International Journal of Engineering Research and Development
e-ISSN: 2278-067X, p-ISSN: 2278-800X, www.ijerd.com
Volume 12, Issue 10 (October 2016), PP.52-57

An Adaptive Approach to Posistioning And Optimize Size of DG Source to Minimise Power Loss in Distribution Network

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Abstract: In this paper an advance technique particle swarm optimization (PSO) is presented. The objective is to reduce the power loss of distribution network without disturbing the voltage and current constraints. To minimize the power loss, the location and size of distribution generation (DG) is optimized by using PSO. The IEEE 33 and 66 radial bus network is designed by using Matlab Software and tested with purposed methodology. The results obtained by PSO are also compared with ABC.
Keywords: Distribution generation (DG); Optimal size and location; Distribution Network; Particle swarm optimization (PSO).

I. INTRODUCTION

As per increase in the demand of electricity the load on power system is increasing day by day. The distribution network in power system plays an important role to distribute electricity in a wide area. The power system which we are adopting is basically radial bus distribution system. The main problem while using redial system as a distribution network is power loss due to voltage drop is a great concern. Around 13% of the generated power is wasted as heat during transmission of power, so it is very important to reduce power loss to improve voltage profile and increase the efficiency of the network. Among of various methods used to minimize losses placement of DG sources is one of best method. The optimal DG placement and sizing issues for minimizing power and energy losses in distribution networks have attracted great attention in recent years. The main consideration of this new arena is to operate several DG units near load centers instead of expanding central generation station.

DG may come from a variety of sources and technologies. DGs from renewable sources, like wind, solar and biomass are often called as ‘Green energy’. In addition to this, DG includes micro-turbines, gas turbines, diesel engines, fuel cells, stirling engines and internal combustion reciprocating engines [2–4]. Now-a-days, wind energy has become one of the most competitive among of all the renewable energy available with us. DGs have a group of advantages such as economical, environmental and technical. The economical advantages are reduction of transmission and distribution cost, electricity price and saving of fuel. Technical advantages have a wide area like, line loss reduction, increased system voltage profile and hence increased power quality and relieved transmission and distribution congestion as well as grid reinforcement. There are many reasons for increasingly use of DG technologies. It is more economic than running a power line to remote locations and DG-unit usually requires shorter installation times and the investment risk is not so high

Distributed Generators (DGs) are generally defined as the generating plants serving a customer on-site or providing support to a distribution network, connected to the grid at distribution-level voltages [1]. The traditional generators which we are using basically depend upon conventional resources of energy such as fossil fuels and hydro plants, but they are not environment friendly and cause a huge amount of pollution. So now a day it is necessary to use new sources of energy as an input power source to DG which are non polluting. DGs are commonly small scale generation which gives the solution of power losses by injecting power in the bus. DGs are also known as ‘Embedded Generation’ and ‘Disperse Generation’. According to CIGRE DGs are defined as the generating plants with generating capacity not exceeding than 100 MW and are connected to distribution network that are neither centrally planned nor dispatched [5].

It is a great challenge to optimize the size and location of DG for this purpose proper planning and detailed analysis of distribution network is required. There are a number of methodologies and techniques have been developed for this purpose, these methodologies and techniques are based on analytical tools and optimization programs. Population-based optimization methods are widely used for operational and planning studies and have given satisfactory results over the years. Population-based optimization methods include genetic algorithms [6, 7] artificial bee colony algorithm [8], tabu search [9] and particle swarm optimization [10]. In this paper PSO is the purposed methodology, the result obtained are also compared with ABC.

The DG are basically classified into four categories as:
Type I DG: which are able of inject real power only, like photovoltaic, fuel cells etc. is the good examples of type-I DG. Type II DG: capable of injecting reactive power only to , e.g. kvar compensator, synchronous compensator, capacitors etc. Type III: DG capable of injecting both real and reactive power, e.g. synchronous machines.
Type IV: DG capable of injecting real but consuming reactive power, e.g. induction generators.

Problem Formulation

To improve the voltage profile of network PSO has been used. To minimize the distribution system real power loss load sensitivity formula commonly known as exact loss formula [11] is used. For N bus system, loss minimization formula is given in equation (1).

$$P_L = \sum_{i=1}^{N} \left(\alpha_{ij} (P_i P_j + Q_i Q_j) + \beta_{ij} (Q_i P_j + P_i Q_j) \right) \qquad \ldots (1)$$

Where

$$\alpha_{ij} = \frac{r_{ij}}{V_i V_j} \cos(\delta_i - \delta_j) \qquad \ldots (2)$$

$$\beta_{ij} = \frac{r_{ij}}{V_i V_j} \sin(\delta_i - \delta_j) \qquad \ldots (3)$$

and

$$Z_{ij} = r_{ij} + jx_{ij} \qquad \ldots (4)$$

Where Z_{ij} is line impedence between bus i and bus j.

$$P_i = P_{Gi} - P_{Di} \qquad \text{and} \qquad Q_i = Q_{Gi} - Q_{Di}$$

Where P_i and Q_i are active and reactive power injections at bus *i*, P_j and Q_j are reactive power injections at bus j. δi is voltage magnitude at bus i and δj is voltage magnitude at bus j and r_{ij} is the resistance of line between bus *i* and bus j.

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

$$\alpha_{ij} = \frac{\partial P_L}{\partial P_i} = 2\alpha_{ii} P_i + 2\sum_{j=1}^{N} (\alpha_{ij} P_j - \beta_{ij} Q_j) \qquad \ldots (5)$$

Sensitivity factor are evaluated at each bus by using the values obtained from the base case load flow. The bus having lowest loss sensitivity factor will be best location for the placement of DG. Conventional load flow studies like Gauss seidal, Newton raphson and fast decoupled load flow methods are not suitable for distribution load flows because of high R/X ratio. A load flow method for distribution systems i.e. backward sweep and forward sweep method for load flow that offers better solution was proposed.

The following constraints should be satisfied:

- For each bus voltage constraint i.e. $\pm 5\%$ of rated voltage must be satisfied.

$$V_{min} \leq V_i \leq V_{max} \qquad \ldots (6)$$

- Current in a feeder or conductor, must be well within the maximum thermal capacity of the conductor

$$I_i \leq I_i^{rated} \qquad \ldots (7)$$

- The right of way buses are excluded.

II. PURPOSED METHODOLOGY

PSO algorithm is used to optimize the location and size of DG. The procedure to calculate losses by PSO is as following:

1) PSO introduction:

Particle swarm optimization (PSO) is a population-based optimization method first proposed by Kennedy and Eberhart in 1995, inspired by social behavior of bird flocking or fish schooling [12]. The PSO as an optimization tool provides a population-based search procedure in which individuals called particles change their position (state) with time. In a PSO system, particles fly around in a multidimensional search space. During flight, each particle adjusts its position according to its own experience (This value is called P best), and according to the experience of a neighboring particle (This value is called G best), made use of the best position encountered by itself and its neighbor a shown in Fig (1).

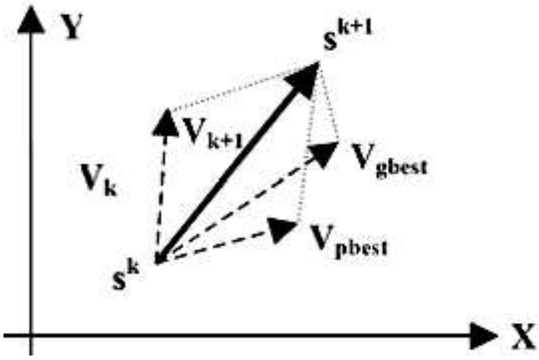

Figure 1: Concept of a searching point by PSO

Velocity of each agent can be modified by the following equation:

$$v_{id}^{k+1} = \omega_i v_{id}^{k} + c_1 rand\left(pbest_{id} - s_{id}^{k}\right) + c_2 rand\left(gbest_{id} - s_{id}^{k}\right) \quad \ldots (8)$$

Using the above equation, a certain velocity, which gradually gets close to pbest and gbest can be calculated. The current position (searching point in the solution space) can be modified by the following equation:

$$s_{id}^{k+1} = s_{id}^{k} + v_{id}^{k+1}, \quad i = 1,2,.....,.n \quad d = 1,2,.....,.m \quad \ldots (9)$$

Where,
s^k is current searching point
s^{k+1} is modified searching point
v^k is current velocity
$v^{k+1}$is modified velocity of agent i
v_{pbest} is velocity based on pbest,
v_{gbest} is velocity based on gbest
n is number of particles in a group,
m is number of members in a particle
p_{besti} is p_{best} of agent
g_{besti} is g_{best} of the group,
ω_i is weight function for velocity of agent i
c_i is weight coefficients for each term.

To find out the weight function following equation is used:

$$\omega_i = \omega_{max} - \frac{\omega_{max} - \omega_{min}}{k_{max}}.k \quad \ldots (10)$$

Where, ω_{min} and ω_{max} are the minimum and maximum weights respectively. k and k_{max} are the current and maximum iteration.

Appropriate value ranges for C_1 and C_2 are 2. Appropriate values for ω_{min} and ω_{max} are 0.4 and 0.9 respectively. (Eberhart et al, 2000) [13]

PSO Procedure:
Step 1: Input line and bus data, and bus voltage limits.

Step 2: Calculate the loss using distribution load flow based on backward sweep-forward sweep method.

Step 3: Randomly generates an initial population (array) of particles with random positions and velocities on dimensions (Size of DGs and Location of DGs) in the solution space. Set the iteration counter $k = 0$.

Step 4: For each particle if the bus voltage is within the limits as given above, evaluate the total loss in equation (1). Otherwise, that particle is infeasible.

Step 5: For each particle, compare its objective value with *the individual best*. If the objective value is lower than *Pbest*, set this value as the current *Pbest*, and record the corresponding particle position.

Step 6: Choose the particle associated with the minimum *individual best Pbest* of all particles, and set the value of this *Pbest* as the current *overall best Gbest*.

Step 7: Update the velocity and position of particle using (8) and (9) respectively.

Step 8: If the iteration number reaches the maximum limit, go to Step 9. Otherwise, set iteration index $k = k + 1$, and go back to Step 4.

Step 9: Print out the optimal solution to the target problem. The best position includes the optimal locations and size of DG and the corresponding fitness value representing the minimum total real power loss.

(2) ABC introduction

The artificial bee colony algorithm approach is established from foraging behavior of real honey bees. ABC is introduced by Karaboga [14] as a new heuristic method for solving multidimensional optimization problems.

Honey bee swarm consists of three kinds of bees:

- **Employed bees:** Randomly search for food source positions (solutions) and then share the information that is nectar amounts by dancing with the bees waiting in the hive. Duration of dance depends on the nectar amount (fitness value) of the food source.
- **Onlooker bees:** Watch dances of various employed bees and chose the good food source position according to quality of that food source.
- **Scout bees:** An employed bee of the source which is abandoned becomes a scout and starts to search a new food source randomly.

Test system:

The distribution network is designed in Matlab. The radial distribution network is designed for IEEE 33 bus and 69 bus. The location and size of DG is calculated in both networks by using PSO and ABC algorithms.

The 33 bus network has 32 branches as shown in single line diagram of network in fig (2)

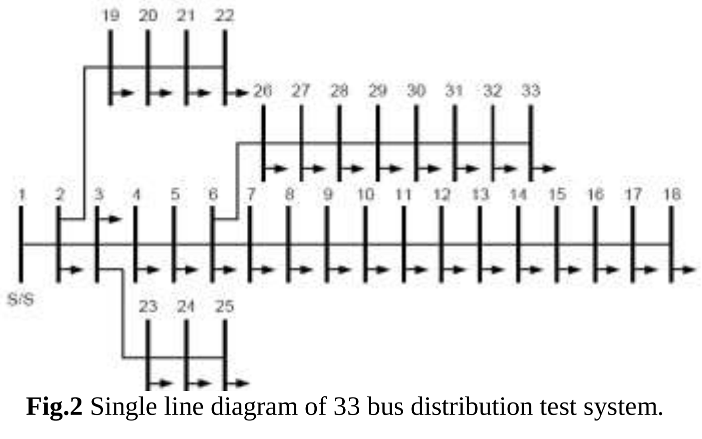

Fig.2 Single line diagram of 33 bus distribution test system.

The total active and reactive load on 33 bus network is 3.72MW and 2.3MVAR respectively.

The single line diagram of 69 bus network is shown in fig (3) In IEEE 69 bus radial network total active and reactive load is 3.8MW and 2.69MVAR..

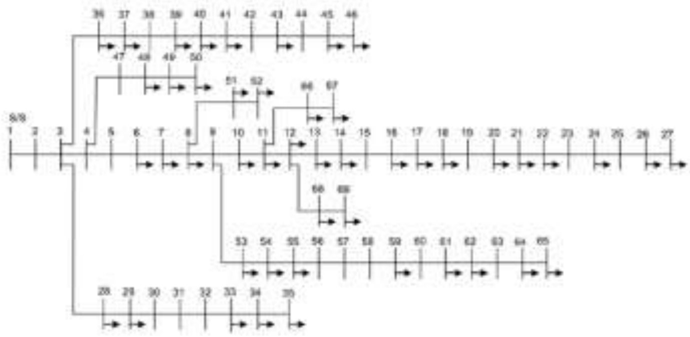

Fig.3 Single line diagram of 69 bus distribution test system.

III. RESULTS

Based on the analytical expression, the optimum size of DG is calculated at each bus for the test system and bus having least total power loss will be the optimal location for the placement. The optimized location of DG for 33 bus network by both methods i.e. PSO and ABC is bus 6, similarly in 66 bus network the location of DG is bus 61 for both methods. The results obtained by ABC are shown in Table I and the results obtained by PSO are shown in Table II. As we can see in both tables the real power losses without DG are 0.211MW and 0.225MW for 33 and 66 bus network respectivel

Table I Results of ABC for test system

Test System	Optimal location	Optimal size (MW)	ABC parameters	Loss (MW) without DG	Total loss (MW) with DG
33 bus	Bus 6	3.0971	CS=20, MCN=30	0.211	0.0672
69 bus	Bus 61	2.2389	CS=30, MCN=40	0.225	0.0238

Table II Results of PSO for test system

Test System	Optimal location	Optimal size (MW)	PSO parameters	Loss (MW) without DG	Total loss(MW) with DG
33 bus	Bus 6	2.5317	$C_1= C_2=2$ ω_{max} =0.9 ω_{min} =0.4	0.211	0.0584
69 bus	Bus 61	1.8078	$C_1= C_2=2$ ω_{max} =0.9 ω_{min} =0.4	0.225	0.0231

IV. CONCLUSIONS

This paper has presented the reduction in power losses of distribution network with the use of DG. In this paper various techniques to optimize size and location are defined. The proposed approach PSO is implemented on the network and is compared with ABC. The proposed PSO approach for optimal placement of DGs not only reduces the line losses but also minimize the sizes of DGs. In 33 bus network percentage reduction of losses is 68.15 for ABC and is 72.32 for PSO, similarly in 69 bus network percentage reduction of losses is 89.42 for ABC and is 89.73 for PSO. So in the data obtained from results we can see that the PSO gives better results than ABC.

REFERENCES

[1]. T. Ackermann, G. Andersson, L. Soder. “Distributed generation : A definition. Electric Power System Research", Volume: 57, Issue 3, 2001, pp. 195–204.

[2]. Martin G. Renewable energy gets the green light in Chicago. IEEE Power Energy Mag 2003;22(November/December):34–9.

[3]. Sonderegger RC, Henderson D, Bubb S, Steury J. Distributed asset insight. IEEE Power Energy Mag 2004(May/June):32–9.

[4]. Rahman S. Green power: what is it and where can we find it? IEEE Power Energy Mag 2003(January/February):30–7

[5]. CIGRE: Impact of increasing contribution of dispersed generation on the power system. Working Group 37.23; 1999

[6]. Mardaneh, M., Gharehpetian, G.B.: ‘Siting and sizing of DG units using

[7]. GA and OPF based technique'. Proc. Region 10 TENCON Conf., 2004, pp. 331–334
[8]. Gandomkar, M., Vakilian, M., Ehsan, M.: 'Optimal distributed generation allocation in distribution network using Hereford Ranch algorithm'. Proc. Eighth Int. Conf. Electrical Machines and Systems, 2005, pp. 916–918
[9]. Abu-Mouti, F.S., El-Hawary, M.E.: 'Optimal distributed generation allocation and sizing in distribution systems via artificial bee colony algorithm', IEEE Trans. Power Deliv., 2011, 26, (4), pp. 2090–2101
[10]. Nara, N., Hayashi, Y., Ikeda, K., Ashizawa, T.: 'Application of tabu search to optimal placement of distributed generators'. Proc. IEEE PES Winter Meeting, pp. 918–923
[11]. Dias, B.H., Oliveira, L.W., Gomes, F.V., Silva, I.C., Oliveira, E.J.: 'Hybrid heuristic optimization approach for optimal distributed generation placement and sizing'. Proc. IEEE Conf., 2012
[12]. Kazemi A., Sadeghi M., 2009. Sitting and sizing of distributed generation for loss reduction, Power and Energy Conference, APPEEC, pp.1-4, Asia-Pacific, Wuhan
[13]. Kennedy J., Eberhart R., "Particle Swarm Optimizer," IEEE International Conference on Neural Networks , Perth(Australia), IEEE Service Centre Piscataway, NJ, IV, pp1942-1948, 1995
[14]. Eberhart R.C.and Shi Y., 2000. Comparing inertial weights and constriction factor in particle swarm optimization, Proceedings of the International Congress on Evaluating Computation, San Diego,Calfornia, IEEE service center, Piscataway, NJ, pp 84-88.
[15]. D. Karaboga, "An idea based on honey bee swarm for numerical optimization," Technical Report TR06, Computer Engineering Department, Erciyes University, Turkey, 2005
[16]. Hung DQ, Mithulananthan N, Bansal RC. Analytical expressions for DG allocation in primary distribution networks. IEEE Trans Energy Convers 2010;25(3):814–20.
[17]. P. N. Hrisheekesha and J. Sharma. "AI Applications to Distribution System with Distributed Generation", International Journal of Computer Applications 1(14):38–42, February 2010.