THE DISTRIBUTION NETWORK RECONFIGURATION BY USING MULTI-POPULATION EVOLUTIONARY PROGRAMMING (MPEP) FOR LOSS MINIMIZING

Mohammad Hanif bin Jifri

Bachelor of Electrical Engineering (Industrial Power)

2015

THE DISTRIBUTION NETWORK RECONFIGURATION BY USING MULTI-POPULATION EVOLUTIONARY PROGRAMMING (MPEP) FOR LOSS MINIMIZING

MOHAMMAD HANIF BIN JIFRI

A report submitted in partial fulfillment of the requirement for the degree of Bachelor of Electrical Engineering (Power Industry)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

"I hereby declared that I have read through this report entitle "The Distribution Network Reconfiguration by Using Multi-Population Evolutionary Programming (MPEP) for Loss Minimizing" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering."

Signature : ……

Supervisor's Name : ……

Date : ……

Dedicated, in thankful application for support, encouragement and understandings to my beloved mother and father.

I declare that this report entitle "The Distribution Network Reconfiguration by Using Multi-Population Evolutionary Programming (MPEP) for Loss Minimizing" is the result of my own project except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

Name : ……

Date : ……

ACKNOWLEDGEMENT

First of all, I am greatly thankful to ALLAH SWT on His blessing to make this project successful.

I would like to express my gratitude to my supervisor, Mr. Mohamad Fani bin Sulaima for his valuable guidance, enthusiasm and motivation given throughout the progress of this project.

I would also like to thank my parents for always being there to support me at all times and for giving me the courage and strength that are necessary to carry on with this project. Thanks for their encouragement, love and emotional supports that they had given to me.

I would also like to thank all my friends who had given me the advice, courage and support in completing this Thesis. Their views and tips are very useful.

Last but not least, I would like to thank all the lecturers who have been very friendly and helpful in providing me with necessary information for my project.

ABSTRACT

Electric power distribution loss and reliability are major concerns in power system as the demand of electrical energy by customers keep increasing day by day. One of the suggested methods to minimize these problems is by doing reconfiguration process to existing distribution network. A reconfiguration is performed by opening or closing the sectionalizing switches and need to maintain the feeder in radial network. This study presents a method of Distribution Network Reconfiguration (DNR) by using Multi Population Evolutionary Programming (MPEP). The main objectives of this study are to minimize the power losses and improve the voltage profile. The performance of the Multi-population Evolutionary Programming (MPEP) method will be investigated and the impact to the distribution network will be analyzed and the algorithm (MPEP) will be applied on IEEE 16, 33 and 69 busses radial distribution systems network. The real result will be compared with the conventional initial network and other optimization technique which is conventional Evolutionary Programming (EP). The results of this study is hoped to help the electrical engineers (Power System) in Malaysia in order to solve the losses problem in the distribution network plant at the same time increasing the efficiency of the real distribution system.

ABSTRACT

Kehilangan kuasa elektrik pengagihan dan kebolehpercayaan adalah kebimbangan utama dalam sistem kuasa kerana permintaan tenaga elektrik oleh pelanggan semakin meningkat dari hari ke hari. Salah satu kaedah yang dicadangkan untuk menghadapi masalah ini ialah dengan melakukan proses konfigurasi semula rangkaian pengedaran yang sedia ada. A konfigurasi semula dilakukan dengan membuka atau menutup suis sectionalizing dan perlu mengekalkan feeder dalam rangkaian jejari. Kajian ini membentangkan kaedah Distribution Network Reconfiguration (DNR) dengan menggunakan kaedah Multi-Population Evolutionary Programming (MPEP). Objektif utama kajian ini adalah untuk mengurangkan kehilangan kuasa dan meningkatkan profil voltan. Prestasi Multi-Population Evolutionary Programming (MPEP) kaedah akan disiasat dan impak kepada rangkaian pengagihan akan dianalisis dan algoritma (MPEP) akan digunakan pada IEEE 16, 33 dan 69 bas Radial rangkaian sistem pengagihan. Keputusan sebenar akan dibandingkan dengan rangkaian awal konvensional dan teknik pengoptimuman Evolutionary Programming (EP). Hasil kajian ini diharap dapat membantu para jurutera elektrik (Sistem Kuasa) di Malaysia bagi menyelesaikan masalah kerugian dalam tumbuhan rangkaian pengedaran pada masa yang sama meningkatkan kecekapan sistem pengagihan yang sebenar.

TABLE OF CONTENTS

CHAPTER	TITLE		PAGE
	ACKNOWLEDGEMENT		**i**
	ABSTRACT		**ii**
	TABLE OF CONTENTS		**iii**
	LIST OF TABLES		**vii**
	LIST OF FIGURES		**viii**
	LIST OF APPENDICES		**ix**
1	**INTRODUCTION**		**1**
	1.1	Motivation	1
	1.2	Problem Statement	2
	1.3	Objective	2
	1.4	Scope	2
2	**LITERATURE REVIEW**		**3**
	2.1	Overview	3

CHAPTER	TITLE		PAGE
	2.2	Distribution Network Reconfiguration (DNR)	3
	2.3	Voltage Profile	6
	2.4	Power Loss	8
	2.5	Optimization Method in Network Reconfiguration	9
	2.6	Evolutionary Programming	11
	2.7	Multi-Population Evolutionary Programming (MPEP) in power system.	13
	2.8	Summary of the Chapter	13
3	**METHODOLOGY**		**14**
	3.1	Introduction on Multi-Population Evolutionary Programming (MPEP)	14
	3.2	Mathematical Formulation	14
	3.3	Evolutionary Programming	18
	3.4	Multi-population on Evolutionary Programming	21
	3.5	Implementation Method of MPEP	21
		3.5.1 Initialization	23
		3.5.2 Fitness Calculation	24
		3.5.3 Mutation	24
		3.5.4 Multi Population Technique	25
		3.5.5 Fitness Calculation & Combination	25

CHAPTER	TITLE	PAGE
	3.5.5 Tournament Selection	26
	3.5.6 Convergence Test	26
4	**RESULT**	**28**
	4.1 Overview	28
	4.2 The Simulation and Test System	28
	4.3 Data Collection	32
	4.3.1 Part A: Power Losses Reduction (PLR)	32
	4.3.2 Part B: Voltage Profile Improvement (VPI)	38
5	**ANALYSIS AND DISCUSSION**	**42**
	5.1 Part A: Power Losses Reduction (PLR)	42
	5.2 Part B: Voltage Profile Improvement (VPI)	49
6	**CONCLUSION AND RECOMMENDATION**	**52**
	6.1 Conclusion	52
	6.2 Recommendation	52
REFERENCES		**53**
APPENDICES		**59**

LIST OF TABLES

TABLE	TITLE	PAGE
4.1	Comparison Power Losses between EP-16 and MPEP-16.	33
4.2	Comparison Power Losses between EP-33 and MPEP-33.	34
4.3	Comparison Power Losses between EP-69 and MPEP-69.	35
4.4	Comparison Voltage Profile between Initial, EP-16 and MPEP-16.	38
4.5	Comparison Voltage Profile between Initial, EP-33 and MPEP-33.	39
4.6	Comparison Voltage Profile between Initial, EP-69 and MPEP-69.	40
4.7	Comparison Voltage Profile between Initial, EP-69 and MPEP-69.	41
5.1	Comparison Losses between 16-bus, 33-bus, and 69-bus	43

LIST OF FIGURES

FIGURE	TITLE	PAGE
3.1	Flowchart of Evolutionary Programming	20
3.2	Flowchart for Implementation MPEP Algorithm	27
4.1	Initial Configuration of the 16-Bus Radial Distribution System	29
4.2	Initial Configuration of the 33-Bus Radial Distribution System	30
4.3	Initial Configuration of the 69-Bus Radial Distribution System	31
4.4	Power Losses Reduction for 16kV	36
4.5	Power Losses Reduction for 33kV	36
4.6	Power Losses Reduction for 69kV	37
5.1	16-Bus after reconfiguration MPEP	45
5.2	33-Bus after reconfiguration MPEP	46
5.3	69-Bus after reconfiguration MPEP	47
5.4	16-Bus voltage profile improvement comparison between Initial, EP and MPEP reconfiguration.	49
5.5	33-Bus voltage profile improvement comparison between Initial, EP and MPEP reconfiguration.	50
5.6	69-Bus voltage profile improvement comparison between Initial, EP and MPEP reconfiguration.	50

LIST OF APPENDICES

APPENDIX	HOME		PAGE
A	1.	MATLAB Coding EP IEEE-16 Bus Test System	59
	2.	MATLAB Coding MPEP IEEE-16 Bus Test System	62
B	1.	MATLAB Coding EP IEEE-33 Bus Test System	65
	2.	MATLAB Coding MPEP IEEE-33 Bus Test System	69
C	1.	MATLAB Coding EP IEEE-69 Bus Test System	73
	2.	MATLAB Coding MPEP IEEE-69 Bus Test System	77

CHAPTER 1

INTRODUCTION

1.1 Motivation

There are three main parts in an electric power system; generate, transmit and distribute electrical supply to customers [1]. In distribution network, there are 33kV, 22kV, and 11kV of voltage level that interconnected to the transmission part of a power system. For 415V and 240V of level voltage, electric supply from the distribution power system to the consumer level. In developed countries such as Malaysia, the power losses should not more than 10%. As consumers keep increasing day by day, the demand of electric energy also increasing and as a result, the distribution lines are heavily loaded. From Electricity Supply Industry in Malaysia 2008 and 2012 report [2], maximum demand of grid system in Peninsular Malaysia has increasing from 13,620 MW on 2007 to 15,826 MW on 2012. While, total yearly electricity demand has increased in Peninsular Malaysia for 2008 was 99.548 GWh to 108,473 GWh in 2012. Hence, it is crucial to improve the reliability and efficiency of the distribution system network. The reliability of power supply is needed in order to minimize power losses and able to improve the voltage profile based on the distribution systems.

1.2 Problem Statement

In order to make sure a reliable and secure the system economically, the high demand in power system has become as a challenging job to most of the power system engineers. This is due to the heavy loaded network that would increase the load current drawn from the source and at the same time, it leads to an increasing in voltage drop and system losses. Each feeder in a distribution system has a different mixture of commercial, residential and industrial type loads, and it is well known that the daily load variations of these load types are dissimilar. With this regards, the ratio of power loss occurs on all lines in the network will not be constant. In order to give the best performance to the radial distribution structure and enhance the network efficiency, reconfiguration of the distribution network is needed. By changing the position of the switches in the existing network, different power loss is gained.

1.3 Objective

The objectives of this research are:

i. To reduce the power losses in the distribution network systems

ii. To improve the voltage profile in the distribution network systems

1.4 Scope

The scope for this research are to reduce the power losses in the distribution network systems and improve the voltage profile in the overall system with this scope are carry out on IEEE 16, 33, and 69 bus radial distribution network system in MATLAB environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

These parts are reviewed on five sections which are Distribution Network Reconfiguration, Voltage Profile, Power Losses, and related previous work. In Distribution Network Reconfiguration, research about the distribution network system will be presented to explain more about the distribution network system either for their type, or radially. In voltage profile and power losses, the studies with specific research performing voltage profile improvement and power loss reduction. Meanwhile, for related previous work, it is a finding on distribution network reconfiguration for power losses considering voltage profile improvement by variety of optimization method tested on 33kV bus radial.

2.2 Distribution Network Reconfiguration (DNR)

Distribution system is a low voltage system. It is a complex system because it consists of branches and sources compared to the transmission network. The voltage from the transmission line is reduced using a transformer to a lower value. Distribution systems normally use voltages of 11kV, 22kV and 33kV. The typical distribution line voltage in Malaysia is 11kV and 22kV.

An 11kV/415V transformer is used to supply 3-phase consumers and 240V is supplied to single-phase consumers such as houses and similar loads. The design of distribution systems is divided into three types which are radial, loop and mesh systems. However, in practice, all these designs are normally combined or incorporated together [3].

Distribution networks are configured by branch in tree-shaped net and it usually operated radially. It also can be closed if necessary in order to maintain the reliability and flexibility and opened in distribution network usually. Under certain load state, the bus voltage, branch current and bus injection current are also got when the load flow of tree-shaped network is calculated. The changes of bus voltage are considered to be slight during the reconfiguration operation, so the bus injection currents can be considered to be constant. Some branches must be opened and become to be links in order to maintain the distribution network in radial formation, that mean the number of the links must not be changed [4].

The characteristics of distribution network are an insufficient information about loads, radial or weakly meshed topology, multiphase and unbalanced operation; unbalanced distributed load, extremely large number of branches and nodes; also have high resistance to resistance ratio (R/X) [5].

The connection of distribution network is divided into three types which are radial, ring and mesh system. Usually, ring and mesh system can be developed for the radial distribution network. The distribution network is developed from a cascaded system which has a lot of branches, buses, loads and switches. The network is divided into several radial systems so that they can be easily analyzed and isolate if any fault happened [6].

In generally it have two types of switches in distribution networks, one is the normally closed switches, which connect line sections, and the other normally open switches on the tie-line, which connect two feeders or loop type laterals. The latter type is referred to as tie switches and the former type is called sectionalizing switches. It have two type of switches which are designed for both protection and configuration management. The process of changing the topology of distribution networks by opening or closing of these two types of switches are network reconfiguration [7].

Electric power distribution losses are the one of major concern in power system as the demand of electrical energy is increasing day by day. Minimum monitoring systems such as local and manual control of capacitors, sectionalizing switches and voltage regulators are dealing in most of distribution system network [8].

There are a few approaches had been introduced for improving the efficiency of electrical networks and one of approach had been introduced is a reconfiguration of the distribution network. Reconfiguration of the distribution network is restructuring the power lines which connect various buses in a power system [9].

Ahuja and Pahwa presented an algorithm based on hybridization of pheromones derived from ant colony optimization with crossover operator and was applied to minimize real losses in distribution systems using reconfiguration. The algorithm maintained a population of candidate solutions and a table of pheromones to reinforce better edges during search process. Exploration for better solutions was performed by means of crossover operator directed by the information stored in the pheromone table. The hybrid approach had been successfully implemented on three test networks [10].

Nayak solved a feeder reconfiguration problem in the presence of distributed generators to minimize the system power loss while satisfying operating constraints using Hyper Cube-Ant Colony Optimization (HC-ACO) algorithm. Loss Sensitivity analysis was used to identify optimal location for installation of DG units. Simulations were conducted on 33 – bus radial distribution system at four different cases to verify the efficacy of the proposed method with other recent published approaches reported in the literature. The results were fast and effective [11].

Configuration can be done from time to time since the distribution network consist different load characteristics such as residential, commercial and industrial type of loads. Besides that, the distribution network is loaded at a specific time in a day. There are a lot of benefits of network reconfiguration [12]:

1. Efficient electric distribution network
2. Improves voltage stability
3. Smooth the peak demand
4. Increase network reliability
5. Reduce cost installation of switching equipment

6. Minimize the real power losses

7. Relieves the overloading of network components and in the feeders

8. Balancing system load

2.3 Voltage Profile

In power systems operation voltage stability is an important factor to be considered planning since voltage instability would bring to system collapse. The problem that exist can been defined as inability of the power system to provide non-uniform consumption of reactive power or reactive power of large power systems in contingency situation, especially in developing countries because of non-uniform growth of load demand in the reactive power management side. In voltage stability analysis the loads generally play a key role and therefore the voltage stability is known as load stability [13].

The connection of micro generations can be affected by systems voltage profile, usually at the point of connection resulting in an increase in the local voltage. With reactive power injection one of the most effective methods for improving network voltage profiles in several significant operational problems which can be achieved by other more conventional methods or employing suitable devices. Distributed Static Series Compensated (DSSC) is suggested to improve voltage profile in the power distribution networks [14].

Voltage profile can be calculated along a given transmission line during a system transient. This method can be used to detect low level of voltage signals that appear along the length of a long transmission line during transients caused by switching events or faults also useful in obtaining screen shots of waveforms used in animation of travelling wave transients. Voltage profile can be recovered at intermediates points along the length of the line using time series model. The voltage profile along a transmission can be obtained by back-solving the line's traveling wave equations along the length of the line for the desired discrete points once the terminal bus voltage are known [15].

The optimization problem is subjected to system constraints consisting of load-point voltage limits, radial configuration format in feeder reconfiguration problem to the distribution system with distributed generation can be solved by improve the bus voltage profile. The advantages of distribution feeders by changing the open/ closed status of its sectionalizing and tie switches in order to find a real power loss reduction, balancing system load, bus voltage profile improvement, increasing system security and reliability, and power quality improvement. Secondary goal impacting in useful life of equipment can be seen by minimizing switch-on/switch-off operations [16].

The impact of maintaining the load bus voltages within permissible limit will ensure the quality and reliability of supply to the customer [17]. Changes in the power demands and system configuration will give impact towards voltage levels either high or low in the systems and by reactive power generation reallocating the voltage profile can be improved. To improve voltage profile system in a power systems, it is necessary to improve the realization of reactive power generations.

The security and reliability problem with the system operation will always occur if there is a stress condition in power systems due to many factors such as overexploitation of existing transmission systems, the limited number of new power station projects, and new regulations, are affecting them. In the form of a progressive rise or fall of voltages in some buses resulting instabilities may occur. If the voltage instable, may results in loss of load in an area, transmission line tripping, and other elements by protective system that leads to cascading outages [18].

Distributed generation is any electricity generating technology installed by a customer or independent electricity producer that is connected at the distribution system level of the electric grid. Due to the installation of DGs in the system, the total power loss can be reduced and voltage profile of the buses can be improved due to this power quality of the distribution system is improved. Therefore, Particle Swarm Optimization (PSO) is proposed based approach is tested on an IEEE 30-bus test system [19].

In [20], two modes of operation voltage-control mode and reactive power control mode modified the system loss and voltage profile. A coordinated static VAr compensator (SVC)

device is proposed. A performance index for evaluating the impact of VAr optimization with coordinated SVC model on loss minimization and voltage improvement are proved.

2.4 Power Loss

Active and reactive power in a system need to be control for power loss minimization and improving voltage profile, which by optimizing the active power flow with network reconfiguration and reducing reactive power by capacitor control can achieves these goals. Two different properties and limitations will strengthen each other in the combination of capacitor control and network reconfiguration for better optimization results in distribution systems [21].

Commercial, residential and industrial type loads have a different mixture for each feeder in a distribution systems and it is well known that the daily load variations of these load types are dissimilar. In terms transfer of altering the level of loads are effective on the feeders being switched, but also in improving the voltage profile along the feeders and effecting reductions in the overall system power losses. The topology of an Electrical Distribution System (EDS) can be suitably modified the radial structure of the distribution feeders from time to time, by changing the open/closed states of the switches to transfer loads from one feeder to another, may significantly improve the operating conditions of the overall system also can minimize the real losses [22].

Altering the topological structures of distribution feeders by changing the open and closed states of normally-closed and normally-open switched is the purpose of network reconfiguration. However, it would lead to the improvement of quality, reliability and economic such as in voltage profile, service restoration, energy efficiency, loss minimization and also load leveling. The dropping in voltage magnitude and intensification in distribution losses will affect the performance of distribution system turn out to be inefficient [23].

A great deal of work has been done on feeder reconfiguration mainly in the context of active power loss reduction because the cost of MW loss occupies considerable amount of operating cost in distribution system and therefore small amount achieved from loss reduction is still attractive for electric power utilities. Using a three-phase power flow algorithm the system

power losses and bus voltages are solved. The advantages from feeder reconfiguration is obtained such as real power loss reduction, balancing system load, bus voltage profile improvement, and increasing system security and reliability [24].

2.5 Optimization Method in Network Reconfiguration

For distribution network reconfiguration of electric energy distribution, a methodology based on Ant Colony System (ACS) algorithm is proposed in [25]. Constraints such as transmission capabilities and voltage magnitudes limits, it is said to be very flexible method in finding the optimal network with lower transmission losses. It said that ACS is the suitable method in reconfiguration because of its positive feedback, distributed computation, and greedy heuristic.

In [26], the complexity of new generation power system has contributed to the high power losses and over load in the distribution network. Therefore, Rank Evolutionary Particle Swarm Optimization (REPSO) is proposed. The method that use lead the improvement of voltage profile while solves the overload problem by reducing the power losses respectively.

In [27], for power losses reducing in distribution network, the Network Partitioning Theory novel method is proposed which also offer numerous advantages without limitation towards the maximum size of distribution systems in real time. The computational burden of the reconfiguration not only reduces by the partitioning operation serves but also minimize losses on line from the cut set. It is said that proposed algorithm can be used also in industrial and electric utility applications.

Most of the power system engineers worried about the high demand in power system and it became as a challenging job. The method using Evolutionary Particle Swarm Optimization (EPSO) is proposed. Therefore, the power losses is minimized and also improve the voltage profile in the overall power system meanwhile reduced the computational time [28].

In [29], results that got reflects in distribution network reconfiguration sometimes is because of the computation time of the algorithm to finalize in the program. A method of load forecasting which adopted GA algorithm is proposed in solve the distribution network reconfiguration for power losses.

The distribution systems problems can generally be divided into two different categories: long-term planning and operational planning. Multi-Objective Evolutionary Programming Method is applied in order to overcome the problem and the weakness of traditional GA. Actual data was used and also providing achieves the better performance [30].

The minimum the feeder losses, the better the distribution network which will act as a target function [31]. Radical distribution network is decided each nodes in degree using Hopfield neural network and either it will be used or not. The state of switch can be decided correspondingly same as the scheme of reconfiguration. For energy function, radial supplying and feeder power losses are considered. Some line also may have no switches so the energy function takes that into consideration.

Network reconfiguration for loss reduction in distribution systems is a very important way to save energy. Fuzzy Controlled Evolutionary Programming is proposed to improved Evolutionary Programming application in distribution network reconfiguration. Using heuristics methods and mathematical optimization techniques or combination show the positive result within the power losses is minimized and improve the reliability of power supply by changing the status of existing sectionalizing switches and ties. Distribution loss minimum reconfiguration is an improved by Fuzzy Controlled Evolutionary Programming technique [32].

In [33], power distribution connects all from generation to consumer. The objective is to minimize the power losses of distribution network. The genetic simulated annealing algorithm is proposed which cover all the speed in simulated and solve for premature convergence in GA.

For distribution system, loss reduction is important in saving the energy in [34]. The method using Ant Colony System (ACS) algorithm is proposed and is said to be very flexible