses of the distribution network [4]. Further, planning of DGs is essential to enhance the performance of the distribution system.

In [5]-[13], the DGs allocation was carried out utilizing different algorithms for minimizing power loss in the radial distribution system. Hung et al. [5] suggested analytical method for optimal allocation of the DER unit to minimize power loss. Singh et al. [6] modified PSO has considered to place the DGs at different penetration levels to reduce the losses of the distribution system. Elazim et al. [7] proposed a flower pollination optimization algorithm to solve the DGs allocation problem in large scale distribution networks. In [8] a method is applied to minimize the losses and viability analysis in electricity market scenarios. Multi-objective PSO approach is used to consider multi-objective criteria for minimizing active power loss along with the pollutants emission by optimum size of DGs in Indian distribution system [9]. Moreover, a lot of research work with several approaches and optimization methods has been used for allocation of the DGs in balance distribution system [10]. However, line of the distribution system is un-transposed. Moreover, the loads of the distribution system are unequally distributed in the whole power system. Therefore, DGs planning according to balanced distribution network is not a realistic approach.

In addition, Hegazy et al. [11] used a supervised big bang-big crunch method to minimize the annual energy losses in the unbalanced distribution systems. Supervised firefly algorithm is applied to find the optimal location and capacity of dispatchable DGs in unbalanced distribution feeders for power/energy loss minimization without violating the system constraints [12]. Samir et al. [13] used the PSO algorithm for optimal allocation of DGs in the unbalanced distribution system. In literature, artificial intelligence based heuristic algorithms have been widely practiced for planning of distributed energy resources with any type of power system constraints. However, some algorithms-specific control parameters are introduced in all heuristic based methods, which have needed tuning for achieving the global solution. Moreover, computational efforts can be increased by improper tuning of algorithms-specific control parameters. Moreover, Jaya algorithm is simple, single-phase and specific parameter-less, which is used to achieve admirable outcomes [14].

In this paper, a Jaya algorithm is used to DGs planning on environmental structure of MATLAB simulation in a co-simulation framework with OpendDSS functionality. Moreover, co-simulation environment with OpendDSS program is applied to solve the three phase power flow problem for optimal allocation of type I and type III DGs in the IEEE 123 bus three-phase unbalanced radial distribution systems. The optimal placement and sizing of DGs maximizes the energy loss while maintaining the desirable node voltage. To show the strength of the applied algorithm, simulation results are compared with a recently published article [13].

2. Problem Formulation

The optimal penetration of DGs power for optimal allocation problem is formulated to minimizing the active power losses. The benefits associated with DGs mainly depend upon how optimally they are allocated in the radial distribution system while node voltage and all constraints of the power system should be preserved in the proper boundary. Further, the aim of this object function is described as:

$$F = \max\left[\zeta\left(\sum_{p=1}^{3}\sum_{i=1}^{n_b}\mathrm{Re}\left(\left|I_i\right|^2.R_{ij}\right)_a - \sum_{p=1}^{3}\sum_{i=1}^{n_b}\mathrm{Re}\left(\left|I_i\right|^2.R_{ij}\right)_b\right)\right] \qquad \forall i,j \in n_b \tag{1}$$

2.1 Voltage limits at load bus and slack bus

The voltage at each bus (V_m) should lie within the specified boundaries which is five percent from the rated value according to distribution feeder regulation. The voltage magnitudes and angle of the slack bus must be one and zero, respectively, throughout the duration of DGs planning.