A Heuristic Approach for Multi Objective Distribution Feeder Reconfiguration: Using Fuzzy Sets in Normalization of Objective Functions

Armin Ebrahimi Milani, Islamic Azad University, Iran
Mahmood Reza Haghigham, Tarbiat Modarres University, Iran

ABSTRACT

The reconfiguration is an operation process used for optimization with specific objectives by means of changing the status of switches in a distribution network. This paper presents an algorithm for network configuration based on the heuristic rules and fuzzy multi objective approach where each objective is normalized with inspiration from fuzzy set to cause optimization more flexible and formalized as a unique multi objective function. Also, the genetic algorithm is used for solving the suggested model, in which there is no risk of non-linear objective functions and constraints. The effectiveness of the proposed method is demonstrated through several examples in this paper.

Keywords: Distribution Systems, Fuzzy Logic, Genetic Algorithm, Multi-Objective Function, Optimization, Reconfiguration

1. INTRODUCTION

In the original configuration of a distribution network there are some normally open (N.O.) and some normally closed (N.C) switches. Clearly, in order to reach specific purposes, we can close some of N.O switches and open corresponding N.C ones. The whole mentioned operation for reaching a new optimized configuration is named “Reconfiguration of distribution networks”.

In general, reconfiguration methods can be divided to two groups: “General” and “Specific”. In the specific methods, one initial answer is obtained and is used in a specific algorithm to reach further answers up to an improvement point considering the constraints of the problem. In general methods, an algorithm is used for solving the problem and a large range of answer are obtained, among which by performing an
operation the most improved answer is selected as a final one.

So far, several different techniques have been presented to resolve the network reconfiguration problem. For instance, Civanlar et al. in (Civanlar, Grainger, Yin, & Lee, 1998) described a formula to estimate the loss change resulting from the transfer of a group of loads from one feeder to another feeder. In Baran and Wu (1989) a heuristic algorithm was employed to minimize the power loss and load balancing, while Liu, Lee, and Vu (1989) developed a global optimality condition for the problem and two solution algorithms.

Shirmohammadi et al. (Shirmohammadi & Hong, 1989) described a technique for the reconfiguration of distribution networks to decrease their resistive line losses and included results pertaining to large scale system examples. In Wang, Chiang, and Darling (1996) explicit loss reduction and line flow formulas were developed to determine efficiently the switching operations.

Recently, AI-based approaches have been described to solve the problem and the results of such methods as the expert system (Liu, Lee, & Venkata, 1988), Genetic algorithm (Nara, Shiose, Kitagawa, & Ishihara, 1992), neural network (Kim, Ko, & Jung, 1993), simulated annealing (Chang & Kuo, 1994), evolutionary programming (EP) (Lin, Cheng, & Tsay, 1999), and fuzzy logic (Zhou, Shirmohammadi, & Liu, 1997; Prasad, Ranjan, Sahoo, & Chaturvedi, 2005) are all encouraging. Where their methodologies in (Zhou, Shirmohammadi, & Liu, 1997) combined the optimization techniques with heuristic rules and fuzzy logic for efficiency and robust performance and (Prasad, Ranjan, Sahoo, & Chaturvedi, 2005) presented a fuzzy mutated genetic algorithm for optimal reconfiguration of radial distribution systems. This method involves a new chromosome representation of the network and a fuzzy mutation control for an effective search of solution space.

As it is clear, in the most introduced methods a uni-objective function is considered for solving the problem and due to the importance of the power loss minimization, reconfiguration with the purpose of reduction in loss is highly signified.

In this essay four objectives, included in one multi-objective function with weight factors related to each objective are considered as following:

1. Minimization of the system’s power loss;
2. Minimization of the deviation of nodes voltage;
3. Minimization of the branch current constraint violation;
4. Load balancing among various feeders.

For normalization of each function, fuzzy sets are used to make reconfiguration more flexible not only to satisfy realistic objectives and soft constraints, but also to supply rigorous mathematical and heuristic approaches within the problem-solving process.

The fuzzy set theory provides an excellent framework for integrating the mathematical and heuristic approach into a more realistic formulation of the reconfiguration, while keeping an efficient computation (Huang, 2002). Owing to the non-commensurable characteristics of the objectives, a conventional approach that optimizes a single objective function is inappropriate for this problem. The fuzzy sets is therefore adopted to simultaneously consider the multiple objectives and to obtain a fuzzy satisfaction maximizing decision.

Meanwhile, Genetic algorithm is considered to be an efficient method for solving the large-scale combinatorial optimization problem, due to its ability to search global or near global optimal solutions and its appropriateness for parallel computing in which there is no risk of non-linear objective functions and constraints.

Finally the numerical results of the proposed method used on a simple network are provided for more study.

2. PROBLEM FORMULATION

As mentioned earlier, reconfiguration of distribution feeders is done by means of changing the
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