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LAPORAN PROJEK

SARJANA MUDA

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

Siti Noratika binti Othman

BACHELOR OF ELECTRICAL ENGINEERING (INDUSTRIAL POWER)

June 2014

"I hereby declare that I have read through this report entitled "A Distribution Network Reconfiguration by using Rank Evolutionary Particle Swarm Optimization (REPSO) for power loss minimization" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (industrial Power)"

Signature : ....

Supervisor's name: ....

Date : ....

A DISTRIBUTION NETWORK RECONFIGURATION BY USING RANK EVOLUTIONARY PARTICLE SWARM OPTIMIZATION FOR POWER LOSSES MINIMIZATION.

SITI NORATIKA BINTI OTHMAN

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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.

Signature: ……………………………………........

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Date: ………………………………………........

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.

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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.

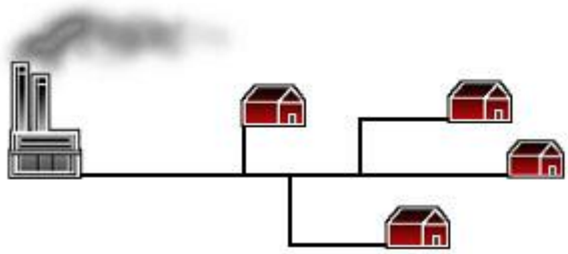

Figure 2.1. Radial configuration

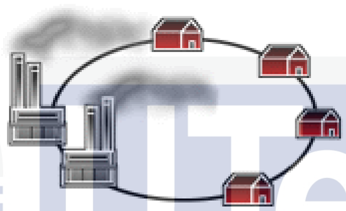

Figure 2.2. Loop configuration.

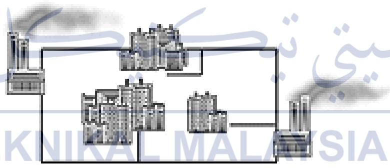

Figure 2.3. Mesh configuration.

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 regulation on feeders for a morecomplete distribution operation planning algorithm basedon the proposed MAPSO and the developed optimization MAPSO method with hashingscheme integrated can be applied to other similar powersystem optimization problems as well to achieve theoptimal solution more effectively.

2.3 Summary And Discussion Of The Review

From the previous related works, there are many research have been done to find the optimal solution for reducing power losses in the distribution networks systems. There are more than ten types of heuristics methods that have been developed and introduced by the previous researchers. Moreover, this heuristics methods can be seen has been introduced first in 1977 by Kenedy and Eberhart [16]. But until now, there are many more methods that have been introduced to find the best and the fastest way to reduce power losses without any risks to the system. Therefore, from all the previous work that many researchers have adequate, the new proposed method REPSO is help to be better than others which can come in their fastest way solving the optimal solution as well as reducing the power losses.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Overview

In the previous works, the techniques such as PSO, EPSO, MPSO, EP and many other heuristics methods have been introduced by many researchers in helping to reduce the power losses in the distribution network system. But, the optimal solution has never been achieved. This project proposed a new method that is known as the Rank Evolutionary Particle Swarm Optimization (REPSO). This is a new method consists of the combination of the Evolutionary Particle Swarm Optimization (EPSO) and the traditional Particle Swarm Optimization (PSO).

3.2 Rank Evolutionary Particle Swarm Optimization (REPSO) Technique

REPSO technique is a combination of the tradisional particle swarm optimization (PSO) and the evolutionary programming. There are three concept in the hybridization of REPSO, which are combination, selection and ranking concepts.

3.2.1 PSO Technique

The idea of developed PSO is originally from Kenedy and Eberhart in 1975 [16]. This idea is inspired from the choreography of a bird flock when they seek for food. The birds will move in certain speed and position to get the food. The movements they have made are based on their experiences and their friend's experience which can be concluded as P_{best} and G_{best}. As they move, they have their own velocity and the new velocity which is known as the v(i+1) and the new position x (i+1) can be obtained by the expression below:

$$v_{i+1} = \omega V_i + c_i r_i \,(P_{best} - x_i) + c_2 r_2 \,(G_{best} - x_i) \quad (3.1)$$

$$x_{i+1} = v_{i+1} + x_i \quad (3.2)$$

In PSO, there are several main steps that is important in getting the PSO algorithm. The steps are:

i. Initialization for the randomize population (x), REPEAT.

ii. Get the fitness

iii. Calculate the P_{best}andG_{best} for all the populations.

iv. Find the new velocity for each population.

v. New position, Xnew is adjusted.

vi. Fulfilled the requirements?If no, REPEAT.

vii. If yes, END.

3.2.2 EPSO Technique

Evolutionary Particle Swarm Optimization (EPSO) has been introduced by Miranda [3] that has combine the evolutionary programming concept to the PSO algorithm in order to solve the ptimal problem effectively. Most of the conventional PSO does not use selection and mutation process such as in [25] and [26]. EPSO is different in its adaptive recombination as it compared with other adaptive evolutionary techniques. There are many research that shown EPSO are proven to be efficient, accurate and robust and with successful application to the power system problems as in [27]-[29].

3.2.3 Development of the Hybridization Method of REPSO

This study is seeks for minimizing the power losses in the distribution network by using the hybridization of REPSO technique. The propsed algorithm is based on the EPSO and PSO.

In order to get the faster solution for the proposed algorithm, there are involving the integrated process of inserting the concept of combination, selection and ranking the evolutionary programming (EP) into the traditional particle swarm optimization (PSO. In REPSO, the best particles will move to the new position and the empty will be replaced by other particles. The selected of the new position of these particles are much more different when it is compared to the PSO algorithm as they are being done by using the concept of combination and selection method in evolutionary programming. The ranking process in introduced the proposed technique which is responsibility to rank the possible optimal selection in order to get the best number before the convergence process.

The flow process of the proposed algorithm is shown in the flow chart below:

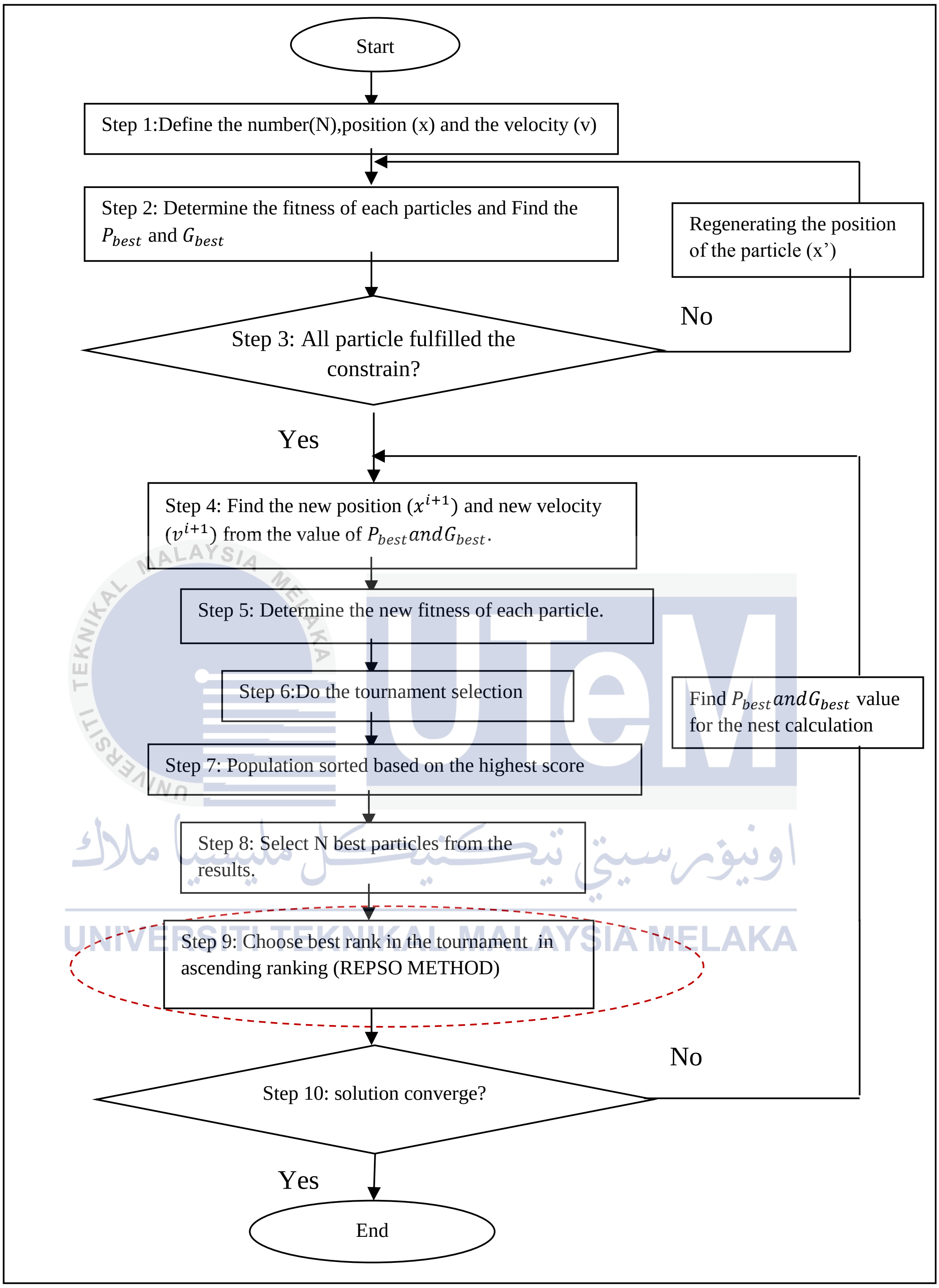

Figure 3.1: The flow chart of the Rank Evolutionary Particle Swarm Optimization Algorithm.

Step 1: Define the number (N), position (x) and the velocity (v).

The population of N particles is initialized with random position, x and the velocity of each particle is set to zero.

Step 2: Determine the fitness of each particle and find the P_{best} andG_{best},

The generated particles will be tested for it fitness to the reduced power losses. The final stage of this stage is when the local P_{best} is set as the current position and also as the objective value of particle and while G_{best} known as global best and its objectives is set as the best initial particles.

Step 3: All particles fulfilled the constraints?

If the values of the particle and the object value obtained from the particles are within the constraints of the system, the particle is accepted and vice versa. If the value obtained is not within the constraints, the new particle will be generated and this step will continuously repeated until the numbers of particles are out of boundary.

Step 4: Find the new position (x^{i+1}) and new velocity (v^{i+1}) from the value of $P_{best} and G_{best}$.

From the values of P_{best} andG_{best}, calculate the new velocity, (v^{i+1}) and the new position (x^{i+1}) by using the equation (3.1) and (3.2). for this step, by using the value of new position, the evaluations of the objectives of all particles is made.

Step 5: Determine the new fitness of each particle.

The new fitness is determined by using the value of the new position. So, the combination of the set of new position and the old position is happened here in this step and this combination will be contested in a tournament.

Step 6: Do the tournament selection process.

In this step, the tournament happened involved the combination of the set of new position and the old position. When the fitness is better, a position gains the score. The concept of EP is integrated in this step, when the selection process is done.

Step 7: Population sorted based on the highest score.

Starting with the highest score to the lowest score, the positions will be sorted out right after the tournament and selection process is done. The lowest score will be targetted as the maximum power lossses while the highest score will be targetted as minimum power losses.

Step 8: Select N best particles from the results.

The N numbers of positions with the best score from the results can be considered as survival positions which are used for the next iteration. These positions have been used as the newest P_{best} and the position with the highest score is used as the newest G_{best}.

Step 9: Choose best rank in the tournament.

For this step, after the newest P_{best} and the newest G_{best} are set, the best rank that won in the tournament is set to be the best rank that will be used throughout the process.

Step 10: Solution converge

In order to determine the stopping criteria of this optimization search process, the convergence process is required. The new position and the best rank set will be tested for convergence. The process will repeat continuously from step 1 to step 9 until the convergence is achieved. But, if the convergence is once achieved, then the optimization process is terminated.

3.3 Formula Formulation and the Implementation of REPSO to DNR

Throughout this research, all the data and programming have been written and noted so that the entire work becomes easier. The data for the load flow bus, load flow Newton-Raphson and bus admittance data are taken from the 1998 by H. Saadat. For this entire network, the 33-bus and 69-bus data are taken and analyzed accordingly. As the data is completely inserted into the data network, thus the proposed method consists of REPSO programming which consists of PSO and EPSO programming has been stimulated in MATLAB environment. The comparison between the conventional results and the stimulation results have been done and minimum value of power lossed has been verified respectively.

The mathematical formulation for the expression that can relate with the objectives are as follows:

$$\text{Minimize } f_1 \text{ (x,v)} = \sum_{i=1}^{n} Losses_i \quad (3.3)$$

Where,

n is the number of branches

x is the continous control variable

v is the discrete control variable

losses is the power losses at classified at i branch

Moreover, there are some constraints that should be considered during the process of analysis. The constraints are:

A. The voltage constraints

In order to maintain the power quality of the system, the voltage magnitude should be based on within its particular limits.

$$V_{min} \leq V_{bus} \leq V_{max} \quad (3.4)$$

The particular limits for voltage at eah bus is within 1.05 and 0.95 (±5).

B. Power flow constraints

Each and every branch in the power flow has its own permissible range. This range should be followed clearly and the constraints are strictly lies within it.

C. Radial configuration constraints

The constraints of the radial configuration should be considered to avoid any excess of current flow through the system. Therefore, in order to ensure the radial network to be maintained, several constraints must be taken into account. Several standard rules have been adopted for selection of switches. Those switches that do not belong to any loop, connected to the sources and contributed to a meshed network have to be closed.

The implementation process of REPSO is shown in the Figure 3.2:

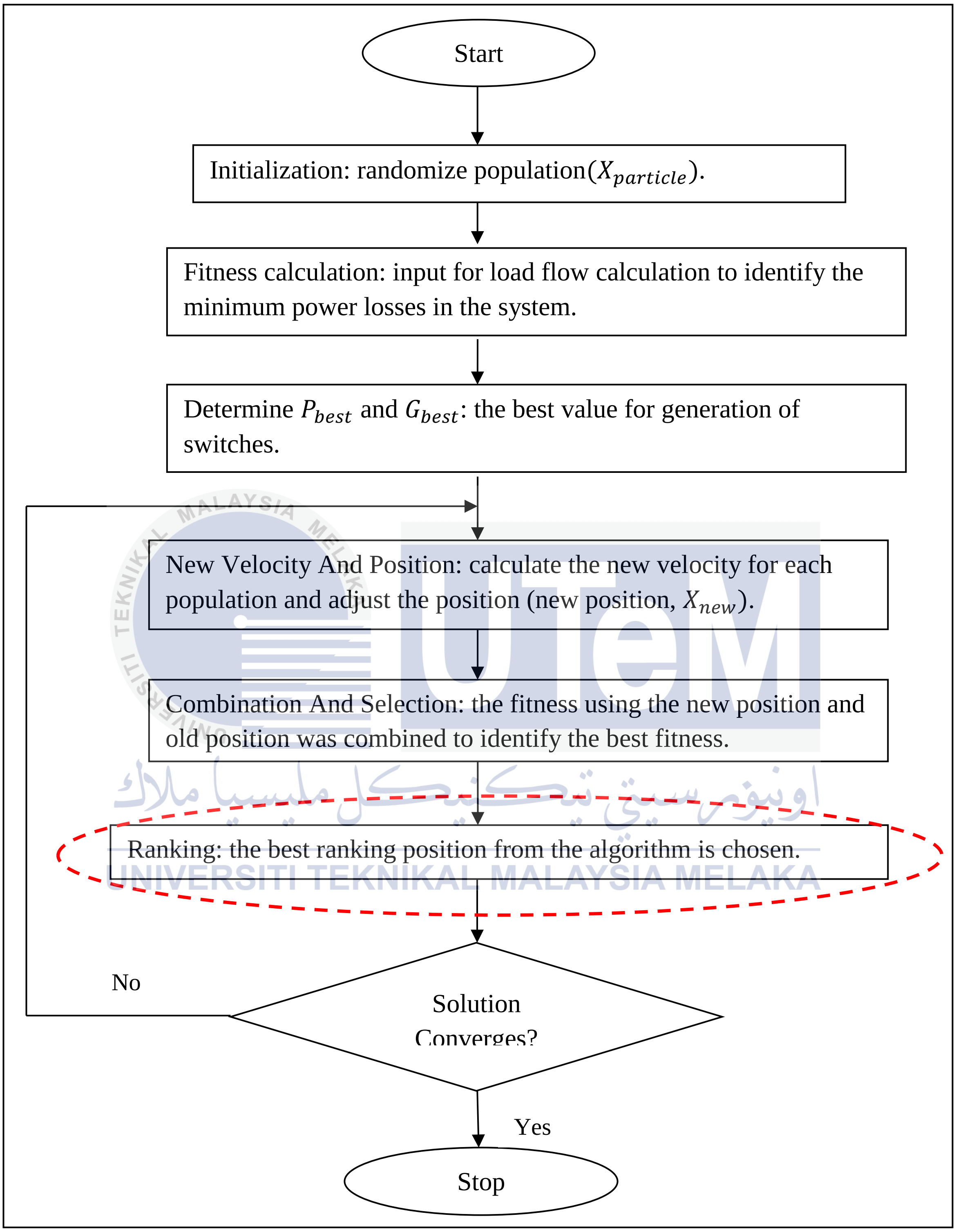

Figure 3.2: Implementation of REPSO in Network Reconfiguration.

3.3.1 Initialization.

All the input system data which involved in order to run the REPSO such as network data, buses data, lines data and voltage limit are inserted in the MATLAB sotfware programme. To determine the initialization population, the switches is selected from the set of its original tie switches. By the existing of the random generator, those variables involved will be generated by the system in the program. Thus, in the next step, in order to compute the power losses, all the variables will be utilized. In this work, the particles acted as the tie switches and the appropriate equation is represented as below:

$$X_{particles} = [\ S_1, S_2, S_3, \ldots\ldots.., S_y\ ] \qquad (3.5)$$

Where :

y = no of tie switches.

In this step, the parameters of REPSO that involved such as number of particles (N), weighting factor, C_1 and C_2 and the maximum number of iteration are analized. There are several constraints that should be aware and considered to ensure the radial network is maintained. For the selection of switches, there are several important rules that have been taken seriously.

i. Rule 1: All switches that do not belong to any loop are to be closed.
ii. Rule 2: All switches are connected to the sources are to be closed.
iii. Rule 3: All switches contributed to a method network need to be closed.

3.3.2 Fitness Calculation

In this study, the fitness fucntion or also known as the objective function that needs to be optimized and hence solved is the power losses of the system. For this step, there are two random variables, those are position, X and velocities, Y which will randomly generated along with the initial populations of particles. For each and every particle that fulfills the requirements or constraints mentioned in section 3.3.1, the power flow will be accomplished and by using the Newton-Raphson load flow program , the total power total loss will be calculated.

3.3.3. Determine P_{best} and G_{best}

These are the two values that need to be updated and recorded during this searching process. In the solution space, these values are related with the best solution that is has extended so far by each particles which retains path of its coordinate. These two best values are noted as the P_{best} and G_{best}. These P_{best} and G_{best} are important to represent the generation of the tie-switches and the power losses in the network system.

3.3.4 New Velocity and Position.

In this step, by applying the equation (3.1) ad (3.20), the particles' velocity and position are updated. The particle's velocity is signifies as the switches while the total power loss of all switches is verified by using the new position.

3.3.5 Combination and Tournament Selection.

After the new position, X_{new} is obtained, the values of the new position is used in determining the new fitness value or else know as the total power losses. Hence, both the set of the new position,X_{new} and the old set position, X will be combined together and this combination of new and old set position will be contested in a tournament. When the fitness is better than other contenders, a position gains the score and vice versa. This tournament is contested as randomly. The priority selection strategy is used throughout the selection strategy process. The old set position and the new set position were sorted in this technique in descending order according to power losses in the system.

3.3.6 Ranking.

In this technique, the best ranking position is chosen according to the least values of power losses which has ben sorted from the combination of the old and new set of the position. The best ranking position is selected as the best rank which used in the radial network system in order to help reducing the power losses.

3.3.7 Convergence Test.

The best ranking position is set to be the new position set which will be tested for convergence. Until the convergence is achieved, the process will be repeated from step (3.3.2) to (3.3.6). And, if the convergence has been achieved, then the optimization process is stopped.

3.4 The List Of Data That Will Be Used Throughout The Test

The data used throughout the study is attached in the Appendix.

CHAPTER 4

RESULTS AND DISSCUSSION

4.1 Overview

The optimization programming has been written by using MATLAB (version 2010b) package in window based computer. The CPU was installed with 2.0GB of Ram while the processor used is Intel® Core™ Duo. The proposed algorithm was tested using a real 33-bus and 69-bust IEEE est system.The results of the study has been analyzed in order to find the optimal solution for power losses in the system by determining the optimum switching configuration or the “open status” tie-switches. In this chapter, the implementation of PSO, EPSO and REPSO algorithm into 33kV bus and 69kV bus will be discussed and the results will be compared according to the total power losses, computating time and voltage profile improvement.

4.2 Project Achievement

The simulation of PSO, EPSO and REPSO programming are run in the MATLAB for 20 times and the system is tested in the comprehensive performance of 33kV and 69kV IEEE test system.

4.2.1 Results Obtained For 33kv IEEE Test System

The PSO, EPSO and REPSO algorithm is run in the MATLAb software for more than 20 times and the system is tsted in the comprehensive performance of 33kV test system. the overall network consists of 33 loads, with five initial tie-swtiches which will be opened at 33, 34, 35, 36 and 37. The random numbers which is generated during initialization which consists of fives switches reconfiguration represented as S1, S2, S3, S4 and S5.

4.2.1.1 Power Losses Reduction

The results obtained for the sectionalizing swtiches, total power losses and the computational times are recordeed and summarized into tables 4.1, 4.2 and 4.3. Only the best ten values of power losses for each algorithm is included in the tables.

Table 4.1: The best ten values of power losses after reconfiguration with PSO algorithm

No of Iteration	Open Switches	Total Power Losses (kW)	The Computational Time (s)
1	32,28,11,33,34	120.7	11.84
2	33,28,34,8,17	125.8	23.01
3	8,17,33,9,28	126.4	10.68
4	9,28,33,14,32	121.3	20.95
5	8,28,32,33,34	122.5	19.20
6	33,28,14,17,8	125.5	28.32
7	6,4,16,30,14	136.5	1.98
8	9,17,33,28,34	125.3	27.19
9	33,6,14,28,34	146.1	28.65
10	8,33,9,28,32	123.5	12.52

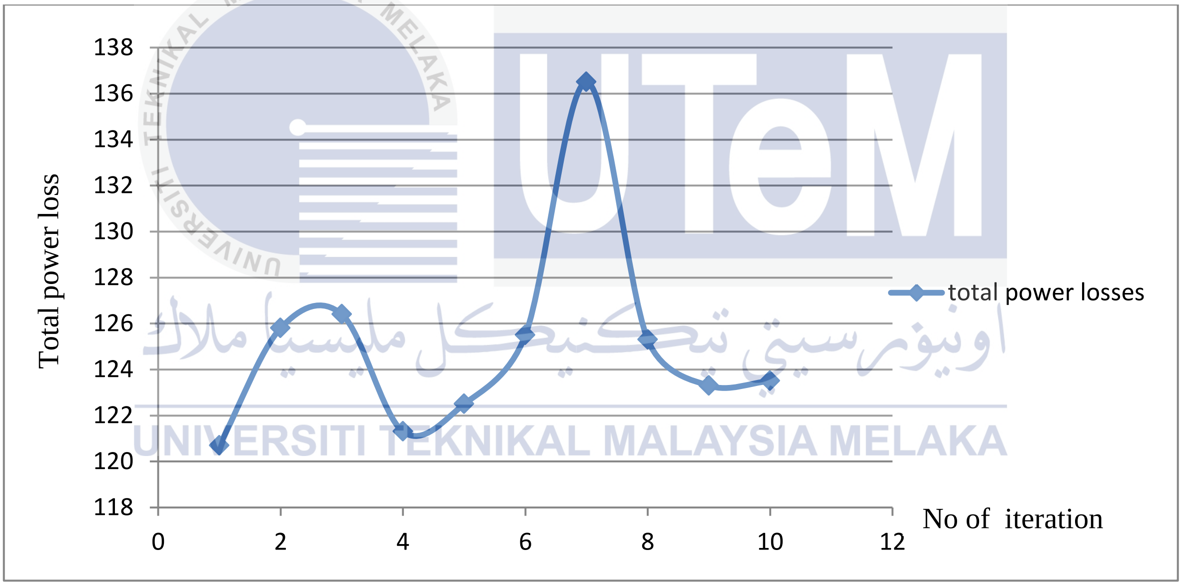

Figure 4.1: Number of iteration versus the total power losses for PSO algorithm

Table 4.2: The best ten values of power losses after reconfiguration with EPSO algorithm

No of Iteration	Open Switches	Total Power Losses (kW)	The Computational Time (s)
1	32,33,28,34,10	120.9	11.44
2	14,33,17,26,8	131.1	13.62
3	8,33,9,28,32	123.5	12.52
4	33,34,35,28,9	178.6	20.27
5	11,28,33,34,35	166.7	14.23
6	33,34,11,32,28	120.7	13.11
7	33,27,34,35,36	145.9	10.75
8	33,34,28,9,17	125.3	20.86
9	28,32,14,33,9	121.3	11.72
10	28,34,11,32,33	120.7	8.47

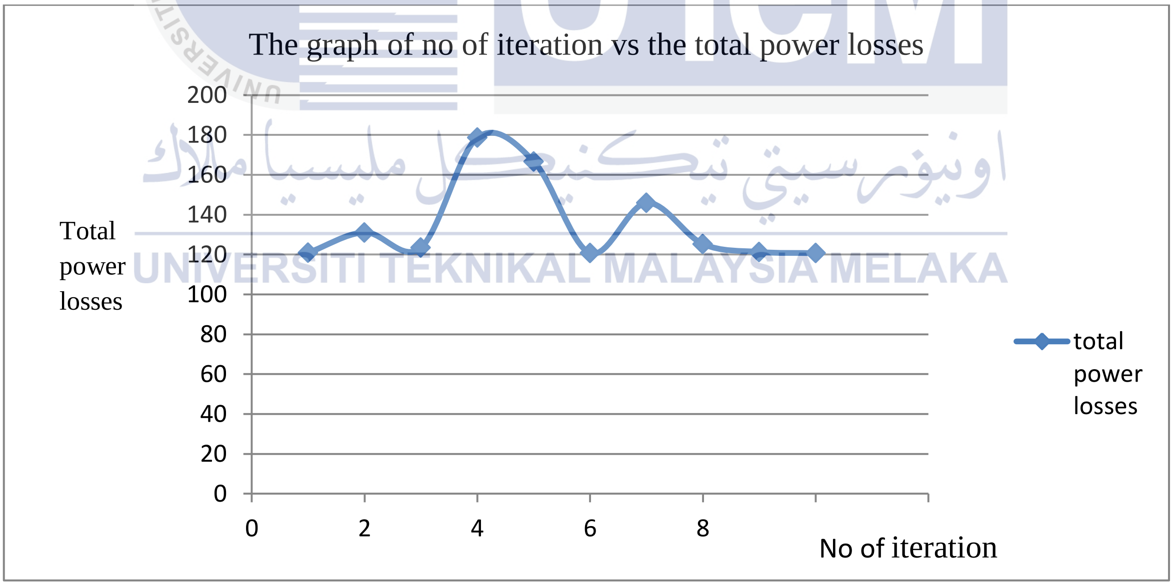

Figure 4.2: Number of iteration versus the total power losses for EPSO algorithm

Table 4.3: The best ten values of power losses after reconfiguration with REPSO algorithm

No of Iteration	Open Switches	Total Power Losses (kW)	The Computational Time (s)
1	29,4,27,33,15	126.2	1.601347
2	32,28,11,33,34	120.7	9.974740
3	8,17,33,9,28	126.4	9.238584
4	8,28,32,33,34	122.5	16.034950
5	8,14,28,17,33	125.5	24.898925
6	33,34,9,29,14	121.3	12.907871
7	9,17,33,28,34	125.3	8.869190
8	9,33,28,14,32	121.3	3.937764
9	28,9,8,32,33	123.5	4.562043
10	13,17,34,16,33	133.9	8.03948

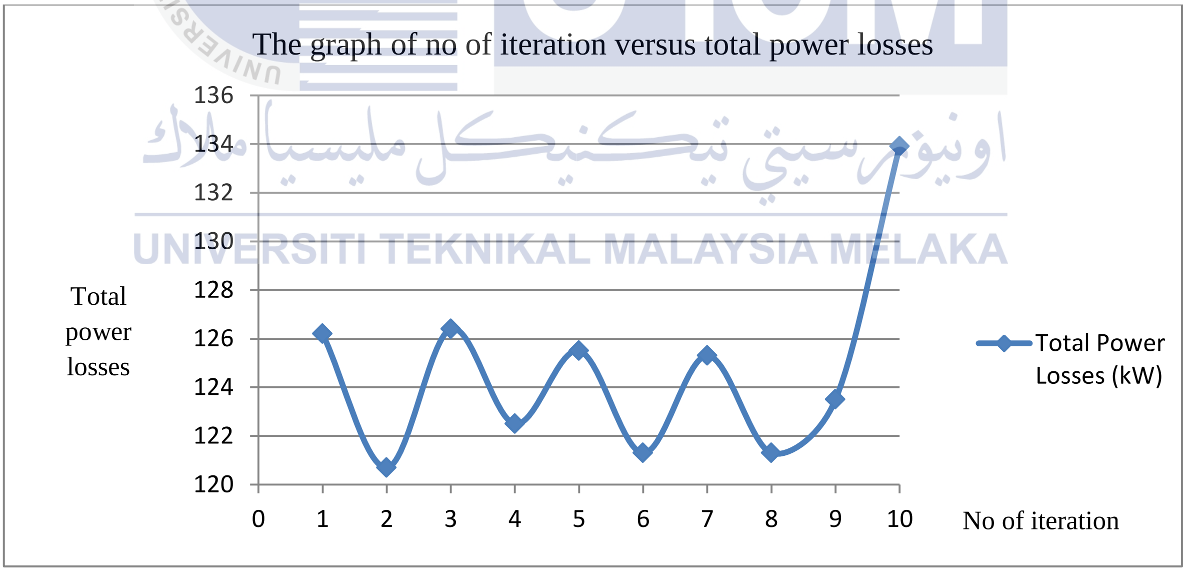

Figure 4.3: The total power losses versus the no of iteration for REPSO algorithm

Tables 4.1, 4.2 and 4.3,show the results that have been taken according to the sectionalizing switches to be opened, the total power losses and the computational time for PSO, EPSO and REPSO respectively. From all the best values of total power losses; three graphs are plotted, which are Figure 4.1, Figure 4.2 and Figure 4.3. They are represented the number of iteration versus the total power losses for PSO, EPSO and REPSO algorithm sequentially.

Table 4.4 shows the analysis results of the 33-bus test system for three cases, case 1; the original initial network, case 2; the reconfiguration with PSO, and case 3; the reconfiguration with EPSO and case 4 is the reconfiguration by with REPSO:

Table 4.4: The analysis results for 33-bus test system for the three cases

Parameters	Case 1: original initial network.	Case 2: after reconfiguration using PSO.	Case 3: after reconfiguration using EPSO.	Case 4: After reconfiguration with REPSO algorithm.
Switch to be opened.	33,34,35,36,37	33,6,14,35,36,37	14,33,17,26,8	32,28,11,33,34
Total power loss (kW).	202.7kW	146.1	131.1	120.7kW
Loss Reduction (kW)	-	56.6	71.6	82
Percentage of Loss Reduction (%)	-	27.92	35.32	40.45
Computational time (s)		28.65	13.62	9.97

Table 4.4 shows the numericals results for four cases consists of original initial network, PSO algorithm, EPSO algorithm and REPSO algorithm. It can be seen that, if the PSO, EPSO and REPSO are applied to the distribution network system, the valued of the power losses is considerable decrease. These three heuristic methods have proven to be the good optimization techniques in order to reduce the system power losses after reconfiguration. For case 2 and case 3, the reduced of power losses are 202.7 kW to 146.1kW and 202.7kW to 131.1kW respectively. Furthermore, the percentage of the power reduction can be seen as 27.92% for case 2 and 35.32% for case 3. But, for case four, it has the highest total power which is from 202.7kW to 120.7kW, given a percentage of 40.45%. It means that, REPSO is the best algorithm to solve the optimal solution if to be compared to PSO and EPSO. In terms of computational time, REPSO has a shorter time in

getting the total power losses which is 9.97 that is better than PSO and EPSO which can only achieved the optimal solution after 28.65s and 13.62s correspondently.

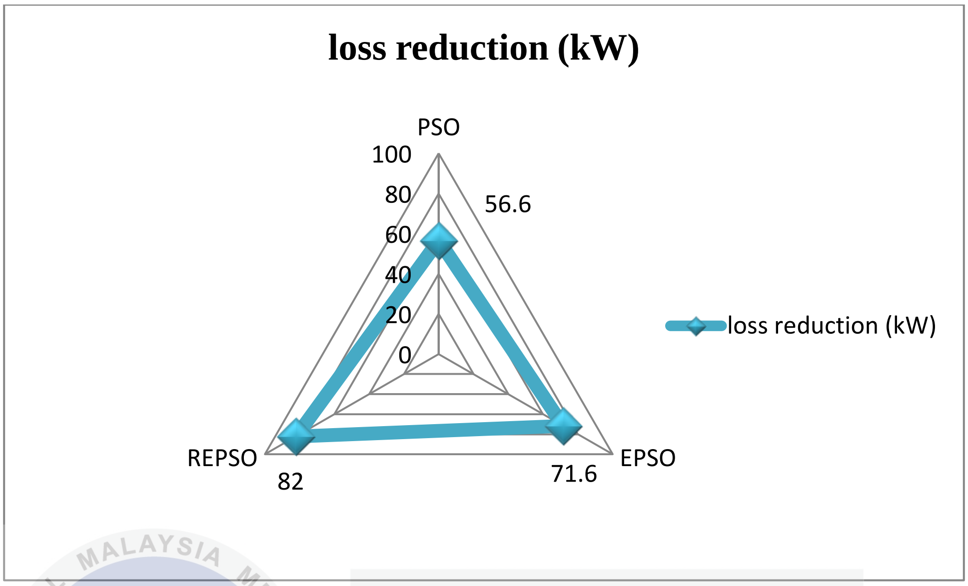

Figure 4.4: The comparison of total power losses reduction between PSO, EPSO and REPSO algorithm.

4.2.1.2 Convergence time

The convergence time between three methods are compared. The following Table 4.5 show the results for the convergence time between three cases:

Table 4.5: The Convergence Time Analysis for Simulation

Parameters	Convergence time (s)
Case 2:PSO	28.65
Case 3:EPSO	13.62
Case 4: REPSO	9.97

The Table 4.5 presents REPSO algorithm that perform the shortest time taken which is 9.97seconds only if to be compared to PSO and EPSO which takes longer time to converge, 28.65 seconds and 13.62 seconds resultantly.

Figure 4.5: The comparison of the convergence time between PSO, EPSO and REPSO algorithm

4.2.2 Results for 69kV IEEE Test System

The program build are also executed to be tested on 69kV bus test system as shown in Figure 4.6. The overall network consists of 69 loads, five initial tie-switches or sectionalizing switches which opened at S69, S70, S71, S72 and S73 and also has 73 branches. The overall system run same as with 33kV bus test system. The random numbers is generated during initialization which consists of five switches reconfiguration which is represented as S1, S2, S3, S4 and S5. The analysis results for this test is shown as in Table 4.6 and Table 4.7 for the analysis of power loss reduction and convergence time subsequently.

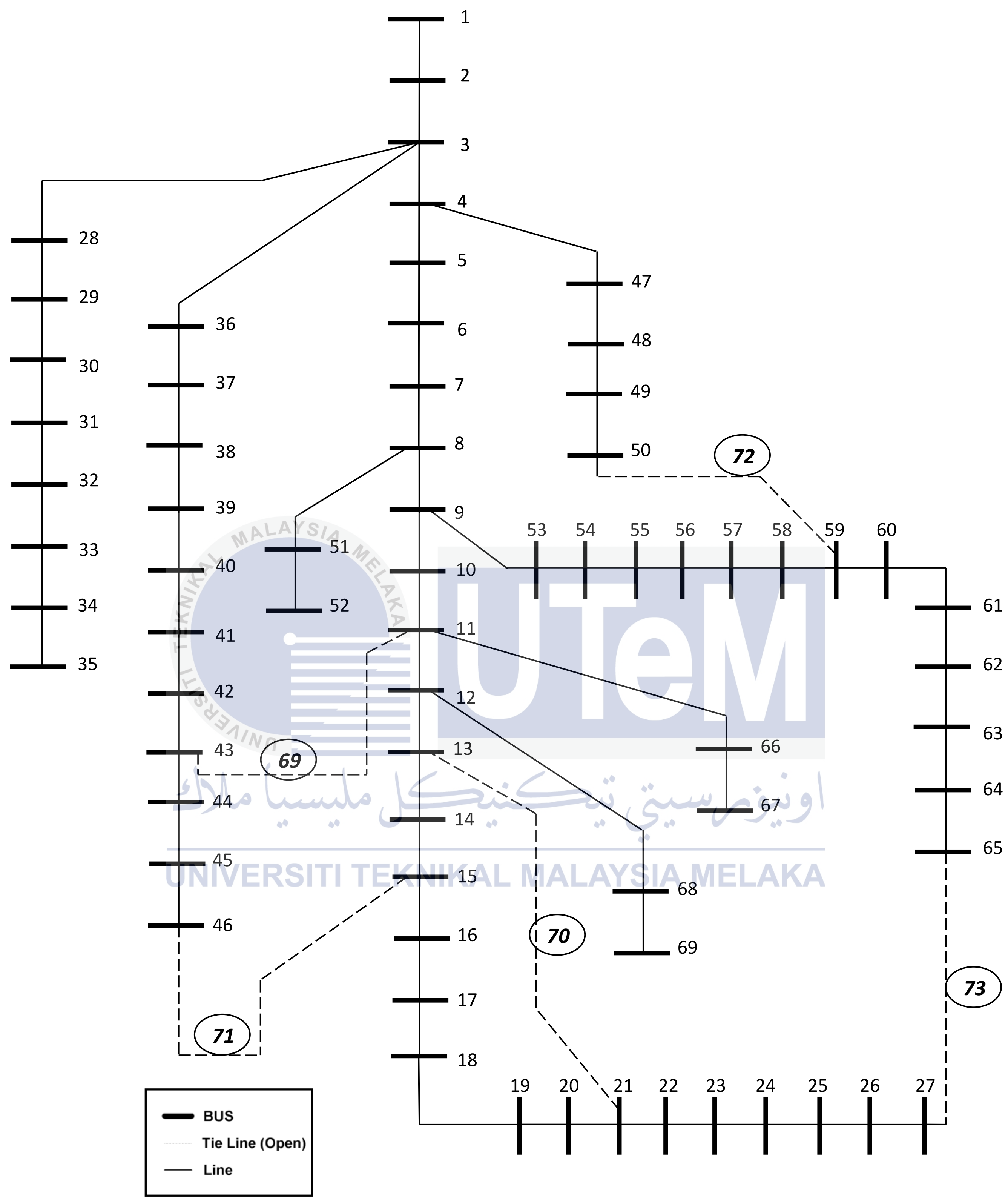

Figure 4.6: 69kV bus test system

4.2.2.1 Power Loss Reduction

Table 4.6:The analysis results for 69kV-bus test system for the four cases

Parameters	Case 1: original initial network	Case 2: after reconfiguration using PSO	Case 3: after reconfiguration using EPSO	Case 4: After reconfiguration with REPSO algorithm
Switch to be opened.	69,70,71,72,73	8,57,22,12,19	38,3,69,22,54	69,20,56,14,72
Total power loss (MW).	0.0889	0.0550	0.0520	0.0500
Loss Reduction (MW)	-	0.0339	0.0369	0.0389
Percentage of Loss Reduction (%)	-	38.13%	41.51%	43.76%
Computational time (s)		21.852637s	11.11761s	15.044023s

From the Table 4.6, it can be seen that REPSO achieved the highest percentage of the power loss reduction if to be compared to the other two methods, PSO and EPSO. REPSO is able to reduce the power loss from 0.0889MW in the original configuration to 0.0500MW with the percentage of reduction is 43.76%. Therefore, when REPSO is compared to the other two other techniques, PSO is only able to reduce power loss from 0.0889MW to 0.0550MW while EPSO is able to reduce power loss from 0.0889MW to 0.0520MW, which means that REPSO has the highest total power reduction. If the comparison is made on the percentage of power losses reduction, REPSO has the highest percentage of reduction which is 43.76%, slightly higher than 38.13% and 41.51% for PSO and EPSO respectively. Therefore, it can be concluded that REPSO are still the best method to reduce power losses in power system compared with PSO and EPSO techniques for 69kV bus test system. The comparison or the power losses reduction for the three cases are shown in Figure 4.7 .

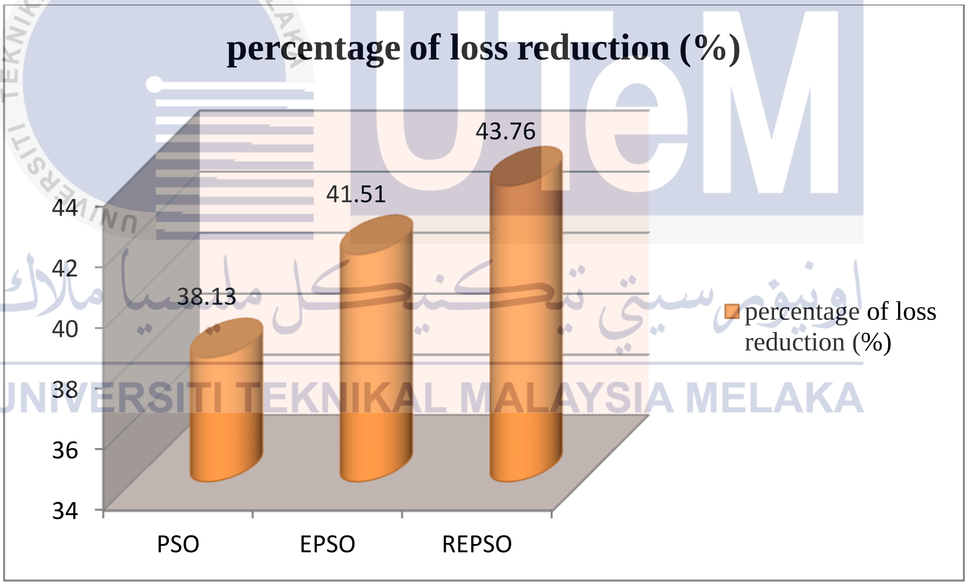

Figure 4.7 : The comparison of power losses reduction between PSO, EPSO and REPSO

4.4.2.2 Computational Time

The computational time for proposed technques to solve the 66kV optimal reconfiguration problem is analyzed in this section. Table 4.7 shows the convergence time for the three cases accordingly.

Table 4.7: the computational time for the three cases

Parameters	Computational time (s)
PSO	21.852637s
EPSO	11.11761s
REPSO	15.044023s

From the Table 4.7, EPSO achieved the fastest time in getting the sectionalizing switches which is 11.11761s compared to the other two methods which can only get the results after 21.852637s and 15.044023s for PSO and REPSO respectively. The aimed for this paper is to achieve REPSO technique as the fastest way to reduce the power losses but for the 69kV test system, EPSO is faster than REPSO by 4seconds. This is because, in 69kV bus test system, REPSO has to take longer time than EPSO due to the ranking elements which it needed to choose the best configuration to help the power losses. Therefore, it can be concluded that, REPSO is still the bes technique that can reduce highest power losses in distribution network system but it takes a longer time for configuration bigger than 33kV bus system. lthough REPSO is not the fastest, but the time taken to get the results is still fast. The comparison for the computational time between the three case can be seen in Figure 4.7.

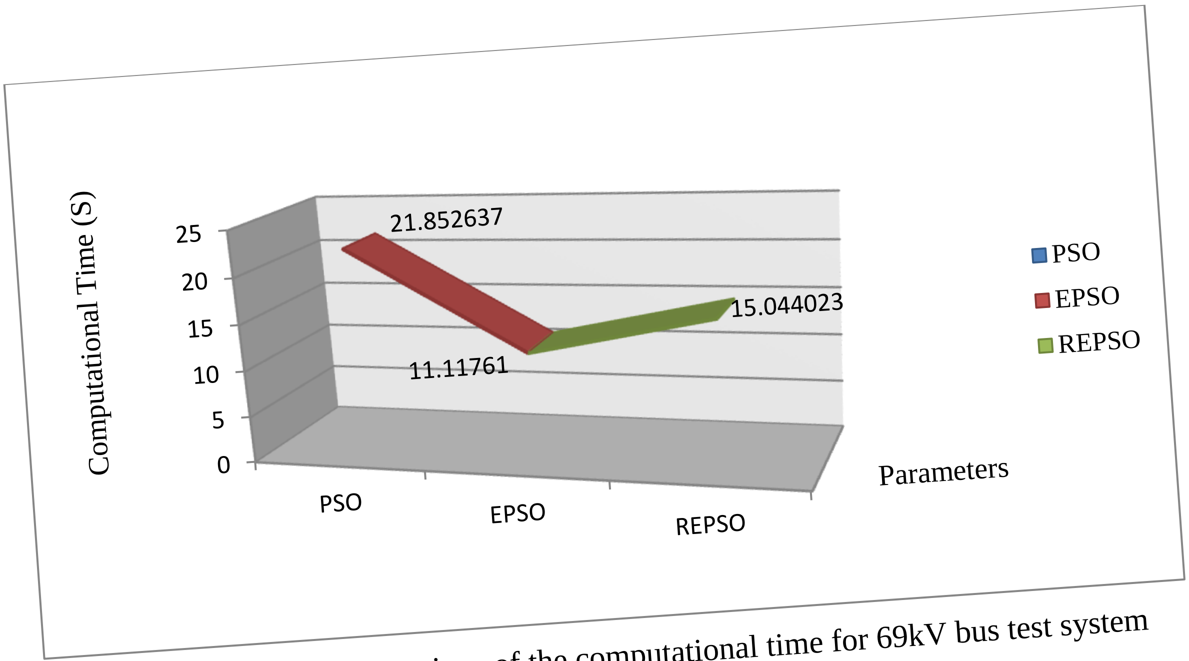

Figure 4.8 : The comparison of the computational time for 69kV bus test system

4.3 The 33-Bus Test System and Simulation Results

The algorithm of PSO, EPSO and REPSO are tested in 33-bus test system. The sectionalizing switch of both algorithm are obtained. The following Figure 4.8 shows the 33-bus initial configuration while Figure 4.9, 4.10 and 4.11 show the 33-bus reconfiguration with PSO, EPSO and REPSO algorithm respectively. The sectionalizing switch of each configuration are shown by the dotted line and are labelled by tie-line.

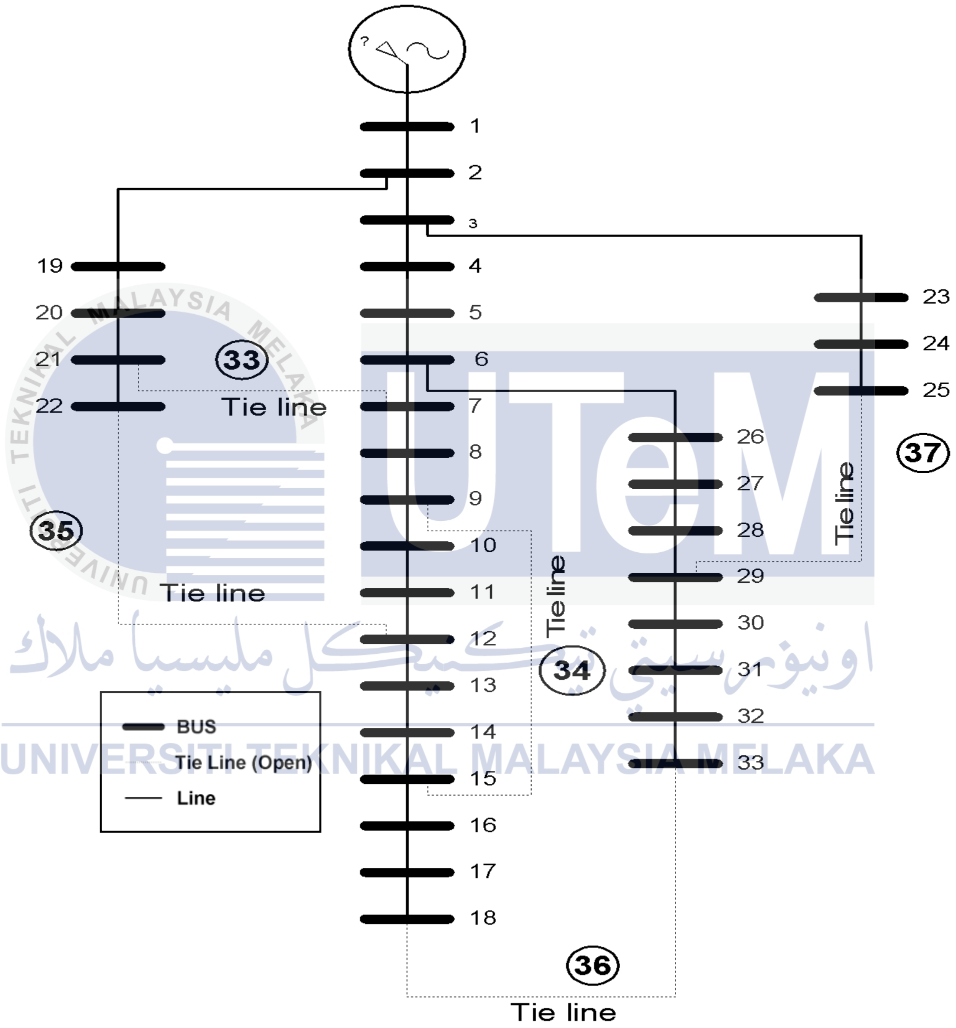

Figure 4.9: The initial 33-bus configuration

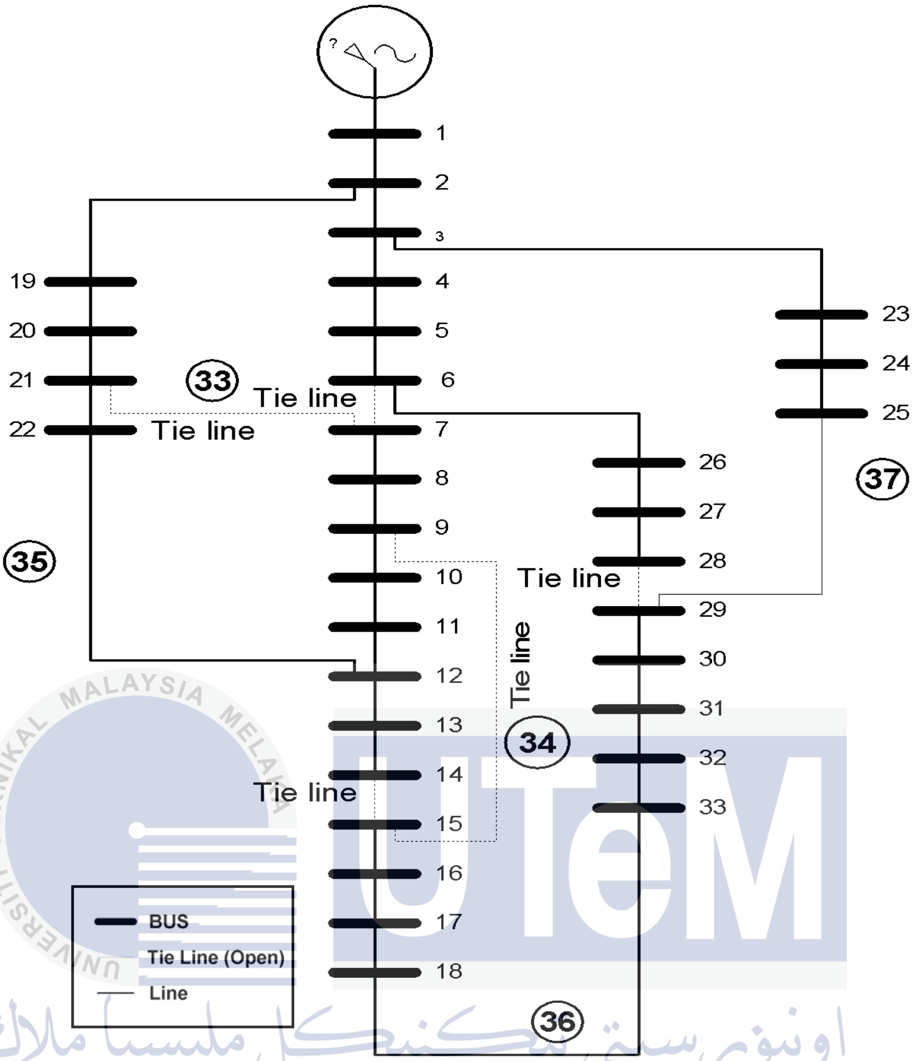

Figure 4.10: The 33-bus radial after reconfiguration with PSO

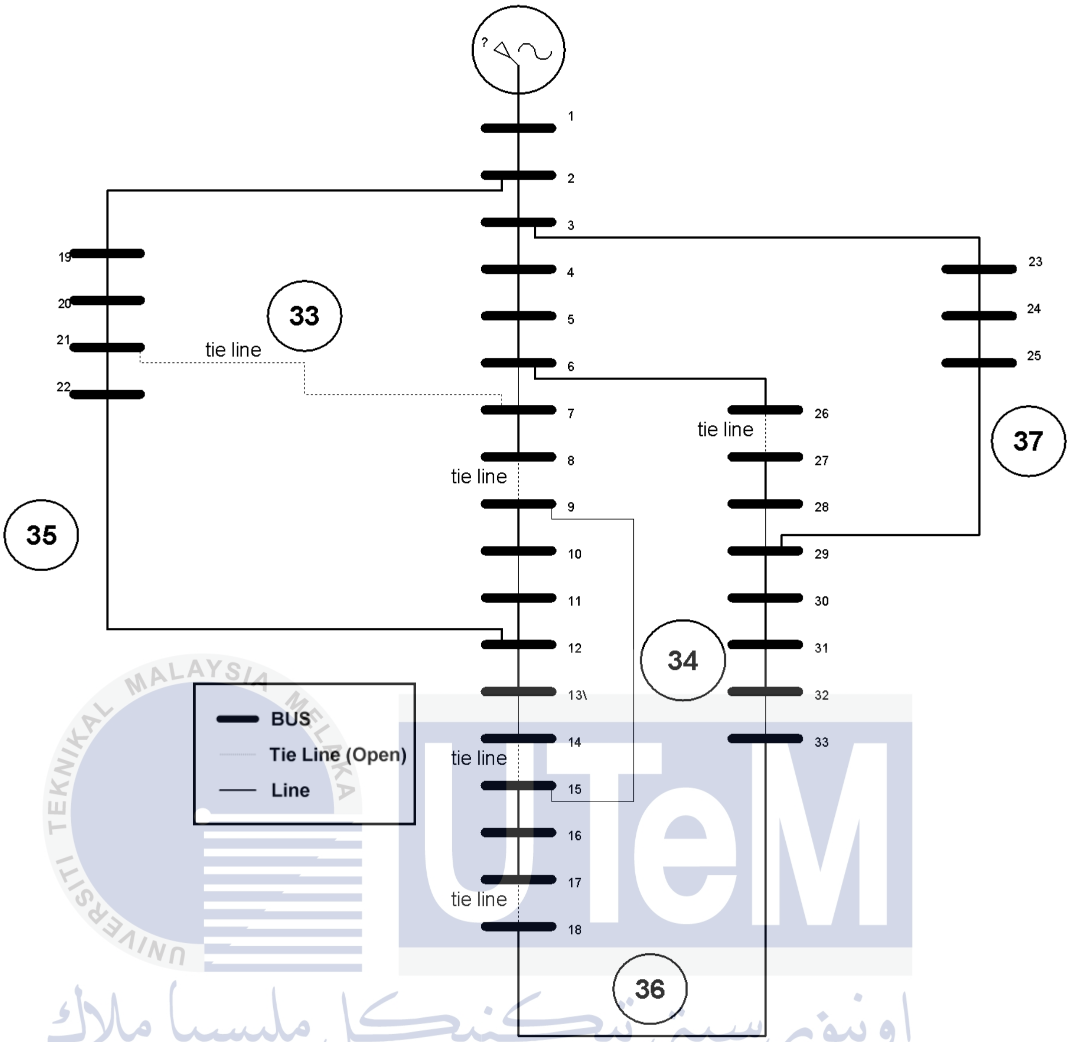

Figure 4.11 : The 33-bus radial after reconfiguration with EPSO

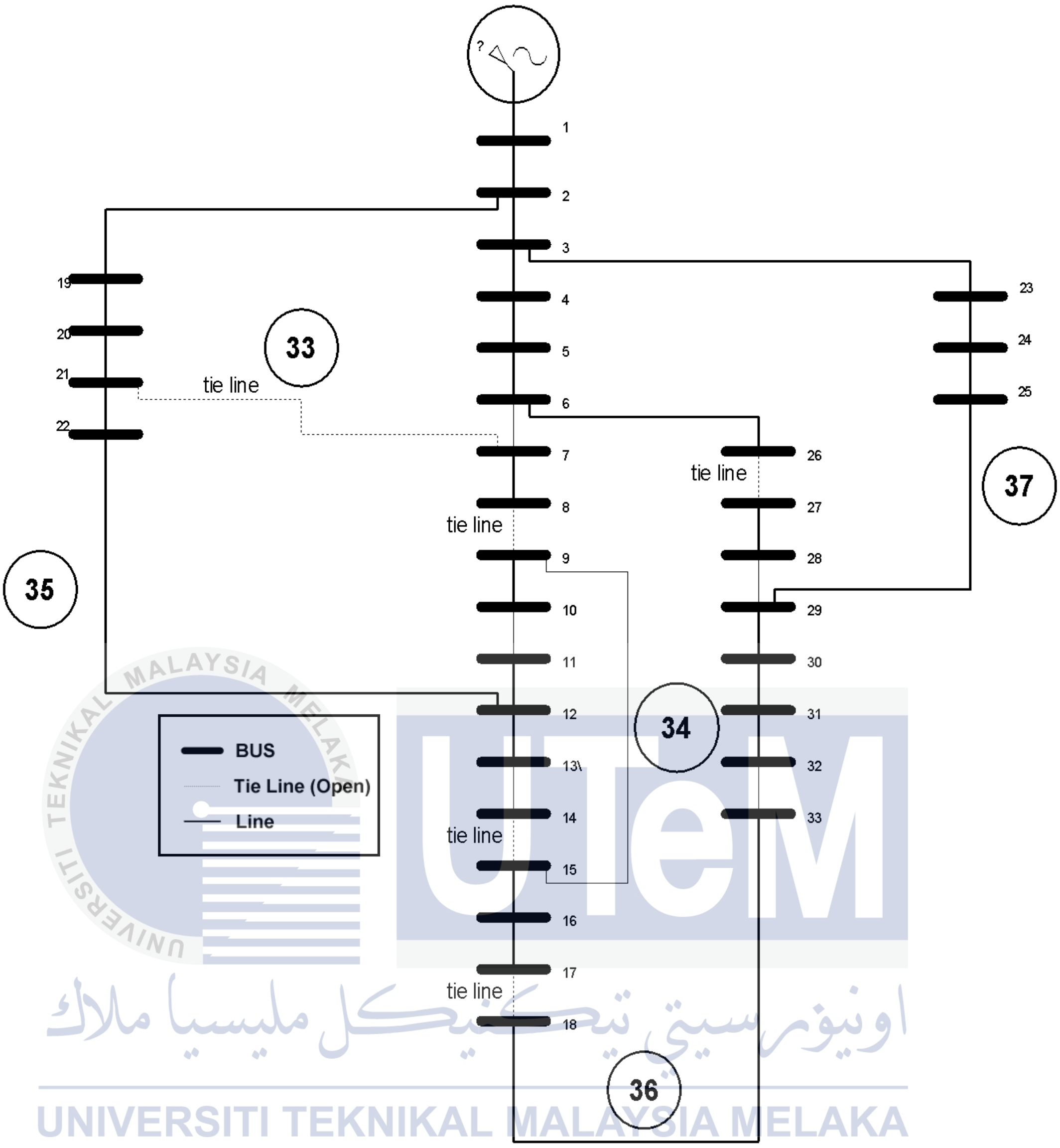

Figure 4.12: The 33-bus radial after reconfiguration with REPSO algorithm

4.4 The 69-Bus Test System And Simulation Results

The results of PSO, EPSO and REPSO are successfully obtained after tested in 69kV bus test system. The 69-bus initial configuration is shown in Figure 4.6 while Figure 4.13, 4.14 and 4.15 show the 69-bus reconfiguration with PSO, EPSO and REPSO algorithm simultaneously. The sectionalizing switch of each configuration are shown by the dotted line and are labelled by tie-line.

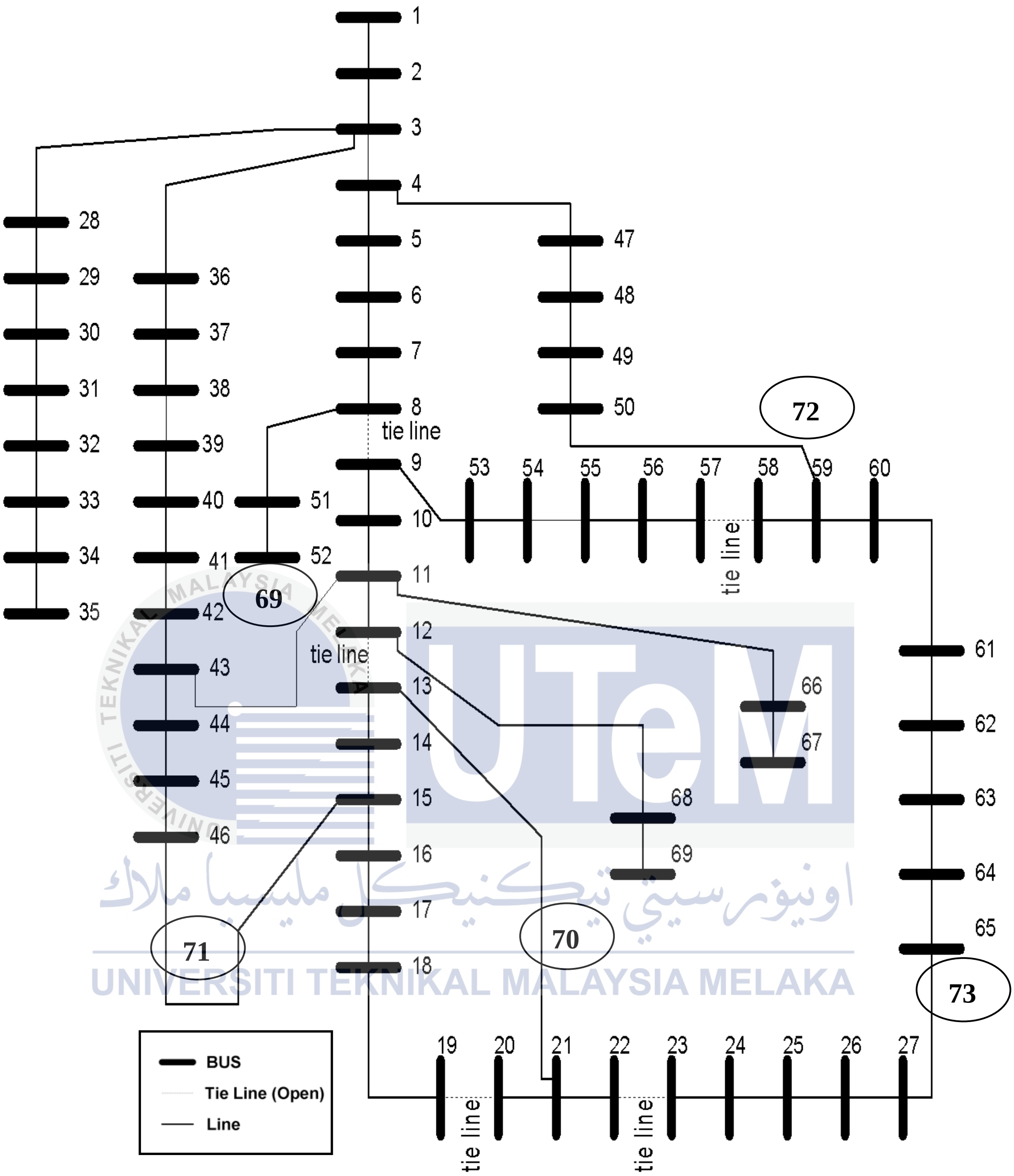

Figure 4.13: The 69-bus radial after reconfiguration with PSO

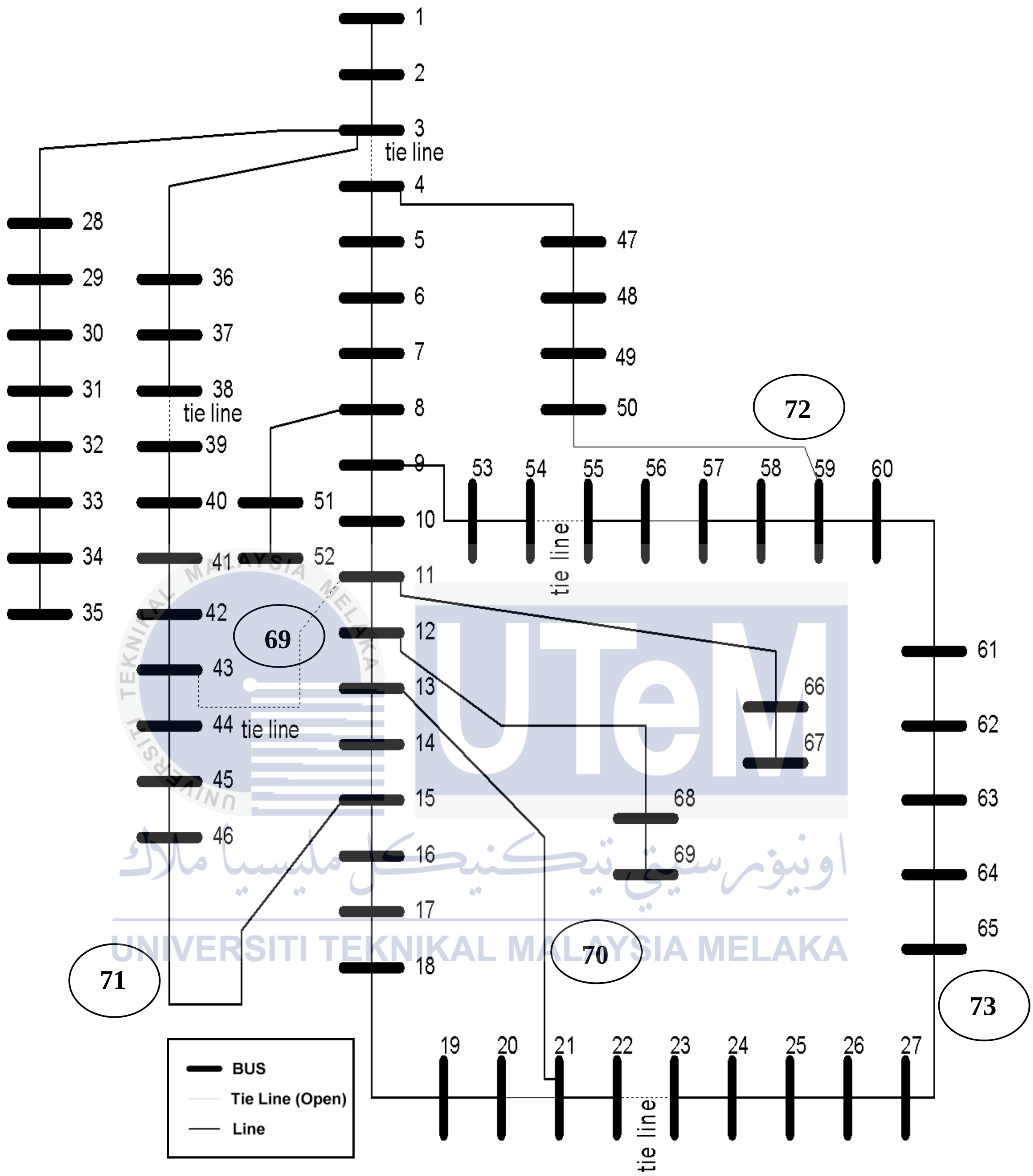

Figure 4.14: The 69-bus radial after reconfiguration with EPSO

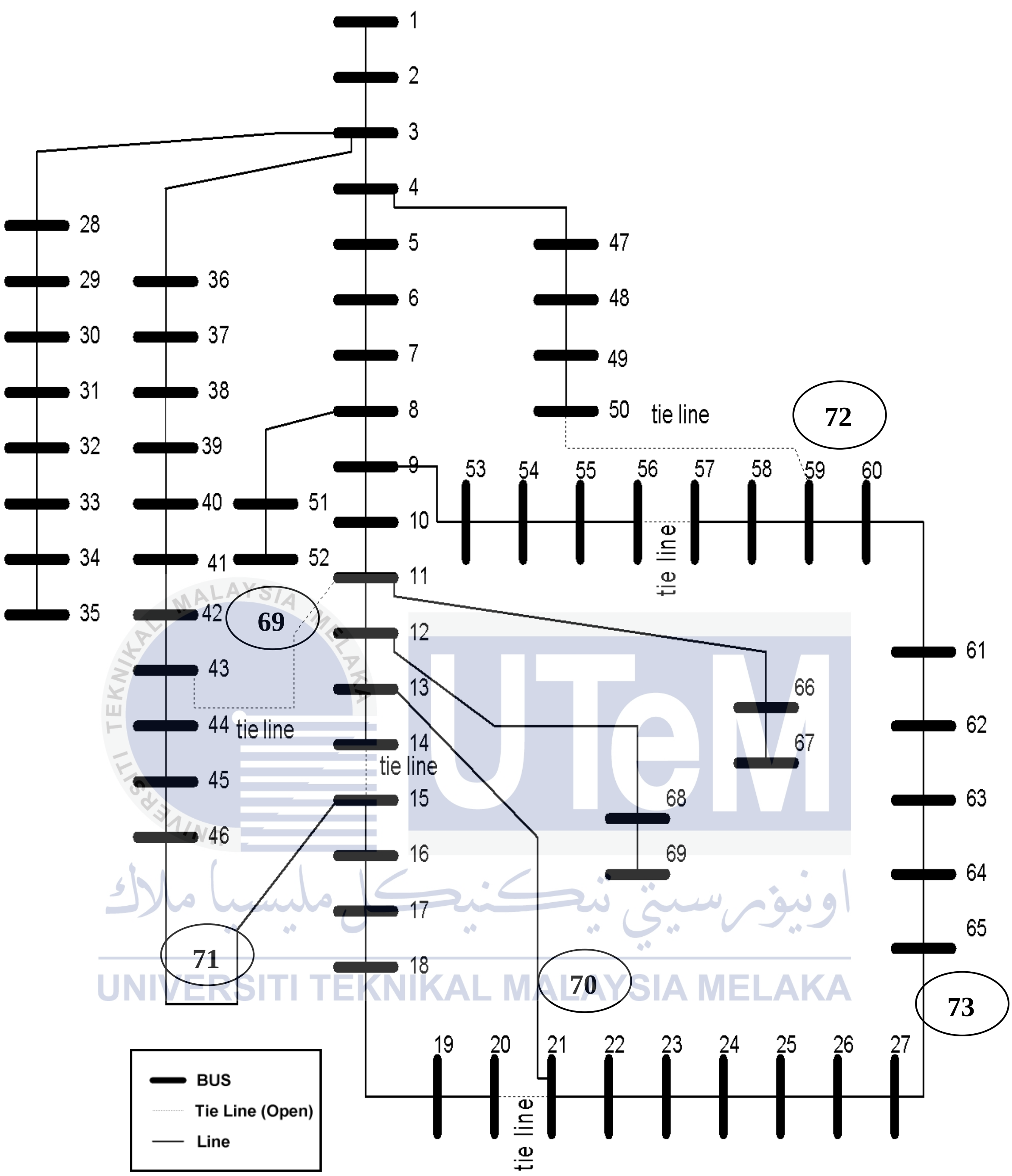

Figure 4.15: The 69-bus radial after reconfiguration with REPSO

4.5 Summary of Results

From the results, it can be summarized that REPSO are able to reduce highest total power losses in shortest way in 33kV bus test system but in 69kV bus test system, it is still able to achieve the highest power losses but it takes a sightly longer tme . This is due to the ranking concepts which in 69kV bus test system, there are more elements to be sorted and then ranking them to get the one the best. In 33kV, REPSO is able to reduce power losses from 202.7kW to 146.1kW in only 9.97seconds. Eventhough it is not the fastest in 69kV, but it still can be considered as fast technique because it only takes 15.044023 seconds to reduce from 0.0889MW to 0.0500MW which are only slightly behind the fastest algorithm which is 11.11761s. The summarization of both configuration using the three algorithms can be seen in Table 4.8:

Table 4.8: The summarization of analysis results for 33kV and 69kV

Parameters	Total Power Losses		Computational Time (S)	
Bus Test System / Algorithm	33kV (kW)	69kV (MW)	33kV	69kV
PSO	146.1	0.0550	28.65	21.852637
EPSO	131.1	0.0520	13.62	11.11761
REPSO	120.7	0.0500	9.97	15.044023

CHAPTER 5

CONCLUSION

5.1 Conclusion

A distribution network reconfiguration method which is based on REPSO technique has been introduced. The main goal of this work is to minimize the power losses and improve the computing time is successfully analyzed by implementation of the three optimization methods which are PSO, EPSO and REPSO correspondingly. The power losses are positively being reduced and the best optimal value has been achieved by REPSO algorithm. Thus, the implementation of REPSO is proved to give the great impact for the whole network reconfiguration system.

5.2 Recommendation

The power system engineer should incorporate methodology to measure the real potential of the proposed method so that the optimal solution of a distribution network system can be achieved in real network environment. The real power losses would be minimised after the implemetation, therefore the distribution system would be more efficient and reliable.

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APPENDICES

Appendices A: The 33-Bus Data

```
clc
clear
%BASEMVA = 100     BASEVOLT = 132     ERROR TOL = 1E-004
basemva = 100;
basevoltage = 132;
ep = 1E-004;
maxiter=10;
accuracy=0.0001;

busdata1= [
      1  1  1  0    0  0  0  0  0  0  0  0
      2  0  1  0    0  1  0.6 0  0  0  0  0
      3  0  1  0    0  0.9 0.4 0  0  0  0  0
      4  0  1  0    0  1.2 0.8 0  0  0  0  0
      5  0  1  0    0  0.6 0.3 0  0  0  0  0
      6  0  1  0    0  0.6 0.2 0  0  0  0  0
      7  0  1  0    0  2  1  0  0  0  0  0
      8  0  1  0    0  2  1  0  0  0  0  0
      9  0  1  0    0  0.6 0.2 0  0  0  0  0
      10  0  1  0    0  0.6 0.2 0  0  0  0  0
      11  0  1  0    0  0.45   0.3 0  0  0  0  0
      12  0  1  0    0  0.6 0.35   0  0  0  0  0
      13  0  1  0    0  0.6 0.35   0  0  0  0  0
      14  0  1  0    0  1.2 0.8 0  0  0  0  0
      15  0  1  0    0  0.6 0.1 0  0  0  0  0
      16  0  1  0    0  0.6 0.2 0  0  0  0  0
      17  0  1  0    0  0.6 0.2 0  0  0  0  0
      18  0  1  0    0  0.9 0.4 0  0  0  0  0
      19  0  1  0    0  0.9 0.4 0  0  0  0  0
      20  0  1  0    0  0.9 0.4 0  0  0  0  0
      21  0  1  0    0  0.9 0.4 0  0  0  0  0
      22  0  1  0    0  0.9 0.4 0  0  0  0  0
      23  0  1  0    0  0.9 0.5 0  0  0  0  0
      24  0  1  0    0  4.2 2   0  0  0  0  0
      25  0  1  0    0  4.2 2   0  0  0  0  0
```

```
          26  0   1   0      0   0.6 0.25    0    0    0    0    0
          27  0   1   0      0   0.6 0.25    0    0    0    0    0
          28  0   1   0      0   0.6 0.2 0   0    0    0    0
          29  0   1   0      0   1.2 0.7 0   0    0    0    0
          30  0   1   0      0   2   6   0   0    0    0    0
          31  0   1   0      0   1.5 0.7 0   0    0    0    0
          32  0   1   0      0   2.1 1   0   0    0    0    0
          33  0   1   0      0   0.6 0.4 0   0    0    0    0 ];

%                          Line code
%      Bus  bus      R       X     1/2 B   = 1 for lines
%      nl   nr       p.u.    p.u.  p.u.    > 1 or < 1 tr. tap at bus nl
linedata1=[   1   2   0.000529155  0.000356061    0     1
  2   3   0.002829431 0.00190303      0     1
  3   4   0.002101125 0.001412121     0     1
  4   5   0.002187213 0.001470455     0     1
   5    6   0.004700413 0.005356061     0     1
  6    7   0.00107438  0.004687879 0          1
  7    8   0.004083448 0.001781061 0          1
  8    9   0.005910813 0.005606061 0          1
  9    10  0.005991736 0.005606061 0          1
  10   11  0.001128903 0.000493182 0          1
          11   12  0.00214876  0.000983333 0          1
          12   13  0.008425161 0.008749242 0          1
          13   14  0.003108356 0.005400758 0          1
  14    15  0.003391299 0.003984848 0          1
  15    16  0.004282599 0.000303030 0          1
  16    17  0.007397268 0.013037879 0          1
  17    18  0.004201102 0.004347727 0          1
  2    19  0.00094123  0.001185606 0          1
  19    20  0.00863292  0.010268939 0          1
  20    21  0.002350207 0.003624242 0          1
  21    22  0.004068526 0.007100758 0          1
  3    23  0.002589532 0.002336364 0          1
  23    24  0.005153811 0.005371970 0          1
  24    25  0.005141758 0.005356818 0          1
  6    26  0.001165634 0.000783333 0          1
  26    27  0.001631084 0.001096212 0          1
  27    28  0.00607725  0.007074242 0          1
  28    29  0.004616047 0.005307576 0          1
  29    30  0.002912075 0.001958333 0          1
  30    31  0.00559286  0.007294697 0          1
  31    32  0.001782025 0.002741667 0          1
  32    33  0.001957645 0.004016667 0          1
  8   21    0.0114800   0.0114800   0          1
```

```
9   15   0.0114800   0.0114800   0          1
        12  22   0.0114800   0.0114800   0          1
        18  33   0.0028696   0.0028696   0          1
        25  29   0.0028696   0.0028696   0         1];
```

Appendices B: The load flow data

```
%clc
disp(tech)
fprintf('                    Maximum Power Mismatch = %g \n', maxerror)
fprintf('                          No. of Iterations = %g \n\n', iter)
head =['    Bus  Voltage  Angle    ------Load------    ---Generation---   Injected'
'    No.  Mag.     Degree     MW       Mvar       MW       Mvar       Mvar '
'                                                                     '];
disp(head)
for n=1:nbus
     fprintf(' %5g', n), fprintf(' %7.3f', Vm(n)),
     fprintf(' %8.3f', deltad(n)), fprintf(' %9.3f', Pd(n)),
     fprintf(' %9.3f', Qd(n)),  fprintf(' %9.3f', Pg(n)),
     fprintf(' %9.3f ', Qg(n)), fprintf(' %8.3f\n', Qsh(n))
end
    fprintf('      \n'), fprintf('    Total              ')
    fprintf(' %9.3f', Pdt), fprintf(' %9.3f', Qdt),
    fprintf(' %9.3f', Pgt), fprintf(' %9.3f', Qgt), fprintf(' %9.3f\n\n', Qsht)
```

Appendices C1:The bus admittance matrix for power flow solution data

```
j=sqrt(-1); i = sqrt(-1);
nl = linedata(:,1); nr = linedata(:,2); R = linedata(:,3);
X = linedata(:,4); Bc = j*linedata(:,5); a = linedata(:, 6);
nbr=length(linedata(:,1)); nbus = max(max(nl), max(nr));
Z = R + j*X; y= ones(nbr,1)./Z;      %branch admittance
for n = 1:nbr
if a(n) <= 0
   a(n) = 1; elseend
Ybus=zeros(nbus,nbus);     % initialize Ybus to zero
% formation of the off diagonal elements
for k=1:nbr;
      Ybus(nl(k),nr(k))=Ybus(nl(k),nr(k))-y(k)/a(k);
      Ybus(nr(k),nl(k))=Ybus(nl(k),nr(k));
end
end
% formation of the diagonal elements
for  n=1:nbus
for k=1:nbr
if nl(k)==n
        Ybus(n,n) = Ybus(n,n)+y(k)/(a(k)^2) + Bc(k);
elseif nr(k)==n
        Ybus(n,n) = Ybus(n,n)+y(k) +Bc(k);
else, end
end
end
clear Pgg
```

Appendices C2: The Newton-Raphson data

```
ns=0; ng=0; Vm=0; delta=0; yload=0; deltad=0;
```

```
nbus = length(busdata(:,1));
kb=[];Vm=[]; delta=[]; Pd=[]; Qd=[]; Pg=[]; Qg=[]; Qmin=[]; Qmax=[];  % Added (6-8-00)
Pk=[]; P=[]; Qk=[]; Q=[]; S=[]; V=[]; % Added (6-8-00)
for k=1:nbus
n=busdata(k,1);
kb(n)=busdata(k,2); Vm(n)=busdata(k,3); delta(n)=busdata(k, 4);
Pd(n)=busdata(k,5); Qd(n)=busdata(k,6); Pg(n)=busdata(k,7); Qg(n) = busdata(k,8);
Qmin(n)=busdata(k, 9); Qmax(n)=busdata(k, 10);
Qsh(n)=busdata(k, 11);
if Vm(n) <= 0
    Vm(n) = 1.0; V(n) = 1 + j*0;
else delta(n) = pi/180*delta(n);
    V(n) = Vm(n)*(cos(delta(n)) + j*sin(delta(n)));
    P(n)=(Pg(n)-Pd(n))/basemva;
    Q(n)=(Qg(n)-Qd(n)+ Qsh(n))/basemva;
    S(n) = P(n) + j*Q(n);
end
end
for k=1:nbus
if kb(k) == 1, ns = ns+1; else, end
if kb(k) == 2
  ng = ng+1; else, end
ngs(k) = ng;
nss(k) = ns;
end
Ym=abs(Ybus); t = angle(Ybus);
m=2*nbus-ng-2*ns;
maxerror = 1; converge=1;
iter = 0;
%%%% added for parallel lines (Aug. 99)
mline=ones(nbr,1);
for k=1:nbr
for m=k+1:nbr
```

```
if((nl(k)==nl(m)) && (nr(k)==nr(m)));
            mline(m)=2;
elseif ((nl(k)==nr(m)) && (nr(k)==nl(m)));
         mline(m)=2;
else, end
end
end
%%%   end of statements for parallel lines (Aug. 99)

% Start of iterations
clear ADCJDX
while maxerror >= accuracy && iter <= maxiter % Test for max. power mismatch
for ii=1:m
for k=1:m
   A(ii,k)=0;      %Initializing Jacobian matrix
end, end
iter = iter+1;
for n=1:nbus
nn=n-nss(n);
lm=nbus+n-ngs(n)-nss(n)-ns;
J11=0; J22=0; J33=0; J44=0;
for ii=1:nbr
if mline(ii)==1   % Added to include parallel lines (Aug. 99)
if nl(ii) == n || nr(ii) == n
if nl(ii) == n ,  l = nr(ii); end
if nr(ii) == n , l = nl(ii); end
         J11=J11+ Vm(n)*Vm(l)*Ym(n,l)*sin(t(n,l)- delta(n) + delta(l));
         J33=J33+ Vm(n)*Vm(l)*Ym(n,l)*cos(t(n,l)- delta(n) + delta(l));
if kb(n)~=1
                J22=J22+ Vm(l)*Ym(n,l)*cos(t(n,l)- delta(n) + delta(l));
                J44=J44+ Vm(l)*Ym(n,l)*sin(t(n,l)- delta(n) + delta(l));
else, end
if kb(n) ~= 1  && kb(l) ~=1
                    lk = nbus+l-ngs(l)-nss(l)-ns;
```

```
                ll = l -nss(l);
% off diagonalelements of J1
                A(nn, ll) =-Vm(n)*Vm(l)*Ym(n,l)*sin(t(n,l)- delta(n) + delta(l));
if kb(l) == 0  % off diagonal elements of J2
                A(nn, lk) =Vm(n)*Ym(n,l)*cos(t(n,l)- delta(n) + delta(l));end
if kb(n) == 0  % off diagonal elements of J3
                A(lm, ll) =-Vm(n)*Vm(l)*Ym(n,l)*cos(t(n,l)- delta(n)+delta(l)); end
if kb(n) == 0 && kb(l) == 0  % off diagonal elements of  J4
                A(lm, lk) =-Vm(n)*Ym(n,l)*sin(t(n,l)- delta(n) + delta(l));end
elseend
else , end
else, end
end
  Pk = Vm(n)^2*Ym(n,n)*cos(t(n,n))+J33;
  Qk = -Vm(n)^2*Ym(n,n)*sin(t(n,n))-J11;
if kb(n) == 1
     P(n)=Pk; Q(n) = Qk; end% Swing bus P
if kb(n) == 2
       Q(n)=Qk;
if Qmax(n) ~= 0
        Qgc = Q(n)*basemva + Qd(n) - Qsh(n);
if iter <= 7                  % Between the 2th & 6th iterations
if iter > 2                % the Mvar of generator buses are
if Qgc  < Qmin(n),       % tested. If not within limits Vm(n)
             Vm(n) = Vm(n) + 0.01;    % is changed in steps of 0.01 pu to
elseif Qgc  > Qmax(n),   % bring the generator Mvar within
             Vm(n) = Vm(n) - 0.01;end% the specified limits.
else, end
else,end
else,end

end
if kb(n) ~= 1
    A(nn,nn) = J11;  %diagonal elements of J1
```

```
    DC(nn) = P(n)-Pk;
end
if kb(n) == 0
    A(nn,lm) = 2*Vm(n)*Ym(n,n)*cos(t(n,n))+J22;  %diagonal elements of J2
    A(lm,nn)= J33;        %diagonal elements of J3
    A(lm,lm) =-2*Vm(n)*Ym(n,n)*sin(t(n,n))-J44;  %diagonal of elements of J4
    DC(lm) = Q(n)-Qk;
end
end
DX=A\DC';
for n=1:nbus
  nn=n-nss(n);
  lm=nbus+n-ngs(n)-nss(n)-ns;
if kb(n) ~= 1
   delta(n) = delta(n)+DX(nn); end
if kb(n) == 0
   Vm(n)=Vm(n)+DX(lm); end
end
  maxerror=max(abs(DC));
%if iter == maxiter && maxerror > accuracy
%fprintf('\nWARNING: Iterative solution did not converged after ')
% fprintf('%g', iter), fprintf(' iterations.\n\n')
%fprintf('Press Enter to terminate the iterations and print the results \n')
%converge = 0; pause, else, end

end

if converge ~= 1
   tech= ('                       ITERATIVE SOLUTION DID NOT CONVERGE'); else,
   tech=('                    Power Flow Solution by Newton-Raphson Method');
end
V = Vm.*cos(delta)+j*Vm.*sin(delta);
deltad=180/pi*delta;
i=sqrt(-1);
```

```
k=0;
for n = 1:nbus
if kb(n) == 1
    k=k+1;
    S(n)= P(n)+j*Q(n);
    Pg(n) = P(n)*basemva + Pd(n);
    Qg(n) = Q(n)*basemva + Qd(n) - Qsh(n);
    Pgg(k)=Pg(n);
    Qgg(k)=Qg(n);     %june 97
elseif  kb(n) ==2
    k=k+1;
    S(n)=P(n)+j*Q(n);
    Qg(n) = Q(n)*basemva + Qd(n) - Qsh(n);
    Pgg(k)=Pg(n);
    Qgg(k)=Qg(n);  % June 1997
End
yload(n) = (Pd(n)- j*Qd(n)+j*Qsh(n))/(basemva*Vm(n)^2);
end
busdata(:,3)=Vm'; busdata(:,4)=deltad';
Pgt = sum(Pg);  Qgt = sum(Qg); Pdt = sum(Pd); Qdt = sum(Qd); Qsht = sum(Qsh);

%clear A DC DX  J11 J22 J33 J44 Qk delta lk ll lm
%clear A DC DX  J11 J22 J33  Qk delta lk ll lm
```

Appendices C3: Paper Published in 2014 Fifth International Conference on Intelligent System Modelling and Simulation (ISMS2014)

2014 Fifth International Conference on Intelligent Systems Modelling and Simulation

A DNR by Using Rank Evolutionary Particle Swarm Optimization for Power Loss Minimization

Mohamad Fani Sulaima, Siti Atika Othman
Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka
Malacca, Malaysia.
fani@utem.edu.my, hairilatika@gmail.com

Mohd Saifuzam Jamri, Rosli Omar, Marizan Sulaiman
Faculty of Electrical Engineering
Universiti Teknikal Malaysia Melaka
Malacca, Malaysia.
saifuzam@utem.edu.my, rosliomar@utem.edu.my, marizan@utem.edu.my

Abstract- **Distribution Network Reconfiguration (DNR) is required to identify the best topology network in order to fulfill the power demand with minimum power losses. This paper proposes a new method which is called as Rank Evolutionary Particle Swarm Optimization (REPSO). The proposed method is a combination of the Particle Swarm Optimization (PSO) and the traditional Evolutionary Programming (EP) algorithm with a rejuvenation of the additional of ranking element. The main objective of this paper is to reduce the power losses while improving the convergence time. The proposed method will be implemented and the real power losses in the IEEE 33-bus test system will be investigated and analyzed accordingly. The results are compared to the conventional PSO and hybridization EPSO method and it is hoped to help the power system engineer in securing the network with the less power loss in the future.**

Keywords – distribution network reconfiguration; rank evolutionary particle swarm optimization; particle swarm optimization; evolutionary programming

I. Introduction

Distribution Network Reconfiguration (DNR) is an important measure of changing the network topology through the opening and closing the switches. It is also a key research of automatic operation. DNR has been used for many purposes and the main purpose of DNR is to minimize the power losses in distribution network system. Thus, DNR also comes in large scale and is designed in closed loop and opened loop. DNR is also an effective way in order to balance the load, improve the voltage quality and enhance the system security as well [1]. During normal operation of a distribution network, the energy flow has a radial path and passes the normally close switches [2]. 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.

Many researchers have been done the investigation on the combination of various methods and optimization techniques that seems to be able to help in reducing the power losses. The authors in [3] were the first proposed the distribution system reconfiguration for loss reduction. In the late 90's, the heuristics methods on large scale of distribution network appears to be the solution on reducing the power losses in a radial distribution networks [4]. Particle Swarm Optimization (PSO) is widely applied to various types of complex optimization problems. For example, the evolutionary PSO [5], modified PSO [6] and [8], hybrid PSO [7], multiple contingencies by using PSO [9], the distributed hierarchy structure in [10] and the AMPSO that adds stochastic mutation in PSO was introduced in [11].

Unfortunately, in order to get the optimal value, the time taken for these methods is too long. The initial values of the optimization methods such as PSO are easily affecting the convergence result [12], [13]. Therefore, in this work, the concept of combination, selection and ranking will be implemented. The PSO algorithm will be combined with Evolutionary Programming (EP) to from a hybridization method called EPSO and hence, the Rank Evolutionary Particle Swarm Optimization (REPSO) is introduced from the ranking concept. REPSO is introduced in this work to help in finding the most suitable optimal opened switches and thus reducing the power losses in its fastest ways. The analysis performance will be done in the 33kV distribution network configuration and the results will be compared to previous methods which are PSO and EPSO.

In section II, the mathematical formulation and constraints will be discussed. The implementation of REPSO in the DNR, the simulation results and analysis for power losses and computational time and the conclusion will be discussed in Section III, VI and V respectively.

II. Mathematical Formulation and Constraints

The needed for the reconfigurtion of the distribution system in this study is to minimize the power losses in distribution network system. Therefore, the expression that can relate with the objective are as follow:

$$\text{Minimize } f_1(x,v) = \Sigma^{n}_{i=1} \text{Losses}_i \tag{1}$$

Where,

n is the number of branches
x is the continous control variable
v is the discrete control variable
losses is the power losses at classified at i branch.