NETWORK RECONFIGURATION AND DISTRIBUTED GENERATION SIZING IN RADIAL DISTRIBUTION NETWORK USING PARTICLE SWARM OPTIMIZATION

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To my beloved family and friends

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ABSTRACT

The increasing energy demands are stressing the generation and transmission capabilities of the power system. The performance of distribution system becomes degraded due to increase of distribution losses and reduction in voltage magnitude. With addition of Distributed Generation (DG) in effective manner in the distribution system, these problems can be solved to enhance the performance of the system. This project report presents an effective method based on Particle swarm Optimization (PSO) to solve the network reconfiguration problem in the presence of DG with an objective of minimizing real power loss as well as improving voltage profile in distribution network. PSO is used to simultaneously reconfigure and optimum value of DG size in a radial distribution network. A method based on PSO algorithm to determine the minimum configuration is presented and their impact on the network real power losses and voltage profiles are investigated. The method has been tested on IEEE 33-bus test systems to demonstrate the performance and effectiveness of the proposed method**.** The results show that the PSO algorithm for real power loss minimization and voltage profile improvement to be the most effective compare to other methods.

ABSTRAK

Peningkatan keperluan tenaga adalah memberi tekanan kepada janakuasa dan keupayaan penghantaran di dalam sistem kuasa. Keupayaan sistem pembahagi berkurangan disebabkan peningkatan kehilangan penghantaran dan pengurangan di dalam magnitud voltan. Dengan penambahan Penjana Pembahagi(DG) dalam cara berkesan di dalam sistem pembahagi, masalah tersebut dapat diselesaikan untuk meningkatkan keupayaan sistem. Laporan projek ini menunjukkan keberkesanan berdasarkan kaedah Sekumpulan Zarah Pengoptimuman (PSO) untuk menyelesaikan masalah pengstrukturan semula rangkaian bersama DG dengan tujuan merendahkan kehilangan kuasa sebenar beserta meningkatkan profil voltan di dalam rangkaian pengagihan. PSO digunakan dengan serentak bersama pengstrukturan semula dan nilai saiz optimum DG di dalam rangkaian pengagihan jejari. Kaedah berdasarkan algoritma PSO ini mengenalpasti konfigurasi terendah dan kesan terhadap kehilangan kuasa sebenar rangkaian dan profil voltan dikaji. Kaedah ini diuji pada IEEE sistem bas 33 untuk membuktikan keupayaan dan keberkesanan kaedah yang dicadangkan. Keputusan menunjukkan algoritma PSO adalah paling berkesan untuk merendahkan kehilangan kuasa sebenar dan meningkatkan profil voltan berbanding kaedah yang lain.

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LIST OF ABBREVIATIONS

AC	-	Alternating Current
ABC	-	Artificial Bee Colony
ACA	-	Ant Colony Algorithm
ACSA	-	Ant Colony Search Algorithm
AIS	-	Artificial Immune System
BFO	-	Bacterial Foraging Algorithm
CHP	-	Combined Heat and Power
DE	-	Differential Evolution
DG	-	Distributed Generation
EP	-	Evolutionary Program
EPRI	-	Electric Power Research Institute
FS	-	Fuzzy Search
GA	-	Genetic Algorithm
Gbest	-	Global best
GW	-	GigaWatt
HC-ACO	-	Hyper Cube-Ant Colony Optimization
IEEE	-	Institute of Electrical and Electronics Engineers
KV	-	kiloVolt
kW	-	kiloWatt
KWh -	-	kiloWatt hour
MATLAB	-	Matrix Laboratory
MW	-	MegaWatt
Pbest	-	Local best
PSO	-	Particle Swarm Optimization
REPSO	-	Rank Evolutionary Particle Swarm Optimization

TS	-	Tabu Search
TOPO	-	Tie- Open Point Optimization
TD	-	Transmission and Distribution

LIST OF SYMBOLS

f_c	-	Loss function
I_i	-	Current in branch *i*
R_i	-	Resistance of branch *i*
N	-	The total number of branches
k_i	-	The variable that represents the topology status of the branches
p_i^{min}	-	The lower bound of DG output
p_i^{max}	-	The upper bound of DG output
I_k^{max}	-	Maximum current capability of branch k
V_i, V_j	-	Voltage magnitude of bus i and j respectively
δ_i, δ_j	-	Voltage angle of bus i and bus j respectively
Y_{ij}, θ_{ij}	-	Magnitude and angle of *Yij* element in the bus admittance matrix respectively
ΔP_i	-	Difference in real power
ΔQ_i	-	Difference in reactive power
P_{loss}	-	Power loss
P_i, Q_i	-	Real and reactive power of bus *i* respectively
P_j, Q_j	-	Real and reactive power of bus *j* respectively
R_{ij}	-	Line resistance between bus *i* and *j*
V_i, V_j	-	Voltage magnitude of bus *i* and *j* respectively
δ_i, δ_j	-	Voltage angle of bus *i* and *j* respectively
P_i	-	The previous best position
G_i	-	The best of all positions
C_1 and C_2	-	Positive constants
ω	-	The velocity of individual *i* at iteration *k*

$rand_1$, $rand_2$	-	random numbers between [1, 0]
X_i^k	-	The position of individual *i* at iteration *k*
P_i^k	-	The best position of individual *i* up to iteration *k*
G_i^k	-	The best position of the group *i* up to iteration *k*
t_{max}	-	The maximum number of iteration
t	-	The current iteration number
ω_{max}	-	Maximum and minimum of the inertia weight
ω_{min}	-	Maximum and minimum of the inertia weight
S	-	The variable for tie switches
p_g	-	DG size is represented by
β	-	The number of tie line
α	-	The number of DG

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CHAPTER 1

INTRODUCTION

1.1 Overview

Electric power system is the key to industrial progress, which is important to the continual development in the standard of living of the people in the world. Normally, power system network comprise electrical components that used to supply, transmit and distribute electric power. An example of an electric power system is the network that supplies a town and industry with power – for large regions, this power system can be broadly separated into the generators that supply the power, the transmission line that carries the power from the generating centers to the load centers and the distribution system that supply the power to nearby households and industries.

Electricity distribution is the final phase in the delivery of electricity to end-users. The majority of the distribution system feeders are design radially. Radial distribution feeders are delivered through a single voltage source (distribution substation). The main feeders branch into lateral and sub laterals, which finally connect to the customer service switches. The distribution system feeders consist of tie (normally-open) and sectionalizing (normally-closed) switches. These switches are used to enhance the distribution network consistency and to make sure continuous service for the majority of the load in the case of system faults. When a fault happens in the distribution system, the tie and sectionalizing switches can be coordinated so that the fault is separated and loads can be changed from one feeder to another, which minimizes the number of customer affected by the outage fault and reduce the restoration time. The operation of the tie and sectionalizing switches in the distribution system is referred to as *network reconfiguration.* It is one of the methods that have been applied for reducing losses in the distribution system. In 1975, Merlin and Back first proposed the theory of utilizing existing tie and sectionalizing switches to reconfigure the distribution system for minimizing line losses during a specific load condition [1].

Network reconfiguration changes the topological structure of the distribution system via changing the open/closed status of switches resulting in altering loads from the heavily loaded to the lightly loaded feeders while, at one time maintains the radial structure of distribution feeders. The difficulty of network reconfiguration is in general to place the optimal switching configuration, which results in minimum losses in the distribution system. Network reconfiguration is a challenging mission since there could be many probable combinations of sectionalizing switches and tie switches. Moreover, there are multiples of constraints, which must not be violated while finding an optimal or near optimal solution to that problem.

Nevertheless, due to dynamic character of loads, total system load is more than its generation capacity that makes relieving of load on the feeders not possible and for this reason voltage profile of the system will not be recovered to the required level. In order to meet up required level of load demand, DG units are incorporated in distribution network to improve voltage profile, to give reliable and uninterrupted power supply and also to accomplish economic benefits such as minimum power loss, energy efficiency and load leveling. Yet, network reconfiguration and DG placement in distribution networks are consider as independently [2].Studies have showed that inappropriate selection of the location and size of DG may lead to greater system losses without DG.

A lot of researchers studied network reconfiguration and DG placement problem using a variety of methods in the past decade. One of the recent and powerful soft computing techniques being developed is *Particle Swarm Optimization* (PSO) that is initially proposed by Dr. Eberhart and Dr. Kennedy in 1995[3].

1.2 Problem Statement

Reconfiguration in distribution systems is to find the optimal configuration of switches. Meanwhile Distributed Generators (DGs) are normally used in distribution systems to reduce the power disruption in the power system network. Reconfiguration and the installation of DGs in the distribution network, the total power loss can be reduced and voltage profile of the buses of the system can be improved. Simultaneous optimization of reconfiguration and DG power allocation tasks can give a more satisfying solution than separate optimization of each task. Previous work in this area normally focused on a single optimization, which may not be adequate for total improvement of the distribution network. For that reason, the use of an optimization method capable of indicating the best solution for a given distribution network can be very useful for the system planning engineer.

1.3 Objectives

The objectives of this project are as follows:

i. To implement a network reconfiguration method for distribution network connected with DGs to minimize the total real power losses and to improve voltage profile using Particle Swarm Optimization (PSO) algorithm.

ii. To produce an optimum reconfiguration and DGs sizing simultaneously in distribution network.

1.4 Scope of Project

Scope of work focused is as follows:

i. Investigation will cover on the impact of network reconfiguration and DGs sizing on the real power losses and voltage profile in radial distribution network.

ii. The modeling will cover the model of a single-line diagram radial distribution system includes the radial structure and DGs size in improving the real power losses and voltage profile of the distribution network.

1.5 Report Outline

This report has been divided into five chapters and one appendix. Chapter 1 introduces project background in general, explanation of the project objective and scope of work.

Chapter 2 describes several types of electric distribution system. This chapter also includes an explanation of what are network reconfiguration, Distributed Generation (DG) and recent ongoing effort for network reconfiguration and DG planning method.

Chapter 3 explains the proposed methodology to network reconfiguration for distributed network connected with DGs problem. The optimization technique used is particle swarm optimization, which will be applied on standard IEEE-33bus test system.

Chapter 4 includes the tabulated results of power loss reduction and voltage profile with their related diagrams and corresponding discussion.

Chapter 5 presents conclusion derived from this study and recommendations for future works.

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