OPTIMAL ALLOCATION AND SIZING OF DISTRIBUTED GENERATION USING PARTICLE SWARM OPTIMIZATION IN DISTRIBUTION SYSTEM

MOHD ZULHISHAM BIN MOHD RADZI

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Universiti Tun Hussein Onn Malaysia

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ABSTRACT

Distribution Generation (DG) is a renewable energy in small scale located near to the load in distribution system. Installation of DG in power system can reduce the power loss and improve the voltage profile. For load flow, Newton-Raphson method is used to calculate the power losses and voltage magnitude. This project will use Particle Swarm Optimization (PSO) method to test on several cases, without DG installed, single DG, two DG, three DG and 10 DG installed. Varies number of particle, 10, 30 and 50 are used to find the most optimal sizing and location of DG in distribution network. This method has been tested on the standard IEEE-69 bus distribution network using MATLAB R2012a software. The results shows that the most optimize number of DG installed on distribution network is three DG with number of particle N=30. After installing the DG into the distribution system, the power losses of the system is decrease and voltage profile is improved.

ABSTRAK

Penjana pengagihan (PP) adalah satu sumber tenaga yang boleh diperbaharui yang bersekala kecil dan terletak berhampiran denagn beban didalam sistem pengagihan. Pemasangan PP didalam sistem pengagihan dapat mengurangkan kehilangan kuasa dan meningkatkan profil voltan. Untuk aliran beban, kaedah *Newton-Raphson* digunakan bagi mengira kehilangan kuasa dan magnitud voltan. Projek ini menggunakan kaedah Pengoptimuman Kerumunan Zarah dan diuji pada beberapa kes, tanpa pemasangan PP, PP tunggal, dua PP, tiga PP dan 10 PP. Bilangan zarah yan berbeza 10, 30 dan 50 telah dugunakan bagi mendapatkan saiz dan lokasi yang optimum di sistem pengagihan. Kaedah ini telah diuju pada IEEE standard 69 bas rangkain pengagihan menggunakan perisian MATLAB R2012a. Keputusan menunjukkan bilangan pemasangan PP yang paling optimum adalah tiga PP dengan bilangan zarah, N=30. Setelah memasang PP kedalam sistem agihan, kehilangan kuasa berkurangan dan profil voltan meningkat.

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LIST OF SYMBOLS AND ABBREVIATIONS

$\|V\|$	Voltage Magnitude
$\|V\|^{(0)}$	Initial voltage magnitude
n_p	Load Bus Number
δ	Angle
$\Delta P^{(0)}$	Real Power Mismatch
$\Delta Q^{(0)}$	Active Power Mismatch
V_n	Current velocity;
V_{n+1}	Updated velocity;
C_1 and C_2	Acceleration factors;
r_1 and r_2	Randomly generated numbers
w	Inertia weight
k	Iteration index.
P	Real Power
Q	Reactive Power
Pbest	Personal Best
Gbest	Global Best
DG	Distributed Generation
PSO	Particle Swarm Optimization

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CHAPTER 1

INTRODUCTION

1.1 Background History

The growth of any power system grid in the world is and always has been on an accelerating pace, feeding the almost insatiable demand for electrical power for the past century or so [1, 2]. This in turn forces a certain level of intricacy on the power system and that intricacy compounds with time; to the point where the power systems face the inability to progress with ease due to introductions of new transmission systems and construction of generating plants near load centres. As the system grows more complex and burdened with increasing load; various issues regarding cost, pollution, power quality and voltage stability takes centre stage [2].

Distributed Generation (DG) is an electrical power generation unit that is directly connected to a distribution network or placed as nearly as possible to its consumer. The technologies adopted in distributed generation vary in methods of generation including small-scaled gas turbines, wind, fuel cells, solar energy and hydro, etc [1]. DG is both beneficial to the consumers and utilities, much so in places where centralize generations are unfeasible or where deficiencies can be found in transmission systems. Optimally allocating DG units may address all the issues stated before, resulting in reduced power system losses, improved voltage profile, enhance power transfer capability, reduce pollution and cut generation and transmission cost [3,4].

Benefit-wise, DG may offer solutions to the majority of power systems crave. However, installation of a unit at a non-optimal place may have the reverse effect instead to the system; such as increases in system losses followed by an increase in cost [5-8]. With that in mind, selecting the most appropriate place for installation paired with the ideal size of a DG unit is of utmost importance in a large power system. Nevertheless, the optimum choice and allocation of DG is a complex integrative optimization method for which common or older optimization method falls short in implementing such a concept in the system [9].

In order to calculate the power loss and voltage magnitude at each bus, load flow studies is used. Gauss Saidel, Fast Decouple and Newton Raphson is one of the method of load flow studies.in this project, only Newton Raphson method is discussed to solve the load flow problem. This method can operate in high efficiency for large power system.

In optimization, many techniques are used to solve the problem in power system. This project aims to find the optimum sizing and location of DG in power system by using Particle Swarm Optimization (PSO). Particle swarm optimization (PSO) is a population-based optimization method first proposed by Kennedy and Eberhart in 1995, inspired by social behavior of bird flocking or fish schooling [10]. The PSO as an optimization tool provides a population-based search procedure in which individuals called particles change their position (state) with time. In a PSO system, particles fly around in a multidimensional search space. During flight, each particle adjusts its position according to its own experience (This value is called Pbest), and according to the experience of a neighboring particle (This value is called Gbest), made use of the best position encountered by itself and its neighbor.

1.2 Problem Statement

Distribution Generation (DG) plays important role in delivering the power into the distribution system. However, power losses and voltage magnitude must take into consideration in order to produce reliable power to consumer. Non-optimal location and sizing of DG units may lead to losses increase together with bad effect on power losses and voltage magnitude. Many optimization techniques that are used to minimize the losses and improve voltage magnitude by considering the optimal sizing and location of DG. For this project, Particle Swarm Optimization (PSO) is used to find the optimal sizing and location in standard IEEE-69 distribution bus system.

1.3 Objectives

The objectives of the project are as follow:

1. To study about Distribution Generation, load flow by using Newton Raphson method and optimization technique using Particle Swarm Optimization (PSO).
2. To solve sizing and location of Distribution Generation with standard IEEE 69-bus installation by using MATLAB programming.
3. To minimize the losses and improve the voltage profile in a distribution network.

1.4 Scope of Work

In order to archive the objectives of the research, several vital subtasks need to be undertaken; this includes the following:

1. Understand the power flow studies initiated in the process; namely, the Newton-Raphson method.
2. Familiarize with the critical topics surrounding the research; Particle Swarm Optimization (PSO), Distributed Generation (DG) and the MATLAB software.
3. Literature reviews on past till present related research/paper.
4. Develop a program to solve DG in MATLAB based on the PSO algorithm.
5. Test the program on the IEEE-69 bus radial distribution system and any other possible test system to confirm its eligibility.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter explained based on the scope are covered in this project and its separated by four main topic which are Distribution Generation (DG), power flow solution method, optimization technique and Particle Swarm Optimization (PSO). All the main topics referred based on the study from the related journals and conferences.

2.2 Distribution Generation (DG)

Distribution Generation (DG) can be defined as a small generation, which is not directly connected to the transmission system and is not centrally dispatched. Generation is now being connected at distribution level, which has led to the characteristics of the network being changed. If increasing levels of generation are to be accommodated, then there must be a change of thinking regarding the planning about design of the distribution network [12].

2.2.1 Type of Distributed Generation (DG)

In Malaysia, the use of DG in power system is not widely used and still new. DG generates electricity from small scaled systems and operated as power production or can be as small contributor to the power system where it can produce the electricity close to the consumer.

Todays, many type of DG are used such as solar photovoltaic, wind turbine and hydro turbine. For solar type, the most renewable energy is comes directly or indirectly on the sun. It's commonly used for heating, lighting homes and variety of commercial industrial. Then, the wind turbine type are generated with the natural wind use where its converting kinetic energy to electric energy. For hydro turbine plant, the water from a river are stored in a reservoir. Water released from the reservoir flows through a turbine, spinning it and turned activates a generator to produce electricity. Some hydroelectric power types just use a small canal to channel the river water through a turbine and it's doesn't necessarily require a large dam. Figure 2.1 below are show some types of DG are used to generate the energy.

Figure 2.1: Solar Photovoltaic

Figure 2.2: Wind Turbine

Figure 2.3: Hydro Turbine

2.2.2 Benefits of Distributed Generation (DG)

DG is a renewable energy and also many benefits in distribution system. Its benefits are:

a. Can advance the efficiency of the electrical power
b. More dependable power for industries that require continuous service
c. Energy cost saving
d. Saving in transmission and distribution losses
e. Can improve the performance of system reliability and power quality.

2.2.3 Effect Distribution Generation on Distribution Networks and System Losses

Traditionally, the role of distribution networks is mainly confined to the interconnection between generation and transmission systems on one side and load centers on the other side. Consequently such networks are described as "passive" network. However the integration of Distribution Generation into distribution networks in recent years has transformed them from being passive to active network [13]. Distribution Generation therefore could affect the whole range of practices which is already in place in dealing with the planning of future expansion and refurbishment of a distribution network. The safe and efficient operation of a distribution network with Distribution Generation also can assist refurbishment of a distribution network in future expansion.

For system losses affect, are depends on the power flow of the system. As a Distribution Generation is bound to affect power flow of the associated distribution network, the losses of such networks will in turn be affects as well. Recent studies have shown that the Distribution Generation can either help in reducing system losses or causing an increase in their magnitude. This depends on factors including sizing and location of Distribution Generation, the relative magnitude between the generation and the total connected load to the generator and the topology of the network under consideration, whether the network is radial or interconnected [13].

2.2.4 Previous Research on Distribution Generation

Bongkoj Sookananta in [11] presented a method for the determination of the optimal DG in radial distribution networks. This method uses simple load flow method for the calculation of the power flow and losses in the network. A total system loss is used as the objective of optimal DG problem. ACS associated with this technique, the optimal location of DG and the same optimal size can be obtained.

M. H. Sulaiman proposed Firefly algorithm (FA) in determining the optimal location and size of DG [12]. In this paper, flat IEEE 69-bus test system is used to demonstrate the effectiveness of the FA. As a result of the proposed method is good for GA.

Design of a New Cooperative Harmonic Filtering Strategy for Distributed Generation Interface Converters in an Islanding Network by T-L. Lee [13] discusses about a new cooperative harmonic filtering approach for the interface converters of distributed generation sources. A droop control method based on the reactive volt-ampere consumption of harmonics of each interface converter is designed and implemented. From the simulation and laboratory test proved the strategy been produced.

Kirubakaran A. et. al show the DG plays an important role over fossil fuel generation [14] in their paper, Controlled Power Electronic Interface for Fuel-Cell-Based Distributed Generation. For several different DG technologies are increased their popularity due to its high efficiency, cleanliness, modularity, and cost effectiveness. In addition, this paper discussed about the DSP- controlled single stage power electronic interface for fuel-cell-based generation intended for residential/ grid connected applications. This method is used for the varying loads and transient conditions.

This paper is briefly explains to minimizations of the reactive support for DG and is investigated using two different operational perspectives. Ochoa, L.F et.al in their paper Minimization of the Reactive Support for Distributed Generation: Enhanced Passive Operation and Smart Distribution Networks [15] used adopting passive but enhanced power factor and substation settings, and implementing Smart Grid control schemes. The results demonstrate that the enhanced passive approach is able to achieve a performance almost as good as Smart Grid control without the need for any additional investment.

Senjyu, T et. al is presents the optimal control of distribution voltage with coordination of distributed installations, such as the load ratio control transformer, step voltage regulator (SVR), shunt capacitor, shunt reactor, and static var compensator [16]. In this study, SVR is assumed to be a model with tap changing where the signal is received from a central control unit. Moreover, the communication infrastructure in the supply of a distribution system is assumed to be widespread. The genetic algorithm is used to determine the operation of this control. In order to confirm the validity of the proposed method, simulations are carried out for a distribution network model with distributed generation (photovoltaic generation).

Strategic analysis framework for evaluating distributed generation and utility strategies by Ault, G.W et. al [17] obtainable a strategic analysis framework for evaluating distributed generation and distribution utility strategies. The outline is based on the idea of evaluating all distributed generation issues across many scenarios to encapsulate the extensiveness of uncertainties stemming from independent distributed generation in regulated distribution networks. The results from a case study based on the UK situation shows the potential value of distributed generation (both positive and negative) to distribution network operators. The case study also demonstrates the application of the proposed strategic analysis framework and the value of the results produced.

Far, H.G et. al briefly present the islanding protection is an essential and one of the more challenging aspect of distributed generation interconnection protection in Synchronous Distributed Generation Islanding Protection Using Intelligent Relays [18]. This paper proves how intelligent relays, employing multivariate analysis and data mining techniques, can be used for the islanding protection of synchronous distributed generation in the presence of high-speed reclosing. The established methodology is outlined and its presentation is illustrated for a number of diverse system operating states. The performance of the intelligent relays is assessed and compared against currently used islanding protection devices.

The Voltage Control With Inverter-Based Distributed Generation article is proposes by Bollen, M.H.J. et.al [19] to explain a method to use in the voltage source inverters with distributed generation to control the voltage in a distribution network. A droop line is used to prevent hunting between controllers. Analytical expressions are derived for the voltage along a feeder with uniformly distributed load/generation. The proposed algorithm will alleviate the voltage-control problem reported when installing distributed generation.

2.3 Power Flow

In a power system, powers are known rather than currents. Thus, the resulting equations in terms of power, known as the power flow equations, become nonlinear and must be solved by iterative techniques. Power flow studies, commonly referred to as load flow, are the backbone of power system analysis and design. They are necessary for planning, operation, economic scheduling and exchange of power between utilities. In addition, power flow analysis is required for many other analyses such as transient stability and contingency studies [20].

There are three commonly used iterative techniques, namely Newton-Raphson, Gauss-Seidel and Fast Decouple methods for the solution of nonlinear algebraic equation. These techniques are employed in the solution of power flow problems. The earliest algorithm was based on the Gauss-Seidel method, which made it possible, for the first time, to solve the load flow problem for relatively large system. It suffered, however from relatively poor convergence characteristics. Then, the Newton-Raphson method was developed to improve the convergence of the Gauss-Seidel method, but was initially thought to be impractical for realistically sized systems because of computational problem with large networks. The underlying problem for the iterative Newton-Raphson method is the solution of a matrix equation of large dimension [21].

For this project the Newton-Raphson method are used. These methods are most widely used for solving simultaneous nonlinear algebraic equation. Newton's method is a successive approximation procedure based on an initial estimate of the unknown and the use of Taylor's Series expansion [22]. Our study of the method begins by a discussion of the solution of a problem involving only two equations and two variables.

2.3.1 Newton-Raphson Method

The project aim is to minimize the power losses and improve the voltage magnitude in power system. In order to calculate the power loss and voltage magnitude at each bus, Newton-Raphson method is used to solve that's problem in this project. The basic equation, formation and calculation of Newton-Raphson method are discussed for solving voltage magnitude $|V|$ and angle δ, given real (P) and reactive (Q) power injections. The Newton-Raphson procedure is as follow:

Step 1: Choose the initial values of the voltage magnitudes $|V|^{(0)}$ of all n_p loads buses and n 1 angles $\delta^{(0)}$ of the voltages of all the buses except the slack bus.

Step 2: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to calculate a total n-1 number of injected real power $P_{calc}^{(0)}$ and equal number of real power mismatch $\Delta P^{(0)}$.

Step 3: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to calculate a total n_p number of injected reactive power $Q_{calc}^{(0)}$ and equal number of real power mismatch $\Delta Q^{(0)}$.

Step 4: Use the estimated $|V|^{(0)}$ and $\delta^{(0)}$ to formulated the Jacobian matrix $J^{(0)}$.

Step 5: Solve the load flow problem for $\delta^{(0)}$ and $\Delta|V|^{(0)} \div |V|^{(0)}$.

Step 6: Obtain the updates from:

$$\delta^{(1)} = \delta^{(0)} + \Delta\delta^{(0)} \quad (2.1)$$

$$|V|^{(1)} = \Delta|V|^{(0)}\left[1 + \frac{\Delta|V|^{(0)}}{|V|^{(0)}}\right] \quad (2.2)$$

Step-6: Check if all the mismatches are below a small number. Terminate the process if yes. Otherwise go back to step-1 to start the next iteration with the updates given by (2.1) and (2.2)

KCL for current injection:

$$I(i) = \sum_{j=1}^{n} YijVj = \sum_{j=1}^{n} |Yij||Vj|\angle\theta ij + \delta j \quad (2.3)$$

Real and reactive power injection:

$$Pi - jQi = Vi^{*}Ii \quad (2.4)$$

Substitute for Ii yields:

$$Pi - jQi = (|Vi|\angle\delta)\left(\sum_{j=1}^{n} |Yij|\,|Vj|\,\angle\theta ij + \delta j\right) \quad (2.5)$$

Divide into real and reactive parts:

$$Pi = \sum_{j=1}^{n} |Vi|\,|Vj| \cos(\Theta ij - \delta i + \delta j) \quad (2.6)$$

$$Qi = -\sum_{j=1}^{n} |Vi|\,|Vj| \sin(\Theta ij - \delta i + \delta j) \quad (2.7)$$

Cast power equations into iterative form:

$$Pi^{[k]} = \sum_{j=1}^{n} \left|Vi^{[k]}\right| \left|Vj^{[k]}\right| \cos(\Theta ij - \delta i^{[k]} + \delta j^{[k]}) \quad (2.8)$$

$$Qi^{[k]} = \sum_{j=1}^{n} \left|Vi^{[k]}\right| \left|Vj^{[k]}\right| \sin(\Theta ij - \delta i^{[k]} + \delta j^{[k]}) \quad (2.9)$$

Matrix function formation on the system of equations:

$$c = \begin{bmatrix} P_{inj}^{sch} \\ Q_{inj}^{sch} \end{bmatrix} \quad (2.10)$$

$$x^{[k]} = \begin{bmatrix} \delta^{[k]} \\ V^{[k]} \end{bmatrix} \quad (2.11)$$

$$f(x^{[k]}) = \begin{bmatrix} Pinj(x^{[k]}) \\ Qinj(x^{[k]} \end{bmatrix} \quad (2.12)$$

General formation of the equation to find a solution:

$$c = f(x_{solution}) \quad (2.13)$$

$$x^{[0]} = initial\ estimate\ of\, x_{solution} \quad (2.14)$$

The iterative equation:

$$x^{[k+1]} = x^{[k]} + 1 + \frac{c - f(x^{[k]})}{\left[\frac{df(x^{[k]})}{dx}\right]} \quad (2.15)$$

The Jacobian – the first derivative of a set functions $\left[\frac{df(x^{[k]})}{dx}\right]$ a matrix of all combinatorial pairs.

The Jacobian Matrix:

$$\left[\frac{df(x)}{dx}\right] \dot{\rightarrow} \begin{bmatrix} \Delta P \\ \Delta Q \end{bmatrix} = \begin{bmatrix} \frac{\partial P}{\partial \delta} & \frac{\partial P}{\partial |V|} \\ \frac{\partial Q}{\partial \delta} & \frac{\partial Q}{\partial |V|} \end{bmatrix} \begin{bmatrix} \Delta \delta \\ \Delta |V| \end{bmatrix} \quad (2.16)$$

Each non slack bus of the system has two equations like those for ΔP_i and ΔQ_i. Generally, for system with n bus collecting the mismatch equations into vector-matrix form yields:

$$\begin{bmatrix} \frac{\partial P_2}{\partial \delta_2} & \cdots & \frac{\partial P_2}{\partial \delta_n} & |V_2|\frac{\partial P_2}{\partial |V_2|} & \cdots & |V_n|\frac{\partial P_2}{\partial |V_n|} \\ \vdots & J_{11} & \vdots & \vdots & J_{12} & \vdots \\ \frac{\partial P_n}{\partial \delta_2} & \cdots & \frac{\partial P_n}{\partial \delta_n} & |V_2|\frac{\partial P_n}{\partial |V_2|} & \cdots & |V_n|\frac{\partial P_n}{\partial |V_n|} \\ \frac{\partial Q_2}{\partial \delta_2} & \cdots & \frac{\partial Q_2}{\partial \delta_n} & |V_2|\frac{\partial Q_2}{\partial |V_2|} & \cdots & |V_n|\frac{\partial Q_2}{\partial |V_n|} \\ \vdots & J_{21} & \vdots & \vdots & J_{22} & \vdots \\ \frac{\partial Q_n}{\partial \delta_2} & \cdots & \frac{\partial Q_n}{\partial \delta_n} & |V_2|\frac{\partial Q_n}{\partial |V_2|} & \cdots & |V_n|\frac{\partial Q_n}{\partial |V_n|} \end{bmatrix} \begin{bmatrix} \Delta \delta_2 \\ \vdots \\ \Delta \delta_n \\ \frac{\Delta |V_2|}{|V_2|} \\ \vdots \\ \frac{\Delta |V_n|}{|V_n|} \end{bmatrix} = \begin{bmatrix} \Delta P_2 \\ \vdots \\ \Delta P_n \\ \Delta Q_2 \\ \vdots \\ \Delta Q_n \end{bmatrix} \quad (2.17)$$

Real power with respect to the voltage angle:

$$\frac{\partial P_i}{\partial \delta_i} = \sum_{j=1}^{n} |Vi|\,|Vj||Vij| \sin\,(\Theta ij - \delta i + \delta j\,)$$

$$\frac{\partial P_i}{\partial \delta_j} = |Vi||Vj||Vij| \sin(\Theta ij - \delta i + \delta j) \qquad i \neq j \tag{2.18}$$

Real power with respect to the voltage magnitude:

$$\frac{\partial P_i}{\partial |V_{i|}} = 2|Vi||Yii| \cos(\theta ii) + \sum_{j=1} |Vi||Yij| \cos\,(\Theta ij - \delta i + \delta j\,) \tag{2.19}$$

$$\frac{\partial P_i}{\partial |V_{j|}} = |Vi||Vij| cos(\Theta ij - \delta i + \delta j) \qquad i \neq j \tag{2.20}$$

Reactive power with respect to the voltage angle:

$$\frac{\partial Q_i}{\partial \delta_i} = \sum_{j=1}^{n} |Vi|\,|Vj||Vij| \cos\,(\Theta ij - \delta i + \delta j\,) \tag{2.21}$$

$$\frac{\partial Q_i}{\partial \delta_j} = |Vi||Vj||Vij| \cos(\Theta ij - \delta i + \delta j) \qquad i \neq j \tag{2.22}$$

Reactive power with respect to the voltage magnitude:

$$\frac{\partial Q_i}{\partial |V_{i|}} = 2|Vi||Yii| \sin(\theta ii) + \sum_{j=1} |Vi||Yij| \sin\,(\Theta ij - \delta i + \delta j\,) \tag{2.23}$$

$$\frac{\partial Q_i}{\partial |V_{j|}} = |Vi||Vij| sin(\Theta ij - \delta i + \delta j) \qquad i \neq j \tag{2.24}$$

2.3.2 Previous Research on Power Flow

Algorithm based on the Newton-Raphson process has been proposed by Irving, M.R.in [20]. The author uses a partitioned-matrix approach to the Jacobian equation which was previously suggested for array-processor applications. The algorithm is extremely efficient for the resolution of transmission networks but also has specific benefits for lower-voltage networks. This method also applicable to other power system problems including state estimation and dynamic simulations.

Review of Harmonic Load Flow Formulations by Sergio Herraiz, Luis Sainz, and Jordi Clua shows load flow is a process used to obtain the steady state voltage electric power system at the fundamental frequency [21]. Conclusion that can be made from this article is the nonlinear devices in power systems will rise up and lead to study on conventional load flow. In other way, the Sergio Herraiz et al. try to develop different formulation to achieve cooperation among simplicity and reliability. This article state that frequency domain can be classified into three parts such as no harmonic collaboration, and harmonic fundamental power consideration.

Jiann-Fuh Chen et.al proposed another Jacobian matrix [22] to explain the multiobjective power dispatch (MPD) problematic with line flow constraints. Main objectives in this paper are minimization of fuel charge and ecological influence of emission. The author formulated Jacobian matrix from the incremental transmission loss in terms of the sensitivity, line flows, and line resistances. The formulation is implemented on the IEEE 14-bus system and 30-bus system for the multiobjective power dispatch with line flow restraints using the fast Newton-Raphson method. The results found from the proposed settlement calculations approve the advantages of speed and explanation exactness of the AC load flow method respectively.

Newton-Raphson algorithm [23] for 3-phase load flow with R.G.Wasley create solutions that allow representation of all possible due to their inherent unbalances in power-system networks without making any assumptions are important. Newton-Raphson algorithms that form the basis of computer programming for a specific purpose in solving the problem 3-phase load flow. Expansion of the Newton-Raphson algorithm is defined that allows the analysis of power-system network that is not balanced in the frame of reference phase.

S. Zhang et.al has been proposed new basic formulation [24] in Newton-Raphson for power flow problem in which various functional Jacobian matrices. From the new formulation, it produces a result that it is greater than typical method. Moreover, comparison the standard calculation of power flow with the new shows that the new algorithm can conveniently and efficiently model simple control activities likes generator VAR limits, load-tap-changing transformers and variable phase shifting transformers. The author prove that from the column exchange technique it can enhanced Newton-Raphson algorithm for normal, controlled and optimal power flow solutions.

Newton-Raphson algorithm for the dependable explanation of large power networks with implanted FACTS devices by E.Acha et.al created new and efficient algorithm using flexible AC transmission systems (FACTS) [25].Their presence in a Newton-Raphson load flow displaying quadratic convergence are defined and demonstrated by contrast with production grade load flow programs. This article presented models appropriate for measuring the steady-state response of power networks with implanted FACTS controllers.

The classical Newton–Raphson method is generalized to solve no square and nonlinear problems of size $m \times n$ with $m \leq n$. Using this generalized Newton–Raphson method as a core, a new variable dimension Newton–Raphson method is developed in the Variable Dimension Newton–Raphson Method by S. W. N et.al [26]. The variable dimension Newton–Raphson method is prove have better convergence property than the basic Newton-Raphson method. Furthermore, it does not require a proper homotopy map models to run.

This paper discusses about a fast and efficient algorithm by using the finite-different method to extract intrinsic complex permeability and permittivity from the calculation values for Mn-Zn ferrites cores. Ruifeng Huang et.al proves that this method is more efficient than the analytical solution based [27]. In addition, this method shows that it fast in converging that reduces computing time from hours to seconds. In contrast, this method develops significant error when conventional methods are used to calculate either the permeability or the permittivity of the Mn-Zn ferrite cores.

Convergence Acceleration of the Newton–Raphson Method Using Successive Quadratic Function Approximation of Residual is explain thoroughly by Chang Seop Koh et.al presents new ways to find a suitable relaxation factor of the Newton–Raphson method to accelerate the convergence characteristics of a nonlinear finite-element analysis [28]. In the methods, the squared residual of the Galerkin's estimate is consecutively approximated to a quadratic function using the gradients or Brent's method, and a relaxation factor is resolute by minimizing the quadratic function until a quasi-optimum relaxation factor is found.

2.4 Optimization Techniques

Many of algorithm methods that are used to find the minimum or maximum objective function. The algorithm below has been widely used in resolving various difficulties in the application of an electric power system.

1. Ant Colony Optimization (ACO),
2. Simulated Annealing (SA),
3. Genetic Algorithm (GA),
4. Mimetic Algorithm (MA),
5. Differential Evolution (DE)
6. Particle Swarm Optimization (PSO).

2.5 Particle Swarm Optimization (PSO) Technique

PSO is one of the optimization techniques are used to minimize or maximize the objective function such as to solve the problem in power system. For explanations of PSO are covered by natural and algorithm sections.

2.5.1 PSO in Natural Behavior

PSO algorithm is considered as one of the modern heuristic algorithms for optimization developed by Kennedy and Eberhart in 1995, based on the swarm social behavior of birds flocking and fish schooling in nature [10] where that's have their own view point to find food and eventually move only in one direction only for move to the best food in groups. Figure 2.4 are shown the behavior of bird flocking.

Figure 2.4**:** Bird Flocking [10]

2.5.2 PSO in Algorithm

Below are shown the general flow chart of PSO.

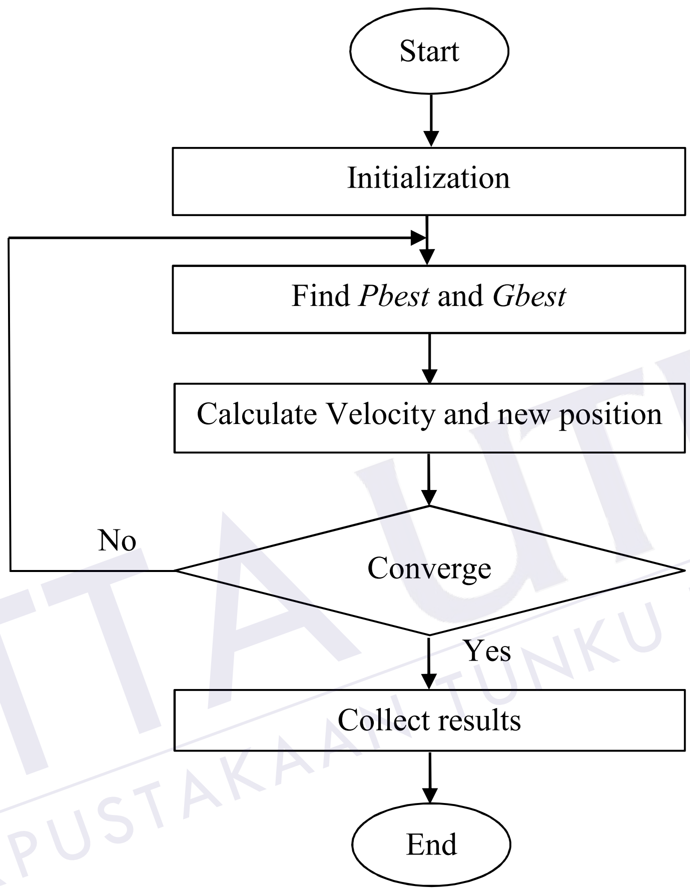

Figure 2.5**:** Particle Swarm Optimization (PSO) General Flow Chart

Flow chart is very important to provide guidance in the work. The PSO techniques for general flow chart are shown in Figure 3.2.and is explained with step by step.

Step 1: In initialization, are included the parameters of PSO and the constraint that are used for their project.

Step 2: The fitness functions are evaluated than the personal best *(pbest*) and global best (*gbest*) are finding for iteration equal to zero in this step.

Step 3: For this step, the value of velocity and position are calculated by using the formula from equation (2.0) and (2.1) below.

Step 4: These steps are repeated to step-3 to calculate the new fitness functions. Then, the new *pbest* and *gbest* are finding referred by new fitness function values when iteration equal to one.

Step 5: Step 3 are repeated to get new velocity and new position when iteration is equal to one.

Step 6: These steps are repeated until the value is converging.

Step 7: Collect all the result.

PSO is one of the optimization techniques that are increasing rapidly to different area of electric power systems. Moreover, PSO is an algorithm that will optimizes a problem with trying to get the best solution with regard to the constraints. This optimization been done through the movement of the particles in process to fin the global optimum solution. Figure 2.6 are shown the concept of searching by PSO and some mathematical formula for the particle's position and velocity in PSO technique.

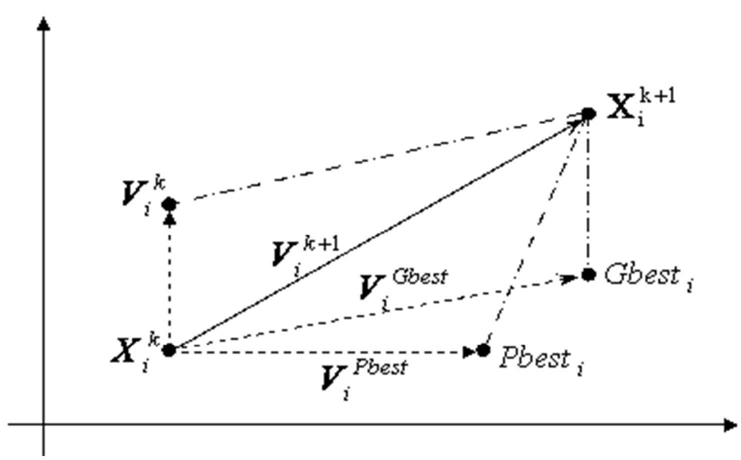

Figure 2.6**:** Concept of a searching by PSO [10]

Velocity of n particle,

$$v_{n+1} = \omega * (v_n + c_1 r_1 (pbest_n - x_n) - c_2 r_2 (gbest_n - x_n)) \qquad (2.0)$$

Best location,

$$x_{n+1} = x_n + v_{n+1} \qquad (2.1)$$

where

V_n	Current velocity;
V_{n+1}	Updated velocity;
C_1 and C_2	Acceleration factors;
r_1 and r_2	Randomly generated numbers with a range of [0,1] to stop the swarm converging too quickly;
w	Inertia weight, which enhance the exploration ability of particles;
$pbest_i^k$	Personal best position particle i achieved based on its own experience;
$gbest^k$	Global best particle position based on overall swarm's experience;
k	Iteration index.

This formula reflects the fact that the motion of each particle is influenced by the position of the best known local and also showed towards the most well-known position in the search space, an efficient position improved found by other particles. This is predictable to travel towards a group of the best solution.

2.5.3 Previous Research on Particle Swarm Optimization

M. H. Moradi in [29] has introduced a PSO to solve the problem of optimal location and size of DG on the distribution system. The purpose of this study is to reduce the loss of power network and better voltage regulation within the framework of the operating system and security constraints in radial distribution systems. The analysis is carried out on the 33 bus system. As a result of this study, using the DG in distribution system results in several benefits such as increased efficiency of all systems, reduce time and better system voltage profile losses.

The method that has been used by M. T. Arab Yar Mohammadi in [30] show that PSO is a better method than GA for optimal sitting and sizing of Distributed Generation (GA) in distribution system. The purpose of this study is optimal distributed generation allocation and size to improve the voltage profile, reduction of losses in the distribution network. PSO is used as a tool for solving and consider the values of the fitness sensitivity PSO algorithm; it is required to apply for the calculation of load flow and harmonics to make the decision.

A Survey of PSO Applications in Electric Power Systems by M.R.AlRashidi and M. E. El-Hawary present a complete analysis of different PSO applications in solve the optimization problem in the section of electric power system [31]. The authors also discusses about the potential upcoming applications in PSO in the part of electric power systems and its possible theoretical studies. Nowadays, many researchers that related to the optimization of the power systems like to combine PSO with other optimization technique where it will produce hybrid tools and improved its accuracy to the electric power system.

Hirotaka Yoshida et.al presents in this paper about the PSO for reactive power and voltage control in view of voltage security assessment (VSA). The new method that has been proposed [32] is develops the original PSO to handle mixed-integer nonlinear optimization problem (MINLP) and regulates an on-line VVC approach with continuous

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