OPTIMUM NETWORK RECONFIGURATION AND
DGs SIZING WITH ALLOCATION SIMULTANEOUSLY
BY USING PARTICLE SWARM OPTIMIZATION

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"I hereby declare that I have read through this report entitle "*Optimum Network Reconfiguration And DGs Sizing With Allocation Simultaneously by Using Particle Swarm Optimization*" and found that it has comply the partial fulfillment for awarding the degree of *Bachelor of Electrical Engineering (Industrial Power)*"

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

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MAY 2014

I declare that this report entitle "*Optimum Network Reconfiguration and DGs Sizing with Allocation Simultaneously by Using Particle Swarm Optimization*" is the result of my own research except as cited I the reference. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……

Name : Nor Mazura Binti Shahrin

Date : ……

To my beloved mother and father

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ABSTRACT

Optimum network reconfiguration and Distributed Generation (DGs) sizing with allocation simultaneously by using Particle Swarm Optimization (PSO) proposed new way of allocation DG based on low voltage profile. This method consists of three stages. The first stage is to identify the switching operation for radial network configuration while observe the power losses and the voltage profile without DG. The second stage is feeder reconfiguration for loss reduction with DGs allocation based on geographical location. The last stage is sizing and allocation DGs at buses with low voltage profile resulted from the first stage to improve the power losses and voltage profile also comparing the result with the second stage. The objective of this method proposed is to show that allocation of DGs simultaneously based on low voltage profile can improve network power losses and improvement of voltage profile. The result shows that improvement on network power losses is 26.07% from Distribution Network Reconfiguration (DNR) method. Four cases were compared which is case one is the initial case and taken as a reference. All three stages were tested on standards IEEE 33 bus system by using Particle Swarm Optimization (PSO) technique in MATLAB software. This method proved that improvement of power losses and voltage profile has been made by switching and DGs sizing and allocation method.

ABSTRAK

Pentatarajahan semula rangkaian secara optimum dan saiz jana kuasa teragih *(Distributed Generation, DG)* dengan penempatan secara tetap menggunakan kaedah *Particle Swarm Optimization (PSO)* dicadangkan sebagai cara baru penempatan jana kuasa berdasarkan profil voltan yang rendah. Kaedah ini mempunyai tiga peringkat. Peringkat pertama ialah dengan mengenal pasti operasi suis untuk rangkain tatarajah secara jejari sambil membuat pemerhatian terhadap kehilangan kuasa dan profil voltan tanpa jana kuasa teragih. Peringkat kedua ialah penyuap tatarajah semula untuk mengurangkan kehilangan kuasa dengan jana kuasa teragih ditempatkan berdasarkan lokasi geografi sesebuah tempat. Peringkat yang terakhir ialah penempatan dan saiz jana kuasa teragih pada bus yang profil voltannya rendah di peringkat pertama untuk mengurangkan kehilangan kuasa dan profil voltan serta membandingkan hasil kajian dengan peringkat kedua. Objektif kaedah ini diperkenalkan adalah untuk menunjukkan bahawa penempatan jana kuasa secara tetap berdasarkan voltan profil yang rendah boleh meningkatkan penurunan kehilangan kuasa dan profil voltan. Hasil kajian menunjukkan penurunan kehilangan kuasa sebanyak 26.07% dengan pembandingan dari kaedah pentatarajahan semula rangkain teragih *(Distribution Network Reconfiguration, DNR).* Empat kes dibandinglan dimana kes satu adalah kes awal diambil sebagai rujukan. Ketiga-tiga peringkat diuji pada standard IEEE 33 sistem bus dengan mengunakan kaedah *Particle Swarm Optimization (PSO)* pada perisian MATLAB. Kaedah operasi suis dan penempatan jana kuasa terbukti dalam meningkatkan penurunan kehilangan kuasa dan profil voltan dalam rangkaian.

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ABBREVIATION	DESCRIPTION
DG	Distributed Generation
PSO	Particle Swarm Optimization
DNR	Distribution Network Reconfiguration
AI	Artificial Intelligent
SA	Simulated Annealing
TA	Tabu Search
FEBE	Family Eugenics Based Evolution Algorithm
ACA	Ant Colony Algorithm
IWO	Invasive Weed Optimization
HSA	Harmony Search Algorithm
PSO	Particle Swarm Optimization
GA	Genetic Algorithm
IA	Immune Algorithm
AIS	Artificial Immune System

CHAPTER 1

INTRODUCTION

1.1 Project background

Distributed Generation (DG) is a small scale technology to provide electric power generation within distribution network. Currently, the model for electricity generation is Centralized Power Plant. This plant is typically combustion or nuclear generated. Centralized power model required distribution from center to outlying consumers. Substation can be placed anywhere from actual user of the power generated which require transmission across distance. The disadvantages of this centralized power model is it produce nuclear waste, low efficiency and high power losses across lengthy transmission lines also environmental distribution where power line are constructed. DG needed to overcome this issue by located the source near or at the end user location within the transmission line.

The two levels of Distributed Generation technologies is local level and end point level. Local level power generation plant is the renewable technologies such as wind turbines, solar system, geothermal energy and biomass. This type of plant is smaller and more efficient also less environmentally damaging or disrupting energy than the centralized power model. For the end point level mostly is the internal combustion engine. The categories of DG that had been suggested by author [1] are as shown in Table 1. In other words, demand-side resources not only based on local generation within distribution system on customers side but also mean to reduce customer demand. To give the maximum use of DG, it has to be installed with optimum sizing and suitable location. Fail to do so will make load node voltage along the feeder to increase.

In this project, PSO technique were choose as problem-solving algorithm method because of less computing time compared to other method. Multiple DGs allocation has high improvement of power losses than single DG allocation. In this case, four DGs installed in order to implement this methodology.

Table 1.0: Distributed Generation ratings [1].

DG categories	DG ratings
Micro	1 Watt < 5kW
Small	5 kW < 5 MW
Medium	5MW < 50 MW
Large	50MW < 300MW

1.2 Problem statement

Nowadays, Distributed Generation (DG) have been used to supply active power but the placement and size of the DG play an important role to give maximum advantage of DG. DG can be located directly to distribution network or connect to the network on customer site. This will supply transmission and distribution grid that distribute power to load centers and from load centers to consumers. Suitable placement and sizing DG can reduced the amount of energy lost in transmitting electricity because electricity is generated near where it is used. The problem is to find the best sit and size of the DG. So, analysis of allocation and sizing is needed to get the maximum use of DG to overcome the problem.

1.3 Objective

The objective of this project is to analyze the optimum size and location of Distributed Generation in order to provide maximum use of Distributed Generation in the network. In order to do that, the objectives are:

i) To reduce network power losses in the network system.

ii) To improve voltage profile of all busses by using allocation of DGs simultaneously.

1.4 Scope

PSO and IEEE33-bus system are tested for this case to find suitable switching place while maintaining close loop system and to determine the optimum size and location of DG. This project use MATLAB programming software analysis to enable users calculate power flow problem. This project focused on:

i) Using PSO as a method to allocate and sizing DG.

ii) Using IEEE33-bus system as a mechanism to illustrate network.

iii) MATLAB software as a tool to conduct investigation.

1.5 Project outline

Thesis outline is summary of all chapters roughly before going through this report. Chapter one consists of introduction, problem statement, objective and scope. In chapter one, objective is clearly highlighted as a benchmark to make sure whether the objective is achievable or not.

Chapter two discussed about literature review related to the project. All papers and journals have been collected and summarizes in chapter two to make further understanding about the project.

Chapter three is about methodology on how this project has been carried out since last semester. In this chapter also consists of list of formulae used and translated into coding in MATLAB and list of cases to taken into consideration.

In chapter four, result and analysis has been presented to show the result from the simulation and explanation of each result. This chapter also discusses the comparison between all cases in this project.

Lastly, chapter five consists of conclusion of the project to show whether the objective is achieve or not. Recommendation also been proposed for further study of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Distributed Generation (DG)

Distribution Generation is a small scale technology use to provide source of active power. It is located near end user of customer or near to the load in the distribution network. Many technologies used for DG for example renewable energy. International Energy Agency (IEA) defined renewable energy as resources that are not depleted such as heat from the sun, wind, biomass, ocean energy, geothermal and falling water. Secondly, technologies such as PV array, diesel engine and battery storage consist of a number of small modules which assemble in factories. Each small module can operate independently regardless of status other modules. If a module broken, other modules still can operate as each module is small compared to large centralised power station. Another aspect is combined heat and power. There are many types of combine production of heat and power for example combined cycle gas turbines, internal combustion engines, combustion turbines, biomass gasification, geothermal, sterling engines and fuel cells. The advantage of this technology is high efficiency if the heat is used locally. Technology categories seem useful relate to distributed generation.

Distribution resources is a demand and supply side resources that can be deployed along electric distribution system as set apart from the transmission system to encounter the energy requirement and reliability as needed by the customers. Distributed resources consist of two aspects. First is distributed generation and second are demand side resources. Distributed generation located at any bus along distribution system or on customer site. Demand side resources also known as load management system which is to

move electricity from peak period to off peak periods to reduce the overall electricity demand. In other words, demand-side resources not only based on local generation within distribution system on customers side but also mean to reduce customer demand.

Distributed capacity term is not widely known because it is difficult to define this term. Distributed capacity uses all aspect of distributed resources with additional requirements for transmission or distribution capacity. The objective of distributed generation is to reduce peak demand but it does not include reverse capacity. In order to overcome this situation, transmission or distribution network has to be able to cover at least some of the generation usually supplied by distributed generation [1].

There are some advantages and disadvantages discussed by author [2]. Some of the advantages of distributed generation are:

i) For a large power grid, DG can be useful addition if implemented in the networking, emergency of AC/DC hybrid transmission system and electricity market reforms. In distributed generation hydro and gas turbine with easy start and fast recovery characteristics can be used as black start power supply.

ii) It can be used for military task because electricity safety is an important component of national security. Large power grids are easy to demolish in case of war or terrorism, it will endanger national security.

iii) It can make up lack of large power grids stability. If electric failures occur, it can provide emergency support which can launch to gradual recovery important load of local power grid in a short time, also prevent system accident to expand. So, DG can increase power grid flexibility, improves power quality and increase reliability.

iv) No need to build power transformer and distribution station can save cost of building large power plants.

v) High efficiency and friendly environmental because based on study, DG can be make from renewable energy also energy efficiency about 65% to 95%.

vi) DG can achieve load power demand in isolated area. Isolated area is too far from existing power system, high investment must be made in order to build transmission and distribution system. DG can be use as small hydropower, wind power, solar power and many more as an effective method to generate electricity.

The problems that will occur upon installation of DG are:

i) It will give impact to system voltage because the system will become from single power radial to network into weak link network of multi-distributed power.

ii) Impact on protection because DG will make radial passive distribution network into active network of small and medium power source. These changes will lead to changes of size fault current, current flow, failure of DG itself will also impact system protection and operation.

DG that connected to grid will give impact on planning, design, operation, control and protection also other implications. In order to maintain the system, DG must be able to accept scheduling, to achieve this goal, through power electronic devices to control and regulate. DG unit is not only needed to improve distribution automation but also have to manage the grid from passive to active.

2.2 Distribution Network Reconfiguration

Distribution network generally designed in closed loop and operated in open loop and it involves large quantity of section switches and small amount of tie-switches. IEEE 33-Bus radial system was illustrated as distribution network for this method. Distribution Network Reconfiguration (DNR) is the process of changing the open/close status of sectionalizing and tie switches in the distribution network. Two types of switches were used in distribution system which is sectionalizing-switches and tie-switches. Sectionalizing-switches are a type of switch that normally opens while tie-switch is vice versa. Objective of DNR is to reduce power losses and relieve overload in the network. In the proposed method, the present of DG with network reconfiguration to improved losses in the system and improve voltage profile. There are three problem-solving algorithms to solve this problem; a) the classical mathematical optimization algorithm. b) heuristic algorithms. c) artificial intelligence (AI) based algorithms such as simulated annealing (SA), tabu search (TA), family eugenics based evolution algorithm (FEBE), genetic algorithm (GA), immune algorithm (IA), and Particle Swarm Optimization (PSO). These algorithms perform well to find the best optimal solution [3-6].

2.2.1 Ant Colony Algorithm (ACA)

Author [3] proposed ACA algorithm to reduce power losses while finding suitable switching operation for distribution system. This algorithm is based on the behaviour of the ants to find food. Each ant leaves a pheromone on their track. The pheromone will make other ants to follow that track. The pheromone evaporates with time, so other ants can reach food by following the shortest path marked with strong quantity of pheromone quantities.

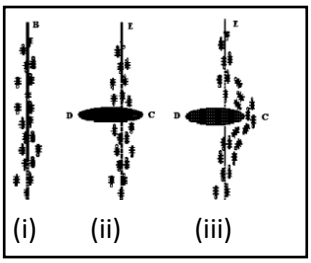

Figure 2.1: Behaviour of the ants [3].

In Figure 2.1 (i), it shows that the ants move in straight line in order to find food from their home. If the obstacle occurs as in Figure 2.1 (ii), they will choose the path randomly and the other ants will choose the shorter path around obstacles that will move faster. The pheromone will be reconstructed rapidly and more ants will choose the shorter paths. Due to the positive feedback, all ants will choose the same paths.

2.2.2 Invasive Weed Optimization (IWO)

This algorithm introduced by Mehrabian and Lucas. It is an algorithm that mimic robustness, adaption and randomness of colonizing weed in simple method for example seeding, growth and competition in a weed colony. The way of reproduction, spatial dispersal and competitive are some of properties of IWO [4].

2.2.3 Harmony Search Algorithm (HSA)

Harmony Search Algorithm proposed by Z. W. Geem and S. Das. This algorithm derived from natural phenomenon of musicians when they play their instruments in order to come up with pleasant harmony [5].

2.2.4 Particle Swarm Optimization (PSO)

Author [6] proposed hybrid particle swarm optimization which is the combination of binary PSO algorithm and the discrete PSO algorithm. Particle swarm optimization introduced by James Kennedy (social-psychologist) and Russell Eberhart (electrical engineer) in 1995. It is based on social metaphor and population based optimization technique.

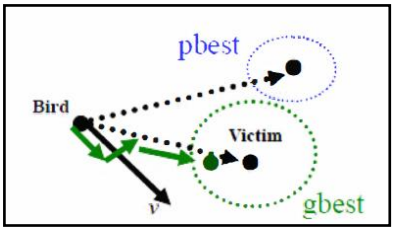

Figure 2.2: Bird's food searching in PSO [7].

Particle swarm is the system model based on basic creatures that move in a group with the same objective for example to search food as shown in Figure 2.2. The group with this relative behaviour including bee swarm, fish school and bird flock. Some of advantages PSO technique over other optimization techniques is:

i) Easy to implement with basic mathematical and logic operations.

ii) It can handle objective function with stochastic nature like represent one of optimization variables as random.

iii) It does not require any good initial solution to start the iteration process.

However PSO also got some disadvantages which is it needs more parameter for tuning also required programming skills to develop and modify the algorithm to suit different optimization problems [7-9].

2.2.5 Genetic Algorithm (GA)

Genetic Algorithm (GA), first introduced by John Holland in the early seventies, is the powerful stochastic algorithm based on principles of natural selection and natural genetics, which has been quite successfully, applied in machine learning and optimization problems. GA is one of the optimization algorithms, which is invented to mimic some of the process observed in natural evolution. To solve a problem, a GA maintains a population of individuals (also called chromosomes) and probabilistically modifies the population by some genetic operators such as selection crossover and mutation, with the intent of seeking a near-optimal solution to the problem. In GA algorithm, the population has 'n'chromosomes that represent candidate solution; each chromosome is an 'm' dimensional real value vector where m is the number of optimized parameters. Therefore each optimized parameter represents a dimension of the problem space. GA is more suitable to find the optimal location of DG because of its integer-based optimization algorithm. Advantages of GA for optimization problems are.

i) The GA does not have much mathematical requirements about the optimization problems. Due to their evolutionary nature, the GA will search for solutions without regard to the specific inner workings of the problem
ii) The evolution operators make GA effective at performing global search
iii) GA provides a great flexibility to hybridize with domain dependent heuristic to make an efficient implementation for a specified problem.

The disadvantage of GA is it does not solve complexes constraints problems easily, especially for exact constraints take more time for huge evolutions [10-12].

2.2.6 Immune Algorithm (IA)

Immune Algorithm (IA) is a biometric intelligent calculation from imitating intelligent behavior of biological immune system. The objective function and constraints correspond to antigen, and the feasible solutions correspond to the antibody [13].

2.2.7 Artificial Immune System (AIS)

This algorithm used to clone expansion and the affinity maturation as minimum forces of evolutionary process. Population of variable, X will be clone by 10, then the number of cloned population is 200. The value of X will be assigned back to the generator and objective fitness is calculated [14].

2.3 Allocation and Sizing Method

There are many ways to do allocation and sizing methods. One of the ways that proposed by [15-19] is located the DG at all busses with using PSO method. Author [16] proposed the method with two DGs allocation at all bus and examine the total harmonic distortion percentage can be reduced with two DG installation. In the other hand, author [18] stated that the location of DG depend on load demand. So, the size of DG will be varying according to the load demand. Other than that, [10] proposed a combination of PSO and GA method in order to find optimal placement and sizing of DG. Genetic algorithm (GA) method were used to find the placement of DG because GA provides great flexibility and suited in solving complex optimization problems [11-12]. After that, the results from GA simulation used in PSO to find optimize the sizing for DG. DG allocation and sizing also can be done by using other algorithm method such as Immune Algorithm as in [13]. IA is a biometric intelligent calculation by imitating the behaviour of biological immune system. The comparison of Evolutionary Programming (EP), Artificial Immune System (AIS) and Particle Swarm Optimization were carried out to find the best techniques for allocation and sizing of the DG. It is proved that PSO technique better than EP and AIS in terms of voltage stability and voltage profile minimization [14]. Optimum allocation and DG sizing can enhance efficiency in the distribution system. Analysis method by [20] is implemented in two IEEE distribution test system. First is three phase unbalanced component model and the second is IEEE 123 node test feeder. The analysis been made conclude that loss reduction and maintaining voltage limit can be possible by allocating and sized DG unit in optimum way to make distribution system more efficient. Network reconfiguration main objective is to reduce power losses while DG sit and size is to improve voltage profile also improve power loss too.