Ain Shams Engineering Journal (2016) xxx, xxx–xxx

Ain Shams University

Ain Shams Engineering Journal

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ELECTRICAL ENGINEERING

Optimal allocation of remote control switches in radial distribution network for reliability improvement

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Received 21 April 2015; revised 5 September 2015; accepted 8 January 2016

KEYWORDS

Differential search algorithm;
Multi-objective function;
Radial distribution system;
Remote control switches;
Repair time;
Restoration time

Abstract This paper presents differential search algorithm in order to solve reliability optimization problem of radial distribution network. Remote control switches have been optimally allocated to improve reliability at a compromised cost. A multi-objective problem has been formulated and solved using differential search algorithm. The test systems considered in this paper are an 8 bus radial distribution network and a 33 bus radial distribution network. Simulation results obtained using differential search algorithm when applied to the test cases, have been compared with those obtained by particle swarm optimization. Differential search algorithm has been found to provide superior results as compared to particle swarm optimization.

1. Introduction

Distribution system reliability has proved to be of great concern in the present days of power system operation. With the deregulation of power system and enhanced competitive environment, the demand for uninterrupted quality power has increased. As distribution system has the greatest contribution to the interruption of supply to a consumer [1]; hence, improving distribution system reliability is of serious concern in today's power market. The enhancement of reliability always incurs a cost as it involves some additional preventive and corrective measures. So, the reliability improvement methods need to be adopted keeping in view the cost involved in the process. Failure rate, repair time and restoration time are some important parameters of defining reliability. Reducing the values of one or more of the above parameters can improve reliability considerably. Several approaches can be adopted to improve reliability, out of which, the present authors have adopted optimal placement of remote control switch (RCS) in the radial distribution network. RCSs are devices, which can isolate or connect a section of a network. Suitable locations of RCSs in a network may reduce the time to resume power and thus improve reliability. Placing one RCS at each segment of a

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Peer review under responsibility of Ain Shams University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.asej.2016.01.001

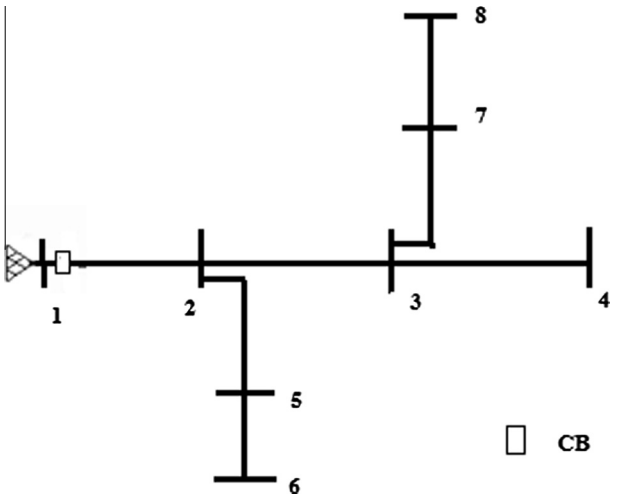

Figure 1 Eight bus network (Test case I).

network definitely improves reliability greatly, but at the same time it may incur a high installation and maintenance cost, as the number of RCSs required is large. Hence, a compromise is required, and here lies the importance of optimal allocation of RCSs. While adopting the present work, a number of literatures have been reviewed in which similar type of work has been done. Some of these are briefly discussed here.

An artificial intelligence technique with multi agent system was used by Bouhouras et al. [2] for performing cost/worth assessment of reliability improvement in distribution networks. Haifenga et al. [3] adopted Monte-Carlo simulation based approach for providing a basis for using a parallel computing environment in power system reliability and cost evaluations. Switch allocation problem has been a topic of research interest for decades and many studies have been performed [4–6]. RCSs are gaining importance in reliability improvement studies with the recent trend of automation. Some studies have been carried out in order to develop strategies for RCS without covering allocation of switches [7,8]. Allocation of switches has been considered in [9–12]. Optimal placement of switches and reclosers has been considered in [13–14]. Abiri-Jahromi et al. [15] utilized mixed integer linear programming (MILP) for optimal placement of sectionalizing switches. Viotto Romero et al. [16] proposed a dedicated Taboo Search (TS) algorithm for optimal switch allocation in distribution systems for automatic load transfer. Bernardon et al. [17] proposed a methodology to consider the impact of RCS when computing the reliability indices and the algorithm for multi-criteria decision making to allocate these switches. Benavides et al. [18] proposed a new iterated sample construction with path relinking (ISCPR) to solve distribution system switch allocation problem. Zheng et al. [19] studied the quantitative impact of automatic switches on the reliability of power distribution systems. Esmaeilian and Fadaeinedjad [20] adopted a Binary Gravitational Search Algorithm (BGSA) for network reconfiguration and capacitor placement in distribution system in order to improve reliability. Tippacon and Rerkpreedapong [21] adopted multiobjective ant colony optimization (MACO) whereas Pombo et al. [22] adopted a memetic algorithm combining Non dominated Sorting Genetic Algorithm II (NSGA-II) with a local search algorithm for switch and reclosure allocation in order to minimize the reliability indices namely average interruption frequency index (SAIFI) and system average interruption duration index (SAIDI) as well as the cost of equipments. Golestani and Tadayon [23] used Linear Fragmented Particle Swarm optimization for optimal switch placement in distribution system. Assis et al. [24] proposed a memetic algorithm based optimization methodology to sectionalizing, tie, manual, and automatic switches in distribution networks. Amanulla et al. [25] used binary particle swarm optimization-based search algorithm to find the optimal status of the switches in order to maximize the reliability and minimize the real power loss. Zou et al. [26] adopted methods including feeder reconfiguration, recloser installation, recloser replacement, and distributed generation (DG) installation to minimize system average interruption duration index (SAIDI), an important reliability index. Brown et al. [27] used sequential feeder method and a multi-objective genetic algorithm (GA) together to solve the optimization of the feeder addition problem in an islanded distribution system with DGs. Vitorino et al. [28] presented the application of an improved genetic algorithm (IGA) to optimize simultaneously loss and reliability of a radial distribution system through a process of network reconfiguration as an optimization. Zhang et al. [29] proposed a reliability-oriented reconfiguration (ROR) method for improving distribution reliability and energy efficiency, based on interval analysis. Pfitscher et al. [30] presented a new methodology for automatic reconfiguration of distribution network, in order to improve network performance indicators, such as losses and reliability. Kavousi-Fard and Akbari-Zadeh [31] proposed a multi-objective distribution feeder reconfiguration problem for reliability enhancement as well as loss reduction. Raofat [32] adopted a GA based method to allocate DGs and RCSs simultaneously in order to reduce energy loss and improve reliability considering multilevel load.

Recently, Pinar Civicioglu [33] introduced a new algorithm named differential search (DS) algorithm to solve the problem of transforming geocentric cartesian coordinates into geodetic coordinates and compared its performance with classical methods and other computational intelligence algorithms. DS algorithm adopts the seasonal migration behavior of many organisms where they shift from one habitat to a more efficient one, in terms of efficiency of food areas. The individual organisms form a *Superorganism* which as a whole move toward more efficient area. The effectiveness of DS algorithm has already been compared with other algorithms such as artificial bee colony algorithm (ABC), self-adaptive differential evolution algorithm (JDE), adaptive differential evolution algorithm (JADE), strategy adaptation based differential evolution algorithm (SADE), differential evolution algorithm with ensemble of parameters (EPSDE), gravitational search algorithm (GSA), particle swarm optimization (PSO) and covariance matrix adaptation evolution strategy (CMA-ES). DS algorithm has been found to solve the problem at a very high level of accuracy [33]. Unlike other algorithms such as differential evolutionary algorithm (DE), JDE, and ABC, DS algorithm may simultaneously use more than one individual during updating steps. An important advantage of DS algorithm over many other algorithms is that DS algorithm has no inclination to correctly approach the best possible solution. Therefore, exploration ability of the algorithm is significantly improved compared to many other existing algorithms. Hence, it may be proved to be a successful strategy for solution of multimodal functions.

Please cite this article in press as: Ray S et al., Optimal allocation of remote control switches in radial distribution network for reliability improvement, Ain Shams Eng J (2016), http://dx.doi.org/10.1016/j.asej.2016.01.001