Proc. of Int. Conf. on Emerging Trends in Engineering & Technology, IETET

Sensitivity Analysis and Optimization of DG Capacity for Power Quality Improvement by using GA

Er.Sanjeev Kumar[1], Er.Kusum[2] and Ankush Gupta[3]
[1]YIET/EED, Yamunanagar, India
Email: sanjeevchoudhary38@gmail.com
[2] MMU/CSE, Ambala , India
[3] M.tech Scholar YIET/EED, Yamunanagar, India
Email: {kusumchaudhary1@gmail.com, ankush03gupta@gmail.com }

***Abstract*—The deregulated electrical utilities have created a challenge and an opportunity for developing various novel technologies. Integration of DG into an existing utility can result in several benefits. These benefits include line loss reduction, reduced environmental impacts, increased overall energy efficiency, relieved transmission and distribution congestion, voltage support and deferred investments to upgrade existing generation, transmission and distribution systems. The proposed work discusses the primary factors leading to increasing interest in Distributed Generation that can reduce line losses, improve voltage profile by Genetic algorithm (GA) and using sensitivity analysis. The benefits of employing DG are analyzed using voltage profile improvement and line losses reduction. The analysis is tested on a standard IEEE-9 bus system and the results are found to be encouraging. This proposed work has considered the benefit of DG on loss reduction for a simple case of a radial distribution line with one concentrated load at the end and DGs placed at different locations. The influences of varying DG location and varying DG power output are considered in this section. With the introduction of DG, line loss reduction can be expected. This factor is analyzed, quantified and presented in this proposed work for different locations of the DG along the feeder and for different DG power outputs.**

***Index Terms*— Genetic Algorithm, Distributed Generators, Radial distribution feeder, Sensitivity analysis.**

I. INTRODUCTION

The term “Distributed Generation” or DG refers to the integrated or stand-alone use of small, modular electric generation close to the point of consumption. It differs fundamentally from the traditional model of central generation and delivery in that it can be located near end-users within an industrial area, inside a building, or in a community. DG may play an increasingly important role in the electric power system infrastructure and market. DG may play an increasingly important role in the electric power system infrastructure and market. The sitting 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 Ref.[1]. DG means small scale generation of electric power by a unit, site close to the load being served. DG technologies range in size from 5kW to 30MW and include both fully commercial systems such as reciprocating engines and others that are primarily in the laboratory such as fuel cells

Grenze ID: 02.IETET.2016.5.28

Ref.[2].The technical merits of DG implementation include voltage support, energy-loss reduction, release of system capacity, and improve utility system reliability. Economical merit is the encompass hedge against high electricity price. By supplying loads during peak load periods, where the cost of electricity is high, DG can best serve as a price hedging mechanism Ref.[3].Several optimization techniques have been applied to DG placement and sizing such as genetic algorithm, tabu search, heuristic algorithms and analytical based method. The 9 bus test feeder is selected to test proposed method Ref[4].

II. Power System Modelling and Problem Formulation

The main goal of the proposed algorithm is to determine the best location and size for new distributed generation resources by minimizing different function related to project aims.

Objective function:

A precise evaluation for the objective function has been selected. The main goal of the proposed algorithm is to determine the best location and size for new DG resources by minimizing different function. Two main goals are taken into considerations to determine the objective formula that is used in point of start: power losses reduction and voltage profile improvement. The objective function and the fitness function F(x) is calculated as given below:

$$F_{(X)} = W_P \times P_L + W_q \times Q_l$$

Where:

P_L : Active Power Loss

Q_L : Reactive Power Loss

F : Fitness Function.

The active and reactive power losses are obtained from load flow program. The load flow solution, evaluation of objective function and fitness function is repeated for all the strings in the population. The procedure to determine the fitness function 'F(x)' is very much application oriented. It is directly associated with the objective function value in the optimization problem.

W_p and W_q : The Objective Function weights (Active and Reactive power losses), subjected to:

$$W_p + W_q = 1$$

Constraints

The main constraints in the optimization process in the proposed methodology are:

- Bus voltage limits

  The bus voltage magnitudes are to be kept within acceptable operating limits throughout the optimization process.

  $$V_{I\,\min} \le |V_I| \le V_{I\,\max}$$

  V_{min} = minimum bus voltage

  V_{max} = maximum bus voltage
- Number and sizes of DGs.

There are constraints associated with the DGs themselves. DGs that are commercially available come in discrete sizes. The total active power injection is not to exceed the total active power demand in radial distribution system.

III. Genetic Algorithm

The developed algorithm for identifying the sizing and location is based on Genetic Algorithm. The development of algorithm is explained with a review on GA. A GA is an iterative procedure which begins with a randomly generated set of solutions referred as initial population. For each solution in set, objective function and fitness are calculated. On the basis of these fitness functions, pool of selected population is formed by selection operators; the solution in this pool has better average fitness then that of initial population. The crossover and mutation operator are used generate new solutions with the help of solution in the pool. The process is repeated iteratively while maintain fixed number of solutions in pool of selected population, as the iteration progress, the solution improves and optimal solution is obtained. During the selection process of the GA, good solutions are selected from the initial generated population for producing offspring. Good solutions are selected randomly from the initial generated population using a mechanism which favours the more fit individuals. Good individuals will probably be selected several times in a generation but poor solutions may not be selected at all. The second GA operator is crossover. Crossover takes place when proper encoding method has been decided. Ref[5]Crossover operates on selected genes from parent chromosomes and creates new offspring. The simplest way how to do that is to choose randomly some crossover point and copy everything before this point from the first parent and then copy everything after the crossover point from the other parent Ref[6].

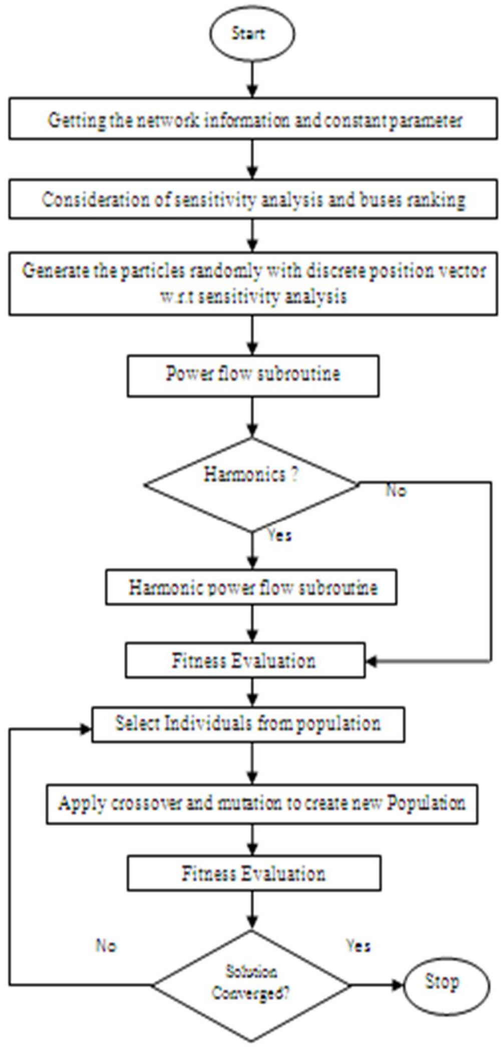

Fig 1: Genetic algorithm based Distributed Generation

The Fig1 shows the process of the simulation that is described above in the form of flowchart based on Sensitivity analysis and Genetic algorithm (GA).The algorithm is tested on a Nine-bus radial distribution system is shown in Fig 3.

IV. Sensitivity Analysis

To identify the location for Distribution Generator in distribution system Sensitivity Factors have been used. One of techniques that is used in the proposed work, is the maximum sensitivity analysis in order to candidate some buses for DG placement. The advantages of this method is reducing the research space and increasing the speed of Genetic algorithm convergence. The estimation of these candidate buses basically helps in reduction of the search space for the optimization problem.

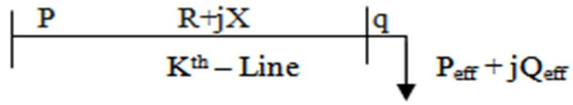

Fig 2: Connected line between p bus and q bus

Consider a distribution line with an impedance R + jX and a load of $P_{eff} + jQ_{eff}$ connected between ‘p’ and ‘q’ buses as given below in Fig 2. According to Figure, supposing a line with impedance of (R + jX) ohm between bus p and bus q, together with load of $P_{eff} + jQ_{eff}$. The active power loss in k^{th} line is shown below:

$$P_{Line-Loss} = [I_K^2] \times R[K] \tag{1}$$

$$I_K = \frac{(p_{eff}[q] + jQ_{eff}[q])*}{(V[q])*} = \frac{P_{eff}[q] - JQ_{eff}[q]}{V[q]*} \tag{2}$$

When substituting equation (2) in (1)

$$P_{Line-Loss}[q] = \frac{(P_{eff^2}[q] + Q_{eff^2}[q])R[K]}{(V[q])^2} \tag{3}$$

So, the sensitivity analysis factor is derived by derivative of $P_{Line\text{-}loss}$ by P_{eff}, as equation (4):

$$\frac{P_{Line-Loss}}{\partial P_{eff}} = \frac{(2 \times P_{eff}[q] \times R[k])}{(V[q])^2} \tag{4}$$

According to equation (4), buses will be ranked and some buses are candidate as the ones which have the most sensitivity for DG placement in order to have the best effect on loss reduction. Only those buses where the normalized voltage magnitude healthy (ie. v[i]/0.95) is less than 1.01 are considered as the candidate buses where the DG placement needs to be done. If the voltage at a bus in the sequence list is such that then bus needs no compensation.

V. Process of Simulation

The process of the simulation that is described above in the form of distribution feeder is based on Sensitivity analysis and Genetic algorithm. The algorithm is tested on a 9-bus radial distribution system is shown in fig 3.

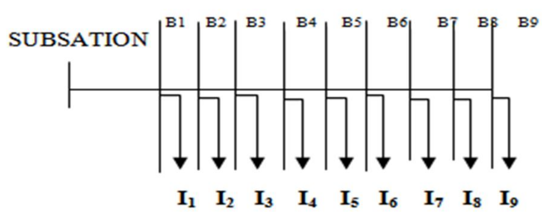

Fig 3: Single line diagram of 9 bus distribution feeder

TABLE I. The 9 Bus IEEE Neiwork Line Data

Sending End Voltage	Receving End Voltage	R (ohms)	X(ohms)
0	1	0.1233	0.4127
1	2	0.0140	0.6050
2	3	0.7463	1.2050
3	4	0.6984	0.6984
4	5	1.9831	1.7276
5	6	0.9053	0.7886
6	7	2.0552	1.1640
7	8	4.7953	2.7160
8	9	5.3434	3.0264

TABLE II. THE 9 BUS IEEE NETWORK BUSES DATA

Bus Number	Active power In KW	Reactive power In KVAR
1	1840	460
2	980	340
3	1790	446
4	1598	1840
5	1610	600
6	780	110
7	1150	60
8	980	130
9	1640	200

VI. RESULT AND DISCUSSION

The algorithm has been developed in MATLAB environment that provides Simulink tool. The detailed procedure for development of Simulink model of a system prototype, its simulation and visualization of results has been explained in this paper. Loss Sensitivity Factor and optimization process by using Genetic algorithm is also discussed in this; it has been used to find out the potential buses for Distributed Generation placement and power quality improvement.

TABLE III: PARAMETER USED IN GA METHOD(IEEE-9 BUS SYSTEM

Parameter	Value
population Size	20
Number of iteration	100
Weight Factor	W_p=0.35 and W_q=0.65

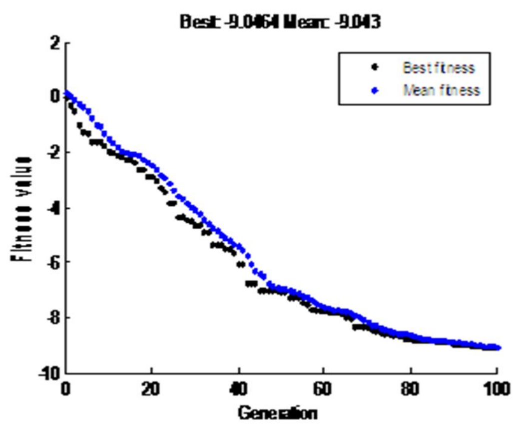

Fig 4: Best fitness and Mean Fitness

Above fig 4 indicates best fitness and mean fitness of the proposed GA based solution methodology in finding the global optimal solution of the DG allocation and sizing problem. Black line indicates the best fitness and blue line indicate mean fitness.

Results of Sensitivity Analysis:

The advantages of sensitivity analysis as mentioned is reducing the search space of GA and consequently increasing the speed of simulation. Without this analysis, it's necessary to import all of the buses in GA algorithm to find the best placement of DGs. The below table giving the buses of 8,2,1,3,9,5,7,6,and 4 to GA algorithm is sufficient to calculate the best placement and sizing among them The result of executing sensitivity analysis is shown in Table 4.

TABLE IV: RESULTS OF SENSITIVITY ANALYSIS

Bus Number	Sensitivity Analysis
8	307×10^{5}
2	2.885×10^{5}
1	4.905×10^{4}
3	2.247×10^{4}
9	1.133×10^{5}
5	5582
7	221.3
6	277.9
4	4.581×10^{4}

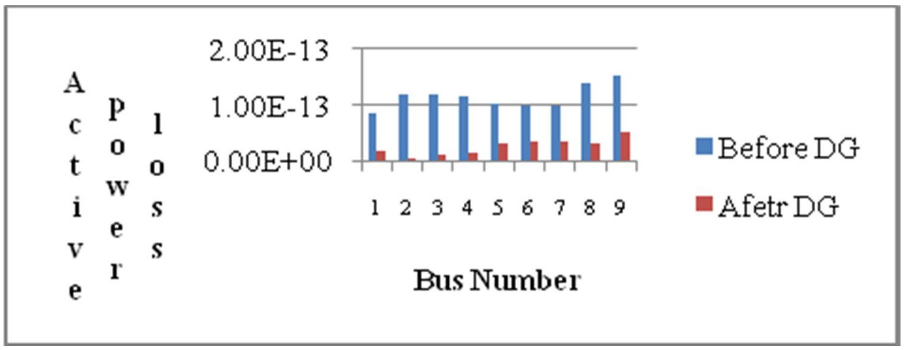

Fig 5: Active power loss before and after DG installation

Results of Voltage Profile Improvements:

The distribution generation results in improved voltage profile at various buses of the power system and to maintain the voltage at the customer site within the operating range. As the current flow through distribution line, voltage drop occurs at the customer terminals. Adopting DG into the existing power system can provide a portion of the real and reactive power to the load this help in decreasing the current along the portion of distribution line. Hence system voltage profile can be improved. The results show in the table 5 by using before DG and after DG.

TABLE V: RESULTS OF VOLTAGE PROFILE IMPROVEMENT

Bus Number	Before DG	After DG
1	1.923×10^{16}	8.74×10^{21}
2	7.061×10^{13}	6.855×10^{21}
3	2.86×10^{13}	5.083×10^{21}
4	2.029×10^{10}	1.027×10^{15}
5	5.69×10^{9}	1.027×10^{15}
6	2.835×10^{9}	7.67×10^{13}
7	3.99×10^{8}	4.846×10^{13}
8	3.79×10^{8}	2.835×10^{9}
9	2.21×10^{8}	1.745×10^{8}

VII. CONCLUSION

In this paper, the GA was tested on a 9- bus test system to find the optimal locations and sizes of DGs in radial distribution system. The above problem has been solved by two step methodologies; the candidate locations for compensation are found using loss sensitivity factor. The sizing has been attempted using Genetic Algorithm. In GA, coding scheme is developed to carry out the allocation problem, which is identification of location and size by one dimensional array. The objective is to minimize the real power loss, improve the voltage profile.

From the study, the following conclusions are drawn.

- The compensation is yielding into increase in voltage profile, reduction in losses.
- The developed algorithm is effective in deciding the allocation of DG for different number of candidate buses.

Sensitivity Factor method has been used to identify the potential buses for DG placement. The buses have been ordered according to decreasing Loss Sensitive Factor.

REFERENCES

[1] T. Ackermann, G. Andersson, and L. Sder, et al. "Distributed generation: a definition," Electric, Power Systems Research, vol. 57, no. 3, pp. 195–204, 2001.

[2] "Distributed Generation", U.S. Department of Energy, Federal Energy Technology Center.

[3] "Distributed Generation: Understanding the Economics", Arthur D. Little White Paper, 1999.

[4] A . Parizad, A. Khazali and M. Kalantar, et al. "Optimal Placement of Distributed Generation with Sensitivity Factors Considering Voltage Stability and Losses Indices", in Proc. IEEE of ICEE 2010, May 11-13, 2010, pp.1-8.

[5] Jen-Hao Teng and Chuo-Yean Chang, et al. "Backward/Forward Sweep-Based Harmonic Analysis Method for Distribution Systems", IEEE Transactions on Power Delivery, Vol. 22, No. 3, July .

[6] Akash T. Davda, Bhupendra. R. Parekh and Manhar D. Desai, et al. "Reduction of Losses and Improvement in Voltage Profile for a 2.8 MVA Distribution Network with Dispersed Generation", 978-1-4673-2868-5/12/$3l.00 ©2012 IEEE.

[7] Ashwani Kumar and Wenzhong Gao, et al. "Voltage Profile Improvement and Line Loss Reduction with Distributed Generation in Deregulated Electricity Markets", IEEE.