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Network Reconfiguration for loss Reduction and Improvement of Voltage Profile in Electrical Distribution System

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ABSTRACT

Now days, the electricity demand is increasing day by day and hence it is very important not only to extract electrical energy from all possible new power resources but also to reduce power losses within the acceptable minimum level in the existing distribution networks where a large amount of power dissipation occurred. Generally a lot of power is remarkably dissipated in distribution system. Among the methods in reducing power losses, network reconfiguration method is employed for loss minimization and exhaustive technique is also applied to achieve the minimal loss switching scheme. As the electricity demand of the power distribution system has been continually increasing with the increasing growth of population, the characteristics of the load will be frequently altered according to customer behavior. Constructions of supplementary power distribution systems are required. System reconfiguration is the process of changing the topology of the distribution network by altering the status of Tie switches, placement of DG's, installation of power factor capacitors etc. The proposed project work is to minimize the Distribution losses, improve voltage profile and System reliability by Network Reconfiguration.

Keywords: *Distributed Generation, Network Reconfiguration and Voltage profile.*

I. INTRODUCTION

As the electricity demand of the power distribution system has been continually increasing with the incessant growth of population, the characteristics of the load will be frequently altered according to customer Behavior. Constructions of supplementary power distribution systems are required. Power losses of the distribution system are more than transmission network due to higher ratio of current to voltage (higher line impedance) of distribution lines compared to transmission ones. Power losses directly affect the operational cost and the voltage profile, especially in heavily loaded power systems. However the large-scale of a power system typically yields a massive power loss, which is one of the most important problems for an electrical system. Many approaches have been proposed in the literature in order to minimize the power loss of an electrical system. The amount of power losses in the electric distribution system and where they largely occur in the system are of a great interest to the engineers in developing a rate structure for different classes of customers. It is necessary to supply additional energy over that required to satisfy the load to compensate for the losses in the system. The locations of these losses may be found in the various components of the power system. One of the most effective techniques is network reconfiguration, because of its simple implementation and low-cost investment. Generally, the electrical distribution system consists of two types of switches, which are tie switches and sectionalizing switches. The status of tie switches is normally open while that of sectionalizing switches is normally closed. The topology of a system can be determined by the statuses of tie and sectionalizing switches. System reconfiguration is the process of changing the topology of the distribution network by altering the statuses of switches. By Network Reconfiguration so we can minimize the distribution losses & improve voltage profile.

II. PROBLEM DEFINITION

Generally in Electrical power distribution system due to increase in load demand of consumer and their nature of load, lot of power quality related issues arises. This problem leads to increase in power loss and change in voltage profile of the line from expected standards. Hence it is necessary to resolve such problems using different Network Reconfiguration techniques such as placements of DGs, installation of power factor improvement Capacitors, Tie Switches etc. So to overcome above said problems, we are going for Network Reconfiguration, which will help to reduce power loss, improve voltage profile and enhance reliability of the system.

III. OBJECTIVES

Objectives of proposed project work is to

1. Simulate standard IEEE 33-Bus electrical distribution system for Loss Reduction and Improvement of voltage profile using Network Reconfiguration.

IV. METHODOLOGY

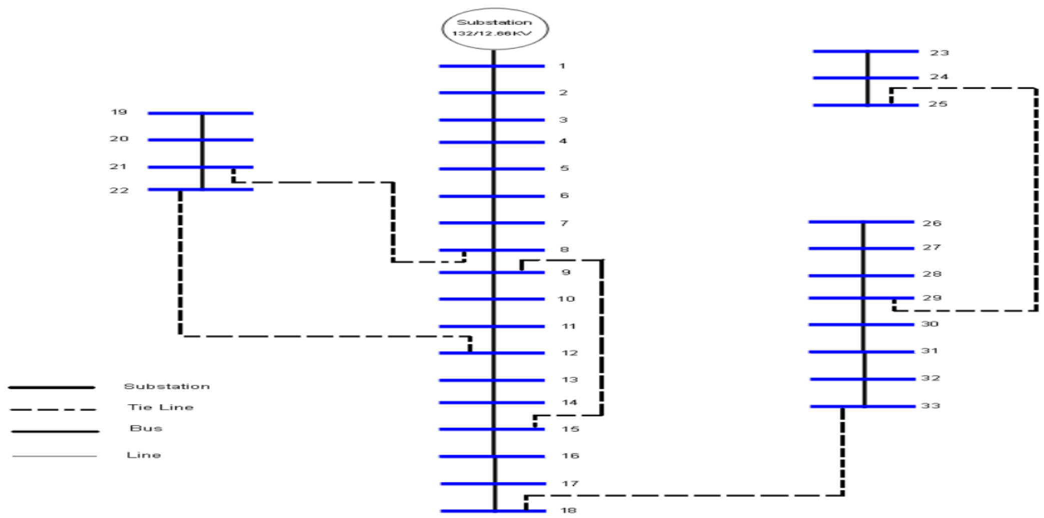


Fig1.Single line Diagram of Standard IEEE 33-Bus system

A single-line diagram is a simplified representationof an electrical system. The symbols and lines are used to represent the nodes and connections in the system, and even electrical characteristics may be included. In a data center, a single-line diagram is used to visualize the power distribution system to improve planning, ensure redundancy and to reduce potential outages. By using standard IEEE 33 bus system data with tie switches single line diagram is drawn in MIPOWR software and simulated to obtain line flows. By using PSO algorithm in matlab software optimal location and sizing is done, further with previous tie switches optimized DGs are placed at particular buses and line flows are obtained.

V. DIFFERENT METHODS

1. Linear Programming method

Linear programming methods have been used extensively for a number of years by power system planners to minimize the capital costs of constructing new or expanding existing power systems. The planner's attempts include the calculation and reduction of the system losses I2R (where, I is the current in and R the resistance of the feeder). It is important to review the linear programming method to determine its suitability for system reconfiguration. The linear programming method is a mathematical optimization technique initiated by Danzig in 1947. The problem is formulated as

Minimize $Z = CX$

Subject to $AX = B$ $X > \mathbf{0}$

Where Z is the cost function (objective function) which needs to be minimized, X is a vector that represents the variables such as currents, voltages, switch status, etc. C is a transposed vector that represents the coefficients of the variables in the cost function. A is a coefficient matrix of the variables in the constraints equations and B is a vector representing the constraint limits. The linear programming method is only applied to the objective function with constraints all in the linear form. And when linear programming is applied to reconfigure the system, for the purpose of reducing the I2R losses, the objective function is no longer linear and linear programming is not valid unless a linearization technique is used. Even when a linearization technique is used, the calculation of the system losses is not accurate, and in order to increase the accuracy, a piece-wise linear approximation of the cost factor has to be applied.

2. Genetic Algorithms

Genetic algorithms have become very popular as a method of finding global optimums. As applied to reconfiguration, the switch states are encoded in strings of 0/1 "chromosomes", and a population of, for example, 50 topologies is built at random. At each iteration, two parent topologies are selected at random for crossbreeding which is a process of combining the chromosomes according to some defined algorithm. Then mutation, a random alteration of some chromosomes, may occur with a certain probability. If the resulting child is better, it replaces an existing topology in the population of 50. This process of crossbreeding continues for a number of iterations. The population also has to be re-seeded periodically with random strings to avoid in breeding. As the population evolves, there will always be a best solution that should steadily improve. Genetic algorithms are most attractive for parallel processing environments, and when each child can be evaluated quickly. The cross breeding and mutation algorithms must be custom designed and tested for each application. Parameters such as the number of crossbreeding per generation, mutation probability, number of generations, population size, and percentage of population reseeded must all be determined by testing. Applications to reconfiguration have used simplified network analysis because many thousands of topologies are considered, so the resulting solution may not be optimal with a more detailed model. The method presented in this dissertation uses more comprehensive analysis with less iteration.

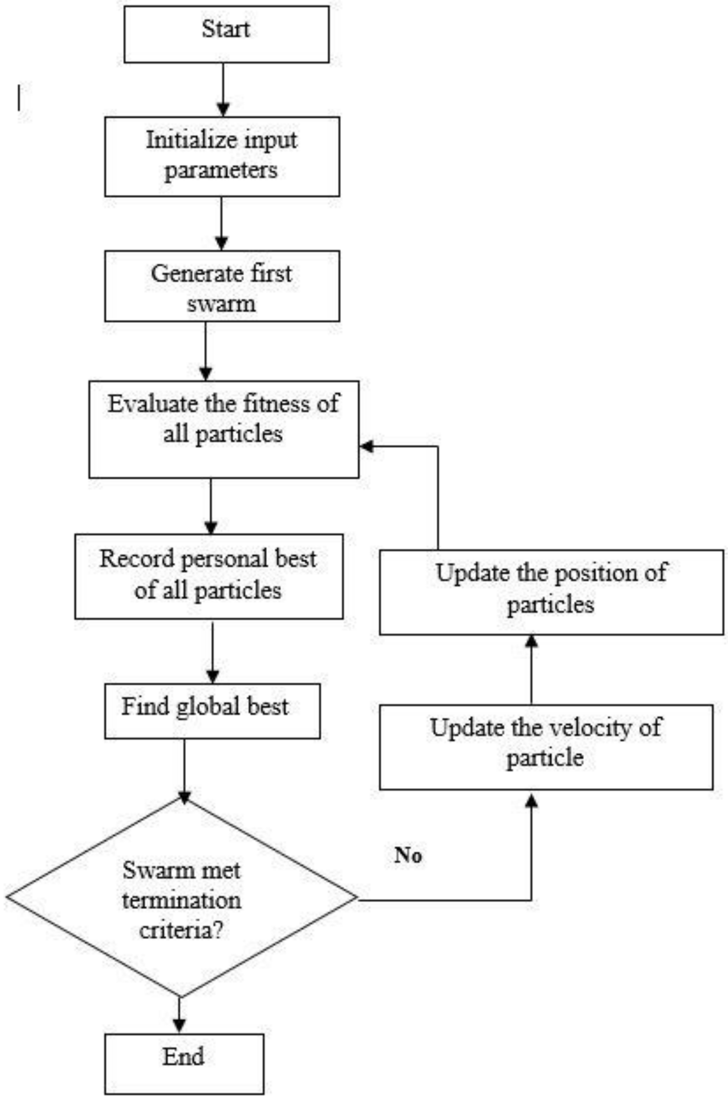
3. Harmony Search Algorithm

The harmony search algorithm (HSA) is a new meta-heuristic algorithm. The harmony search algorithm (HSA) is simple in concept, few in parameters and easy in implementation. The Harmony search algorithm is the concept of natural musical performance processes. The musicians starting with some harmonies, they attempt to achieve better harmonies by improvisation and create iteratively new best solutions based on past solutions on random modifications. Finally HSA gives optimum value. This algorithm was originally developed for discrete optimization and later expanded for continuous optimization. It has been successfully applied to various computational optimization problems such as structural design, water network design, dam scheduling, school bus routing, Sudoku game, musical composition, benchmark and real-world problems.

The HS algorithm initializes the Harmony Memory (HM) with randomly generated solutions. The number of solutions stored in the HM is defined by the Harmony Memory Size (HMS). Then iteratively a new solution is created as follows. Each decision variable is generated either on memory consideration and a possible additional modification, or on random selection. The parameters that are used in the generation process of a new solution are called Harmony Memory Considering Rate (HMCR) and Pitch Adjust Rate (PAR). After a new solution has been created, it is evaluated and compared to the worst solution in the HM. If its objective value is better than that of the worst solution, it replaces the worst solution in the HM. This process is repeated, until a termination criterion is fulfilled.

4. PARTICLE SWARM OPTIMIZATION ALGORITHM (PSO)

Flowchart for PSO Algorithm



Particle swarm optimization (PSO) is one of the bio-inspired algorithms and it is a simple one to search for an optimal solution in the solution space. It is different from other optimization algorithms in such a way that only the objective function is needed and it is not dependent on the gradient or any differential form of the objective. It also has very few hyper parameters.

Main design idea of the PSO algorithm is closely related to two researches: One is evolutionary algorithm, just like evolutionary algorithm; PSO also uses a swarm mode which makes it to simultaneously search large region in the solution space of the optimized objective function. The other is artificial life, namely it studies the artificial systems with life characteristics.

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

Step 2: Setup the set of parameters of PSO such as, number of particles N, weighting factors and C1, C2. 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 S and as for DG size is represented by pg. The proposed particles can be written as:

$$X_{particle} - \{S_1, S_2, \dots S_\beta, P_{g1}, P_{g2}, \dots P_{g\alpha}\}$$

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 the Newton - Raphsonmethod.

Step 4: Randomly generates an initial population (array) of particles with random positions and velocities on dimension in the solution space. Set 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, that particle is infeasible.

Step 6: Record and update the best values. 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 is recorded as P_{best}. Another best value to be recorded is ,which is the overall best value obtained so far by any particle. Pbest and Gbest are the generations of switches, Dg sizes and power loss. This step also updates

P_{best} and G_{best}. At first, we compare the fitness of each particle with its P_{best}. If the current solution is better than its , then replace Pbest by the current solution then, the fitness of all particles is compared with Gbest. If the fitness of any particle is better Than G_{best}, then replace G_{best}.

Step 7: Update the velocity and position of the particles. Eq.(5) is applied to update the velocity of the particles. The velocity of a particle represents a movement of the switches. Meanwhile, Eq.(6) is applied to update the position of the particles.

Step 8: End conditions. Check the end condition, if it is reached the algorithm stops; otherwise, repeat steps 3-7 until the end conditions are satisfied. In this work, we only determine the optimal size of DG while the location of DG is fixed. DG location in the network is fixed as a controlled measure in order to observe the responding changes of DG sizing. Furthermore, the DG location in practical is also depends on the suitability of the area

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VI. RESULTS

Table 1

Simulated Results of Standard IEEE 33 Bus System

Parameters	Base Case
Power loss in KW	202.6
Network Tie switch number	33, 34, 35, 36, 37
Minimum voltage	0.91306 pu@Bus No.18
Maximum voltage @Bus number	1 pu @Bus No.1

Table 1 shows the simulated results of Standard IEEE 33 Bus system. It is observed that the real power loss is 202.6 KW, minimum voltage is 0.91306 pu at Bus Number 18 and Maximumvoltage is 1 at Bus Number 1.

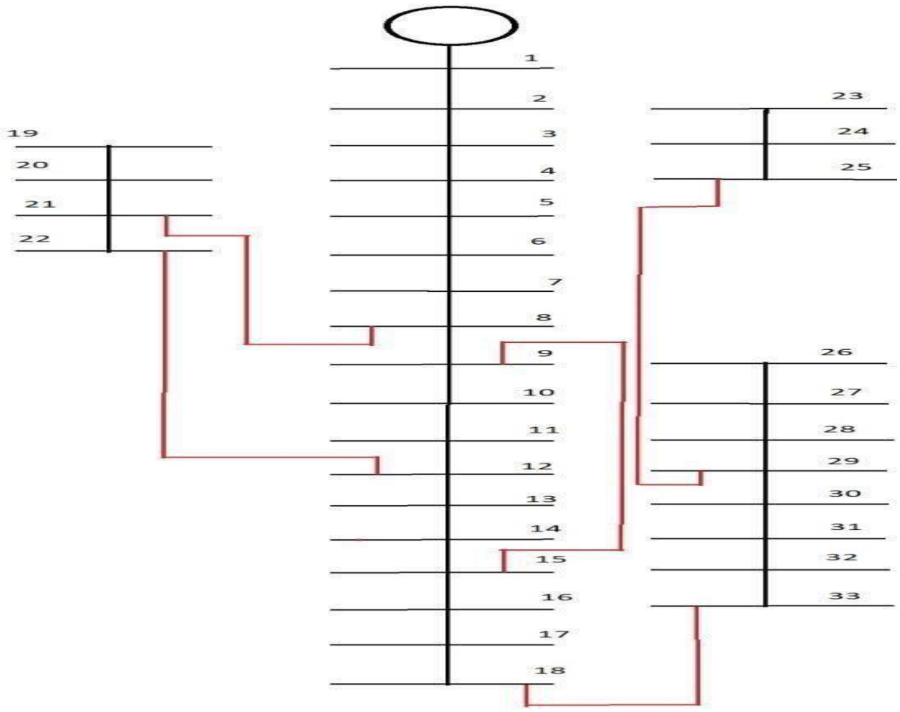

Figure 2 Single line diagram of standard IEEE 33 Bus System

Figure 2 shows the single line diagram of Standard IEEE 33 Bus system, it consists of 5 tie lines connected as shown in figure and the data is taken from Standard IEEE papers. A single- line diagram (also known as an SLD or one-line diagram) is a simplified representation of an electrical system. Symbols and lines are used to represent the nodes and connections in the system, and electrical characteristics may be included as well. In a data center, a single-line diagram is used to visualize the power distribution system to improve planning and troubleshooting, ensure redundancy, and reduce outages.

Table 2

Simulated Result of Standard IEEE 33Bus with DG Placement

Parameters	**DG Placement**
Power loss in KW	28.8091
Network Tie Switches number	33, 34, 35, 36, 37
Optimal DG Location	24 , 14 , 29
Optimal DG size in KW	542 529 874
Minimum voltage @Bus number	0.97302 pu @Bus No.33
Maximum voltage @Bus number	1 pu @Bus No.1

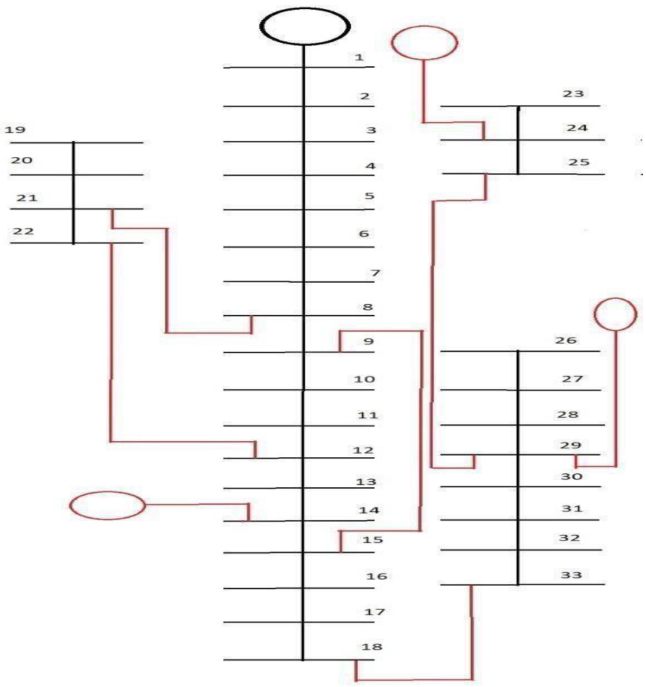

Figure 3 Single Line Diagram of Standard IEEE 33Bus with DG Placement

Figure 3 shows the single line diagram of Standard IEEE 33 Bus system with DG Placement, it consists of 5 tie lines connected as shown in figure. DG's are placed by optimizing the network and it is observed that there is reduction in loss after placing the DG's.

VII. CONCLUSION

The proposed work deals with power loss minimization as prime objective function. The results are verified in Matlab simulation using PSO algorithm. Hence Network Reconfiguration is used to reduces power loss and improve voltage profile in electrical distribution system.

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