DISTRBUTION NETWORK RECONFIGURATION BY USING EVOLUTIONARY PROGRAMING (EP) FOR MINIMIZING POWER LOSSES

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Bachelor of Electrical Engineering (Industrial Power)

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"I hereby declare that I have read through this report entitle "Distribution Network Reconfiguration by Using Evolutionary Programming (EP) for minimizing power losses" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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DISTRIBUTION NETWORK RECONFIGURATION BY USING EVOLUTIONARY PROGRAMMING (EP) FOR MINIMIZING POWER LOSSES

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

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I declare that this report entitle “Distribution Network Reconfiguration by Using Evolutionary Programming (EP) for Minimizing Power Losses” is the result of my own research 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	:	.....
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Date	:	9 JUNE 2014

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To my beloved mother and father

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ABSTRACT

In the worldwide trend toward restructuring the electricity network, there are a lot of problem. System power loss is one of the problems of distribution utilities. There are a lot of things affecting circuit loss such as sub-optimal configuration of the network, unbalance loading and unbalance line impedance. Currently, by the increasing the electricity demand, intelligence algorithm is one of the solutions that may help in minimizing the power losses in the power distribution network. This project presents a reconfiguration of the modern complex distribution network. The main objectives of this study are to minimize the power losses and improve the voltage profile while analysing the consistency and computing time effectively. The performance of Evolutionary Programming (EP) method for 16kV International Electronic Electrical Engineering (IEEE) test system has been compared with Genetic Algorithm (GA). While, EP achived 90% improvement better than GA respectively. From the result obtain, it can be concluded that EP algorithm is better in power loss reduction if to be compared to the GA algorithm. The results of this study is to help the power system engineers in Malaysia in order to solve the losses problem in the plant at the same time increasing the efficiency of the real 16-bus distribution system.

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ABSTRAK

Dalam trend di seluruh dunia ke arah penyusunan semula rangkaian elektrik ; terdapat banyak masalah. Sistem kehilangan kuasa adalah salah satu masalah pengedaran utiliti. Terdapat banyak perkara yang memberi kesan kepada kehilangan litar antaranya adalah seperti sub- optimum konfigurasi rangkaian , beban tidak seimbang dan talian impedans tidak seimbang. Pada masa ini, berdasarkan peningkatan permintaan elektrik, algoritma kecerdasan adalah salah satu penyelesaian yang boleh membantu dalam mengurangkan kehilangan kuasa dalam rangkaian pengagihan kuasa. Projek ini membentangkan konfigurasi semula rangkaian pengedaran kompleks moden. Objektif utama kajian ini adalah untuk mengurangkan kehilangan kuasa dan meningkatkan profil voltan manakala menganalisis konsisten dan masa pengiraan berkesan. Prestasi kaedah "Evolutionary Programming" (EP) untuk 16kV "International Electronic Electrical Engineering" (IEEE) sistem ujian telah dibanding dengan "Genetic Algorithm" (GA). Di mana, EP mendapat peningkatan 90% lebih baik daripada GA. Daripada hasil yang diperolehi, ia boleh disimpulkan bahawa algoritma EP adalah lebih baik dalam pengurangan kehilangan kuasa jika boleh dibandingkan dengan algoritma GA . Hasil kajian ini diharap dapat membantu para jurutera sistem kuasa di Malaysia untuk menyelesaikan masalah kerugian dalam penjanaan pada masa yang sama meningkatkankecekapan sistem pengagihan 16- bas yang sebenar.

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CHAPTER 1

INTRODUCTION

1.1 Research Motivation

A lot of interest in development and studies that can minimize energy cost and reducing transmission and distribution losses. Network reconfiguration is the best technique in order to minimize the losses in 11kV, 16kV, 33kV, 69kV and 129kV distribution system. Nevertheless, the reconfiguration for 16kV distribution network is critical and not frequent in Malaysia. So that, the research on 16kV distribution network by using Evolutionary Programming (EP) could be helpful in finding the optimal solution for this field of study. This study could be useful for Tenaga Nasional Berhad (TNB) or other large company as a reference for minimizing the power losses in the network system.

1.2 Problem Statement

Due to increasing the power system demand from the users, it will effect to the distribution network power losses. Distribution network failure will increase the operating cost and major in economic losses. The arrangement of open and close switches is one of the important role in order to reduce the power losses. In other word, the Evolutionary Programing may help to minimize the power losses in the distribution network system.

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1.3 Objectives

There are two objectives of this project. They are:

- To minimize the power losses in the distribution network system.
- To improve the voltage profile in the distribution network system.

1.4 Scope of Research

Scopes of this project are to focus on minimizing power losses by using the Evolutionary Programming (EP) method. Other than that, is focuses on a research of 16kV distribution network using the 16-bus test system distribution network and while remain on the radial network.

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CHAPTER 2

LITERATURE REVIEW

2.1 Overview

The literature review is past studies related to EP method, GA method and DNR system which is about reducing the power losses, improving the voltage profile and research finding about the performance of the DNR which is using the mathematic and optimization methods for minimizing the power losses that applied on medium voltage. The comparison between EP and GA method are also be review in history to compared their best method. The detail function of EP, GA method and DNR also had been discussed in previous related work.

2.2 Distribution System

The distribution system is the part which contents the distribution substations to consumers' service-entrance equipment. The primary distribution lines are usually in the range of 4 to 34.5kV. The small industrial customers are served directly by primary feeders. The secondary distribution network reduces the voltage for utilitization by commercial and residential consumers. The secondary distribution serves most of the costomers at level of 240/120 V, single-phase, three wire; 208Y/120 V, three-phase, four-wire; or 480Y/277 V, three-phase, four-wire. The power for a typical home is derived from a transformer that reduces the primary feeder voltage to 240/120 V using three-wire line.

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2.3 Types of Distribution Network

a. Radial

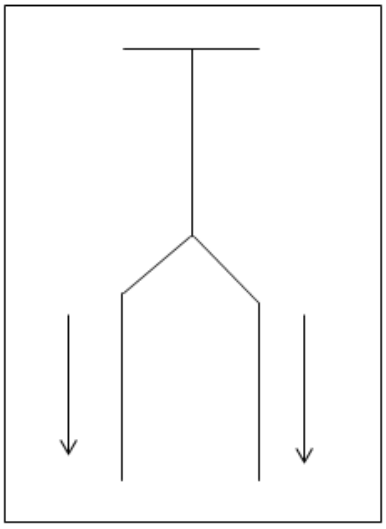

Figure 2.1: Radial system

- For radial, only one path between substation or servise transformer and customer. The power flow is from substation to customer along single path. Furthermore, radial is cheap and predictable to use and simple to analyse.

b. Loop

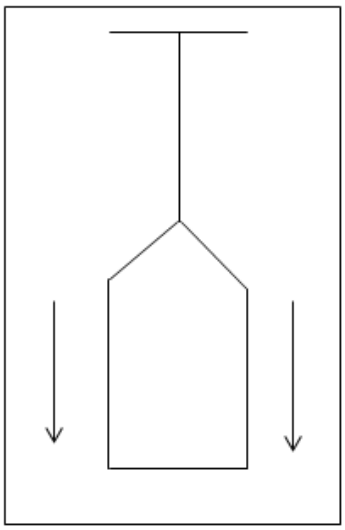

Figure 2.2: Loop system

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- For loop, two path between substation transformer and customer. Power flow is usually from both sides to the middle. The equipment is rated so that service can be maintained if an open point occurs in the system.

- Mesh

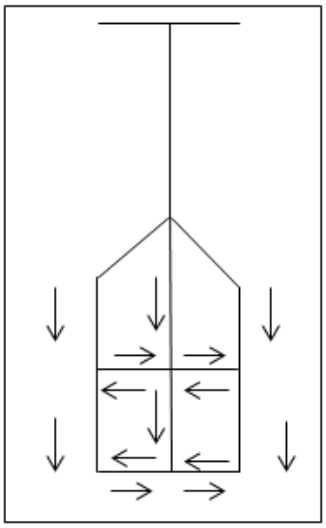

Figure 2.3: Mesh system

- For mesh, multiple path between all point in the network. Power flow between any two points is split along several paths. It is most realible method of distributing electricity. If failure occurs, power instantly reroutes itself. Other than that, it is usually used in high density urban area where maintenance and repairs are difficult and costly.

2.4 History of EP

Evolutionary computation started to receive significant attention during the last decade, although the origins can be detected back to the late 1950's [1]. This technique describe the purpose, the general structure, and the working principles of different approaches, including genetic algorithms (GA), evolution strategies (ES), and evolutionary programming (EP) by analysis and comparison of their most important constituents. In [2] the 1960s, Rechenberg (1965, 1973) introduced "evolution strategies" (Evolutions strategy in the original German), a method that used to optimize the parameters for devices such as airfoils. The idea then was further developed by Schwefel (1975, 1977). The field of

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evolutionary strategies has permanant an active area of research, mostly developing independently from the field of genetic algorithms (although recently the two communities have begun to interact). Fogel, Owens, and Walsh build "evolutionary programming," in 1966, a technique in which candidate solutions to given tasks were represented as finite−state machines, then by randomly mutating and after that selecting the fittest. Several other people working in the 1950s and the 1960s developed evolutionin ideas algorithms for optimization and machine learning. Box (1957), Friedman (1959), Bledsoe (1961), Bremermann (1962), and Reed, Toombs, and Baricelli (1967) all worked in this area, though their work has been given little or none of the kind of attention or follow up that evolution strategies, evolutionary programming, and genetic algorithms have seen.

2.5 History of GA

Genetic algorithms (GAs) were created by John Holland in the 1960s and were developed by Holland and his students and colleagues at the University of Michigan in the 1960s and the 1970s. Holland's original goal was to formally investigate the phenomenon of adaptation as it occurs in nature and to develop ways in which the mechanisms of natural adaptation might be imported into computer systems and not to design algorithm to solve problem which are differ from evolution strategies and evolutionary programming. Adaptation from Holland's book in Natural and Artificial Systems shown the genetic algorithm as an abstraction of biological evolution and gave a theoretical framework for adaptation under the GA. Holland's GA is a method for moving from one population of "chromosomes" to a new population by using a kind of "selection" together with the genetics inspired operators of crossover, mutation, and inversion [2].

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2.6 Previous Related Work

Evolutionary programming from genetic mechanisms, is a random search algorithm. It has good dependability and obvious superiority to solve nonlinear optimization problem with a non-differentiable objective function [3]. From this paper, the author has proposed multi-objective reconfiguration algorithm based on evolutionary programming and considered both objects of minimum power loss and branch load balancing with considering the economy and safety of distribution network which is the operator to select switch to close and to open is designed. So, the efficiency of algorithm is higher and can be applied to large-scale distribution. But, the report does not discuss accordingly in term of the small scale network as an example 16kV distribution network.

In the year 2006, the authors report the multiple objective approach that is considered for load balancing among the feeders and also to power loss minimizing, the deviation of node voltage, and branch current constraint violation. This four objective important to the a radial network structure in which all loads must be energized for the research [4]. From the author's conclusion, a heuristic-based fuzzy multiobjective algorithm is the best and has been proposed to solve the network reconfiguration problem in a radial distribution system. The simulation has proved and proposed on a medium-size distribution network and the results are impressive and encourage the implementation of the result in a large-size distribution network.

Another solution on distribution network reconfiguration is proposed the effect of distribution network reconfiguration in the power grid. This methods analyzed the features of these methods and to solve distribution network reconfiguration problem and applied to distribution network reconfiguration. The solution worked out using the algorithm based on the optimal flow pattern may not be optimal or near optimal. But the algorithm combined with heuristic rules can quickly obtain satisfactory results were in 2010 [5]. From the research, it shows the Genetic Algorithm is suitable for solving DNR problem and the application is wide use to solve the problem.

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In the same year, the research on implementation of an improved genetic algorithm in the distribution system with feeder reconfiguration to minimize real power losses has been reported [6]. A genetic algorithm (GA) is a search technique used in computing to find exact or approximate solutions to optimization and search problems. Genetic algorithms are a particular class of evolutionary algorithms or also known as evolutionary computation that uses techniques inspired by evolutionary biology such as inheritance, mutation, selection, and crossover or also called recombination. This research on 33 bus distribution where the improvement in crossover and mutation and also shown that improved Genetic Algorithm is more efficient and satisfies the conditions of the global.

In [7], the analysis of sensitivity of evolutionary algorithms is to propose a new idea for solving the problem of the optimal reactive power dispatch. This report develops the Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) for reduce real power loss and improve the voltage profile of giving interconnected power system. Then, the EP is method to run to make the iteration complete. Shunt capacitor is one of solution for loss sensitivity. The solution is compared with another method such as simulated annealing and simple quadratic programming.

On the other hand, the ideas of evolutionary programming are a good global optimization method. By introducing the improved adaptive mutation operation and improved selection [8]. This report verifies with the simulation experiment of typical optimization function. The experiment is compared between others algorithm such as evolution strategies, genetic algorithm, simulated annealing (SA), tabu search (TS) and other. Evolutionary programming disadvantages is its slow convergence to a good near optimum. The result after research shows that in new algorithm, evolution is performed with different mutation strategy and the simulation of new adaptive give the best performance in evolutionary programming especially in global convergence.

In the year 2012, “Radial network reconfiguration and load balancing for loss minimization using genetic algorithm” [9]. This paper is tested on 14-bus test system where to reduce load balancing. This paper also tests the result for the 123-bus test system. Then, the paper minimized losses for unbalanced radial three phase system the combined methods of phase load balancing and network reconfiguration. Phase load balancing and

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network reconfiguration in the distribution system is used to reduce circuit losses while satisfying electrical constraints and also can deleting overload condition, balance feeder loads, and improve the voltage profile simultaneously.

The reconfiguration of distribution networks is an important combinatorial problem [10]. This paper is tested on large scale network at area of Energy Australia. The objective of this paper is carried out over two domains simultaneously; there are re-switching strategies and transformer tap-changer adjustment by using the Evolutionary Programming (EP) method. It also implements two evolutionary algorithms in the research. There are, genetic algorithm, applied to re-switching strategies and tap-changer adjustment and the other one of the algorithm is memetic algorithm applied to the same problem with genetic algorithm. From the research, the results show memetic algorithm obtained the best result compared to a genetic algorithm with least the number buses uses with considering the re-switching strategies and tap-changer adjustment.

In [11], the paper has proposed technique determines the best combination of generator that should be dispatched in the system considering loss reducing or improving voltage stability. This paper discusses on generators for performance the reactive power that will lead to non-economical result which is rather unnecessary. So, the research presents a new approach for selecting generators perform optimally using evolutionary programming on IEEE 33-bus bar.

Back to the year 2010, research by Men-Shen Tsai, Member of IEEE, and Fu-Yuan Hsu have done in title “Application of Grey Correction Analysis in Evolutionary Programming for Distribution System Feeder Reconfiguration” [12]. During a feeder reconfiguration, many objective is considered by the distribution system operators. With the complexity of the reconfiguration problems, to solve it the system operators are finding for assistance from a computer program that can provide adequate switching plans to reconfigure the feeders so that the truth goal can be achieved. This author makes differentiation between two distribution system on application of grey correction analysis so it can choose the best and can help the Evolutionary Programming for choosing it feeder in the distribution system.

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Research on "A comprehensive Power Restoration Approach Using Rule-Based Method for 11kV distribution network" had been done on 2008. The problem are to optimize power dispatch, achieve rapid restoration plan with lowest number of switching involved and to reduce technical loss (I^2R) without violating technical and operational constraints in the network [13]. This research done on 11kV underground cable distribution network and choose three test configuration that are one feedback, two feedback and three feedback respectively. Being tested on two conditions with are with and without technical and operational violation. Then, this method is able to perform the best solution restoration plan.

Line loss calculation data used in the previous distribution network reconfiguration was historical load data or real-time data. And that to minimize the realistic significance of distribution network reconfiguration. A new technique is presented in [14]. This research on the year 2008 which is applying the Genetic Programming on Load Forecasting also the distribution network reconfiguration used partheno-genetic algorithm (PGA) and it improved according the features of the distribution network. The research result was presented and the load forecasting adopted GA and also PGA and improved.

Other research is held in the year 1997 and the title is "Distribution Network Reconfiguration on energy loss reduction". The methods was combined with the heuristic rules developed to lead the iterative process and make the energy loss minimization method effective, robust and fast [15]. This method can be used to minimize the energy losses and by further improved heuristic rule used to lead the minimization process. The method is suitable to uses in this research for energy loss reduction.

On August 2004, the other research done by the title is "Voltage Regulation and Power Losses Minimization in Automated Distribution Networks by an Evolutionary Multiobjective Approach" [16]. This research on two different objectives they are the problem on voltage regulation and minimization the power losses then the heuristic strategy used based on fuzzy set theory.

In year 2009, the research on network reconfiguration to study the present of a new method that improved genetic algorithm for loss and reliability optimization in the distribution system. This research done on 69 bus radial distribution system (RDS) [17].

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From the research, it shows that the efficiency of the distribution system is achieved through the improved genetic algorithm for losses and reliability optimization in the distribution system.

In [18], the paper is proposed on distribution network reconfiguration with modified the genetic algorithm. The objective is to minimize the system power loss with applied on 16-bus, 33-bus and real distribution network of Mauritius by changing the status of sectionalizing switches and is commonly done for loss reduction. From the result, genetic algorithm found that the system more likely to obtain the global optimal solution in less time than the exhaustive search and heuristic search methods. The genetic algorithm is improved by chromosome coding, fitness calculation, crossover and mutation pattern where there is problem in distribution network reconfiguration.

In year 2008, research on evolutionary algorithm but focus on the radial distribution network that specified for long interruption and voltage disruption costs [19]. The problem occurs in a radial distribution system under different load conditions and for voltage disruption cost where considers power quality indices such as long duration interruptions and customer process by using simulation method, Mento Carlo. Commonly, electric power distribution system should operate in radial configurations. Strategic point of normally open and normally closes is located along the network. In this research, the result finds that a new method to determine the best configuration by simply changing the status of some few network switches. So, can conclude that can give benefit to the utility and for the customer since aspect related to the network losses, voltage regulation, capacity loading and power quality.

In the other year, 2007. The author makes research on distribution network reconfiguration by using an efficient evolutionary algorithm [20]. This is done by renovation the network structure of distribution feeder by changing the open or close sectionalizing switching. The research can minimize the power losses and also reducing the overloading of the network components. Is test on 14-bus bar test system. This paper proposed different ways to implement the genetic operator which make the algorithm to take advantage of the problem characteristic in order to improve in efficiency, narrow the search space and speed up the process. Then, the combination with an efficient

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