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International Review of Electrical Engineering (I.R.E.E.), Vol. 9, N. 3
ISSN 1827-6660
May – June 2014

Optimization of Distribution Network Configuration with Integration of Distributed Energy Resources Using Extended Fuzzy Multi-objective Method

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Abstract – *This paper proposes a reconfiguration methodology that aims for achieving the minimum active power loss of radial distribution networks with integration of distributed energy resources (DER) in order to improve the distribution system performance. The problems of power system operations and planning schemes will be arising due to the presence of DER to the distribution systems, such losses will rise and the increase of the voltage at which there are many DER. One of the popular efforts to improve the performance of the distribution system is network reconfiguration. In this study, reconfiguration method proposed is based on an extended fuzzy multi-objective approach. Multi-objective function are considered for minimization of the active power loss, deviation of bus voltage, and load balancing among the feeders, while subject to a radial network structure in which all loads must be energized. In this case, all objectives may be simultaneously weighted. The implementation of the extended fuzzy multi-objective for reconfiguration of distribution network with integration of DER on IEEE 77-bus distribution network and Yogyakarta 60-bus distribution network are described. The simulation results show that a 1.80% of efficiency improvement is achieved for IEEE 77-bus network, and a 0.11% of Yogyakarta 60-bus network efficiency improvement is achieved by the method.*

***Keywords**: Fuzzy Logic, Multi-objective, Distribution Networks, Efficiency, Distributed Energy Resources.*

Nomenclature

P_{loss}	Acive power loss.
P_i	Active power flowing out of bus *i*.
Q_i	Reactive power flowing out of bus *i*.
nb	Number of branch.
R_i	Resistance at bus *i*.
V_i	Voltage magnitude at bus *i*.
N_k	Total number of branches in the loop including sectionalyzing-branch and tie-branch when i-th tie-switch is closed.
$P_{loss,i}$	Total active power loss of the system when i-th branch in the loop is opened.
$P_{loss,B}$	Total active power loss before reconfiguration.
α_i	Minimization factor of power loss.
$\mu(\alpha_i)$	Membership value for power loss.
β_i	Maximization factor of bus voltage deviation.
$\mu(\beta_i)$	Membership value for bus voltage deviation.
N_B	Total number of bus of the system.
V_s	Voltage of the substation, in p.u.
$V_{i,j}$	Voltage of node corresponding to the opening of the i-th branch in the loop, in p.u.
$\lvert I_{i,m}\rvert$	Electric current magnitude of branch-m when the i-th branch in the loop is opened.
$I_{c,m}$	Line capacity of branch-m.
χ_i	Maximization factor of branch current loading index.
$\mu(\chi_i)$	Membership value for current loading index.
LBI	Load balancing index, represents the degree of loading among feeders.
$IF_{i,j}$	Electric current of feeder corresponding to the opening of the i-th branch in the loop.
$IFF_{i,max}$	Maximum of all the currents corresponding to the opening of the i-th branch in the loop = $\max(IF_{i,j})$, for $j = 1, 2, 3, \ldots, N_F$.
δ_i	Maximization factor of load balancing index.
$\mu(\delta_i)$	Membership value for load balancing index.
$D_{k,i}$	Fuzzy decision for overal satisfaction.
OS_k	Fuzzy decision for optimal solution.

I. Introduction

Most of power distribution systems operate in radial structure. The distribution systems have sectionalizing switches that remain normally closed and tie switches that remain normally open in order to configure distribution

DOI: http://dx.doi.org/10.15866/iree.v9i3.956

Manuscript received February 2014, revised May 2014, accepted June 2014