Optimal Placement of DG and Capacitor for Minimizing the Power Losses using Genetic Algorithm

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Abstract – *This paper represents an effective method for optimal placement of DG and capacitor in distribution system. The main objective is to reduce the power losses in the system by placing capacitor and DG of optimal size and at optimal location. Distribution system connects the high voltage transmission system and low voltage side, hence it is necessary to keep the system at minimum losses for making our system healthy. Placement of capacitor improves the voltage profile and reduces the power losses and energy losses in power system. capacitor placement works for reactive power compensation. This paper contains the resulting graphs for capacitor and generator placements in the test system, the graphs will show the comparative results of power losses. Newton-Raphson method under load flow study is used to find out the active and reactive losses in the system and genetic algorithm is used to verify the results also by using genetic algorithm toolbox in MATLAB software we get the size and location of capacitor and DG in test system. Genetic algorithm is an optimization technique used here to find the effective , efficient and best location and size for the capacitor and DG placed in system. Hence the main aim is to find out the optimal location and size of capacitor and DG by using genetic algorithm. IEEE-33 bus test system is used to verify the efficiency of genetic algorithm.*

Key words: *DG placement, Capacitor placement, genetic algorithm, distribution generation, power system, load flow.*

1. INTRODUCTION

Distribution generation are the units placed near the load it serves. These are basically small scale generators that produces several KW to tens of MW of power. They may or may not be connected to the grid. DG units use many types of generation techniques for example biomass, gas turbine, wind turbine, solar voltaic and diesel engines. DG is also known as embedded generation, on site generation, decentralized generation. DG collects energy from different other sources and hence improves security of supply, also the connection of DG to network increases the stability of power system [1]. Many approaches have been proposed to solve DG sizing and placement in distribution system. Sree L. payyala presents a methodology for presenting a mixed Techno-Economic assessment of biomass based generators. The main aim of this paper was to find out the optimal plant size and location that satisfies both economic and technical terms [2]. Prakornchai Phonrattanasak presents a paper for finding out the perfect sizing and location of DG in power system having minimum cost in test system. Here it uses multi objective particle swarm technique to find minimum economic cost and emission when the DG have variable sizing and location. The result of this paper gives best position of DG in test system having minimum economic cost [3]. M. Gandomkar, M.Vakilian, M.Ehsan presents a paper by using Hereford Ranch algorithm for finding the optimal position and size of DG in distribution radial feeders [4].

Many techniques are used to determine the optimum position and size od DGs. The two-third rule is commonly used in the placement of capacitors in distribution system, have been presented in [5]. Vivek Kumar Shrivastava presents a paper in which classical grid search algorithm that is based on successive load flows is used to obtain optimal location and size of multiple DGs in radial network. It is used to minimize total active power losses and also improves the system's voltage profile [6]. R. M. kamel and B. Kermanshahi presents the paper in which modified economic dispatch method is used [7].

In this paper the capacitor and DG are optimally placed in IEEE-33 bus test system. Genetic algorithm is used to find out the size and location for optimal placement of DG in test system. By placing the DG optically we can effectively reduces the power losses in the system.

This paper contains some sections which are as follows- section 2 contains distribution generation, section 3 contains genetic algorithm, section 4 contains problem formulation, section 5 contains results and then conclusions.

2. DISTRIBUTION GENERATION

In simple words we can say that DG is a term that indicates a technology which is placed near a utility's service area and hence enhance the quality of service. Currently many definations are used for distribution generation, some of them are-[8]

1. According to Cardwell, distributed generation is a generation between 500KW to 1MW.
2. Gas Research Institute presents that distributed generation is in between 25KW to 25MW.
3. Rastler and Preston said that the DG size is in between few KW to 100 MW.
4. Also the Electric Power Research Institute explains that the DG generation ranges from a few KW to 50MW.

The important reasons for effective increase in the use of Distribution Generation are-[9]

1. Since DG units are placed near the consumer sites hence the cost related to transmission and distribution get reduced.
2. Now it is more easier to find the economic and effective places for small scale generators.
3. DG plants have less installation times and also the investment risk levels are low.
4. Dg can work on renewable sources also which reduces the pollution and are cost effective too.
5. DGs have range from 10KW to 15MW.

The purpose of DG is to fulfill the increasing demand for electricity in particular areas and perform some activities self-sufficient in case of power production and hence gaining energy savings [10].

3. GENETIC ALGORITHM

Genetic algorithm is used as an optimization technique which is a population based search technique. It follows the saying of Darwin that is 'survival of the fittest' hence it works on the theory that says select the best and remove the rest. Genetic algorithm was first introduced by John Holland of Michigan University in 1970's. Genetic algorithm are the procedures depend upon natural selection and genetics. It is an iterative process which continues a constant size population of candidate solutions. Each iteration process have three genetic operators that are-

1. Reproduction
2. Crossover
3. Mutation

These three operators perform to produce a new population also the chromosome of new population are generated by the value of the fitness which is related to cost function. According to Darwin's theory only the fittest and most suited elements of population can survive and produce offspring and hence transfer their biological heredity to upcoming new generations. By the use of these three genetic operators and evaluations, improved new populations of candidate solution are obtained. If the aim of search is not achieved then again the GA generates new offspring by using these three operators and this process is continued till the search aim is not achieved. They generate a new set of individuals, a population therefore new offspring are generated from parents. The heredity is stored in the chromosome of individuals shown in an optimization problem by a particular numeric code. The effectiveness of each member according to the optimization problem considered is calculated by using a fitness value which is derived from the objective function directly.

Steps for genetic algorithm:-

1. Start: create random population of m chromosomes.
2. Fitness: Find the fitness of each chromosome in the population.
3. New population:
   (a) Selection-it is based on the fitness function.
   (b) Recombination-cross-over chromosomes
   (c) Mutation-mutate chromosomes
4. Acceptation: accept or reject the new one
5. Replacing the old: replace the old population by new.
6. Test: test for problem standard
7. Loop: carry on with step 2-5 until the standard is fulfilled.

4. PROBLEM FORMULATION

The main problem in power system is power loss. There are many techniques used to reduce this power loss in the system. Newton-Raphson method under load flow analysis is used to find the size and location of capacitor in DG and then calculate the power losses. Also for finding the size and location of DG and capacitor genetic algorithm is applied.

4.1 Power flow equations

For distributed system power flow equations are as follows-[11]

Objective function

Minimization = $\sum_K^M P_{LOSS},K$

P_K =Real power flowing out of bus k

Q_k = reactive power flowing out of bus k.

P_k'=real power flowing out of bus k after rearrangement.

Q_k'= reactive power flowing out of bus k after rearrangement.

P_{LK+1}= real power flowing out of bus K+1

Q_{LK+1}= reactive power flowing out of bus K+1.

Loss= total power loss of the feeder or system

V_k= voltage at bus k.

$P_{K+1}=P_k-P_{loss,k}-P_{LK+1}$ (1)

$P_k-\frac{R_k}{V_k^2}\{P_k^2+(Q_k+Y_{k1}|V_k|^2)^2\}-P_{LK+1}$

$Q_{k+1}=Q_k-Q_{loss,k}-Q_{LK+1}$ (2)

$Q_k-\frac{X_k}{|V|_k^2}\{P_k^2+(Q_k+Y_{k1}|V_k|^2)^2\}-Y_{k1}|V_k|^2-Y_{k2}|V_k|^2-Q_{LK+1}$

$|V_{K+1}|^2=|V_k|^2+\frac{R_k^2+X_k^2}{|V|_k^2}(P_k^2+Q_k^2)-2(R_kP_k+X_kQ_k)$

$|V_k|^2+\frac{R_k^2+X_k^2}{|V|_k^2}(P_k^2+(Q_k+Y_k|V_k|^2)^2)-2(R_kP_k+X_kQ_kY_kV_k)^2$

(3)

Power loss in line connecting K and K+1 can be find out as-

$P_{loss(k,k+1)}=R_k(\frac{P_k^2+Q_k^2}{|V|_k^2})$ (4)

Power loss equation:

$P_{T,loss}=\sum_{k=1}^{m} P_{loss\,(k,k+1)}$

5. RESULTS

Finally the power losses get reduced by placement of capacitor and DG effectively and optimally in IEEE-30 bus test system. After the placement of capacitor there is some considerable improvement in the voltage profile. Here in this paper the results are obtained by using 30 population size and 51 iterations in genetic algorithm toolbox in MATLAB software. By the placement of capacitor in test system power factor improves and reactive power get compensated. Therefore power losses get reduced. The data for this research paper is obtained from load flow programme on MATLAB software are performed on a laptop with processor AMD A4-3330MX APU with radeon™HD graphics 2.20 GHz and RAM of 2.00 GB.

Table-1: capacitor location, capacitor value, DG location, DG value and losses

S.no	Capacitor location	DG location	Capacitor value(MVAr)	DG value	Losses(MW)
1	No capacitor	-	-	-	0.2050
2	30th bus	-	1.49	-	0.1510
3	30th bus	30th bus	1.49	1.271	0.0924

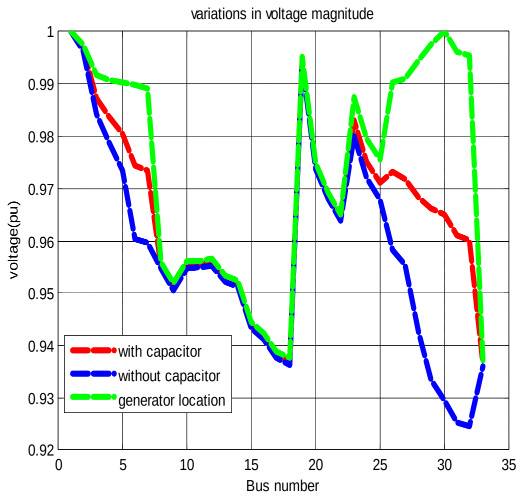
Table 1 displays the losses coming after or before placing the capacitor and DG in IEEE-33 bus test system.

According to tabular results-

When the capacitor is not placed in the test systems the losses are highest ie 0.2050MW. this result is obtained in GA toolbox in MATLAB by performing 51 iteration with a population size of 30.calculated elapsed time for this procedure is 77.0982 seconds in without capacitor placement case and 79.9321 seconds in with capacitor placement case. Finally got the capacitor location at bus number 30 of size 1.49 MVar where minimum power loss is 0.1510 MW. Hence the power loss get reduced by placing a capacitor of 1.49 Mvar at 30th bus on IEEE-33 bus test system.

Secondly we placed a DG on 30th bus. The location and size of DG is calculated through GA toolbox MATLAB software. Hence at 30th bus DG of value 1.271 MW is placed and now the losses get reduced to 0.0924 MW. Therefore the minimum power loss is obtained by placing a DG of size 1.271 MW and a capacitor of size 1.49 MVar at bus no. 30 in IEEE-33 bus test system.

The elapsed time for calculation of DG location and size is 85.514466 seconds.

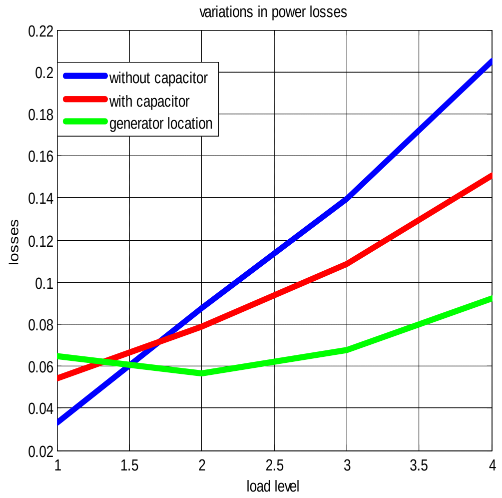


Graph 1-representation of voltage magnitude

Here graph 1 shows voltage magnitude curves of all load conditions. The thing to be noted is the shapes of graphs of voltage profile at all load levels are almost similar except some minor changes in voltage magnitude. Voltage increases by placing capacitor and the results are better after capacitor placement.

But the increase in voltage magnitude is highest in case of placement of DG.

Here the red colored curve shows the voltage magnitude curve after placement of capacitor. Blue curve shows the voltage magnitude for the case where capacitor is not present. Green colored curve shows the voltage magnitude curve for DG.



Graph 2: variation in power losses

This is a graphical representation of power losses vs variable load by applying GA. Here the resulting graph shows that losses are high without placement of capacitor, losses get reduced when capacitor is placed and losses get further reduced when DG is placed with capacitor. Hence we conclude that location and size of DG and capacitor is an important consideration for reducing the power losses in the system.

CONCLUSION

An optimization technique named genetic algorithm has been represented in this paper to find out the optimal sizes and locations of capacitor and DG to place in a power system at different variable load levels. IEEE-33 bus test system is used to verify the results of genetic algorithm. Here with the help of genetic algorithm get the best location and size of capacitor and DG which reduces the power losses effectively. Hence the aim of this paper is to minimize the power losses and increases the efficiency of power system.

REFERENCES

[1] Aarti Ashok kumar, Abhilash R. Masannagri, Anurag K. srivastava and Noel N. Schulz, *Impact of Biomass based distribution generation on electric grid*, clean university 2008, ISBN 978-1-4200-8502-0

[2] Sree L. payyala student member, and Tim C. green senior member, *sizing of distributed generation plant through techno economic feasibility assessment*,IEEE 1-4244-0493-2/2006

[3] Prakornchai Phonrattanasak, *optimal placement of DG using multiobjective particle swarm optimization*, 2010 international conference on mechanical and electrical technology.

[4] M.Gandomkar, M.Vakilian, M.Ehsan, *Optimal distributed generation allocation in distributed network using Hereford Ranch algorithm*, sharif university of technology, Tehran, Iran.

[5] Samir Dahal, Hossien Salehfar,*Optimal location and sizing of distributed generators in distributed networks*,IEEE 978-1-4799-1255-1/13/2013

[6] Vivek kumar shrivastava, O.P Rahi,*Optimal location of distribution generation sources in power system networks*,978-1-4673-0766-6/12/2012 IEEE.

[7] R.M Kamel and B. kermanshahi, *Optimal size and location of distributed generators for minimizing power losses in a primary distribution network*, computer science and engineering and electrical engineering vol 16,no.2.pp. 137-144@sharif university of technology,dec 2009

[8] .Thomas Ackermann, Goran Anderson, Lenneart Soder, *Distributed generation-a definition,*0378-7796/01@2001,electric power systems research 57 (2001) 195-204.

[9] W.S Tan, M.Y Hassan, M.S Majid, *Multi population genetic algorithm for allocation and sizing of distributed generation*,2010 IEEE international power engineering and optimization conference, Meleka, Malaysia.

[10] Mahda Jenabali Jehromi, Ebrahim Farjah, *mitigating voltage sag by optimal allocation of distributed generation using genetic algorithm*, 9th international conference, electrical power quality and utilization,Barcelona, 9-11, October 2007.

[11] Neha Goyal and Pushpendra singh, *optimal placement of capacitors in radial distributed system to minimizes the losses at variable load levels*, International Journal on Recent and Innovation Trends in Computing and Communication, volume:02, issue:8, august 2014.