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

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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 : ………………………………

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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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LIST OF ABBREVIATION

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.

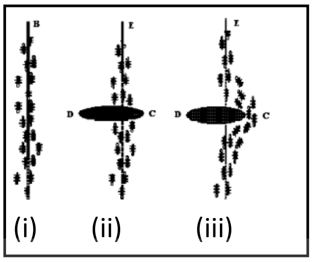


Figure 2.1: Behaviour of the ants [3].

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.

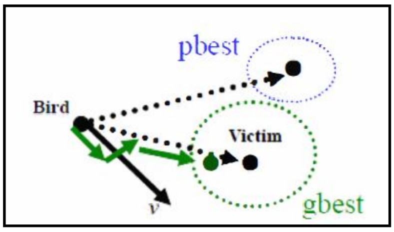


Figure 2.2: Bird’s food searching in PSO [7].

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.

2.3.1 Power Losses

Installation of Distributed Generation is able to reduce power losses because the location of the DG is nearness of the load. With this sitting, they can produce higher loss reduction between the network systems. Power losses in distribution system vary with various factor depend on the system configuration. Distribution losses define as the difference between the electricity entering the distribution network and that leaves it; arise for technical and other reasons. The technical reasons relate to the physics of electricity distribution though affected by the engineering and economic decisions in for example, specifying the sizes of cables and transformers. The other reason may be because of theft, inaccuracy in measurement and timing differences. There are two parts of power losses which is real power losses and reactive power losses. Real power losses are due to resistance along the line while reactive power losses are because of reactive element within the system [19].

2.3.2 Voltage Profile

Voltage profile is a graphical representation of voltage versus time. When a voltage different occurs, voltage profile is created in space for example voltage profile between two charges. Voltage profile play important role to consumers because basic demand running near to the rated load. With DG, it can support to raise low voltage at the end of the feeder [21].

2.4 Summary of literature review

Distributed Generation is a small scale power supply that connected at near end of user so it can reduce power losses. There are many advantages of having DG in the network but it also has some disadvantages. However the disadvantages can be overcome by having correct way and procedure of DG installation. Some of the way is by doing simulation of distribution network to find the best sit and size of the DG. Many algorithms proposed by researchers in order to find DG allocation and sizing. All algorithms also have their own pros and cons. Study on the literature review is to find the best algorithm to be used in the simulation. Particle Swarm Optimization shown to be very suitable to carry on this project other than another algorithm. Network reconfiguration method is a way to find switching operation in a network while keeping the network in radial system. DNR method main objective is to reduce power losses. Additional DG can make reduction of power losses is higher. Based on study, it shows that many ways can be made to find best sit and size of the DG. Best allocation and sizing will give high loss reduction and better of voltage profile.

CHAPTER 3

METHODOLOGY

3.1 Introduction

Summarization of this project was shown in flowchart of Figure 3.1. After confirmation of the title and do the literature review, the coding of PSO were develop to implement in the network of IEEE33-bus system. The simulation is done by using MATLAB as a tool to conduct the investigation. The simulation will carry on four DGs placement at low voltage profile from distribution network reconfiguration technique.

The system used for this method is tested on standard IEEE 33 bus test system as shown in Figure 3.2 The system load is assumed to be constant with S_{base}= 100MVA and V_{base}=12.66kV. The load and line data is referred in [22]. The total load of the system is 3715kW and 2300kVar. The maximum sizing for DG is set to 5MW and the population for test system is 50. All calculation is in per unit. Four cases are considered for this:

a) Case 1: Initial case.
b) Case 2: The system with DNR by switches with radial configuration.
C) Case 3: Feeder reconfiguration with allocation and sizing DG based on suitability of geographical location [17].
D) Case 4: DNR, DG sizing and allocation based on lowest voltage profile on case 2.

Case 1 is the initial case takes as reference whereas case 2 is switching configuration, meanwhile case 3 and case 4 is same method which is DNR and DGs sizing and allocation but the allocation for case 3 is refer to [17] and allocation for case 4 is based on lowest voltage profile on case 2.

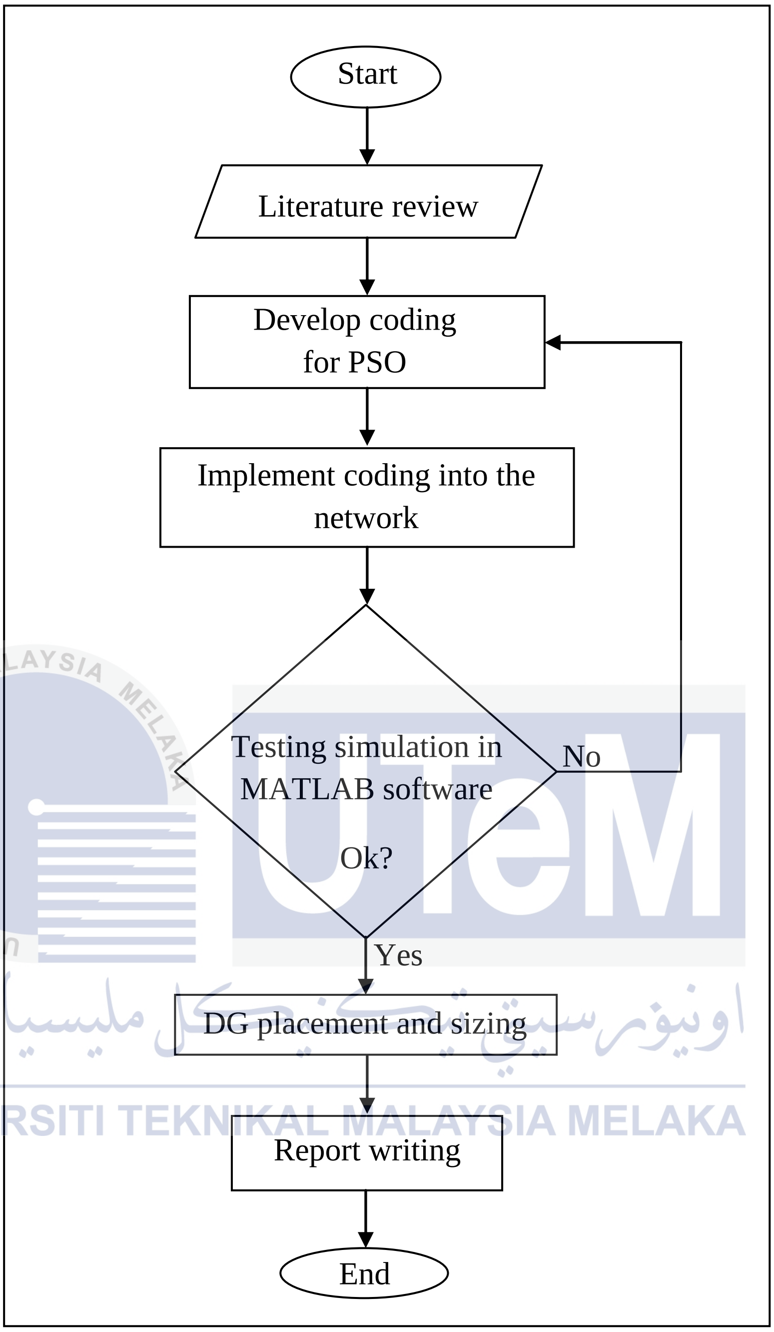


Figure 3.1: Flowchart of project methodology.

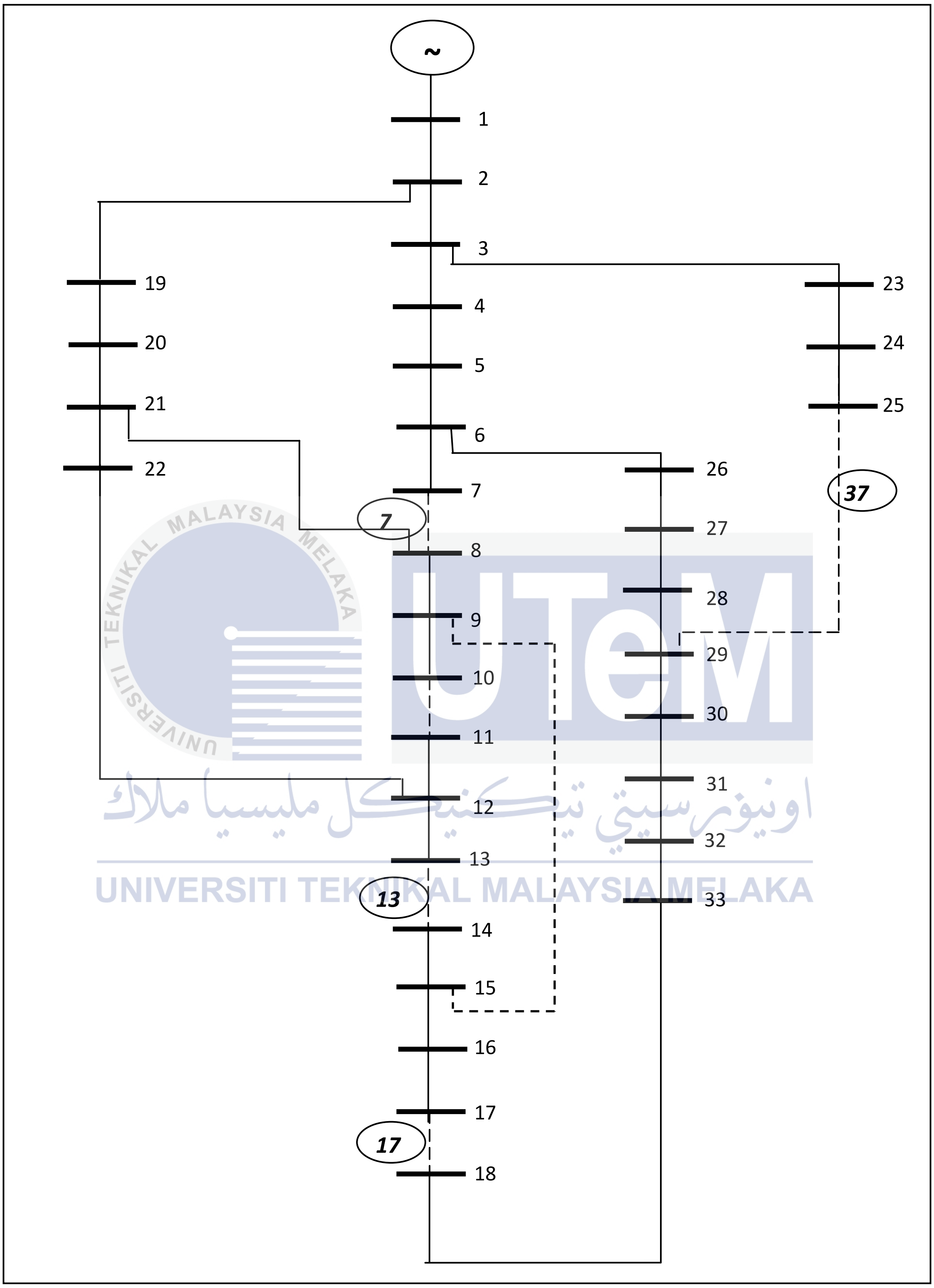


Figure 3.2: Initial configuration of 33 bus radial system.

3.2 Problem Formulation

3.2.1 DNR technique

The objective for DNR is to find radial network structure in order to minimize power losses. The problem can be formulated as in equation (3.1)

$$\text{Min } P_{losses} = \sum_{n=1}^{n} |I_i|^2 k_i R_i \qquad i \in N \qquad (3.1)$$

Where;

I_i= current in branch i,

R_i= resistance of branch i,

N= total number of branches,

k_i= variable that represent the topology status of the branches (1= close, 0= open).

A. Radial Network Constraint

Radial network structure was composed in considering in the distribution network

B. Node Voltage Constraint

Voltage magnitude V_i at each node must be within its range to maintain power quality which

$V_{min} \leq V_{bus} \leq V_{max}$

The minimum voltage is 0.95 and maximum voltage is 1.05 (±5%).

C. Generator Operation Constraint

All DGs units are allowed to operate within acceptable limit where P_i^{min} and P_i^{max} are the lower and upper bound of DG output which

$P_i^{min} \leq P_g \leq P_i^{max}$

D. Feeder Capability Limits

The limits of feeder capability which

$|I_k| \leq I_k^{max} \quad k \in \{1,2,3 \cdots l\}$

Where;

I_k^{max}= maximum current capability of branch *k*.

3.2.2 PSO Technique

This concept of algorithm is simple, easy to realize and strong optimization ability. It has been used widely for optimization function, neural network training and other engineering field [7]. The concept of PSO is its particle move towards each other to find *pbest* and *gbest.* The best solution achieved by that particle in the solution space is known as *pbest* while *gbest* is value obtained by any particle in the neighborhood of that particle. Figure 3.3 shows the random weighted acceleration time at each step. Based on flowchart in Figure 3.4, each particle tries to relocate its position by using the information;

i) The current positions.
ii) The current velocities.
iii) The distance between the current position and pbest.
iv) The distance between the current position and *gbest* [8].

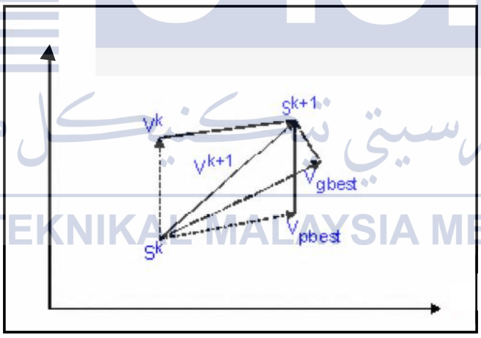


Figure 3.3: Concept of modification of a searching point by PSO [10].

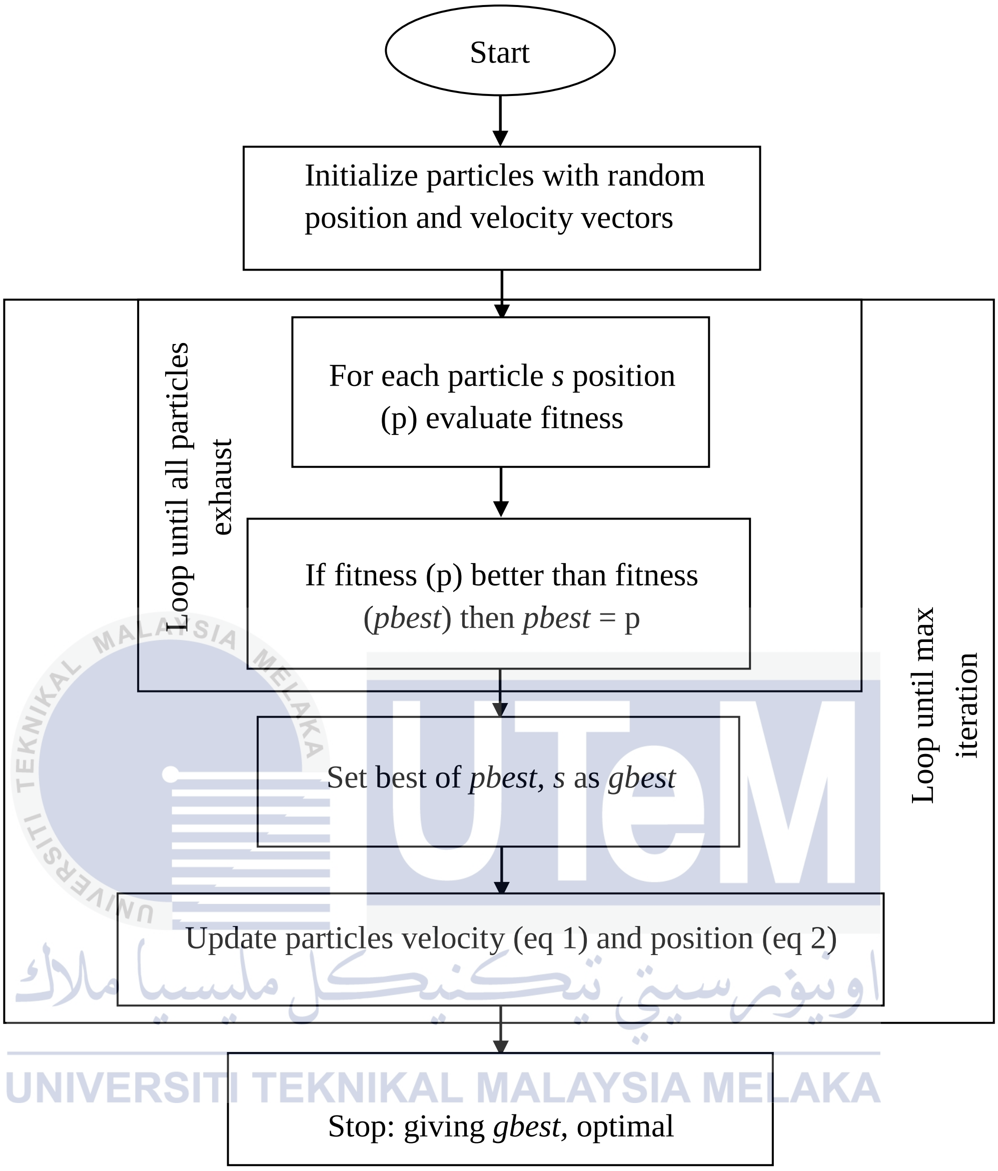


Figure 3.4: Flowchart of PSO algorithm [10].

The modification of the particle's position can be modeled by using equations (3.2) and (3.3).

$$v_i^{k+1} = wv_i^{k} + c_1 r_1 (pbest_i - s_1^{k}) + c_2 r_2 (g_{best} - s_i^{k}) \tag{3.2}$$

$$s_i^{k+1} = s_i^{k} + v_i^{k+1} \tag{3.3}$$

Where,

$c_{1,} c_2$: The weighting factor,

$r_{1,} r_2$: The random numbers between 0 and 1,

ω : The weighting function,

v_1^{k} : The current velocity of particle *i* at iteration *k*,

v_1^{k+1} : The modified velocity of particle *i*,

s_1^{k} : The current position of particle *i*at iteration *k*,

s_1^{k+1}: The modified position of particle *i*,

$pbest_i$: The personal best of particle *i*,

$gbest_i$: The global best of the group.

The weighting function is set according to equation (3.4).

$$\omega(t+1) = \omega_{\max} = \frac{\omega_{\max} - \omega_{\min}}{t_{\max}} \times t \tag{3.4}$$

Where;

$t_{\max}$ = maximum number of iterations,

t = current iteration number,

$\omega_{\max}$ =maximum inertia weight,

$\omega_{\min}$ = minimum inertia weight.

The procedure of PSO implementation is as follows:

Step 1: The input data including network configuration, line impedance and status of DGs and switches are to be read.

Step 2: Set up the set of parameters of PSO such as number of particles N, weighting factors and C_1 and C_2. The initial population is determined by selecting the tie switches and DG size randomly from the set of the original population. The variable for tie switches represented by P_g.The proposed particles can be written as equation (3.5):

$$X_{particle} = \left\{S_1, S_2, \cdots S_\beta, P_{g1}, P_{g2}, \cdots, P_{g\alpha}\right\} \tag{3.5}$$

Where β is the number of tie line and α is the number of DG.

Step 3: Calculate the power loss using distribution load flow based on Newton-Raphson method.

Step 4: randomly generates an initial population (array) of particles with random positions and velocities on dimension in the solution space. Set the iteration counter k=0.

Step 5: For each particle, if the bus voltage is within the limits, calculate the total loss using distribution load flow. Otherwise, the particle is infeasible.

Step 6: Record and update the best value. The two best values are recorded in the searching process. Each particle keeps track of its coordinate in the solution space that is associated with the best solution it has reached so far. This value denoted as P_{best}. Another best value denoted as G_{best}, which is the overall best value obtained so far by any particle. P_{best} and G_{best} are the generation of switches, DG sizes and power loss. This step also updates P_{best} and G_{best}. At first, the fitness of each particle compare with its P_{best}. If the current solution is better than its P_{best}, then replace P_{best} by the current solution then the fitness of all particles is compared to G_{best}. If the fitness of any article is better than G_{best}, then replace G_{best}.

Step 7: Update the velocity and position of particles. Equation (3.2) is applied to update velocity of the particles. The velocity of a particle is representing as the movement of the switches. Meanwhile, equation (3.3) is to update the position of the particles.

Step 8: End conditions.

Check the end condition, if it is reached the algorithm stop or else repeat step 3-7 until the end condition is satisfied.

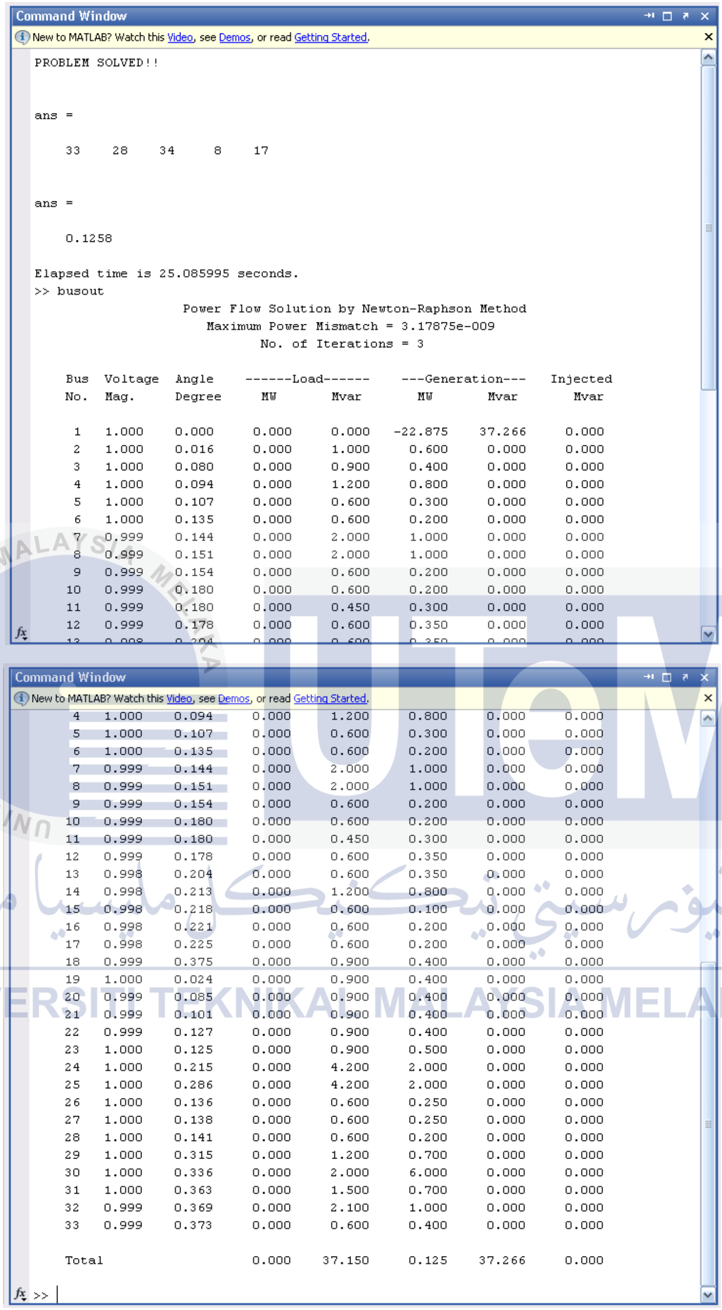
In this procedure, only the size of DG is determined while the location is fixed at low voltage profile based on case 1. The location is fixed as control measure to observe changing in DG sizing. DG location in real life also depends on the suitability of the area. Case 1 problem formulation used is DNR technique only meanwhile case 3 and case 4 used the problem formulation of DNR technique and PSO technique.

CHAPTER 4

RESULTS AND DISCUSSION

The simulations were carried out by using MATLAB software and the simulation result is as shown in Figure 4.1, Figure 4.2 and Figure 4.3. For case 2, the simulation results consist of switching operation, power losses in MW, computation time and voltage profile for each bus. For case 3 and case 4 is same with case 2 but with additional size of DGs is present. Table 4.1 shows the summary of the result from the simulation done in the MATLAB software.

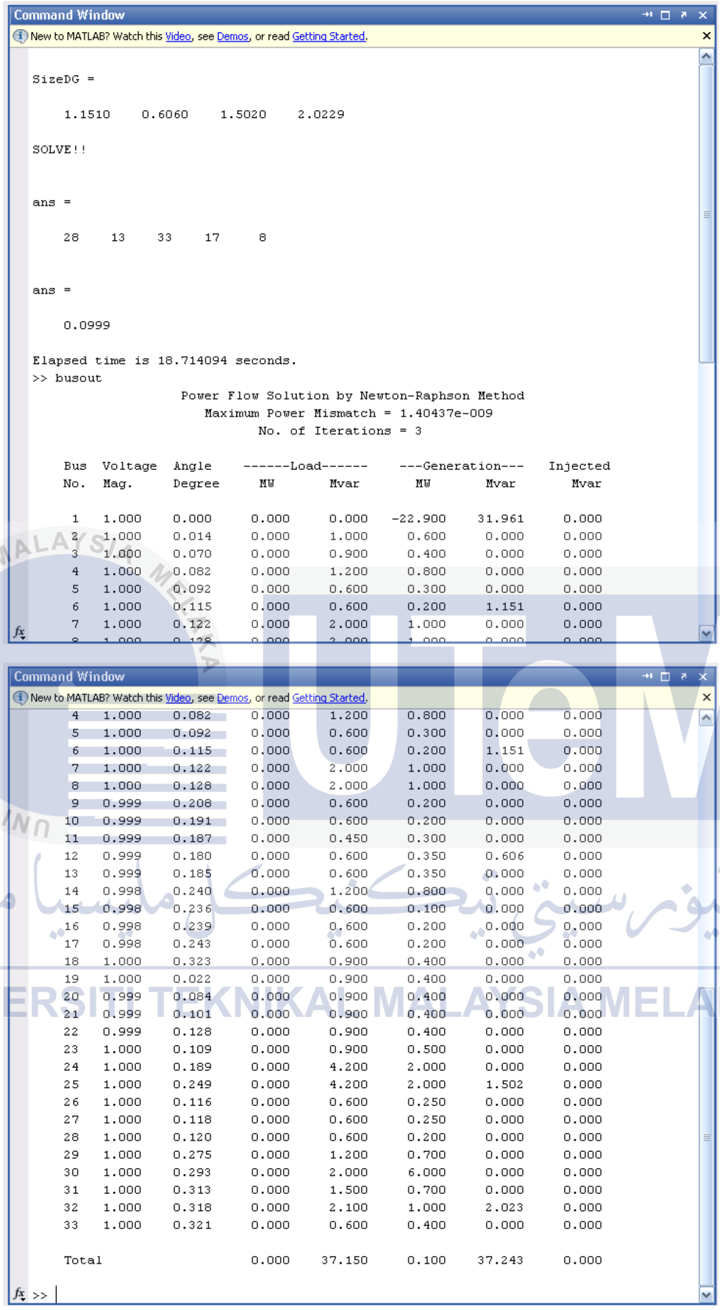
Figure 4.1 is the simulation result for case 2 which is switching switches while maintaining the radial configuration. Figure 4.2 and 4.3 is the simulation result for case 3 and case 4 which both is the switching and DGs sizing.



```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
PROBLEM SOLVED!!


ans =

    33    28    34     8    17


ans =

    0.1258

Elapsed time is 25.085995 seconds.
>> busout
                   Power Flow Solution by Newton-Raphson Method
                      Maximum Power Mismatch = 3.17875e-009
                             No. of Iterations = 3

    Bus  Voltage  Angle    ------Load------    ---Generation---   Injected
    No.  Mag.     Degree     MW       Mvar       MW       Mvar      Mvar

     1   1.000    0.000     0.000     0.000   -22.875    37.266    0.000
     2   1.000    0.016     0.000     1.000     0.600     0.000    0.000
     3   1.000    0.080     0.000     0.900     0.400     0.000    0.000
     4   1.000    0.094     0.000     1.200     0.800     0.000    0.000
     5   1.000    0.107     0.000     0.600     0.300     0.000    0.000
     6   1.000    0.135     0.000     0.600     0.200     0.000    0.000
     7   0.999    0.144     0.000     2.000     1.000     0.000    0.000
     8   0.999    0.151     0.000     2.000     1.000     0.000    0.000
     9   0.999    0.154     0.000     0.600     0.200     0.000    0.000
    10   0.999    0.180     0.000     0.600     0.200     0.000    0.000
    11   0.999    0.180     0.000     0.450     0.300     0.000    0.000
    12   0.999    0.178     0.000     0.600     0.350     0.000    0.000
```

```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
     4   1.000    0.094     0.000     1.200     0.800     0.000    0.000
     5   1.000    0.107     0.000     0.600     0.300     0.000    0.000
     6   1.000    0.135     0.000     0.600     0.200     0.000    0.000
     7   0.999    0.144     0.000     2.000     1.000     0.000    0.000
     8   0.999    0.151     0.000     2.000     1.000     0.000    0.000
     9   0.999    0.154     0.000     0.600     0.200     0.000    0.000
    10   0.999    0.180     0.000     0.600     0.200     0.000    0.000
    11   0.999    0.180     0.000     0.450     0.300     0.000    0.000
    12   0.999    0.178     0.000     0.600     0.350     0.000    0.000
    13   0.998    0.204     0.000     0.600     0.350     0.000    0.000
    14   0.998    0.213     0.000     1.200     0.800     0.000    0.000
    15   0.998    0.218     0.000     0.600     0.100     0.000    0.000
    16   0.998    0.221     0.000     0.600     0.200     0.000    0.000
    17   0.998    0.225     0.000     0.600     0.200     0.000    0.000
    18   0.999    0.375     0.000     0.900     0.400     0.000    0.000
    19   1.000    0.024     0.000     0.900     0.400     0.000    0.000
    20   0.999    0.085     0.000     0.900     0.400     0.000    0.000
    21   0.999    0.101     0.000     0.900     0.400     0.000    0.000
    22   0.999    0.127     0.000     0.900     0.400     0.000    0.000
    23   1.000    0.125     0.000     0.900     0.500     0.000    0.000
    24   1.000    0.215     0.000     4.200     2.000     0.000    0.000
    25   1.000    0.286     0.000     4.200     2.000     0.000    0.000
    26   1.000    0.136     0.000     0.600     0.250     0.000    0.000
    27   1.000    0.138     0.000     0.600     0.250     0.000    0.000
    28   1.000    0.141     0.000     0.600     0.200     0.000    0.000
    29   1.000    0.315     0.000     1.200     0.700     0.000    0.000
    30   1.000    0.336     0.000     2.000     6.000     0.000    0.000
    31   1.000    0.363     0.000     1.500     0.700     0.000    0.000
    32   0.999    0.369     0.000     2.100     1.000     0.000    0.000
    33   0.999    0.373     0.000     0.600     0.400     0.000    0.000

    Total                   0.000    37.150     0.125    37.266    0.000

>>
```

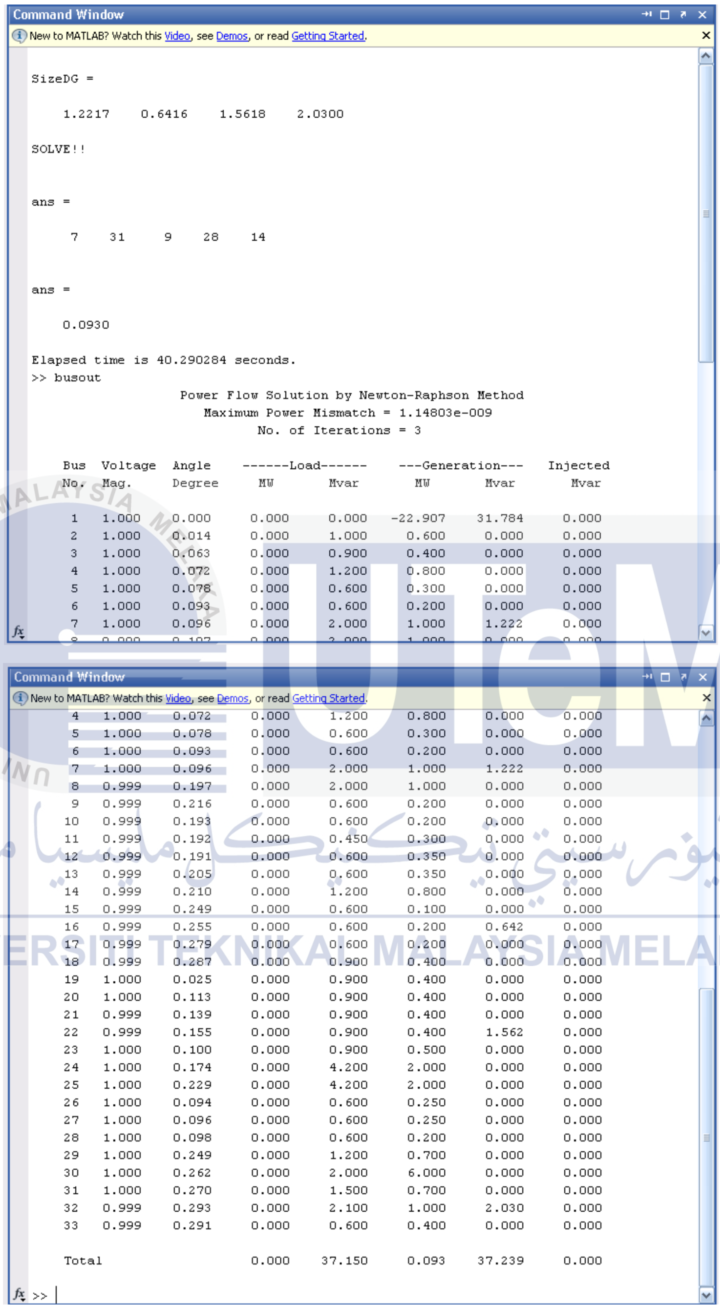
Figure 4.1: Simulation result for case 2.



```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.

SizeDG =

    1.1510    0.6060    1.5020    2.0229

SOLVE!!


ans =

    28    13    33    17     8


ans =

    0.0999

Elapsed time is 18.714094 seconds.
>> busout
                   Power Flow Solution by Newton-Raphson Method
                      Maximum Power Mismatch = 1.40437e-009
                             No. of Iterations = 3

    Bus  Voltage  Angle    ------Load------    ---Generation---   Injected
    No.  Mag.     Degree     MW       Mvar       MW       Mvar       Mvar

      1  1.000    0.000     0.000     0.000   -22.900    31.961     0.000
      2  1.000    0.014     0.000     1.000     0.600     0.000     0.000
      3  1.000    0.070     0.000     0.900     0.400     0.000     0.000
      4  1.000    0.082     0.000     1.200     0.800     0.000     0.000
      5  1.000    0.092     0.000     0.600     0.300     0.000     0.000
      6  1.000    0.115     0.000     0.600     0.200     1.151     0.000
      7  1.000    0.122     0.000     2.000     1.000     0.000     0.000
```

```
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
      4  1.000    0.082     0.000     1.200     0.800     0.000     0.000
      5  1.000    0.092     0.000     0.600     0.300     0.000     0.000
      6  1.000    0.115     0.000     0.600     0.200     1.151     0.000
      7  1.000    0.122     0.000     2.000     1.000     0.000     0.000
      8  1.000    0.128     0.000     2.000     1.000     0.000     0.000
      9  0.999    0.208     0.000     0.600     0.200     0.000     0.000
     10  0.999    0.191     0.000     0.600     0.200     0.000     0.000
     11  0.999    0.187     0.000     0.450     0.300     0.000     0.000
     12  0.999    0.180     0.000     0.600     0.350     0.606     0.000
     13  0.999    0.185     0.000     0.600     0.350     0.000     0.000
     14  0.998    0.240     0.000     1.200     0.800     0.000     0.000
     15  0.998    0.236     0.000     0.600     0.100     0.000     0.000
     16  0.998    0.239     0.000     0.600     0.200     0.000     0.000
     17  0.998    0.243     0.000     0.600     0.200     0.000     0.000
     18  1.000    0.323     0.000     0.900     0.400     0.000     0.000
     19  1.000    0.022     0.000     0.900     0.400     0.000     0.000
     20  0.999    0.084     0.000     0.900     0.400     0.000     0.000
     21  0.999    0.101     0.000     0.900     0.400     0.000     0.000
     22  0.999    0.128     0.000     0.900     0.400     0.000     0.000
     23  1.000    0.109     0.000     0.900     0.500     0.000     0.000
     24  1.000    0.189     0.000     4.200     2.000     0.000     0.000
     25  1.000    0.249     0.000     4.200     2.000     1.502     0.000
     26  1.000    0.116     0.000     0.600     0.250     0.000     0.000
     27  1.000    0.118     0.000     0.600     0.250     0.000     0.000
     28  1.000    0.120     0.000     0.600     0.200     0.000     0.000
     29  1.000    0.275     0.000     1.200     0.700     0.000     0.000
     30  1.000    0.293     0.000     2.000     6.000     0.000     0.000
     31  1.000    0.313     0.000     1.500     0.700     0.000     0.000
     32  1.000    0.318     0.000     2.100     1.000     2.023     0.000
     33  1.000    0.321     0.000     0.600     0.400     0.000     0.000

    Total                   0.000    37.150     0.100    37.243     0.000

>>
```

Figure 4.2: Simulation result for case 3.



Command Window

New to MATLAB? Watch this Video, see Demos, or read Getting Started.

```
SizeDG =

    1.2217    0.6416    1.5618    2.0300

SOLVE!!


ans =

     7    31     9    28    14


ans =

    0.0930

Elapsed time is 40.290284 seconds.
>> busout
                   Power Flow Solution by Newton-Raphson Method
                      Maximum Power Mismatch = 1.14803e-009
                             No. of Iterations = 3
```

Bus No.	Voltage Mag.	Angle Degree	------Load------ MW	Mvar	---Generation--- MW	Mvar	Injected Mvar
1	1.000	0.000	0.000	0.000	-22.907	31.784	0.000
2	1.000	0.014	0.000	1.000	0.600	0.000	0.000
3	1.000	0.063	0.000	0.900	0.400	0.000	0.000
4	1.000	0.072	0.000	1.200	0.800	0.000	0.000
5	1.000	0.078	0.000	0.600	0.300	0.000	0.000
6	1.000	0.093	0.000	0.600	0.200	0.000	0.000
7	1.000	0.096	0.000	2.000	1.000	1.222	0.000
8	0.999	0.197	0.000	2.000	1.000	0.000	0.000
9	0.999	0.216	0.000	0.600	0.200	0.000	0.000
10	0.999	0.193	0.000	0.600	0.200	0.000	0.000
11	0.999	0.192	0.000	0.450	0.300	0.000	0.000
12	0.999	0.191	0.000	0.600	0.350	0.000	0.000
13	0.999	0.205	0.000	0.600	0.350	0.000	0.000
14	0.999	0.210	0.000	1.200	0.800	0.000	0.000
15	0.999	0.249	0.000	0.600	0.100	0.000	0.000
16	0.999	0.255	0.000	0.600	0.200	0.642	0.000
17	0.999	0.279	0.000	0.600	0.200	0.000	0.000
18	0.999	0.287	0.000	0.900	0.400	0.000	0.000
19	1.000	0.025	0.000	0.900	0.400	0.000	0.000
20	1.000	0.113	0.000	0.900	0.400	0.000	0.000
21	0.999	0.139	0.000	0.900	0.400	0.000	0.000
22	0.999	0.155	0.000	0.900	0.400	1.562	0.000
23	1.000	0.100	0.000	0.900	0.500	0.000	0.000
24	1.000	0.174	0.000	4.200	2.000	0.000	0.000
25	1.000	0.229	0.000	4.200	2.000	0.000	0.000
26	1.000	0.094	0.000	0.600	0.250	0.000	0.000
27	1.000	0.096	0.000	0.600	0.250	0.000	0.000
28	1.000	0.098	0.000	0.600	0.200	0.000	0.000
29	1.000	0.249	0.000	1.200	0.700	0.000	0.000
30	1.000	0.262	0.000	2.000	6.000	0.000	0.000
31	1.000	0.270	0.000	1.500	0.700	0.000	0.000
32	0.999	0.293	0.000	2.100	1.000	2.030	0.000
33	0.999	0.291	0.000	0.600	0.400	0.000	0.000
Total			0.000	37.150	0.093	37.239	0.000

```
>>
```

Figure 4.3: Simulation result for case 4.

Table 4.1: Summary results of case study.

Items	Case 1	Case 2	Case 3	Case 4
Power loss (kW)	202.7	125.8	99.9	93
DG location (bus)	-	-	6 12 25 32	7 16 22 32
Loss reduction (%)	-	37.90	50.70	54.12
Time (seconds)	-	25.06	18.71	40.29
Switch opened	33 34 35 36 37	33 28 34 8 17	28 13 33 17 8	7 31 9 28 14

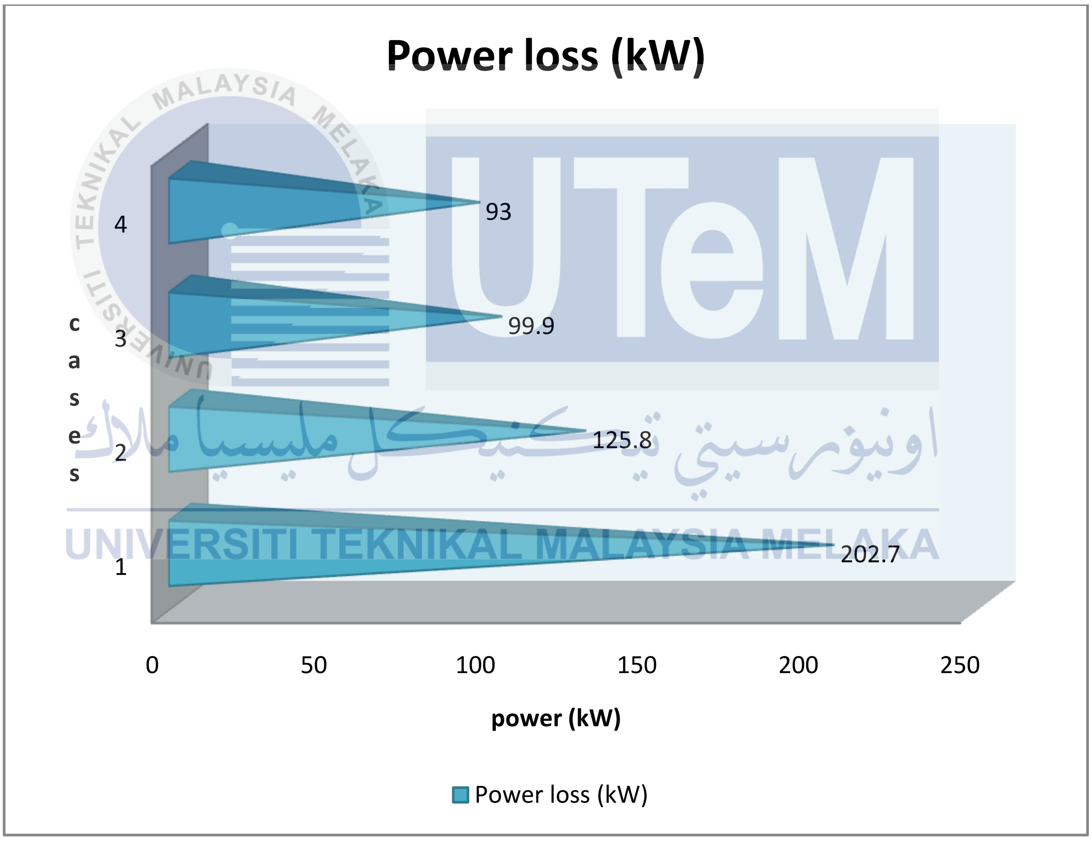


Figure 4.4: Power losses for all cases.

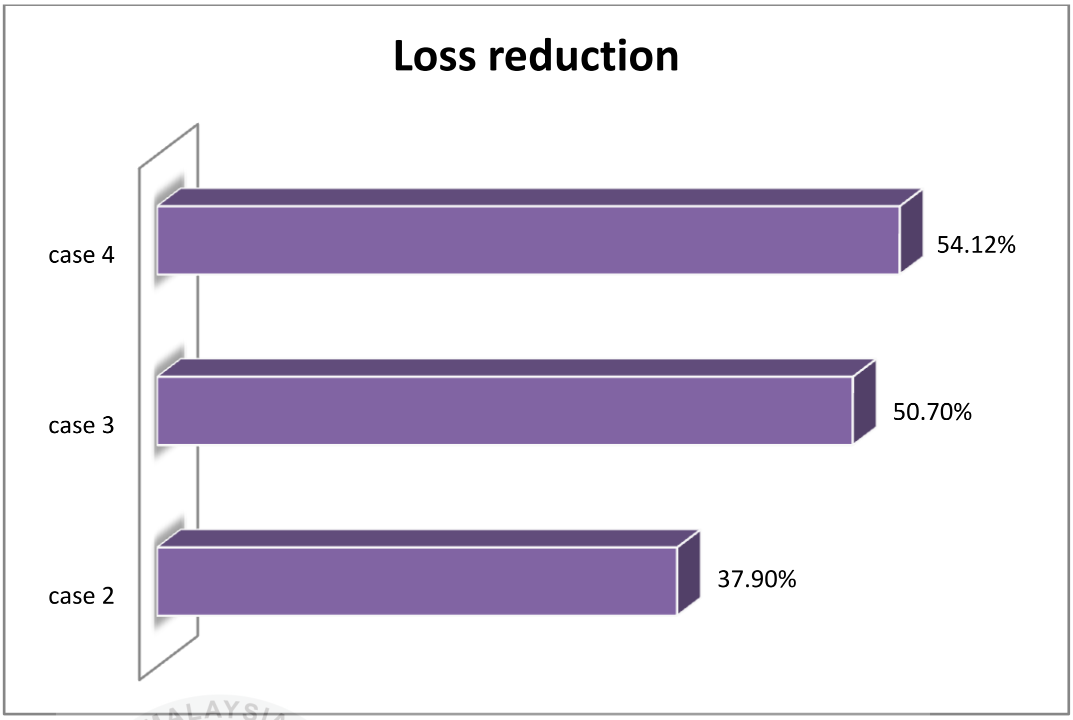


Figure 4.5: Loss reduction from initial case in percentage.

The result in table 4.2 show that the initial case with opened switch at bus number 33, 34, 35, 36, 37 and 38 with power loss 202.7kW [9]. Figure 4.4 show the power losses for all cases. Based on Figure 4.4, case 2 show that power loss reduced to 125.8kW for distribution network reconfiguration simulation. The difference of power losses between initial case to case 2 is 76.9kW, case 3 is 102.8kW and to case 4 is 109.7kW. In the other hand, the difference between power losses of case 3 and case 4 is 6.9kW. Besides that, Figure 4.5 shows the loss reduction for all cases with reference to case 1 the initial case. Both case 3 and case 4 is with present of DG. So, it show that with present of DG, power losses can be reduced to more than half percent from the initial power losses in the network.

Case 2 and case 4 is related because low voltage profile resulted in case 2 were used to allocation DGs at the selected buses. From case 2, at bus 13 to 17, the voltage profile is 0.998 while at bus 7 to 12, 18, 20 and 32 to 33 the voltage profile is 0.999. Others buses voltage profile is 1.

Based on the voltage profile result in case 2, DGs allocation were simultaneously place at bus number 7, 16, 22 and 32. As for case 3, it is tested to compare the result with case 4. Allocation of DG in case 3 is based on geographical location which means more load at bus 6, 12, 25 and 32. Figure 4.6 show the network reconfiguration with DGs allocation at bus 6, 12, 25 and 32 and Figure 4.7 show that the network reconfiguration with DGs allocation at bus 7, 16, 22, and 32.

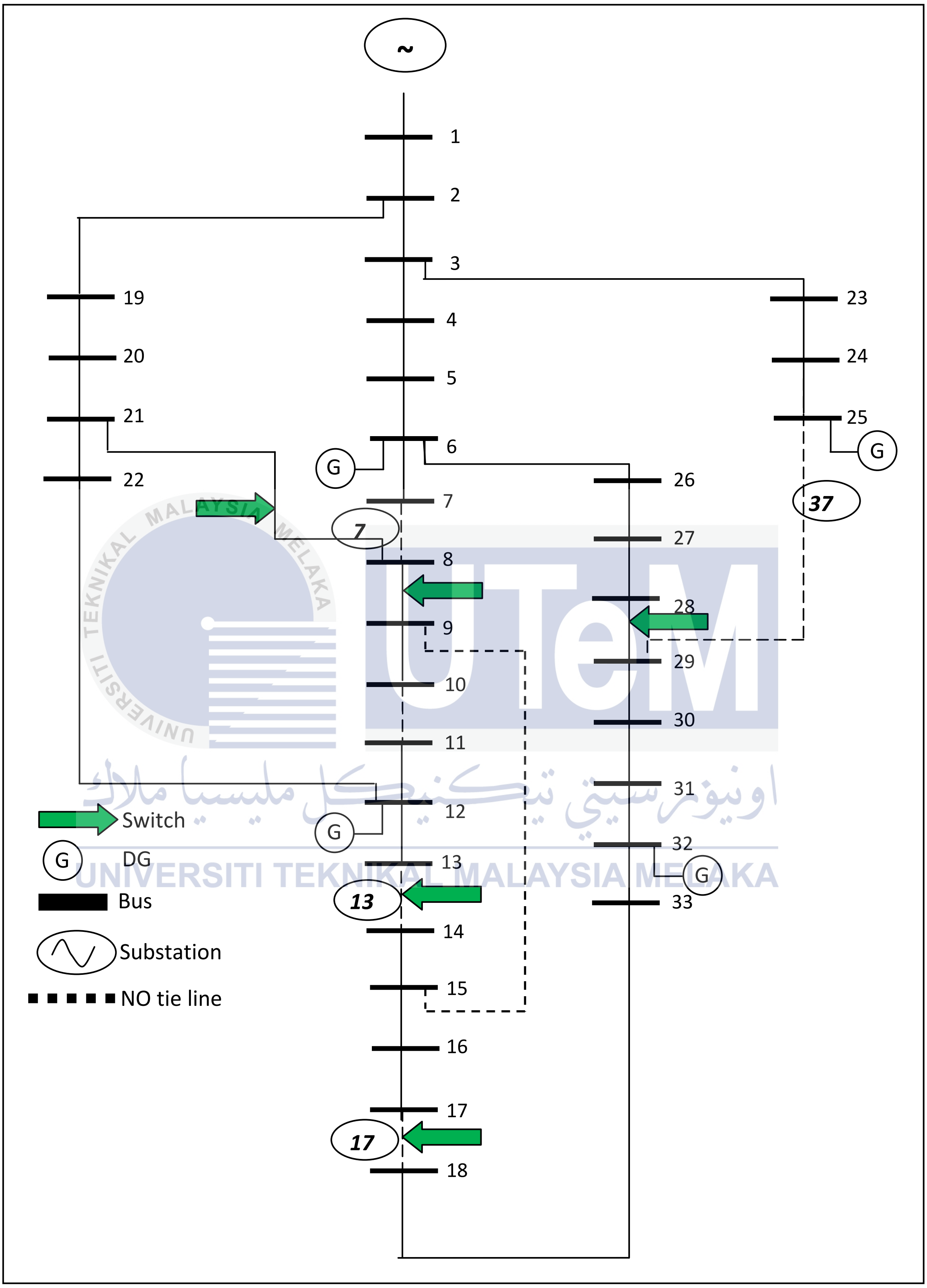


Figure 4.6: Network reconfiguration with allocation of DG for case 3.

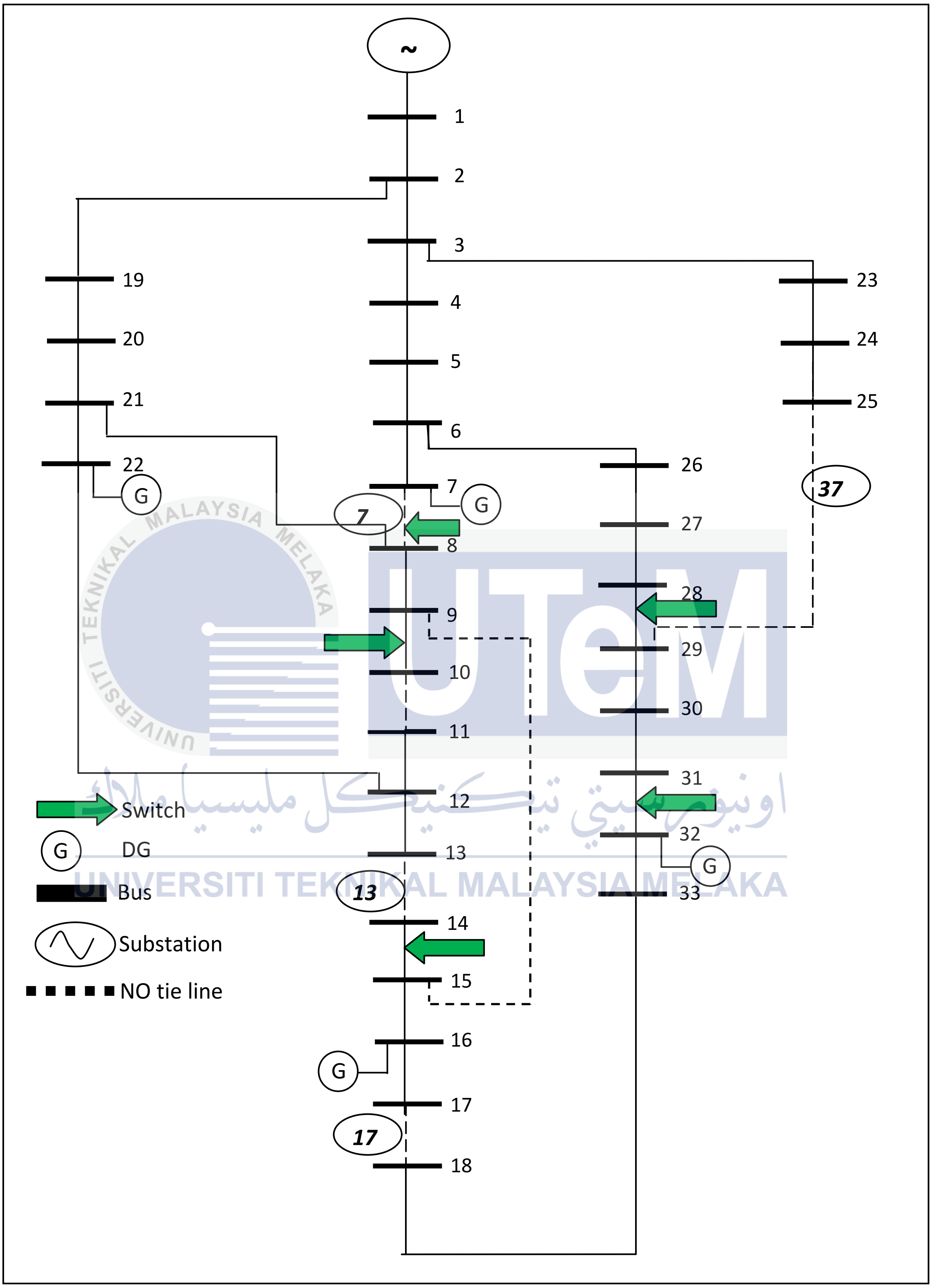


Figure 4.7: Network reconfiguration with allocation of DG for case 4.

Table 4.2: DGs sizing for case 3.

No of DGs	Location (bus no)	DGs size (MW)
DG 1	6	1.151
DG 2	12	0.606
DG 3	25	1.5021
DG 4	32	2.0229

Table 4.3: DGs sizing for case4.

No of DGs	Location (bus no)	DGs size (MW)
DG 1	7	1.2217
DG 2	16	0.6416
DG 3	22	1.5618
DG 4	32	2.0300

Table 4.2 and table 4.3 shows the DGs location and its sizing. DGs sizing for case 3 and case 4 is approximately the same because there is no big different between the size of the DGs for both cases. DGs allocation for case 3 is based on the stability of geographical of location methods [9]. Meanwhile for case 3 is based on observation of voltage profile from case 2. DGs are located at the lowest voltage profile from that case. The result show that allocation of DG based on voltage profile can improved power losses as discussed earlier.

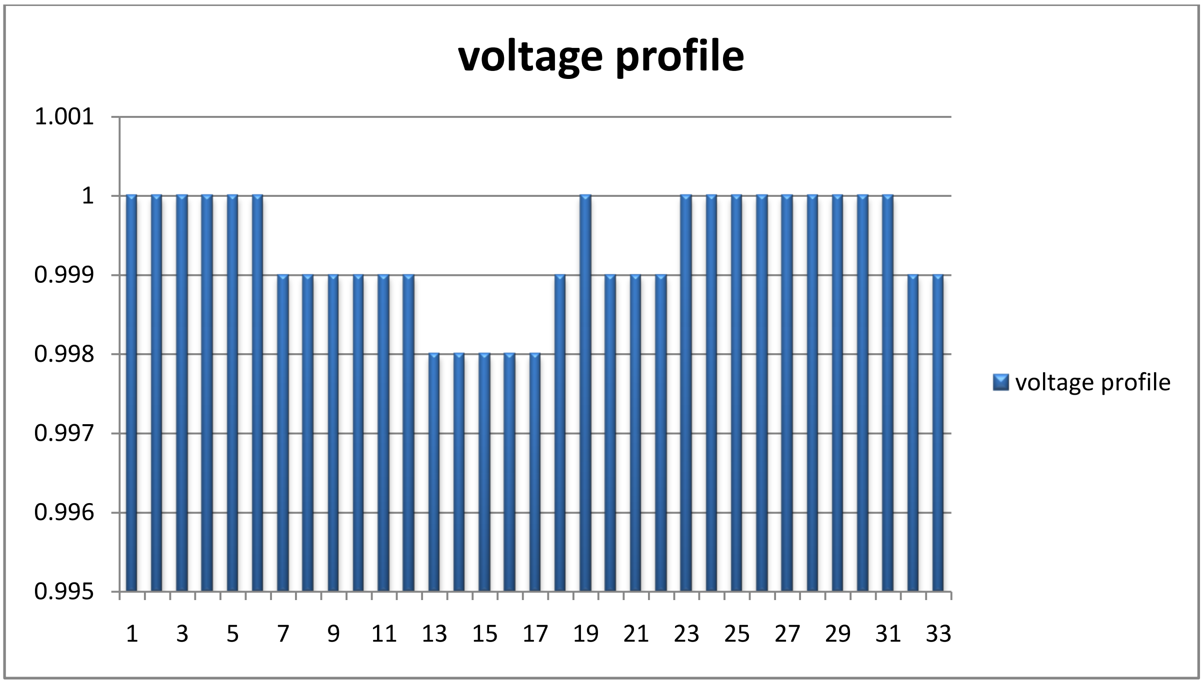


Figure 4.8: Voltage profile for case 2.

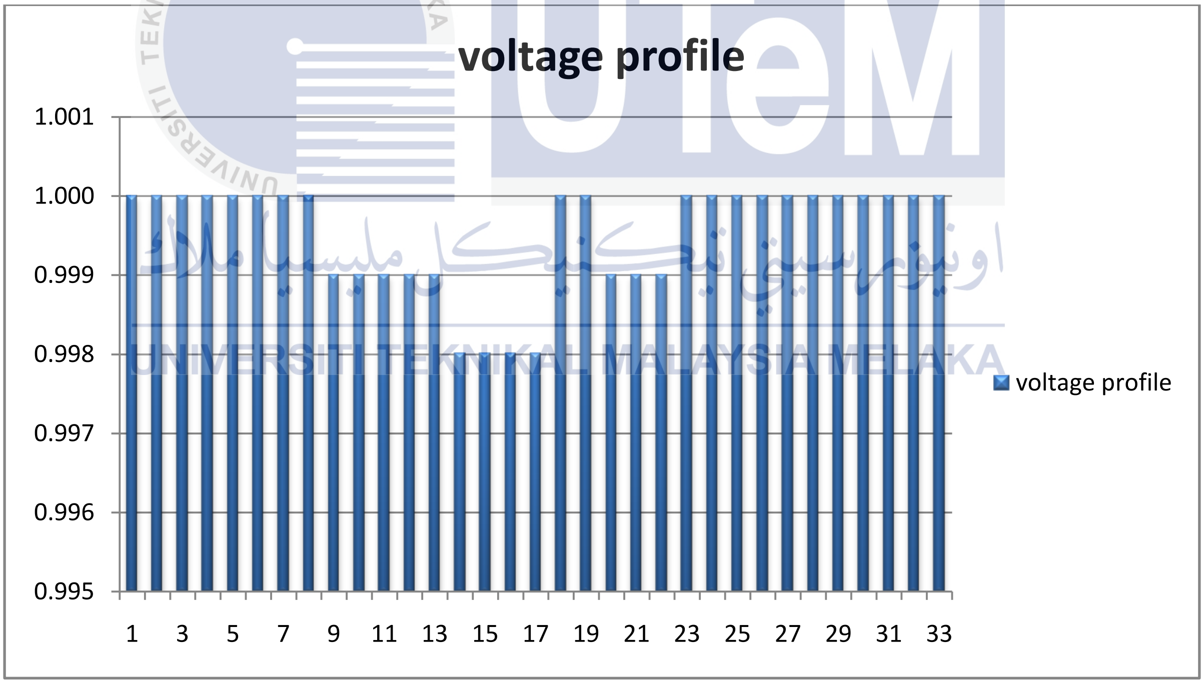


Figure 4.9: Voltage profile for case 3.

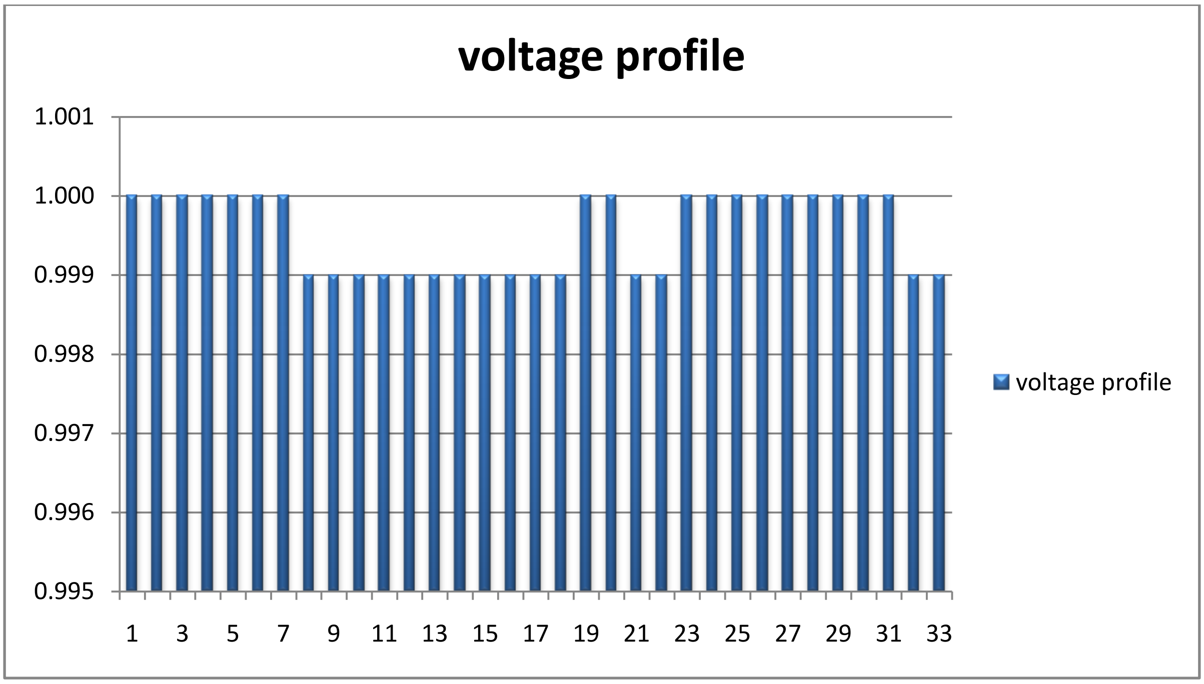


Figure 4.10: Voltage profile for case 4.

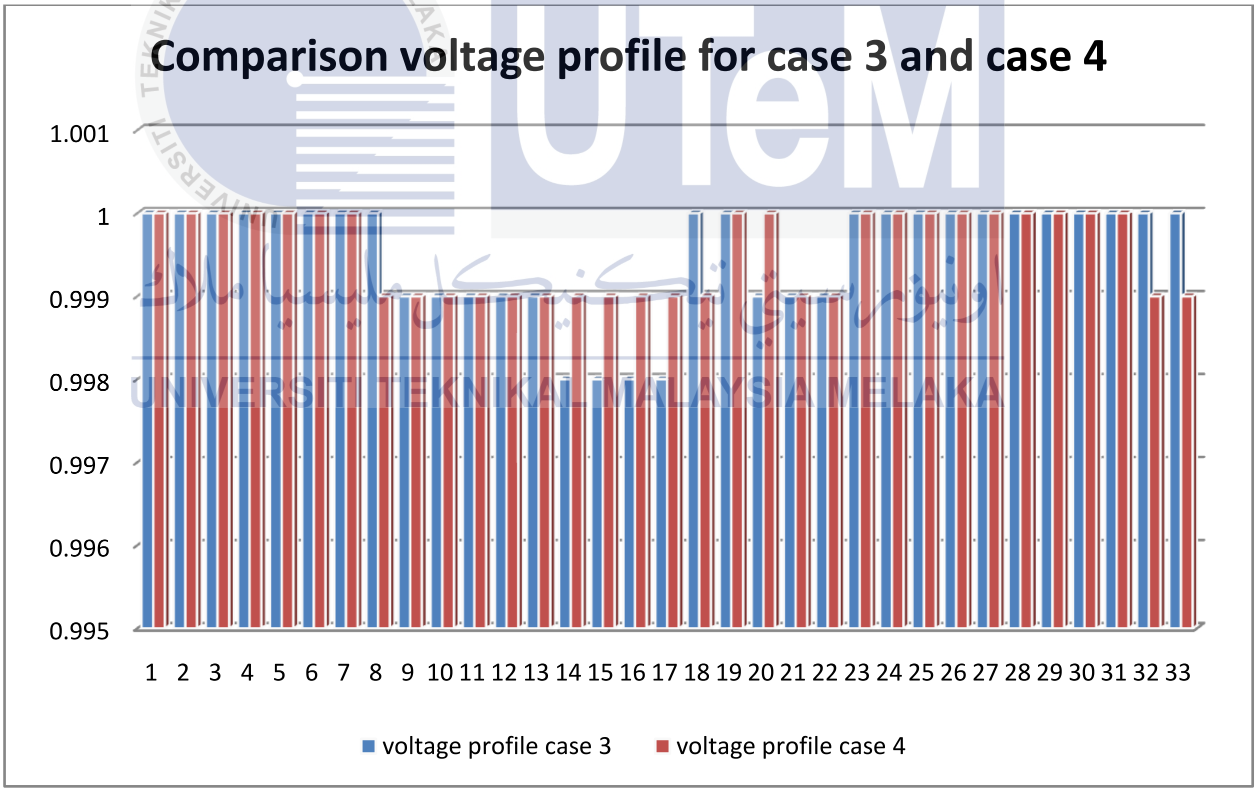


Figure 4.11: Comparison of voltage profile for case 3 and case 4.

Figure 4.8, Figure 4.9 and Figure 4.10 shows the voltage profile for case 2, case 3 and case 4. Based on the results in Figure 4.10, it shows that allocation DG based on voltage profile can improved the voltage profile itself for the system. Figure 4.11 show the comparison of voltage profile for case 3 and case 4. It is because both case 3 and case 4 is same with the present of DG after network reconfiguration but different in term of allocation of DGs. It shows that allocation of DG based on low voltage profile also can be done in order to reduce network power losses and improving voltage profile. The minimum voltage profile for case 2 and case 3 is 0.998 compared to minimum voltage profile for case 4 is 0.999. Voltage profile for case 4 is more stable because the range is only between 0.999 and 1 compared to case 2 and case 3. In the other hand, allocation and sizing of DG also improves voltage profile because DG were located at the bus with low voltage profile.

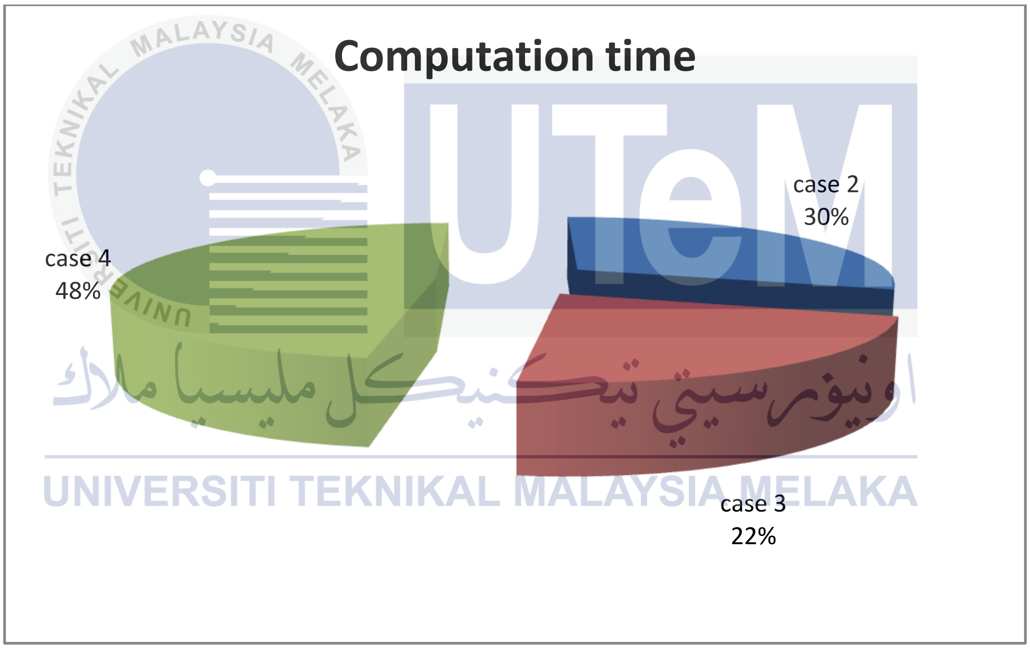


Figure 4.12: Computation time for case 2, case 3 and case 4.

Figure 4.12 is the computation time for case 2, case 3 and case 4. From the figure, it show that case 3 take the shortest time follow by case 2 and case 4 take the longest time to compute the simulation. Case 2 take 25.085995s, case 3 18.71409s and case 4 40.29028s. The computation time were not affected the performance of the system. It is just the time taken for the simulation in MATLAB for all cases.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective of this project to show that allocation of Distributed Generation (DG) based on low voltage profile simultaneously can improve power loss and voltage profile. There are many ways to do the allocation of DG as discussed in chapter two. Besides that, Distribution Network Reconfiguration operation main purpose is to reduce power loss. With additional of DG after reconfiguration also can reduce power loss about half percent from the initial network system. The loss reduction after DNR and DGs allocation both is 50.7% and 54.12%.

Distributed Generation was simultaneously select at four buses which are having low voltage profile. Because of allocation of DG at low voltage profile, the voltage profile had been in the optimum range which is from 0.999 to 1 compare to the allocation based on geographical location.

For the conclusion, Particle Swarm Optimization (PSO) is one of the best methods to find DG sit and size also to find sectionalizing switch of the network. Location of DG also play an important role in the distribution network because fail to do so will give problem to the network such as frequency and voltage not in synchronization which can cause collapsed to the entire system. This project have fulfilled its objective which it can reduce network power losses and improve the voltage profile of the system by allocation the DGs simultaneously by using PSO method.

5.2 Recommendation

This project represent of network reconfiguration and DG allocation and sizing with method of placing DG at low voltage profile based on network reconfiguration result. In future, other method such as Ant Colony Algorithm (ACA), Invasive Weed Optimization (IWO), Harmony Search Algorithm (HSA), Genetic Algorithm (GA) and many more can be used to compare the method of DG allocation and find the best way to do sit and size of the DG. Other ways is comparison can be made based on algorithm while fixing the others parameters. So, computation time can take into consideration to find the best algorithm method.

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LIST OF APPENDIXS

APPENDIX A

Items	20 weeks (W)																				
											0	1	2	3	4	5	6	7	8	9	0
Briefing by FYP committee								MID-SEMESTER BREAK													
Designation of IEEE-33 bus system network																					
Development of PSO in DG network																					
Verification of PSO implementation																					
Result and analysis																					
Report preparation																					
Log book writing																					
Presentation of the project																					
Submission of log book to supervisor																					
Submission report for evaluation																					
Collect report for correction																					
Submission of report in PDF format																					

APPENDIX B

```
tic

IEEE_33; %Call data
N=20; %%N value must above 20
sel=20;
N_switch=5;
x_1=max(length(linedata1(:,1)));
nbus=x_1;

%%%%%%%%%%%%%%%%%%%%%% 1st step  initialisation

%Initialization of PSO parameters
wmax=0.9;
wmin=0.4;
itmax=300; %Maximum iteration number
c1=2.0;
c2=2.0;

for ite=1:itmax
    W(ite)=wmax-((wmax-wmin)/itmax)*ite;
end
%****************************************************************
N=20;
ub=[3.000 3.000 3.000 3.000];
lb=[1.000 0.500 1.500 2.000];
D=4;
for i=1:D
        P(:,i,1)=rand(N,1).*(ub(1,i)-lb(1,i))+lb(1,i);  %random from up
and lower limit
end

for i=1:4
 Pmin(1,i)=min(P(:,i));
end

P;
Pmin;
SizeDG=Pmin
busdata1(7,8)=SizeDG(1,1);
busdata1(16,8)=SizeDG(1,2);
busdata1(22,8)=SizeDG(1,3);
busdata1(32,8)=SizeDG(1,4);

%****************************************************************



% for ite=1:itmax
%     W(ite)=wmax-((wmax-wmin)/itmax)*ite;
% end
% %****************************************************************




x_2=x_1-1; %15
k_1=1;
```

```
while k_1<=N

    x(1,1) = ceil((x_1).*rand(1,1));

    k=2;
    while k<=N_switch
        flag=1;

        y = ceil((x_1).*rand(1,1));

        for KK=1:k-1
            if y==x(1,KK)
                flag=0;
            end
        end
        if flag ~=0
            x(1,k)=y;
            k=k+1;
        end
    end
    Candidate(k_1,:,1)= transpose(x);
    busdata=busdata1;
    linedata=linedata1;

    for L=1:N_switch
        linedata(Candidate(k_1,L),3)=10000;
        linedata(Candidate(k_1,L),4)=10000;
    end

    %%%%%%%%%%%%%----------------loadflow calculation-------------
%%%%%%%%%%%%%%%%%%%
    %%%%%%%%%%%%%----------------loadflow calculation-------------
%%%%%%%%%%%%%%%%%%%
    lfybus;  % form the bus admittance matrix
    lfnewton;
%------------------------------lineflow
    SLT = 0;
% fprintf('\n')
% fprintf('                              Line Flow and Losses \n\n')
% fprintf('     --Line--  Power at bus & line flow    --Line loss--
Transformer\n')
% fprintf('     from  to     MW      Mvar     MVA       MW      Mvar
tap\n')
for n = 1:nbus
busprt = 0;
   for L = 1:nbr;
       if busprt == 0
%          fprintf('   \n'), fprintf('%6g', n), fprintf('      %9.3f',
P(n)*basemva)
%          fprintf('%9.3f', Q(n)*basemva), fprintf('%9.3f\n',
abs(S(n)*basemva))

       busprt = 1;
       else, end
       if nl(L)==n      k = nr(L);
       In = (V(n) - a(L)*V(k))*y(L)/a(L)^2 + Bc(L)/a(L)^2*V(n);
       Ik = (V(k) - V(n)/a(L))*y(L) + Bc(L)*V(k);
       Snk = V(n)*conj(In)*basemva;
       Skn = V(k)*conj(Ik)*basemva;
       SL  = Snk + Skn;
```

```
            SLT = SLT + SL;
            elseif nr(L)==n  k = nl(L);
            In = (V(n) - V(k)/a(L))*y(L) + Bc(L)*V(n);
            Ik = (V(k) - a(L)*V(n))*y(L)/a(L)^2 + Bc(L)/a(L)^2*V(k);
            Snk = V(n)*conj(In)*basemva;
            Skn = V(k)*conj(Ik)*basemva;
            SL  = Snk + Skn;
            SLT = SLT + SL;
            else, end
              if nl(L)==n | nr(L)==n
%               fprintf('%12g', k),
%               fprintf('%9.3f', real(Snk)), fprintf('%9.3f', imag(Snk))
%               fprintf('%9.3f', abs(Snk)),
%               fprintf('%9.3f', real(SL)),
                  if nl(L) ==n & a(L) ~= 1
 %                 fprintf('%9.3f', imag(SL)), fprintf('%9.3f\n', a(L))
                  else, %fprintf('%9.3f\n', imag(SL))
                  end
              else, end
  end
end
SLT = SLT/2;
% fprintf('   \n'), fprintf('    Total loss                         ')
% fprintf('%9.3f', real(SLT)), fprintf('%9.3f\n', imag(SLT))
%-----------------------------------------------------------------------


    if(iter<=maxiter)
        fitness(k_1,1,1) =real(SLT);
        k_1=k_1+1;
    end

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
%
end


%%%%%%%%%%%%%%%% 2nd Step calculate fitness

output1=[Candidate fitness];

[r,c]=size(output1);
output2=(sortrows(output1,c));
output3=output2(1:20,:);

yfit(:,1,1)=output3(:,end);
xn(:,:,1)=output3(:,1:end-1);


Vel=zeros(sel,N_switch,1);  %%%% set all initial velocity to zero

%%%%%%%%%%%%% all initial position = pbest

[C,I]=min(yfit(:,1,1)); %%%%%% Gbest

B(1,1,1)=C;
XX(1,1,1)=I;
gbest(1,:,1)=xn(I,:,1);
```

```
yb(1,1,1) =C;

%*********************************************************

%Matrix composed of gbest vector
for p=1:sel
    for r=1:N_switch
        G(p,r,1)=gbest(1,r,1);
    end
end

ybest(1,1,1)=yb;

pbest(:,:,1)=xn(:,:,1);


for i=1:N_switch
Vel(:,i,2)=W(1)*Vel(:,i,1)+c1*rand*(pbest(:,i,1)-
xn(:,i,1))+c2*rand*(G(:,i,1)-xn(:,i,1));
end

xn(:,:,2)=xn(:,:,1)+Vel(:,:,2);
xn=round(xn);

xc=xn(:,:,2);

for i=1:sel
    for n=1:N_switch
        check=xc(i,n);
        if check>nbus
            check=nbus;
            xc(i,n)=check;
        end
        if check<1
            check=1;
            xc(i,n)=check;
        end
    end
end

for i=1:sel
    [r,c,v]=find(xc(i,:)==x_1);
    vv=numel(v);
    if vv>1
        for j=1:N_switch
            check_1=xc(i,j);
            n=1;
            while n<=N_switch
                if j~=n
                    check_2=xc(i,n);
                    test=isequal(check_1,check_2);
                    if test==1 && check_1==1
                        check_2=check_2+1;
                        xc(i,n)=check_2;
                    elseif test==1
                        check_2=check_2-1;
                        xc(i,n)=check_2;
                    end
                end
```

```
                n=n+1;
            end
        end

    else
        for j=1:N_switch
            check_1=xc(i,j);
            n=1;
            while n<=N_switch
                if j~=n
                    check_2=xc(i,n);
                    if check_2==check_1
                        check_2=check_2+1;
                        xc(i,n)=check_2;
                    end
                end
                n=n+1;
            end
        end
    end
end

xn(:,:,2)=xc;

BV(1,1)=min(yfit);


%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
for pso=2:itmax;

NN=xn(:,:,pso);
x=NN;
count=1;
while count<=length(x(:,1))

    busdata=busdata1;
    linedata=linedata1;


    linedata(x(count,:),3)=10000;
    linedata(x(count,:),4)=10000;


    %%%%%%%%%%%%%-----------------loadflow calculation-------------
%%%%%%%%%%%%%%%%%%%
    %%%%%%%%%%%%%-----------------loadflow calculation-------------
%%%%%%%%%%%%%%%%%%%
    lfybus;    % form the bus admittance matrix
    lfnewton;
%-----------------------------lineflow
    SLT = 0;
% fprintf('\n')
% fprintf('                           Line Flow and Losses \n\n')
% fprintf('     --Line--  Power at bus & line flow    --Line loss--
Transformer\n')
% fprintf('     from  to     MW      Mvar      MVA       MW      Mvar
tap\n')
for n = 1:nbus
busprt = 0;
```

```
   for L = 1:nbr;
       if busprt == 0
%          fprintf('   \n'), fprintf('%6g', n), fprintf('      %9.3f',
P(n)*basemva)
%          fprintf('%9.3f', Q(n)*basemva), fprintf('%9.3f\n',
abs(S(n)*basemva))

       busprt = 1;
       else, end
       if nl(L)==n      k = nr(L);
       In = (V(n) - a(L)*V(k))*y(L)/a(L)^2 + Bc(L)/a(L)^2*V(n);
       Ik = (V(k) - V(n)/a(L))*y(L) + Bc(L)*V(k);
       Snk = V(n)*conj(In)*basemva;
       Skn = V(k)*conj(Ik)*basemva;
       SL  = Snk + Skn;
       SLT = SLT + SL;
       elseif nr(L)==n  k = nl(L);
       In = (V(n) - V(k)/a(L))*y(L) + Bc(L)*V(n);
       Ik = (V(k) - a(L)*V(n))*y(L)/a(L)^2 + Bc(L)/a(L)^2*V(k);
       Snk = V(n)*conj(In)*basemva;
       Skn = V(k)*conj(Ik)*basemva;
       SL  = Snk + Skn;
       SLT = SLT + SL;
       else, end
         if nl(L)==n | nr(L)==n
%           fprintf('%12g', k),
%           fprintf('%9.3f', real(Snk)), fprintf('%9.3f', imag(Snk))
%           fprintf('%9.3f', abs(Snk)),
%           fprintf('%9.3f', real(SL)),
             if nl(L) ==n & a(L) ~= 1
 %             fprintf('%9.3f', imag(SL)), fprintf('%9.3f\n', a(L))
             else, %fprintf('%9.3f\n', imag(SL))
             end
         else, end
  end
end
SLT = SLT/2;
% fprintf('   \n'), fprintf('    Total loss                         ')
% fprintf('%9.3f', real(SLT)), fprintf('%9.3f\n', imag(SLT))
%-----------------------------------------------------------------------

    if(iter<=maxiter)
        fitness(count,1,pso) =real(SLT);


    else

    end

    count=count+1;
end



for i=1:sel
    yfit(i,1,pso)=fitness(i,1,pso);
end

for i=1:sel
```

```
    if (yfit(i,:,pso)==0)
        yfit(i,:,pso)=yb(:,:,pso-1);
        xn(i,:,pso)=gbest(:,:,pso-1);

    else
        yfit(i,:,pso)=fitness(i,:,pso);
        xn(i,:,pso)=xn(i,:,pso);
    end
end

BV(1,pso)=min(yfit(1,1,pso));

    %%%%%%%%%%%%% Pbest and Gbest matrix

        [C,I]=min(yfit(:,1,pso));

        B(1,1,2)=C;

        gbest(1,:,pso)=xn(I,:,pso);


   %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%calculate
yb%%%%%%%%%%%%%%%%%%%%%%%%%%%%

   yb(1,1,pso)=C;
   D=max(yfit(:,:,pso));
   C=min(yfit(:,:,pso));

    if  D-C<=0.001;
        fprintf('SOLVE!!\n\n');
        break
    end

        [C,I]=min(yb(1,1,:));


    if yb(1,1,pso)==C
        gbest(1,:,pso)=gbest(1,:,pso);
    else
        gbest(1,:,pso)=gbest(1,:,I);
    end


    %%%%%%%%%%%%%Matrix composed of gbest vector
    for p=1:sel
        for r=1:N_switch
            G(p,r,pso)=gbest(1,r,pso);
        end
    end

    for i=1:sel;
          [C,I]=min(yfit(i,1,:)) ;
         if yfit(i,1,pso)==C
            pbest(i,:,pso)=xn(i,:,pso);
         else
            pbest(i,:,pso)=xn(i,:,I);
         end
    end
```

```
% %     %%%%%%%%%%%%%%%%%% find new position%%%%%%%%%%%%%%%%%%%%%%%%%%%%

for i=1:N_switch
    Vel(:,i,pso+1)=W(pso)*Vel(:,i,pso)+c1*rand*(pbest(:,i,pso)-
xn(:,i,pso))+c2*rand*(G(:,i,pso)-xn(:,i,pso));
end

    xn(:,:,pso+1)=xn(:,:,pso)+Vel(:,:,pso+1);

    xn=round(xn);

xc = xn(:,:,pso+1);

for i=1:sel
    for n=1:N_switch
        check=xc(i,n);
        if check>nbus
            check=nbus;
            xc(i,n)=check;
        end
        if check<1
            check=1;
            xc(i,n)=check;
        end
    end
end

for i=1:sel
    [r,c,v]=find(xc(i,:)==x_1);
    vv=numel(v);
    if vv>1
        for j=1:N_switch
            check_1=xc(i,j);
            n=1;
            while n<=N_switch
                if j~=n
                    check_2=xc(i,n);
                    test=isequal(check_1,check_2);
                    if test==1 && check_1==1
                        check_2=check_2+1;
                        xc(i,n)=check_2;
                    elseif test==1
                        check_2=check_2-1;
                        xc(i,n)=check_2;
                    end
                end
                n=n+1;
            end
        end

    else
        for j=1:N_switch
            check_1=xc(i,j);
            n=1;
            while n<=N_switch
                if j~=n
                    check_2=xc(i,n);
                    if check_2==check_1
                        check_2=check_2+1;
```

```
                        xc(i,n)=check_2;
                    end
                end
                n=n+1;
            end
        end
    end
end

xn(:,:,pso+1)=xc;


end

NN(1,:)
yfit(1,:,pso)
toc
```

APPENDIX C

M. N. M. Nasir et al. / International Journal of Engineering and Technology (IJET)

Optimum Network Reconfiguration and DGs Sizing With Allocation Simultaneously by Using Particle Swarm Optimization (PSO)

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Abstract—This paper presents three stages of methodology. The first stage is to identify the switching operation for radial network configuration while observe the power losses and the voltage profile without Distributed Generation (DG). The second stage is based on previous paper which is feeder reconfiguration for loss reduction with DGs. 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 54.92% from Distribution Network Reconfiguration (DNR) method. 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 by switching and DGs allocation method.

Keyword-Distributed Generation, switching operation, loss reduction and voltage profile.

I. Introduction

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. 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 [1]. 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 [2].

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].

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 [7]. Particle swarm is the system model based on basic creatures that move in a group with the same objective for