Electric Power Systems Research 80 (2010) 893–897

Contents lists available at ScienceDirect

Electric Power Systems Research

journal homepage: www.elsevier.com/locate/epsr

A fuzzy expert system for loss reduction and voltage control in radial distribution systems

A.Y. Abdelaziz*, S.F. Mekhamer, M.H. Nada

Electrical Power and Machines Department, Faculty of Engineering, Ain Shams University, 1 Elsarayat Street, Abdo Basha Square, Abbassia, Cairo, Egypt

ARTICLE INFO

Article history:
Received 8 June 2007
Received in revised form
29 September 2009
Accepted 30 December 2009
Available online 20 January 2010

Keywords:
Capacitor placement
Fuzzy expert system
Voltage regulator
Power loss reduction
Voltage profile

ABSTRACT

In this paper, two methods for improving voltage profile and minimizing total system losses in radial distribution feeders are presented. The first method concerns with the capacitor allocation problem. Fuzzy expert system (FES) is used to select the best candidate nodes for capacitors to be installed in order to maximize total loss reduction and total net savings. The second method illustrated the voltage regulator problem. In this method, the location and the tapping ratio of the voltage regulators are determined in order to minimize total system losses while keeping the voltage within specified limits. The two methods have been applied to two test feeders. Comparison with other techniques is included to ensure methods validity and superiority.

1. Introduction

Optimal reactive power and voltage control for distribution system involves the installation of fixed shunt capacitors and tap-changing voltage regulators along distribution feeders. This can improve voltage profiles for all end-use customers and reduce real power losses. Many studies and several algorithms have been presented for reactive power compensation problem solution. These algorithms are classified into analytical, numerical programming; heuristic techniques and artificial intelligence based (AI-based) methods [1–3]. Also, many papers have dealt with the problem of capacitor allocation in distribution systems using artificial neural networks (ANN). Some of these papers are devoted to ANN-based control of capacitors in distribution systems for the purpose of power loss reduction with and without considering voltage regulators [4–6].

Although these previous methods to solve the capacitor allocation problem have various merits, their efficiency rely entirely on the goodness of the data used. Fuzzy-set theory (FST) provides a remedy for any lack of uncertainty in the data. Furthermore, fuzzy logic has the advantage of including heuristics and respectively engineering judgements into the capacitor allocation optimization process.

Mekhamer et al. [7] have presented two new heuristic techniques by assuming every node in the system as a candidate node. They selected the node that gives maximum cost reduction (first technique) and the node that gives maximum loss reduction (second technique).

In Ref. [8], a fuzzy-based approach for capacitor placement in a distribution system has been presented. The problem as a fuzzy-set optimization problem has been formulated to minimize the real power loss and the system cost with voltage limiting constraints. Two membership functions of voltage sensitivity and real power loss have been stated and the intersection principle was used as a decision making to find the optimum locations at which capacitors should be installed.

In Ref. [9], the authors presented the same membership functions used in Ref. [8] but they replaced the real losses by reactive losses membership function and instead of using the intersection principle as a decision making, they used the dot product to determine the suitable locations of capacitors.

In Ref. [10], the authors made some modifications in the weighting factors of the membership functions presented in Refs. [7,8] which give better results by giving an importance of 20–30% to the voltage sensitivity index and an importance of 70–80% to the power loss index.

A fuzzy logic based algorithm to select the best candidate nodes by creating two input membership functions for voltage and power loss index and an output one for capacitor placement suitability has been presented in Ref. [11]. Capacitor sizing algorithm and variational technique are used to determine the optimal size of

* Corresponding author. Tel.: +20 10 1372930.
E-mail addresses: almoatazabdelaziz@hotmail.com, ayabdelaziz@gawab.com (A.Y. Abdelaziz).

0378-7796/$ – see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.epsr.2009.12.020