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Optimal Size and Location of Distributed Generator in Radial Distribution Network by Using Genetic Algorithm

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***Abstract*:** *This paper proposes the implementation of genetic algorithm to detect the optimal size and optimum location for the placement of DG in the radial distribution networks. The placement of DG reduces power loss and improve in voltage profile in the network. The optimal location of DG is determined by using the loss sensitivity factor and voltage stability index. Power flow analysis is done by using the sweep algorithm method. The proposed optimization technique is examined on standard 69-bus test system and the obtained results are compared with the comprehensive load flows.*

Keywords- *Distributed generation (DG), Genetic algorithm, Loss sensitivity factor, Voltage stability index.*

I.INTRODUCTION

Recently, there is tremendous increment in the integration of distributed generation (DG) units at the distribution level. DG placement, reduces power loss in the system, enhance the power system stability and improve the power quality. In order to get more efficiency we should place the DG in suitable location with optimal size. The advantages of DG[1]depends on how these devices are placed in the distribution system based on the best location and optimal size. The capacity of DG plants ranging in from l0kW to 15MW.

Advantages of DG are as follows:

1) DG units are closer to consumers, Therefore Transmission and Distribution (T&D) costs are reduces.
2) It increases reliability of electrical system
3) Provision of ancillary services, including reactive power
4) DG plants have good efficiencies
5) It gives an emergency power supply.

Placing of DG influence the various parameters of power system. Those are consist of voltage profile, line losses, short circuit current, system reliability and stability. In order to install a DG units these parameters have to be appropriately investigated. Distribution generation has many types which includes wind turbines, photovoltaic cells, fuel cells, battery energy, storage systems, micro turbines, internal combustion engine, cogeneration system, biomass, micro turbines, small hydroelectric plants etc.

II LOAD FLOW ANALYSIS

Conventional Gauss Seidel (GS) and Newton Raphson methods may become inefficient in the analysis of distribution systems, because of its radial structure, high R/X ratio and unbalanced loads, etc. These features make the distribution systems load flow analysis different and difficult as compared to the transmission systems, that is why we are using different methods to analysis distribution systems. Here we are using backward and forward sweep method because of its low memory requirements, computational efficiency and robust convergence characteristic. In this study, backward and forward sweep method is used to find out the load flow solution. During backward sweep the branch currents are calculated and during forward sweep bus voltages are calculated[2].

Backward sweep: The distribution system having N number of nodes, the load current of each node is calculated as:

$$\overline{I_L}(m) = \left\{\frac{P_L(m) - jQ_L(m)}{\overline{V}(m)}\right\} \qquad [m=1,2,3……..N]$$

Where, PL (m) and QL (m) symbolize the total $\overline{I_L}, \overline{V}$power demand at node m and the phasor quantities, such as then, the current in each branch of the system is determined as:

$$\bar{I}(mn) = \bar{\bar{I}}_L(n) + \sum\nolimits_{m\in\tau} \bar{I}_L\,(m)$$

Where, the set τ exists of all nodes which are placed beyond the node n.

***Forward sweep*:** This case is used after the backward sweep so as to calculate the voltage at each node of a distribution system as follows:

$$\bar{V}(n) = \bar{V}(m) - \bar{I}(mn)Z(mn)$$

Where, nodes n and m represent the receiving and sending end nodes respectively for the branch mn and Z(mn) is the impedance of the branch.

Loss Sensitivity Factor

Sensitivity factor method is based on the principle of linearization of original nonlinear equation around the initial operating point, this helps to reduce the number of solution space.

Objective function for power loss minimization is mathematically formulated as follows[9].

$$\text{Minimize } \sum_{i=1}^{n}(P_{loss} + Q_{loss})$$

Total active power loss in radial distribution system is given by

$$P_{loss} = \min(\sum_{i=1}^{n} (Ii)2 * Ri)$$

Total reactive power loss in radial distribution system is given by

$$Q_{loss} = \min(\sum_{i=1}^{n} (Ii)2 * Xi)$$

Loss Sensitivity

The real power loss of the system is given below. This is popularly referred as “ EXACT LOSS” formula.

$$P_L = \sum_{i=1}^{N} \sum_{J=1}^{N} \alpha_{ij}^{(P_iP_j+Q_iQ_j)} + \beta_{ij}{}^{(Q_iP_j-P_iQ_j)}$$

$$\alpha_{ij} = \frac{r_{ij}}{V_iV_j} Cos(\delta_i - \delta_j) \qquad [MW]^{-1}$$

$$\beta_{ij} = \frac{r_{ij}}{V_iV_j} Sin(\delta_i - \delta_j) \qquad [MW]^{-1}$$

The sensitivity factor of real power loss with respect to real power injection from DG is given by

$$\frac{\partial P_L}{\partial Q_i} = 2\sum_{i=1}^{N}(\alpha_i Q_j + \beta_i P_j)$$

The sensitivity factor of real power loss with respect to real power injection from DG is given by Sensitivity factors are evaluated at each and every bus, firstly using the values obtained from the base case power flow. The buses are ranked in decreasing order of the values of their sensitivity factors to form a priority list. The top-ranked buses in the priority list are first to be studied alternatives location. This is generally done to take into account of the effect of non-linearity’s present in the system. The first order sensitivity factor are based on linearization of the original non-linear equations around the initial operating point and is biased towards function which has higher slope at the initial condition, that might not identify the global optimum solution. Therefore, priority list of candidate location is prerequisite to get the optimum solution.

Voltage Stability Index

A new steady state VSI is proposed for identifying the node, which is most sensitive to voltage collapse and is expressed in below equation

$$VSI(j) = |V_i|^4 \;\; 4\left[[P_iX_{ij} + Q_iR_{ij}]\right]^2 - \; 4\left[[P_iR_{ij} + Q_iX_{ij}]\right]|V_i|^2$$

Optimal Size of DG

To obtain the optimal size of DG, the following steps are taken as follows,

First, the DG is placed at the node with least value of VSI.

1.The size of DG is varied from a minimum value to a value equal to feeder loading capacity in constant steps until the minimum system losses is determined.

The DG size which results in minimum losses is taken as optimal size.

Proposed Methodology for Optimal Size

In this a new methodology is proposed to find the optimum size and location of DG in the distribution system. This methodology requires load flow to be carried out only two times, one for the base case and another at the end with DG included to obtain the final solution. As the total power loss against injected power is a parabolic function and at minimum losses the rate of change of losses with respect to injected power becomes zero[6].

$$\frac{\partial P_L}{\partial P_i} = 2\sum_{i=1}^{N}(\alpha_i P_j + \beta_i Q_j) = 0$$

the real power injection at node i, which is the difference between real power generation and the real power demand at that node.

$$P_i = P_{DGi} - P_{Di}$$

PDGi is the real power injection from DG placed at node i, and PDi is the load demand at node i. By combining above equation one can get following equation.

$$P_{DGi} = P_{Di} + \beta_{ij}Q_i + \sum_{i=1,j=1}^{N} (\alpha_{ij}P_j - \beta_{ij}Q_j)$$

The above equation gives the optimum size of DG for each bus i, for the loss to be minimum.

III GENETIC ALGORITHM

The steps for genetic algorithm are shown as follows;

1. Create an initial set of n candidate solutions
2. Evaluate each member of the population using some fitness function and find the best fitness functions among them these are the parents of next fitness function.
3. Generate a new population of offspring by using parent candidates. This can be performed by using one or more

evolutionary operators such as crossover and mutation[10].

(i) Crossover: crossover takes two parents, cuts them each into two or more pieces and recombines the pieces to create a new offspring.

(ii) Mutation: mutation copies an individual but with small, random modifications such as changing a bit from zero one or one to zero

The objective function for power loss minimization and voltage profile improvement is shown as follows[8].

Minf(x)={F1(x),F2(x)}

$$F1(x) = \min\left(\sum_{i=1}^{n} (Ii)2 * Ri\right)$$

$$F2(x) = VP = \sum_{i=1}^{n} Vi$$

$$\frac{\partial P_L}{\partial P_i} = 2\sum_{i=1}^{N}\left(\alpha_i P_j + \beta_i Q_j\right) = 0$$

Vi is the voltage magnitude at bus i in per-uniti, and N is the total number of buses in the distribution system.

IV SIMULATION RESULTS

The proposed method is illustrated with IEEE 69 bus radial distribution test system. Based on the proposed methodology, the optimal DG sizes for all the buses are found in termsof their optimal real power production.

The voltage profile before placing DG and after placing DG is shown in below figure. From the results it can be observed that the voltages obtained from after placing DG is greater than before placing DG and the active power losses reduced from 224.69 to 84.29 KW and the reactive power losses reduced from 100.48 to 39.72 KVAR by using LSF and the active power losses reduced from 224.69 to 187.39 KW and the reactive power losses reduced from 100.48 to 79.24KVAR by using VSI.

Table 1: Losses obtained for IEEE 69System by using LSF and VSI

DG Placement	LSF		VSI	
	P Loss(KW)	Q (Requirement)	P Loss(KW)	Q (Requirement)
Before DG	224.69	100.48	224.69	100.48
After DG	82.31	38.54	165.25	75.76

The graphical representation of voltages obtained for IEEE 69 bus Radial Distribution System before and after DG placement by using LSF and VSI is shown in Fig.2 and Fig.3.

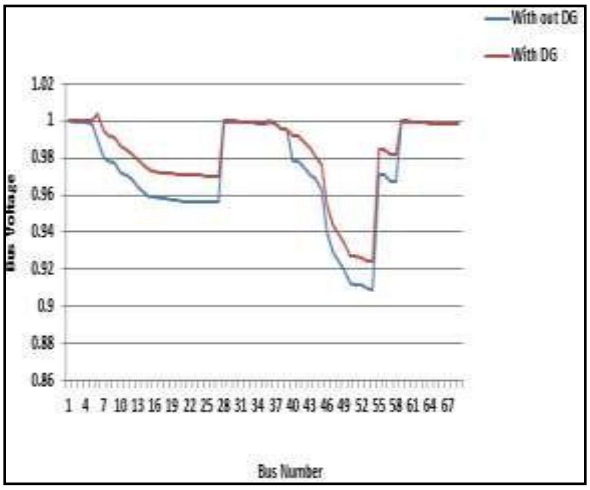
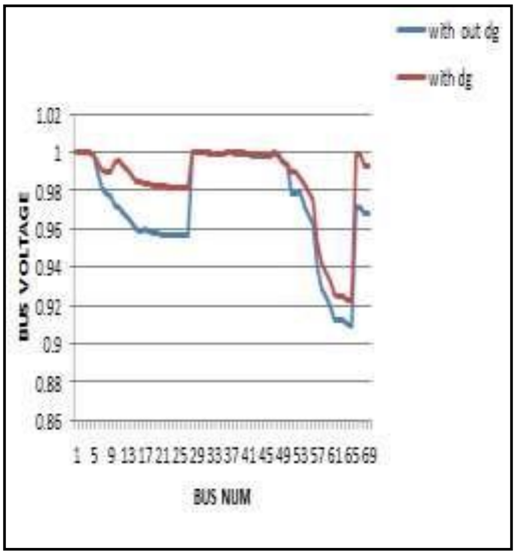


Fig.1. Bus Voltages by LSF before and After DG



Placement in the IEEE 69 Bus Systems

Fig.2. Bus Voltages by VSI before and After DG

Placement in the IEEE 69Bus Systems

In the second case we are doing proposed methodology is only for reactive power injection. Based on that the optimal DG sizes for all the buses are found in terms of their optimal reactive power production. The proposed algorithm is tested for solving IEEE 69 bus systems

The voltage profile before placing DG and after placing DG is shown in below figure. From theresults it can be observed that the voltages obtained from after placing DG is greater than before placing DG and the active power losses reduced from 224.69 to 154.72 KW and the reactive. power losses reduced from 100.48 to 70.22 KVAR by using LSF and the active power losses reduced from 224.69 to 208.65 KW and the reactive power losses reduced from 100.48 to 90.77 KVAR by using VSI

Table 2: Losses obtained for IEEE 69 Bus System by using LSF and VSI

DG Placement	LSF		VSI	
	P Loss(KW)	Q (Requirement)	P Loss(KW)	Q (Requirement)
Before DG	224.69	100.48	224.69	100.48
After DG	154.72	70.22	208.65	90.77

The graphical representation of voltages obtained for IEEE 69 bus Radial Distribution Systembefore and after DG placement by using LSF and VSI is shown in Fig.4. and Fig.5.

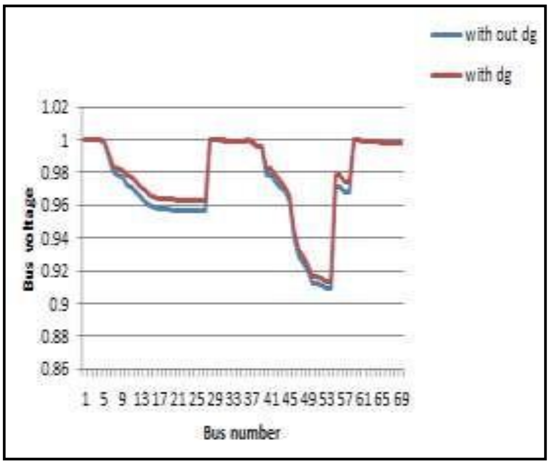


Fig.3.Bus Voltages by VSI before and After DG Placement in the IEEE 69 Bus Systems

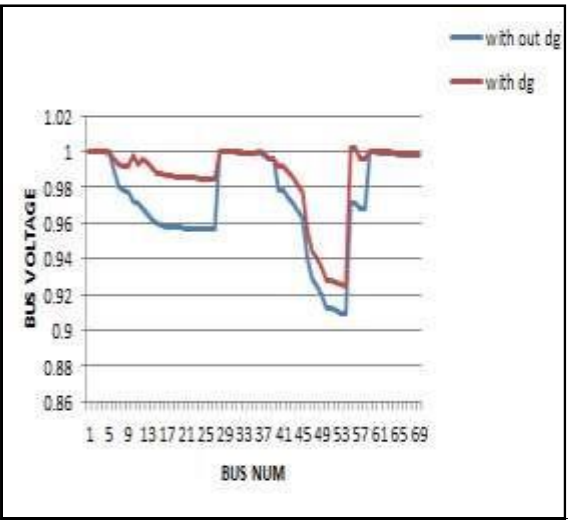
In the third case we are doing proposed methodology for both real and reactive power injection. Based on that, the optimal DG sizes for all the buses are found in terms of their optimal reactive power production and reactive power injection. The proposed algorithm is tested for solving IEEE 69 bus systems.

The voltage profile before placing DG and after placing DG is shown in below figure. From the results it can be observed that the voltages obtained from after placing DG is greater than before placing DG and the active power losses reduced from 224.69 to 39.98 KW and the reactive power losses reduced from 100.48 to 21.63 KVAR by using LSF and the active power losses reduced from 224.69 to 170.54KW and the reactive power losses reduced from 100.48 to 70.15 KVAR by using VSI.

Table 3: Losses obtained for IEEE 69 Bus System by using LSF and VSI

DG Placement	**LSF**		**VSI**	
	P Loss(KW)	**Q (Requirement)**	**P Loss (KW)**	**Q (Requirement)**
Before DG	**224.69**	**100.48**	**224.69**	**100.48**
After DG	**37.86**	**20.62**	**169.47**	**68.25**

The graphical representation of voltages obtained for IEEE 69 bus Radial Distribution System before and after DG placement by using LSF and VSI is shown in Fig.6. and Fig.7



Genetic algorithm results:

The real power losses are reduced after using the genetic algorithm is shown in below table in that we are having 3 cases. In case I before DG losses were taken and case II single DG is assumed, In case III two DG‟s are assumed.

Table 4: Voltage profile improvement

DG Placement	LSF	
	P Loss(KW)	Q (Requirement)
Before DG	224.69	100.48
One DG	84.29	39.72
Two DG‟S	74.5024	34.2510

Thus it can be seen that the proposedmethodology have greater improvement in voltage profile is shown in below figure.

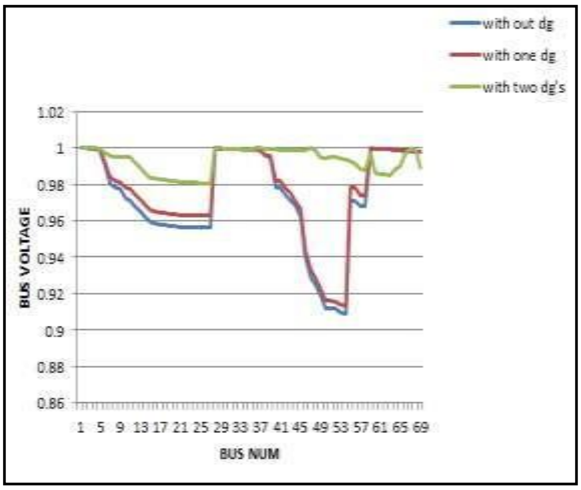


Fig.5. Voltage profile by placing 2 DG's in the IEEE 69 Bus Systems

V CONCLUSION

The results are given for IEEE 69 Bus System. As mentioned in the above table, the total real power loss is minimized by injecting DG 1.8 MW and 1MW at bus 60 and bus 67 respectively. Genetic Algorithm approach attempts to get new fitness function based on reproduction, crossover and mutation.

The genetic Algorithm is involved for reducing the losses in the 69 bus system. This genetic Algorithm is implemented for two DG‟s values in IEEE 69 Bus system. If the system requires more than two DG‟s then, the requirement of chromosomes should increase. The process should be continued until the achievement best fitness function. In this approach, the best fitness function is loss minimization of the power system.

VI REFERENCES

SD.MeeraShareef, T.Vinod Kumar "A Review on Models and Methods for Optimal Placement of Distributed Generation in Power Distribution System". IJEAR Vol. 4, Issue Spl-1, Jan - June 2014

Lingfeng Wang and Chanan Singh,"Reliability - Constrained Optimum Placement of Reclosers and Distributed Generators in Distribution Networks Using an Ant Colony System Algorithm"IEEE Transactions On Systems Vol. 38, No. 6, November 2008

[1] GopiyaNaik S, D. K. Khatod and M. P. Sharma "Optimal Allocation of Distributed Generation © (2012) IACSIT Press, Singapore

[2] N. Prema Kumar, K.M. Rosalina "optimal citing of distribution generation units in Distribution networks based on load centroid method" International Journal of Electrical, Electronics and Data Communication, ISSN: 2320-2084 Volume-1, Issue-10, Dec-2013 [5]Dheeraj K. Khatod, Member, IEEE, Vinay Pant, and Jaydev Sharma "Evolutionary Programming Based Optimal Placement of Renewable Distributed Generators" IEEE Transactions On Power Systems, Vol. 28, No. 2, May 2013.

[6] K. Sathish Kumar, T. Jayabarathi, S. PrabhakarKarthikeyan, I. Jacob Raglend, "Load Flow Solution in Distribution Systems using Modified Forward Substitution Method"IJCSNS International Journal of Computer Science and Network Security, VOL.10 No.2, February 2010.

[7] Puthireddy, Umapathi Reddy, SirigiriSivanagaraju, Prabandhamkam, Sangameswararaju, "power flow analysis of three phase unbalanced radial distribution system" International Journal of Advances in Engineering & Technology, March 2012.

[8] Mojtaba Nouri, Mahdi BayatMokhtari, Sohrab Mirsaeidi , Mohammad Reza Miveh "improvement of loadability in Distribution system using genetic Algorithm" Advanced Computing: An International Journal (ACIJ), Vol.3, No.3, May 2012.

[9] M.Jegadeesan ,V.Keerthana "Optimal Sizing and Placement of Distributed Generation in Radial Distribution Feeder Using Analytical Approach" International Journal of Innovative Research in Science, Engineering and Technology Volume 3, Special Issue 3, March 2014.

[10] RashmiPriya, Surya Prakash "Optimal Location and Sizing of Generator in Distributed Generation System" International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering, Vol. 2, Issue 3, March 2014.