Faculty of Electrical Engineering

OPTIMAL LOCATION AND SIZING OF DISTRUBUTED GENERATOR USING PSO AND GA ALGORITHMS IN POWER SYSTEM

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Optimal Location and Sizing of Distrubuted Generator Using PSO And GA Algorithms In Power System

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in fulfilment of the requirements for the degree of Master of Electrical Engineering
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DECLARATION

I declare that this project entitled "Optimal Location and Sizing of Distrubuted Generator Using PSO and GA Algorithms in Power System" is the result of my own research except as cited in the references. The project has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	AYAT SALEH HASSAN
Date	:	....

APPROVAL

I hereby declare that I have read this project and in my opinion this project is sufficient in terms of scope and quality for the award of Master of Electrical Engineering (Industrial Power).

Signature	:	....
Supervisor Name	:	PROF IR . Dr. MARIZAN BIN SULAIMAN.
Date	:	....

DEDICATION

I would like to present my work to those who did not stop their daily support since I was born, my dear Father, and my kindness Mother, they never hesitate to provide me all the facilities to push me foreword as much as they can. This work is a simple and humble reply to their much goodness I have taken over during that time. Thank you for giving me a chance and I love them.

I also dedicate this project to my husband, brothers, and sister who have supported me throughout my life. I always miss and appreciate the memories we had. I love all of you.

ABSTRACT

There are numerous advantages that can be obtained when Distributed Generation (DG) is integrated into the distribution systems. These advantages include improving the voltage profiles and reducing the power losses of the distribution system. Such advantages can be accomplished and confirmed if the DG units are optimally located and sized in the distribution systems. In fact, there are several algorithms used for optimizing the size and finding the best location to install DG units in the power system. Some existing algorithms need to be improved while others, need to add a new parameter for improving the performance of optimization methods and making it more effective and efficient. This research aimed to reduce total power losses and improve voltage profiles of the distribution system by proposing a practical swarm optimizion algorithm GA genetic algorithm to optimize DG size and location by taking into consideration increase number of DG units in the system. The multi-objective function, which represents the summation of product three indices by corresponding weights was utilized to identify the candidate buses to reduce the search space of the algorithm. The suggested algorithm of PSO and GA were tested using IEEE 30 bus test system taking into consideration with the increased number of DGs . After evaluating the robustness and efficiency of the algorithms in finding minimum power losses value, the results showed that the power losses value by PSO is lower than GA and PSO which gave the smallest standard deviation value compared to the GA algorithm and after finding the average time for each algorithm in which it can be said that the PSO is faster than the GA algorithms.

ABSTRAK

Terdapat banyak kelebihan yang boleh diperolehi apabila Distributed Generation (DG) diintegrasikan ke dalam sistem pengedaran. Kelebihan ini termasuk meningkatkan profil voltan dan mengurangkan kehilangan kuasa sistem pengedaran. Kelebihan sedemikian boleh dicapai dan disahkan jika unit-unit DG terletak secara optimum dan bersaiz dalam sistem pengedaran. Malah, terdapat beberapa algoritma yang digunakan untuk mengoptimumkan saiz dan mencari lokasi terbaik untuk memasang unit DG dalam sistem kuasa. Beberapa algoritma yang sedia ada perlu ditingkatkan manakala yang lain, perlu menambah parameter baru untuk meningkatkan prestasi kaedah pengoptimuman dan menjadikannya lebih berkesan dan efisien. Penyelidikan ini bertujuan untuk mengurangkan jumlah kehilangan kuasa dan meningkatkan profil voltan sistem pengedaran dengan mencadangkan algoritma genetik algoritma algoritma GM untuk mengoptimumkan saiz dan lokasi DG dengan mengambil kira peningkatan bilangan unit DG dalam sistem. Fungsi multi-objektif, yang mewakili penjumlahan tiga indeks produk dengan berat yang sesuai digunakan untuk mengenal pasti bas calon untuk mengurangkan ruang pencarian algoritma. Algoritma PSOand GA yang dicadangkan telah diuji menggunakan sistem ujian bas IEEE 30 dengan mengambil kira peningkatan jumlah DGs. Selepas menilai keberkesanan dan kecekapan algoritma dalam menentukan nilai kerugian kuasa minimum. Hasilnya menunjukkan bahawa nilai kehilangan kuasa oleh PSO adalah lebih rendah daripada GA dan PSO memberikan nilai sisihan piawai terkecil berbanding dengan algoritma GA dan selepas mendapati purata masa bagi setiap algoritma dalam kita boleh mengatakan bahawa PSO adalah lebih cepat daripada algoritma GA.

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LIST OF ABBREVIATION

ABC	Artificial Bee Colony
AI	Artificial Intelligence
ACO	Ant Colony Optimization
BA	Bat Algorithm
BFO	Bacterial Forging Optimization
CS	Clonal Selection
CIGRE	International Council On Large Electricity System
DE	Differential Evolution
DIG	Distributed Generation
EPRI	Electric Power Research Institute
FA	Firefly Algorithm
GA	Genetic Algorithm
HPE	Harmonic Power Flow
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
MOO	Multi Objective Optimization
MOF	Multi Objective Function
NN	Neural Network
OPF	Operation Power Factor
PV	Photovoltaics
PSO	Practicle Swarm Optimization

PEM Point Estimate Method

QPLRI Reactive Power Loss Reduction Index

RPLRI Real Power Loss Reduction Index

VDI Voltage Deviation Index

CHAPTER 1

INTRODUCTION

1.1 Background

A crucial role of an electric power system is to generate electricity to meet customer demands, with an acceptable level of reliability in an economical manner. The main functional areas in an electric power system are power generation level, transmission line level, and distribution system level. The main function of the power generation plant is to ensure that enough capacity is available to meet customer demand at any time. Usually, transmission line and distribution systems need to be stable and reliable to ensure that the electricity can be delivered to the consumers where it is needed and when it is needed (Singh et al. 2015).

For many years, electricity distribution networks were used and designed to supply electrical energy to customers; no generation was present on the customer side or on the distribution systems and distribution systems must supply electricity to the customer at an appropriate voltage rating. In the distribution level, the ratio of X/R is lower compared to transmission levels that cause a drop in voltage magnitude and high power losses through radial distribution lines. Approximately, 13% of the total power generated is wasted at the distribution level as real power losses (Kavitha et al. 2014). Nowadays, due to major changes in the electricity market in terms of the environmental policies, technological evolution and also the expansion in power markets, the new concept of allowing the electricity to be generated in small capacity generation is in pressingly being added to the distribution systems of the power network (Torres et al. 2014). The generating of electricity energy at the customer site or through the distribution networks is known as Distributed Generation (DG). These new technologies utilize both unconventional and conventional sources of energy. Often, it may be operated by the utility or the customer. The following reasons have brought this technology to the attention of the electricity companies (Payasi et al. 2011):

i. Availability of small unit generating plants.
ii. Ease of finding places for smaller generation units.
iii. Competition or deregulation policy.
iv. Provision of diverse energy sources.
v. National power requirements.
vi. Lower capital costs and short building times.
vii. Reduced transmission costs because the generation is sited closer to the load.

The operation of DG units may be considered random depending on the customer load. The location of DG units in the distribution system and amount of power delivered from it can increase or decrease the efficiency and reliability of the system and have an effect on its operation. Technical and safety problems may be created by huge supplied power from the DG units (Adefarati & Bansal 2016); (Mohandas et al. 2015); (Torres et al. 2014); (Krutak et al. 2014). Depending on its size and location, DG may cause voltage oscillations, interfere with voltage-control processes, increase fault currents, increase or diminish losses. Additionally, it can reverse the direction of power flow, etc.

If the DG unit is installed at a non-optimal location in the distribution system, the amount of power may induce excess, resulting in an increase in power losses and undesired voltage profiles. Therefore, suitable position and rating of the DG unit is very critical in determining system performance (Krutak et al. 2014). Basically, allocation of DG unit is a complex combinatorial optimization problem which requires synchronous optimization of several objectives such as decreasing of total active and reactive power losses, improving voltage deviation of buses and reducing the short circuit level to maximize the reliability of the network.

The multi-objective optimization pattern offers an attractive option to address the complex optimization issues like optimal DG sizing and placement. Besides, it is important to measure the success of DG implementation in terms of economic feasibility and it is also important to ensure that deployment of DG units in power system improves the technical parameters of the system (Adefarati & Bansal 2016). Thus, many optimization techniques have been employed to solve different multi- objective optimization problems. Artificial intelligence (AI) methods have been used to solve complex DG unit problems as they can provide global or near global solutions.

Artificial intelligence techniques, include mainly Genetic Algorithm (GA) method, Particle Swarm Optimization (PSO) method, Artificial Bee Colony (ABC) method, Ant Colony Optimization (ACO) method, Bacterial Foraging Optimization (BFO) method, Clonal Selection (CS) method, and Firefly Algorithms (FA) method. The main advantage of the AI techniques is that they are relatively versatile for applying various qualitative constraints (Mohandas et al. 2015).

1.2 Problem Statement

The global electricity sector is facing three major challenges: the security of supply to keep up with ever-mounting demand, the fight against climate change, and the global trend toward massive urbanization. Therefore, the demand for electricity generated is increasing rapidly, and the electricity requirements for the utility service vary as a function of the site according to the types and number of consumers in each region. The main tasks of electricity companies are to generate electricity from new sources such as renewable energy sources or distributed generation units to overcome the new demand for energy consumption and energy transfer to the distribution system (Kalkhambkar et al. 2017).

Despite the many benefits of integrating the DG module, technical problems are increasing when the new generation is added to an inappropriate location in the power distribution network (Loan et al. 2014). An inappropriate location with an ideal size of DG units may result in an increase in total active and interactive energy losses with a detrimental effect on the voltage size. The increase or decrease in energy flow may exceed the limits on certain lines.

Several studies have proposed differential evolution (DE). More recently, has attracted researchers' attention because it provides rapid convergence, ease of implementation, and greater precision in finding the optimal solution (Bawan n.d.). The Particle Swarm Optimization (PSO) is used in this research to determine the optimal size and best way of DG modules to improve the characteristics of the carrier voltage and reduce the loss of energy in the distribution system. A multi-objective function can be used in determining the optimal allocation of DG units in terms of reducing total energy loss and improving the voltage profile.

1.3 Research Objectives

The main purpose of this work is to find the best and optimal size and location to DG units. That is to improve the electrical voltage and reduce the lost power of the distribution system. Thus, here we explore the main objectives of this work:

- The formulation of a multi-objective function to solve the ideal DG positioning problem and scaling by looking at different indicators such as the real and reactive energy loss reduction index and the voltage deviation indicator.
- To suggest the technique of Particle Swarm Optimization (PSO) to determine the size of DG and its location in the distribution system.
- To investigate the effect of increase number of DG module penetration on the loss of system energy and voltage files and validation of the results obtained by using (PSO) with those obtained by the Genetic Algorithm (GA).

1.4 The Scope of Work

Any time that a task of doing a research is to be undertaken, the essential guideline is to define explicitly the scope of the study and it is basically means all those things that will be covered in the research project.

The current research focuses on finding the best location and ideal size for DG units that can improve the stability of distribution networks and maximize the benefits of large penetration. Technical issues arising when connecting the DG module to the distribution systems are taken into account. The technical challenges presented in this dissertation are to reduce losses and improve the voltage profile. The technique presented in this work includes the identification of the optimal plan for integrating the DG module using the PSO optimization algorithm, and then comparing the results with those obtained from the application of the GA algorithm. Technical constraints and limitations are considered in the energy system processes to ensure a good result. The algorithm is tested on the (IEEE 30-bus) to demonstrate the breadth and applicability of the technology.

1.5 Methodology

The methodology deals with the formulations of the power flow, multi-objective function and partical swarm optimization (PSO). Generally, the power flow is formulated using the full Newton-Raphson load flow and the Jacobian matrix to calculate total power loss in the system with and without DG unit. The multi objective function is formulated taking into account three key factors which are: real and reactive power loss reduction and voltage profile improvement to identify the critical buses while, PSO is used to calculate the optimal size and find the best location according to a reduction in the power losses. Both equality and inequality constraints are defined and applied in this study. Figure 1.1 shows the flow chart of writing this dissertation by identifying the steps of preparing all of the requirements in order to complete this work starting from the collecting of literature review till we reach the stage of writing the report.

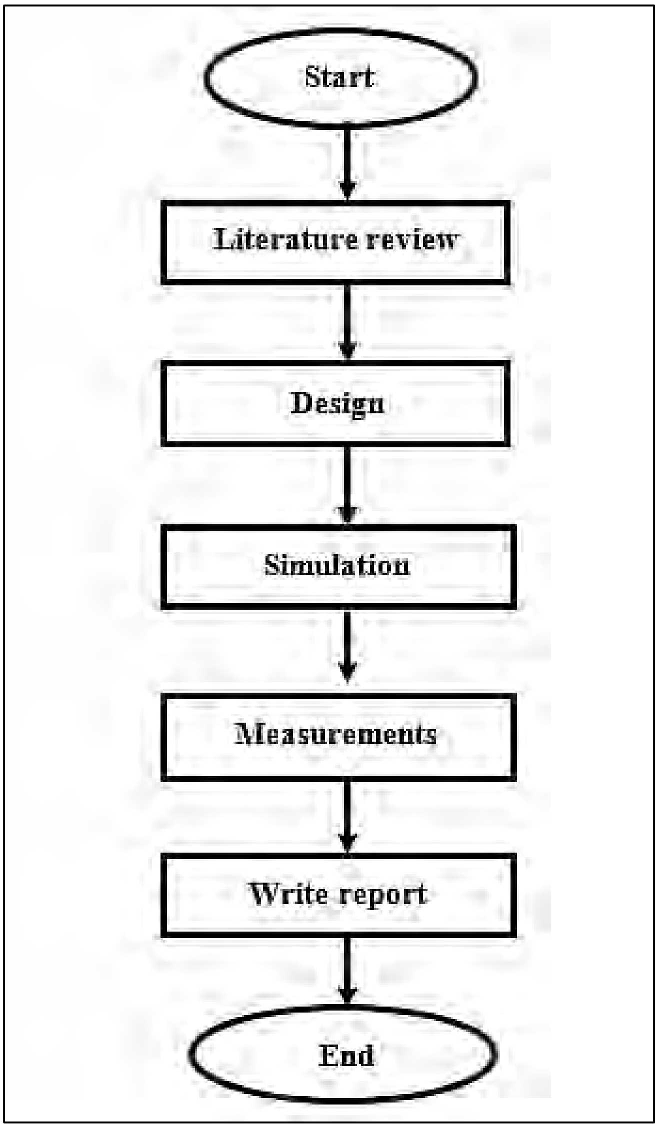

Figure 1.1: Flow chart of dissertation stages

1.6 Dissertation Layout

This study has organized in five chapters . Chapter 1 provides information about distributed generation (DG) and its effects on power systems. Also, it gives an overview on the research background and statement of the research problem with regard to the importance of optimal sizing and the best placement of DG units to ensure voltage stability exists in the network at all times. The objectives of the study, the scope of work, and the methodology are presented in this chapter. Chapter 2 reviews previous studies in three sections: the first section is a summarized introduction to the chapter, followed by a description and discussion of the distributed generation and its impact on the power networks, while, the multi objective evolutionary Algorithm is discussed in the second section. In the last section, the highlights on optimization approaches for location and sizing of DG are presented.

Chapter 3 describes the methodology and development of the proposed algorithm for best placement and optimal sizing of DG units in the distribution system. Some theoretical background of corresponding PSO technique is introduced here. Chapter 4 shows the implementation of the proposed optimization technique in widely-used test system. Test results are analyzed and discussed to verify the applicability of the proposed technique.Chapter 5 presents the conclusion, limitations and recommendations for future work.