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A DISTRIBUTION NETWORK RECONFIGURATION BY USING RANK EVOLUTIONARY PARTICLE SWARM OPTIMIZATION (REPSO) FOR POWER LOSSES MINIMIZATION

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

Faculty of Electrical Engineering

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2014

I declare that this report entitled “A Distribution Network Reconfiguration by using Rank Evolutionary Particle Swarm Optimization (REPSO) for power loss minimization” 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 candidate of any other degree.

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To my beloved father and mother, Mr Othman bin Sukaimi and Mrs Thosira binti Tahirin, thank you for all your support to me in finishing this project. I really appreciated on what you two have done to me. To my dedicated supervisor, Mr Mohamad Fani bin Sulaima, thank you for all the time you given to help me finishing this project.

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ABSTRACT

Distribution network reconfiguration (DNR) is an important measure of optimizing the electrical system and a key research on the automatic operation. Distribution network reconfiguration has been used for several purposes, usually for loss reduction. .In this report, there are several objectives that have been highlighted to be achieved. Firstly, is to reduce the power losses in the distribution network reconfiguration by using rank evolutionary particle swarm optimization (REPSO). Secondly, to analyze the computational time. The effectiveness of the new REPSO method for the DNR is a new method that is based on the evolutionary particle swarm optimization (EPSO) and the traditional particle swarm optimization by using the concept of combination, selection and ranking. A comprehensive performance analysis has been carried out on IEEE 33 and 69 bus distribution network system. The proposed method has been implemented and the real power losses in the network system investigated. The successful results of this method can be applied to help in saving the investment, reducing the power cutting as well as the line losses and thus improve the quality of the electrical power system in Malaysia.

ABSTRAK

Konfigurasi semula rangkaian pengedaran (DNR) merupakan langkah penting untuk mengoptimumkan sistem elektrik dan penyelidikan utama mengenai operasi automatik. Pengagihan rangkaian konfigurasi semula telah digunakan untuk beberapa tujuan. Dalam laporan ini , terdapat beberapa perkara yang telah diketengahkan untuk dicapai. Pertama, adalah untuk mengurangkan kehilangan kuasa dalam hal menyusun rangkaian pengedaran dengan menggunakan *Rank Evolutionary Particle Swarm Optimization* (REPSO). Kedua, untuk menganalisis masa pengiraan. Keberkesanan kaedah REPSO yang terbaru ini untuk DNR merupakan satu kaedah baru yang berasaskan *Evolutionary Particle Swarm Optimization* (EPSO) dan *Tradisional Particle Swarm Optimization* (PSO) dengan menggunakan konsep gabungan , pemilihan dan kedudukan. Analisis prestasi menyeluruh akan dijalankan ke atas IEEE 33 dan 69 bas sistem rangkaian pengagihan. Kaedah yang dicadangkan telah dilaksanakan dan kerugian kuasa sebenar dalam sistem rangkaian disiasat. Keputusan yang berjaya dengan menggunakan kaedah ini diharap dapat digunakan untuk membantu dalam menjimatkan pelaburan, mengurangkan pemotongan kuasa serta kehilangan talian dan dengan itu meningkatkan kualiti sistem kuasa electricl di Malaysia.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Motivation

Reconfiguration of the distribution network systems are meant for power losses mitigation. During normal operation of a distribution network, the energy flow has a radial path and passes the normally close switches [1]. As to reduce the power losses, the new method known as the rank evolutionary particle swarm optimization (REPSO) is introduced. The network topologies in the distribution network reconfiguration change through the on/off of the sectionalizing and tie switches in order to get the optimal solution of the power losses. The implemented of REPSO is hoped to be able to find the most suitable configuration which consists of switches that will contribute in lowering the power losses in the distribution network reconfiguration. This new method is hoped to help the system engineers to solve their power losses problem in distribution network system while increasing their quality.

1.2 Problem Statement

Nowadays, the dimension of the reconfiguration of the power distribution network has got larger due to increased scale of the network system. The increasing scale of the distribution network has caused the line losses. Therefore, many have been invested in order to secure the planning due to the connection between the transmission network and consumers facilities. Since 1977, there are many researchers have done the investigation on various method that seems to be able to minimize the power losses. But unfortunately, there is no absolute solution achieved by the researchers in order to reduce the power losses in distribution network system [30].

1.3 Objectives

There are several objectives that have been highlighted in this project. There are:

1. To minimize the power losses in distribution network system 33kV and 69kV bus test system.
2. To analyze the computational time.

1.4 Scope

This project is focus on the implementation of the new algorithm which is known as REPSO. All the coding is done by doing MATLAB and the algorithm is tested on the 33-bus and 69-bus radial IEEE test system.

1.5 Thesis Outline

The comprehensive performance analysis of the Rank Evolutionary Particle Swarm Optimization (REPSO) method in obtaining the optimal solution for 33kV and 69kV bus test system with low power losses and fast computational time in was described in this thesis. Basically, this thesis is divided into five chapters to present the contribution with clarify as follows :

Chapter 1 : Introduction

The chapter details motivation to take up this research work. The identified problem statement, objectives, scopes and significances of the research are defined.

Chapter 2 : Literature Review

This chapter presents the selection of 33kV and 69kV test system as the medium to test the effectiveness of the proposed method, Rank Evolutionary Particle Swarm Optimization (REPSO) as well as describing the previous works of other researches.

Chapter 3 : Research Methodology

In this section, the development of research is continued with developing the hybridization method of REPSO. Each of the steps in succeeding the hybridization of the REPSO method are well explained. In this chapter also described the mathematical formulation and the implementation of REPSO to distribution network reconfiguration (DNR).

Chapter 4 : Results and Discussion

This chapter presents the analysis of the results taken from the both the simulation of REPSO in 33kV and 69kV bus test system. The entire analysis of the research will be discussed.

Chapter 5 : Conclusion and Recommendation

At this chapter, it concludes with the summary of findings with respect to identified objectives and followed by recommendation for future work.

CHAPTER 2

LITERITURE REVIEW

2.1 Overview

Rank evolutionary particle swarm optimization, which is known as REPSO is a new method proposed in helping reduced the power losses in the distribution network system. Since 1977, thre are many researches have done the investigation on various types of methods that seems to be able to helping reducing the power losses. But, unfortunately, until now, there is no absolute solution achieved by the researchers in order to reduce the power losses with a fast computatinonal time in distribution network system.

2.1.1 Types of distribution network system

There are several types of distibution network that existed and widely used in many countries. The common types of distribution network system is radial, loop and mesh configuration. A radial system has only one power source for a group of customers. The advantages of radial distribution systems are the lower cost for construction and they are built mostly in sparsely populated areas. The disadvantages of radial distribution is when a power failure occur, the short circuit or a downed power line would interrupt the power in the entire line simultaneously. For a loop system, it is usually tied into an alternate power source. The power will loops through the service area and returns to the original point as the name 'loops' implies. By placing switches in strategic locations, the utility can supply power to the customer from either direction. If one source of power fails, switches are thrown (automatically or manuaaly) and power can be fed to customers from the other source. Loops system are more expensive than the radial system because of more switches and conductors are required, but the resultant improved system reliability is often worth for price. Moreover, the loop system provides better continuity of service than the radial system with only short interruptions for switching. The mesh systems are the most

complicated and interlocking loop systems. A given customer can be supplied from two, three, four, or more different power supplies. Obviously, the big advantage of such a system is added reliability. However, it is most expensive. Because of that, it is usually used only in congested, high load density municipal or downtown areas. The Figures 2.1, 2.2 and 2.3 show the radial, loop and mesh configuration respectively.

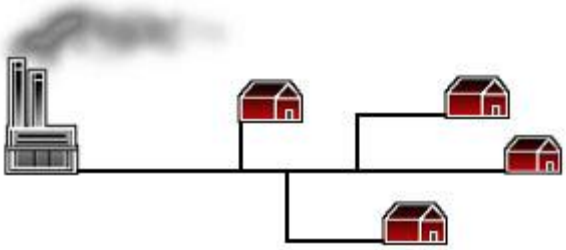

Figure 2.1. Radial configuration

Figure 2.2. Loop configuration.

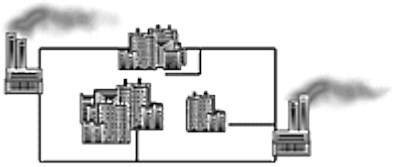

Figure 2.3. Mesh configuration.

2.1.1.1 Distribution Network Reconfiguration(DNR)

Distribution network reconfiguration is a very important in order to reduce the feeder losses and improve system security. Distribution network system consists of three types,radial, loop and mesh. But, of the distribution systems are in radial configuration. A radial distribution system is a combination of sectionalizing switches (Closed) and tie switches (Open). By performing switching actions, the topology of the network can be altered and the best possible configuration can be obtained. The switching action depends on the number of switches, the greater the number of switches, the more possibilities of reconfiguration. There are two types of DNR which are under normal operating condition

and failure condition. For the under failure condition, the recovery technique is called as System Restoration Service.

2.1.1.2 Distribution netwrok reconfiguration under normal operating condition

Distribution network reconfiguration (DNR) is used for several purposes [17]. Under normal operating condition, the system isalso changed. During the normal operations, the load currents change at different time due to the power usages from the different customers. The operation conditions of distribution systemschange when the load currents vary. As the result, the topology of network system so that the real power loss can be reduced and the reliabilities can be improved [18].

2.1.1.3 System restoration service (SRS)

There are two important functions in the operation of a distribution netwrok system which consists of fault location idenfication and system restoration service [19].System restoration of a distribution system is investigated by using artificial intelligence technique [20]. System restoration service (SRS) comes with one main purpose which is to reach a proper restoration plan for the unfaulted zone after a fault has been identified and isolated. After a fault event takes place, the interruption duration and the number of customers affected depend heavily on the effectiveness of the fault location identification algorithm and system restoration service. In a system restoration service, the plan must be devised in a very short period of time in order to reduce outage period and imporve the service realibility. There are many approaches that has been used to analyze the effectiveness of the SRS such as by using the artificial neutral network (ANN) and the pattern recognition method.

2.2 Review of Previous Related Works

Rank evolutionary particle swarm optimization is the best and fastest way to find the approximate optimal solution for power losses minimization. In the late of 90's, the heuristics methods on large scale of distribution network seems to be the solution on

reducing the power losses in a radial distribution networks [2]. There are several new methods that have been developed to reduce the power losses such as switch exchange methods (SEM), improved switch exchange method (ISEM), sequential switch opening method (SSOM), and analytical switch exchange method (ASEM) and analytical sequential opening method (ASSOM). The best methods that has been tested on the 33kV and 69kV IEEE system are the ISEM and SSOM by improving the network model reduction substantially without affecting their results performance. But the SSOM method is not practically used to derive successive radial configurations when it is applied for load balancing.

By the era of 20's, Miranda and Fonseca (2002) have introduced the evolutionary particle swarm optimization (EPSO) to be implemented in power systems [3]. There are same attempts being made by these authors to match together the evolutionary and the particle swarm concepts. They have verified that EPSO is very successful in solving the power system optimization of voltage control and the minimization of the losses in power system. EPSO is also able to find the adequate solutions under a min-max criterion. There are some other papers that have verified the ability of EPSO to reduce power losses such as in [21] and [22]. EPSO also has been further discovered by [23] in which it has made some iteration on the EPSO so that the new method called EIPSO can be produced. It is an algorithm to help in solving the nonlinear optimal scheduling problem. The EIPSO has been applied to solve the optimal spinning reserve for wind-thermal power systems (OSRWT) in helpingthe power system overcome unscheduled generator out-ages and major load forecasting errors without load shedding.

Apart from that, EPSO is presented based on the technique optimal location and sizing of multiple SVCs optimization in order to minimize the transmission loss in power system, as well as to improve the voltage profile [24]. This technique is proved to be efficient when it is compared to the basic technique. Furthermore, further development is recognized in order to apply the proposed method to a large scale of power system or a real power system.

One of the factors that play a key role in reducing power losses is the balancing of loads. It is indirectly in addition to enhancing stability and reliability of an electrical power network. The research on the load balancing in distribution network reconfiguration by

using Binary Particle Swarm Optimization (BPSO) was introduced in [4]. The aim of this paper is to find a way to keep the load in balance condition through the feeder reconfiguration so that the power losses can be reduced and hence the stability and reliability of the distribution network could be enhanced. Besides that, Cui-ru wang and Yun-e Zhanghas introduced the particle swarm optimization (PSO) algorithm into the distribution network reconfiguration due the non-linear optimal problem which gives great impacts on economic benefit of power system [5]. In this research, the network loss decreased substantially and the minimum node voltage rose after the introduction of modified particle swarm optimization algorithm into the DNR. Although this research has successful, but there is some constraint conditions that they have to faced. First, the network must meet the power flow equations, secondly, the branch current and constraints of node voltages, third is the constraint of power up and lastly is the constraint of the network topology.

In [6], the problem objective is only focus on describing the optimal power flow with the power transmission loss. Optimal power flow is a nonlinear constrained and occasionally a combinational optimization problems of power systems. For this paper, it can be proves that PSO can be successfully used to find a near global solution for optimal power flow problems.

The application of hybrid genetic particle swarm optimization algorithm in the distribution network reconfigurations multi-objective optimization was introduced in 2007 by Caiqing Zhang, Jingjing Zhang, and Xihua Gu [7]. This paper aimed to solve the optimal network loss, load balancing and power supply voltage by using method that combined with the evolution idea of generic algorithm (GA) and the population intellectual technique of particle swarm optimization (PSO) algorithm. These two combination will produced a Hybrid genetic particle swarm optimization algorithm (HGPSOA) which is able to display more excellent searching efficiency, convergence than the single intelligent algorithm and the obtaining globally optimal solution.

To reduce the power losses in the distribution networks, a new method has been proposed by [8] which are known as the hybrid particle swarm optimization approach for distribution network reconfiguration problem. This approach is a combination of the binary PSO algorithm and the discrete PSO algorithm. In this approach, the branches are grouped

by merging the equivalent branches in breaking loops and each of the group is encoded in one direction. There are many advantages of this approach; the distribution network is simplified, the length of the code is shortened, generation of invalid particles is avoided and as well as the efficiency in the optimization process is improved in necessary condition.

A very important and fundamental tool for analysis of any power system is the load flow which is as well as being widely used in operational planning stages. In certain application such as in distribution automation and optimization power system, a solution of repeated power flow is needed. In order to solve this problem as efficiently as possible in 2010, L.Mohammadian, A.Mohammadian, S.khani, M.Tarafdare Hagh, and E.Babaei have introduced a hybrid evolutionary method [9]. This method has reduced the power losses more than PSO. It shows that, from time to time, there are many methods that been introduced by the researchers in order to get the most efficient method to reduces the power losses in the distribution network reconfiguration.

In [10], Si-qing Sheng, Yun Cao and Yu Yaoproposed a new planning method which based on the particle swarm optimization (PSO) and the introducing of the chaos searching. This paper verifies the practicability of CPSO when it is implied in the distribution network. Besides that, the chaos particle swarm optimization (CPSO) is obviously improve the search efficiency, thus it is seems to be able to reducing the power losses and the ability of the system is been improved. However, for this paper, it only discussed the basic problem and a further research is needed to be done in other trading form.

Besides that, on the year of 2012, a new method of reducing the power losses has been introducing by K.Kiran Kumar, Dr.N Venkata Ramana, And Dr.S.Kamakshaiah by using the AMPSO algorithm [11]. AMPSO algorithm is stands for Adaptive Mutation Particle Swarm Optimization algorithm which takes nine important steps to be taken too successful. This method is based on statistics of variance population's fitness. In AMPSO, it is actually adds a stochastic mutation operator in the basic steps of PSO algorithm. There is one main advantage of this method which is it eliminates premature convergence.

As the increased in the scale of distribution networks and the dimension for reconfiguration is becoming larger and larger, a distributed hierarchical structure poly-particle swarm for reconfiguration of distribution network was introduced by [12]. This distributed hierarchical structure poly-particle swarm optimization algorithm (DHSPSO) proposed in this paper provides a new ideas for optimization problem of large scale system and DHSPSO is as well function as to divide a larger scale system into many subsystems and do the optimization respectively and then the optimization is then being done according to the optimization results of each subsystem. At the same year, a research is being done which proposed a method that combines the binary particle swarm optimization (BPSO) with discrete particle swarm optimization (DPSO) and multi-agent system (MAS) [13]. When these three components are combined, a new method known as the Novel Hybrid Multiagent-Based particle Swarm Optimization Algorithm (NHMBPSO) is introduced. This new NHMBPSO is successfully tested to be able to undertake a global search with a faster convergence rate and a feature of robust computation when evaluated on standard PG&E 69 nodes network system data but unfortunately, when compare to other types of methods such as HPSO, BPSO, and FEBE, it is still the weakest method in helping reducing the power losses in the distribution network system.

Furthermore, in [14], the authors has presented a paper which proposed an improved forward and backward sweep method and applied the hybrid particle swarm optimization algorithm into the distribution network reconfiguration through simplifying the power the power distribution system. The process distribution network reconfiguration occurred by network simplification in selecting the equivalent branch units randomly and then the optimization combines and regenerates the interior branches units of the selected employing particle swarm optimization which will be adapted to the discrete character.

Due to the increasing demand of power, the line losses are increased proportionally with the power transmission energy. So, as to reduce the line and power losses, an improved multi-agent based on particle swarm optimization is proposed in [15]. This paper has obtained a promising result for the solution of the distribution network reconfiguration problem for power losses. But, there are some points that should be cleared by further investigation in the future. Firstly, a larger-scale practical distribution system with morebuses and more feeders should be used to verify theeffectiveness of the proposed MAPSO. There are other objectives that can be included, like loadbalancing and voltage