



Optimal Placement and Sizing of Distributed Generators in 33 Bus and 69 Bus Radial Distribution System Using Genetic Algorithm

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Abstract: In the present scenario of high and increasing demands of load in the consumer side, the search for alternatives in the conventional generation and power system network is a must. Distributed generation is smart and efficient solution to meet the required demand. Distributed generators are beneficial in reducing the losses effectively compared to other methods of loss reduction. The challenge of identifying the optimal locations and sizes of distributed generation has great research interests nowadays. In order to minimize line losses of distribution system it is important to define the size and location of DG to be placed. With optimal size of DG unit at a suitable location results in reduction in power losses and improvement in voltage. This paper presents a powerful approach to find the optimal size and location of distributed generation units in a radial distribution system using Genetic Optimization algorithm (GA). The total active power losses are minimized and voltage profile is improved. GA fitness function is introduced including the active power losses, reactive power losses and the cumulative voltage deviation variables with selecting weight of each variable.

Keywords: Genetic Algorithm, Load flow.

I. INTRODUCTION

Distributed generators are small size generators, which can come from traditional or some revolutionary technologies such as fuel cells, micro-CHPs, PV panels. Distributed generation may play a very important role in transforming the electric power system infrastructure and existing market trend. The siting of distributed generator in distribution feeders is likely to have an impact on the operations and control of power system, a system designed to operate with large, central generating facilities. Distributed generator benefits are site specific. DG devices can be strategically placed in power systems for grid reinforcement, reducing power losses and on-peak operating costs, improving voltage profiles and load factors, differing or eliminating for system upgrades, and improving system integrity, reliability, and efficiency.

DG sources have attracted serious attention due to their potential solution for some issues, like the deregulation in power system, increasing the power consumption and the shortage of transmission capacities. Integration of DG with power networks (Grid) requires consideration of some issues in terms of numbers and the capacity of the DGs, the best location, the type of network connection, etc.

Here an attempt is made to calculate the DG capacity and its placement for the reduction of the total real power losses in the distribution system through a developed Genetic algorithm MATLAB environment.

II. GENETIC ALGORITHM

The GA was first introduced by John Holland in the early 1970s to simulate processes in natural systems necessary for evolution especially, they follow the principles, which were first introduced by Darwin. The GA is a search technique that is based on the hypothesis of natural selection. The basic principle is the maintenance of a population of solutions to a problem (genotypes) as encoded information on individuals that evolve in time. They combine the survival of the fittest among those feasible solutions in the form of string structures (or genes: in binary form) and a randomized formation exchange to form a search algorithm. Generally, GA comprises three different phases of search procedure and three operators:

- Phase 1: creating an initial population – The genetic search starts with a randomly generated initial population within which each individual is evaluated by means of a fitness function. Individuals in this and subsequent generations are duplicated or eliminated according to their fitness values.

- Phase 2: Evaluating a fitness function –. The solutions of fitness function are subjected to selection pressure based on relative fitness. Each candidate solution is composed of zeros and ones named a chromosome and the set of all chromosomes is created from the previous set.

- **Phase 3: Producing a new population** – In every generation, a new set of string solutions is created from the fittest of the old string solutions set.

After the creation of individuals, they will enter into evolution process. Survival of each individual is dependent on his strength. Strongest individuals will have more chance to live. Genes of strong individuals propagate throughout the population so that two good parents will sometimes have children with better performance than their parents. To achieve the above three GA operators, namely, reproduction, crossover and mutation are used. The new generation solution strings start the genetic operations again and again till the feasible solution is satisfied.

III. LOAD FLOW

Load flow analysis of distribution systems has not received much attention unlike load flow analysis of transmission systems. However, some work has been carried out on load flow analysis of a distribution network, but the choice of a solution method for practical systems is often difficult. In this approach, the voltage magnitude at the buses, real and reactive power flowing through lines, real and reactive losses in lines, and total losses in the system are calculated and it is assumed that the three phase radial distribution networks are balanced and can be represented by their equivalent single line diagrams.

For practical calculations, we have the following equations.

$$I_1 = \frac{|V_1|\angle\delta_1 - |V_2|\angle\delta_2}{R_1 + jX_1}$$

$$P_2 - jQ_2 = V_2 I_1^*$$

where

V_1 and δ_1 voltage magnitude and angle of node 1

V_2 and δ_2 voltage magnitude and angle of node 2

P_2 and Q_2 are total active and reactive power fed through node 2.

It means, the sum of real (reactive) power loads of all the nodes beyond node (2) plus real (reactive) power of node (2) itself plus the sum of real (reactive) power losses of all branches beyond node (2).

$$LP_j = \frac{R_j(P_{m2}^2 + Q_{m2}^2)}{|V_{m2}|^2}$$

$$LQ_j = \frac{X_j(P_{m2}^2 + Q_{m2}^2)}{|V_{m2}|^2}$$

Initially, if $LP(j)$ and $LQ(j)$ are set to zero for all j , then initial estimates of $P(m2)$ and $Q(m2)$ will be the sum of loads of all the nodes beyond node ($m2$) plus the load of the node ($m2$) itself. The convergence criteria of this method is that if, in successive iterations, the difference the real and reactive power delivered from the substation is less than 0.1 KW and 0.1 KVAR, the solution has converged.

IV. METHODOLOGY

- *For loss minimization*

The main goal of the proposed algorithm is to determine the best locations and sizing for new distributed generation resources by minimizing different function, related to project aims. A network with n nodes and m power lines is considered. The network is assumed to be radial, which implies that $n = m + 1$. In this work, we are following a goal for determining the formula that is used in point of start, power loss reduction. The loss minimum formulation is expressed as follows:

$$\min P_{loss} = \sum_{j=1}^{N_l} \Delta P_j = \sum_{j=1}^{N_l} |I_j|^2 \cdot R_j$$

Subject to

$$V_{i \min} \leq V_i \leq V_{i \max}$$

$$I_j \leq I_{j \max}$$

Where

N_l : total number of branches

I_j : max upper capacity bound of branch.

Equality constraint is the operating constraint, i.e., power flow equation. Inequality constraints are nodal voltage constraint and branch capacity constraint.

- *For optimum Sizing of DG*

DG are of various types depending upon how they deliver absorb active power, reactive power or both. Here for simplification of research we have assumed DG delivering active power only that is DG with unity power factor

$$P_{DGi} = \frac{\alpha_{ii}(P_{Di} + Q_{Di}) + \beta_{ii}(\alpha P_{Di} - Q_{Di}) - X_i - aY_i}{a^2\alpha_{ii} + \alpha_{ii}}$$

where

$$\alpha_{ij} = \frac{r_{ij}}{V_i V_j} \cos(\delta_i - \delta_j)$$

$$\beta_{ij} = \frac{r_{ij}}{V_i V_j} \sin(\delta_i - \delta_j)$$

V. RESULT AND DISCUSSION

For application of above algorithm two radial distribution bus system is considered as test subject. In this section, Genetic Algorithm been applied on IEEE 33-bus and IEEE 69-bus radial distribution system and the results are presented. In GA, the population size and crossover probability are chosen as 100 and 0.85 respectively. Table I and Table II shows the optimal capacity and placement of DG units in 33 and 69 radial bus respectively.

Table I Optimum Size and placement of DG in IEEE 33 bus system

BUS NUMBER	30	24	21
OPTIMUM CAPACITY(IN MW)	0.98	1.2	0.62

Table II Optimum Size and placement of DG in IEEE 69 bus system

BUS NUMBER	20	28	53
OPTIMUM CAPACITY(IN MW)	1.1	0.92	0.48

Figure 1: Fitness value of 69 Bus System

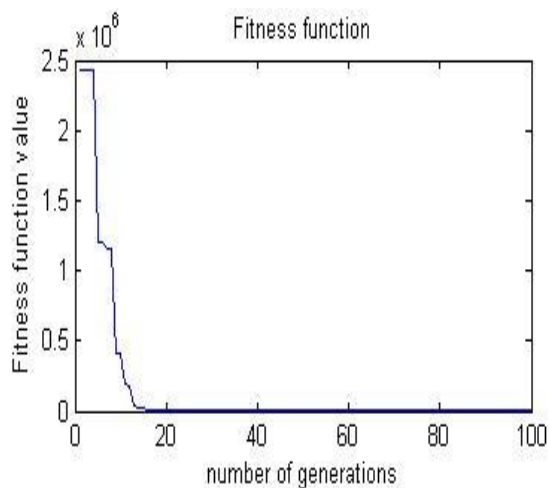
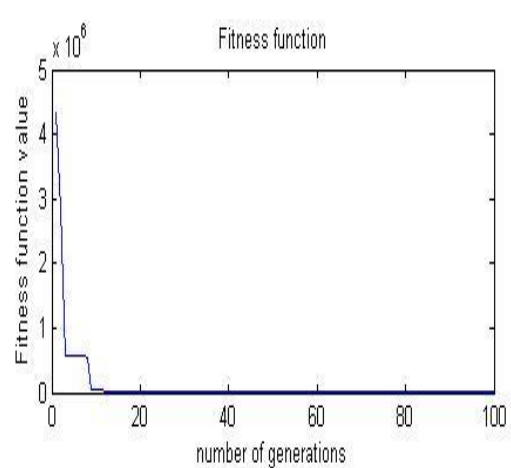


Figure 2: Fitness value of 33 Bus System



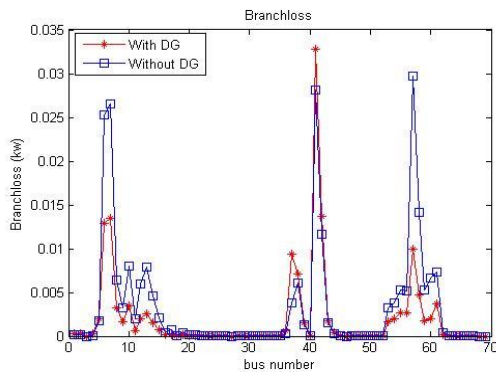


Figure 4: Voltage p.u of 33 Bus System

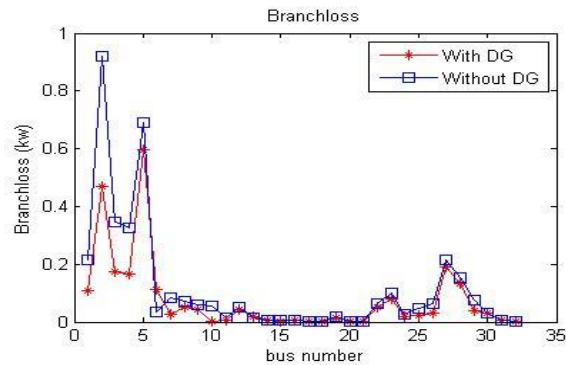


Figure 3: Voltage p.u of 69 Bus System

Figure 5: Branch loss of 69 Bus System

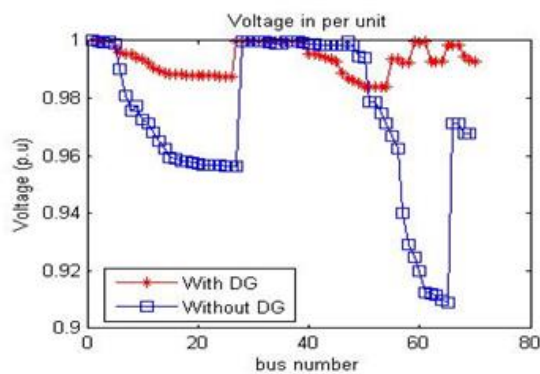
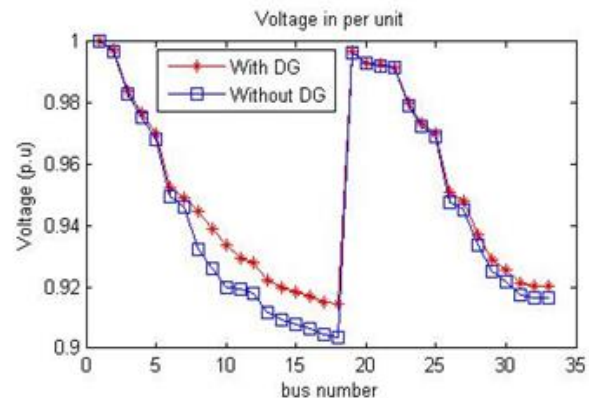


Figure 6: Branch loss of 33 Bus System



VI. CONCLUSION

This paper has proposed and successfully applied GA optimization method to determine optimal location and sizing for DG placement in 33-bus & 66-bus radial distribution systems for minimum value of objective function. By applying GA on objective function, branch power losses are reduced and optimum voltage profile is achieved. GA control parameters (i.e. population size and number of generation) play an important role in the performance of the GA and some permutations and combinations of these parameters can be tested to get the best performance.

VI. REFERENCES

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