

**A COMPARATIVE STUDY OF HYBRIDIZATION  
METHOD OF PARTICLE SWARM OPTIMIZATION  
(PSO) FAMILY FOR NETWORK RECONFIGURATION**

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SWARM OPTIMIZATION (PSO) FAMILY FOR NETWORK  
RECONFIGURATION**

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

**Faculty of Electrical Engineering  
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**2015**

“ I declare that this report entitled “ A Comparative Study of Hybridization Methods of Particle Swarm Optimization (PSO) Family for Network Reconfiguration ” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree ”

Signature : .....

Name : .....

Date : .....

I dedicate this to my parents, teacher, friends and fellow members without whom it was almost impossible for me to complete my thesis work. Thank You

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## ABSTARCT

Electric power distribution loss and reliability are major concerns in power system as the demand of electrical energy by customers keep increasing from day to day. Distribution network reconfiguration (DNR) is one of the method that can be applied in the system to minimize the power loss in existing distribution network. This project proposed the comparative study between the meta-heuristics PSO Family that consists of traditional PSO and hybrid PSO ; EPSO and REPSO. The performance on the power loss, computing time and total cost saving has been applied on the algorithm. A comprehensive performance analysis has been applied on IEEE 33 bus distribution system by using the simulation in the MATLAB environment. The proposed technique has been integrated as well as the real power losses along with computation time in the network system offers also been investigated and justified. From this studies, the best PSO Family algorithm that excel in performance of power losses reduction, computation time and total cost save has been determined. Thus, distribution network reconfiguration can certainly be utilized to greatly assist in conserving the expenditure, decreasing the power losses as well as increase the quality and even reliability of electrical power system throughout Malaysia

## ABSTRAK

Kehilangan kuasa elektrik di bahagian pengagihan kuasa adalah perkara yang membimbangkan di dalam sistem kuasa kerana permintaan tenaga elektrik yang semakin meningkat oleh pelanggan dari hari ke hari. Konfigurasi semula rangkaian pengedaran adalah salah satu kaedah yang boleh digunakan dalam sistem untuk mengurangkan kehilangan kuasa dalam rangkaian pengedaran yang sedia ada. Projek ini berkaitan kajian perbandingan antara meta-heuristik keluarga PSO yang terdiri daripada PSO tradisional dan PSO hibrid; EPSO dan REPSO. Prestasi pada kehilangan kuasa, masa pengkomputeran dan jumlah penjimatan kos telah dikaji keatas algoritma. Analisis Prestasi komprehensif telah dilaksanakan pada 33 IEEE bus sistem pengagihan dengan menggunakan simulasi dalam persekitaran MATLAB. Teknik yang dicadangkan itu telah dikaji dimana kehilangan kuasa sebenar bersama-sama dengan masa pengiraan dalam sistem rangkaian telah dikenalpasti dan dijustifikasikan. Dari kajian ini, algoritma terbaik dari keluarga PSO yang cemerlang dalam prestasi pengurangan kehilangan kuasa, masa pengiraan dan jumlah kos penjimatan telah ditentukan. Oleh itu, rangkaian pengedaran konfigurasi semula pasti boleh digunakan untuk banyak membantu dalam menjimatkan perbelanjaan operasi, mengurangkan kehilangan kuasa serta meningkatkan kualiti dan juga kebolehpercayaan sistem kuasa elektrik di seluruh Malaysia



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# CHAPTER 1

## INTRODUCTION

### 1.1 Motivation

Electricity distribution companies constantly require improvements in service, and an appropriate reduction in cost of the system. Since the distribution system is the biggest section in power system area, by finding the best optimal method that can reduce the power losses that at the same time influences the cost and crucially also leading to significant energy saving. For the past year, distribution network reconfiguration using the heuristics method had been widely study to minimize the power losses. These studies propose to analyze one of the heuristic methods and compare the hybrid PSO algorithm for distribution network reconfiguration. To verify the effectiveness of the proposed method, comparative studies are conducted between the algorithm to find the most excel PSO Family that efficient in power loss reduction, computed time and cost saving.

### 1.2 Problem Statements

Distribution system's network carries electricity from the transmission system that delivers it to the consumer. However, distribution section is one of the prime contributors in power loss. Due to that several the heuristics techniques utilized by experts to resolve optimization issue and Particle Swarm Optimization (PSO) is one of the algorithms that applied on the distribution system to reconfigure the network. Many researchers had enhanced the classical PSO algorithm with other heuristics algorithm such as differential evolution (DE) and evolution programming (EP) that produces hybrid PSO which is more powerful and produce more efficient performance to solve optimization problem. However there is lack of research that has been reported in performance of these hybrids PSO family; Particle Swarm Optimization (PSO), Evolutionary Particle Swarm Optimization (EPSO) and Rank Evolutionary Particle Swarm Optimization (REPSO) that contributed the



minimum power loss and best computing time performances. Moreover, the impact of the performances of the PSO Family algorithms on the total cost saves also have not been conducted. Thus, with knowledge about the effectiveness performance of the heuristics algorithms when applied for the distribution network reconfiguration. It will give advantages for improvement of power system efficiency and better financial planning.

### 1.3 Objective

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

- a) To analyze the power loss after hybrid method of PSO family applied on network reconfiguration
- b) To compare the performance of computing time between hybrid method of PSO Family
- c) To validate the cost saving saving after hybrid method of PSO family applied on network reconfiguration in Malaysia.

### 1.4 Scope

The scope of this paper is mainly focused on comparative studies between PSO, EPSO and REPSO in radial network that contains a group of interconnected radial circuit distribution. Every coding will be carried out by executing MATLAB software simulation along with analyzed upon the 33-bus radial IEEE test system. The Malaysian average selling price [25] were used to analyze the cost saving when the algorithms applied on the network.

### 1.5 Outline

The inclusive functionality evaluation of the PSO Family (PSO, EPSO and REPSO) methods in discovering the optimum alternative for 33kV bus test system with low power losses as well as computational period and total cost save will be analyzed in this thesis. Essentially, this study is broken down right to several parts in order to provide guidelines along with explain as follows:

**Chapter 1 : Introduction**

This section specifies motivation to acquire the following research. The determined problem statement, objectives, scope and significances of the research are outlined in this section.

**Chapter 2 : Literature Review**

This section explains the theory as well as the basic principle and review of previous related work regarding PSO, EPSO and REPSO

**Chapter 3 : Research Methodology**

In this section, the chapter explains the implementation of the PSO Family algorithm for implementation in distribution network reconfiguration (DNR) in 33Kv IEE test system. In this chapter also defined the mathematical formulation along with constrain that need to be obey in the studies.

**Chapter 4 : Results**

This segment provides the evaluation of the results obtained through simulation of MATLAB of PSO, EPSO and REPSO in IEEE 33kV bus. The overall investigation of the findings is going to be investigated.

**Chapter 5 : Conclusion**

This section will summarize the actual finding due to determined objectives along with futurerecommendation

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Theory and basic principle

##### 2.1.1 Types of distribution system

There are three general classification of electrical power distribution system.

##### 2.1.1.1 Radial distribution system

Radial system is the most basic type because the power comes right from a single power source. A generating system supplies power from the substation via radial lines that are extended to the different areas of a community. Radial system is at least efficient in terms of continuous service since there are no back up distribution system connected to the single power source. If any power line opens, one or more loads are disrupted. There is more possibility of power black outs. On the other hand, the radial system is least expensive.

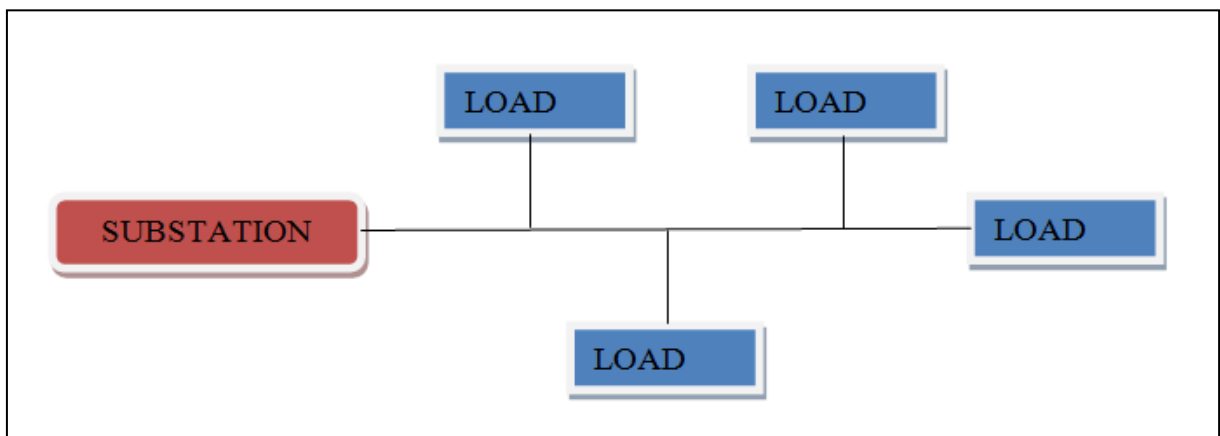


Figure 2.1: Radial Distribution system

### 2.1.1.2 Loop/ Ring distribution system

Ring distribution systems tend to be utilized in heavily populated areas. The distribution lines encircle the services area. Power is supplied from one or more power sources into substations close to the services area. The power is then distributed through the substations via the radial power lines. When a power line is opened, no disruption to other load occurs. The ring system provides a more continues service than the radial system. Attributed to extra power lines and a greater circuit complexity, the ring system is more expensive.

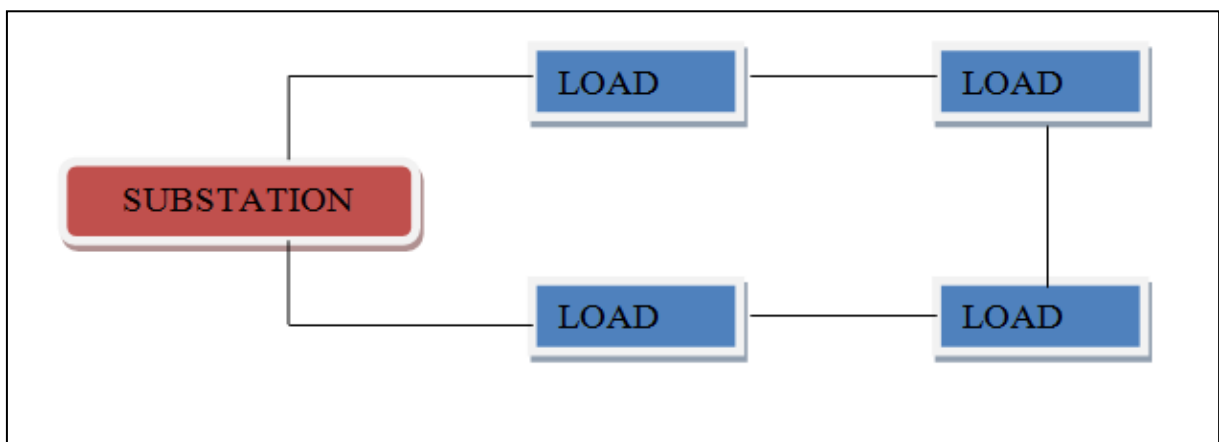


Figure 2.2: Loop / Ring distribution system

### 2.1.1.3 Mesh / Network distribution system

Network distribution systems are usually a combo of the radial as well as ring systems. They commonly result when one of the other systems is expended. This system is much more complex but it offers quite dependable services to consumers which is where each load is fed by two or more circuit.

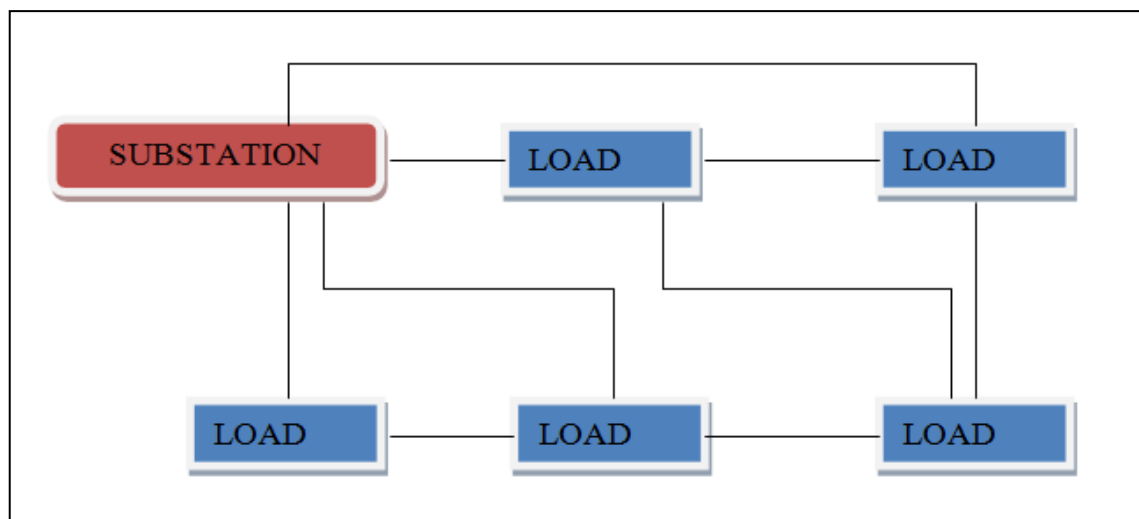


Figure 2.3: Mesh/Network distribution system

### 2.1.2 Distribution network reconfiguration method

Till today Electric power distribution losses in one of the main concern in power system to reduces as the demand of electrical energy is increasing day by day. The techniques of monitoring systems such local and manual control of capacitor, sectionalizing switches and voltages regulator are generally dealing throughout nearly all of distribution system network [1]. To improve the efficiency of the electrical network, there are several techniques that can be applied in the system and the reconfiguration of distribution network is one of the method [2]. The method is performed by opening the sectionalizing switches that usually closed and closing the tie switches that normally open to maintain the feeder in radial network [3], [4]. The switching action depends on the number of switches. Where, the greater the number of switches, the more available options of reconfiguration. Hence, reconstructing the power lines which connect various buses in a power system. The distribution network that consists of different load characteristics such as domestic and industrial can be configured and can be done from time to time.

There are lot of benefits of network reconfiguration [1]–[5]:

- i. Efficient electric distribution
- ii. Improves voltage stability
- iii. Smoothen the peak demand
- iv. Increase network reliability
- v. Reduce cost instillation of switching equipment
- vi. Minimize the real power losses
- vii. Relieves the overloading of network components and in the feeders
- viii. Balancing system load

### 2.1.2.1 Switch Connection

Switch connection was installed in primary distribution system for both protection and configuration management purpose. The ‘radiality’ of the network is sustained, with the ability to manipulating the condition for both two types of switch by opening or closing to reduce resistive line losses.

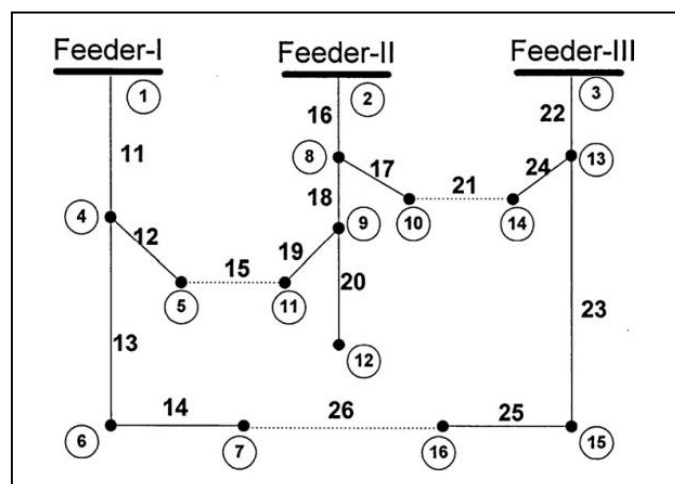


Figure 2.4: 16-Node distribution system [6]

#### **2.1.2.1.1 Closed switches (sectionalizing switches)**

The sectionalizing switches are normally closed. Sectionalizing switch need to be opened to sustain the radial composition of the distribution network. For instance, in Fig. 1, whenever the loads of feeder 2 get heavy under normal operating conditions, the sectionalizing switch linking nodes (9 and 10) must be opened up to sustain the radial structure regarding the network.

#### **2.1.2.1.2 Normally open switches (tie switches)**

The tie switches are generally normally open. It just closed intended for transferring load to distinct feeders. For illustration, in Fig. 1, whenever the loads of feeder 2 turn out to be heavy under normal operating conditions, the tie switch connecting nodes (5-11) may possibly be closed to transfer the load at bus11 from feeder 2 to feeder 1.

The objective of the reconfiguration is to minimize the distribution losses with turning on/off sectionalizing switches. The reconfiguration problem has the following constrains [6]:

1. Power flow equations.
2. Upper and lower bounds of nodal voltages.
3. Upper and lower bounds of line currents.
4. Feasible conditions in terms of network topology.

### 2.1.3 Energy loss reduction and cost reduction

One of the main purpose of heuristic method applied to the Distribution Network Reconfiguration applied to the network is to reduce the power loss in the distribution area. Whilst, the power loss has been reduce, the value of the cost saving will increase. Certain studies had been doned in energy loss reduction in Distribution Network Reconfiguration. In [7] , to reduce the operating cost in the real-time operation environment , Liu and W Edwin apply a new feeder reconfiguration algorithm. Operate as series of open/close switching operation, it reduce the resistive losses in primary distribution feeders and at the same time reduce the cost of system operation. The test results prove efficient and robust of the develop algorithm that operate as decision support tool by using production grade software named FRECON.

The studies of reduction of operational cost continues by [8], where there Enhanced Gravitational Search Algorithm (EGSA) for multi-objective distribution feeder reconfiguration considering reliability, loss and operational cost. EGSA algorithm use to reduce processing time, improve quality and avoid from being trapped in local minima. The paper shows the superiority of EGSA obtain better results with respect to the PSO and GA algorithm when tested on 33 and 70 node test system.

Thus, the energy loss reduction analysis on distribution network reconfiguration also had been doned in [9] and [10] where both paper shows the advantageous of heuristic method to obtain the configuration with minimum active energy losse. The IEEE 33-nodes system were used to test the performance of purposed methodology that significant in the area of distribution network design. The energy loss estimation method based on readily available data studies were conducted in [8]. From this studies, it's compare and verify the results of the energy loss estimation from simulation that is important in distribution networks for planning purpose.