© 2014, Scienceline Publication
www.science-line.com

ISSN: 2322-5114
Journal of World's Electrical Engineering and Technology
J. World. Elect. Eng. Tech. 3(3): 118-122, 2014

JWEET

# Placement of Dispersed Generation with the Purpose of Losses Reduction and Voltage Profile Improvement in Distribution Networks Using Particle Swarm Optimization Algorithm

Kamran Yousefpour

*Department of Engineering Faculty, Islamic Azad University, Sari Branch, Babol, Iran*

*Corresponding author's Email: Kamran.yousefpour@gmail.com

***Abstract*** *– Optimal placement of dispersed generation in electrical distribution systems was carried out considering the voltage profile improvement indexes and decreased losses in this study. It is necessary to find an inappropriate location for dispersed generation, otherwise it may result in increased costs and adverse effects on network losses and the reliability. A model to determine the optimal location and size for dispersed generation using Particle Swarm Optimization algorithm is presented in this study. For this purpose, indexes mentioned above were used in the objective function. The proposed method was applied on the IEEE 33-bus and 69-bus system and the results of dispersed generation placement in the distribution network was examined in three design positions and a position with no dispersed generation. The results indicated the competency of the proposed algorithm.*

ORIGINAL ARTICLE
Received 03 May. 2014
Accepted 20 May. 2014

***Keywords****: Optimal Placement, Dispersed Generation, PSO Algorithm, Voltage Profile, Losses*

## INTRODUCTION

Electrical energy is the most widely used energy carrier for many reasons and this has led to an increasing demand for it. Scarcity and exhaustibility of fossil resources, utilization of renewable energy sources and more efficient methods of energy production have been of wide increasing interest. However, this has led to a high pressure on the transmission and distribution networks, requiring constant development and large amounts of money to be resolved. Electrical energy production at the load location has drawn attention in the past two decades. This has diverse advantages for the power system such as: delayed investments in transmission and distribution lines, decreased losses, profile improvement, voltage stability and increased reliability of the system. The most important step in using dispersed generation resources in these networks is to perform technical and economic studies to determine the locations and their adequate capacities. It is almost impossible to utilize the potentials of such resources and their technical and economic benefits in the distribution networks without sufficient knowledge and conducting optimization studies. Several studies have been conducted in terms of locating dispersed generation units in distribution networks in which reducing the costs of losses, reliability, construction costs of production units and voltage profile stability were purposes of the design.

Dispersed generation has several definitions, however a comprehensive definition and without limitation, is the "electrical energy recourse that is directly connected to the distribution network or the consumer". The values of this generation are different, however the production capacity usually varies from a few kilowatts to several tens of MW. These units are located in the posts and distribution feeders near the loads.

It should be noted that CIGRE defines dispersed generation resources as follows:

1. Not centrally planned (no centralized planning)
2. Not centrally transferred (no centralized utilization)

3- Being connected to the distribution network

4- Less than 50 to 100 MW.

### Literature review

Several methods have been used for placement of DGs so far. Reference [1], indicates an analytical method for optimal placement of DG with unit power factor in power systems. A method to evaluate the effect of DG units on power loss, reliability and voltage profile of distribution networks is indicated in reference [2]. Optimal size and place for DG units is presented in reference [3], based on a predetermined level of losses reduction with the purpose of designing (up to %25). Maximizing the voltage support in radial distribution feeders using one unit of DG is discussed in reference [4]. A method is suggested in [5] for minimizing the power losses by finding optimal size, place and point of optimum performance of the DG unit. To determine the DG unit size and point of performance, sensitivity analysis of the power losses compared to injection flow by the DG unit is used in this reference. The researchers determined the active power of the DG production and its place by the Particle Swarm Optimization and voltage profile improvement in [6]. However the role of the active power of the DG production and the importance of the loads in voltage profile improvement was ignored.

An algorithm to maximize the reduction of load resource costs is suggested in reference [7]. An optimal solution reached by evaluating the costs in DG units is selected based on the maximum losses reduction. Reference 8 suggests an analytical method for calculating the optimal size of the DG unit. Moreover an approximate formula of the losses is suggested in [8] to identify the optimal location of the DG unit. The proposed method is based on the accurate losses formula. Load distribution was carried out twice with and without DG, assuming that only active power was injected by the DG unit. Simulations in [1] - [8], were performed in stable load condition.

**Particle Swarm Optimization Algorithm**

As previously mentioned, the Particle Swarm Optimization algorithm was used in this research to solve the problem. Fig. 1, indicates the Particle Swarm Optimization flowchart. Like other evolutionary algorithms, this algorithm starts with an initial population. In optimization with flocking algorithm method, each bird is a possible solution to the problem. Birds move to the optimal point through random directions in the solution space, while being guided by velocity vectors.

The velocity vectors are in fact factors affecting the bird's movement and include:

- Bird's previous speed
- Bird's memory of its previous best position
- Bird's memory of the best recorded position in the group

Therefore, birds move to the absolute optimal point considering the local optimal points.

The algorithm stages are as follows:

Stage one (group formation):

Swarm matrix is formed as follows:

Swarm (t) = {X1, X2, …, Xj,…XM}

That Xj = [X1j, X2j,… XNGj] T indicates the bird's position and in fact suggesting a possible answer to the economic load distribution problem. Now PFT (Xj) is calculated for each Xj bird (the total cost for the possible solution of Xj). The bird's flying speed should be zero at this stage:

Vij (t) = 0 for i = 1, 2, … NG , j = 1, 2, …, M

Also best position for each bird should be the current position:

Pbestj (t) = Xj (t) for j = 1, 2, …, M

Stage two (Updating Global Best):

The best position among all Pbestj (t)s should be found and placed at the Gbest(t) in order to find the amount of cost for the Global point : PFT (Gbest (t))

Stage 3: (Particle Position Updating):

Bird's speed and position are updated as follows:

Vij (t+1) = w Vij (t) + C1r1 (Pbestij (t) – Xij (t)) + C2r2 (Gbesti (t) – Xij (t))

Xij (t+1) = Xij (t) + Vij (t+1) for i = 1, 2,…, NG, j= 1, 2,..., M

That PFTj (t) = PFT (Xj) is in the repeating t.

Stage 5: if t= max,

Then the optimization process ends and if t=max, then this process is repeated from stage 2 for t+1.

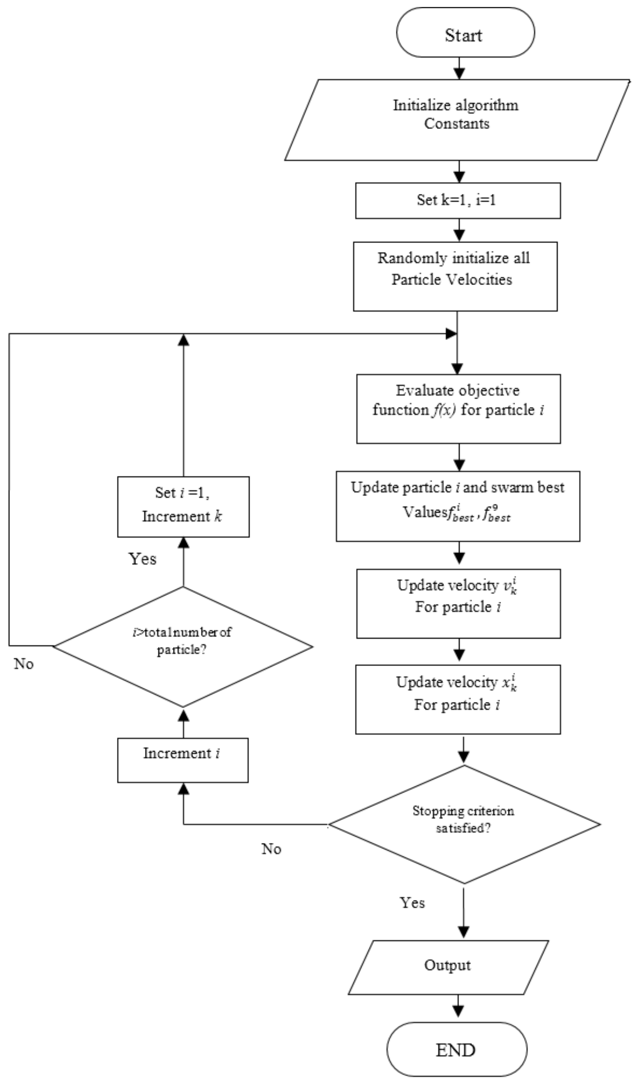


**Fig. 1**: Cuckoo algorithms flowchart

**Mathematical model**

The main purpose of this research is to find the optimal size and location of the DGs in distribution systems to minimize the costs of the system costs, including costs of power and energy losses, reliability related costs, investment costs, performance and maintenance costs for DG installation. In order to obtain more accurate results, the variable load curve is also used with time in this research. Network losses, lines loading and nodes voltage are determined at each load level by means of load distribution. Reliability indexes are calculated using reliability evaluation methods and an objective function is used to solve this problem as follows:

In considering the losses alone, the objective function is itself the losses value.

$$Objective\ Function = Total\ Loss + \sum_{i=1}^{N} \left\| v_i \right| - \left| v_i^{ref} \right\| \quad (1)$$

In considering the Improvement of profile, the objective function voltage is as follow:

$$Objective\ Function = \sum_{i=1}^{N} \left\| v_i \right| - \left| v_i^{ref} \right\| \quad (2)$$

In considering both simultaneously, target function is as follow:

$$Objective\ Function = Total\ Loss + \sum_{i=1}^{N} \left\| v_i \right| - \left| v_i^{ref} \right\| \quad (3)$$

The constraints are as below:

$$m \le M_{\max} \quad (4)$$

$$P_{\min} \le P_{DG}(i) \le P_{\max} \quad (4)$$

$$Q_{\min} \le Q_{DG}(i) \le Q_{\max} \quad (6)$$

$$\sum_{i=1}^{m} P_{DG}(i) \le P_{DG\ total} \quad (7)$$

In which:

m: numbers of DG

Maximum number of DG : $M_{\max}$

The minimum and maximum active power of DG: $P_{\min}$, $P_{\max}$

DG active power $P_{DG}(i)$

$P_{DG\ total}$ The minimum and maximum active power of DG

$$P_{DG-i,\min} \le P_{DG-i} \le P_{DG-i,\max} \quad (8)$$

$$Q_{DG-i,\min} \le Q_{DG-i} \le Q_{DG-i,\max} \quad (9)$$

$$V_{i-\min} \le V_i \le V_{i-\max} \quad (10)$$

The parameters of these equations are defined as follows.

$P_{DG-i,\min}$, $P_{DG-i,\max}$: 1th minimum and maximum active power of distributed generation

$P_{DG-i}$ and $Q_{DG-i}$: 1th active power of distributed generation

$Q_{DG-i,\min}$ and $Q_{DG-i,\max}$: th minimum and maximum active power of distributed generation

$V_i$ :voltage at 1th load point

$V_{i-\min}$ and $V_{i-\max}$: Minimum and maximum voltage at the load point in the island state

**A case study**

In order to demonstrate the accuracy and capability of this model, IEEE 33-bus has been applied. 33 bus network is a radial network. This network is shown in Fig. 2. This network's information is including buses load data and information of lines in [9]. The method used to load flow was Newton Raphson's method and system complete information will be applied after each iteration of the algorithm. The results have examined in four modes in this thesis. Encoding particles in PSO algorithm is as follows:

If a DG has been considered, with the ability to active producing, particle will be bivariate. So that the first variable and second one determine the optimum active power production.

If a DG has been considered, with the ability to active and radioactive producing, particle has 3parts. So that the first variable and second one and the third, respectively determine the optimum active and radioactive power production. To begin initially, load flow has been done on 33 buses system without distributed generation and the results are shown in Table 1 and Fig. 3 Values of power are with units of watts, Var and VA,. Value of Voltage is in per unit and voltage angles are in radians.

In next step, distributed production placement has been done by aim of losses (the first objective function).in this situation, the optimum value of DG with the ability of active power is up to 3000 kw. Table 2 and Fig. 4 show the results in this case

The next study is devoted to the distributed Placement to improve the voltage profile.in this section, the optimum DG has been obtained with the ability of active power production up to 3000 kW. The results obtained are shown in Table 3 and Fig. 5. Voltage error indicator has been derived from sum of buses absolute voltage difference per unit

Finally, Simulation has been considered with loss and voltage index simultaneously and the optimum value of DG with the ability of active power production up to 3000 kw. Fig. 6 and Table 4 shows the results. Indicators of voltage error has been derived from sum of buses voltage difference absolute per unit add to the loss values.

**Table 1.** The values of system loss of 33 buses

| Radioactive waste (W) | Reactive losses (Var) | Total losses (Volt-ampere) | System type |
|---|---|---|---|
| 202.1678 | 136.8880 | 244.1519 | 33bus |

**Table 2:** the results with putting on DG with production of active power and aim of loss reduction

| Bus number | The optimum DG (W) | Total losses (Volt-ampere) |
|---|---|---|
| 5 | 2511.0452 | 128.7136 |

**Table 3.** the results placing a DG active power production to reduce the voltage error

| Bus number | The optimum DG (W) | Total losses (Volt-ampere) | Error indicator Voltage |
|---|---|---|---|
| 8 | 195.6380 | 169.7455 | 0.49856 |

**Table 4.** Results placing a DG with the ability of active power production with aim of voltage errors and loss.

| Bus number | The optimum DG (W) | Total losses (Volt-ampere) | Error indicator + Voltage losses |
|---|---|---|---|
| 6 | 1784.3699 | 132.3269 | 133.3253 |

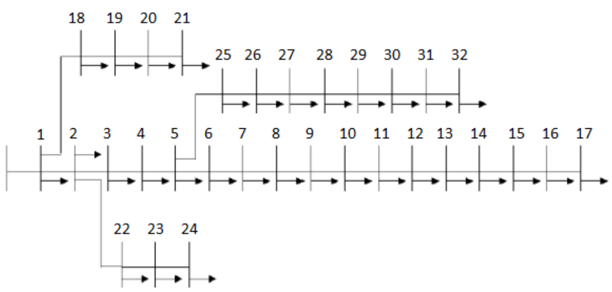


**Fig. 2.** Radial network of 33 bus

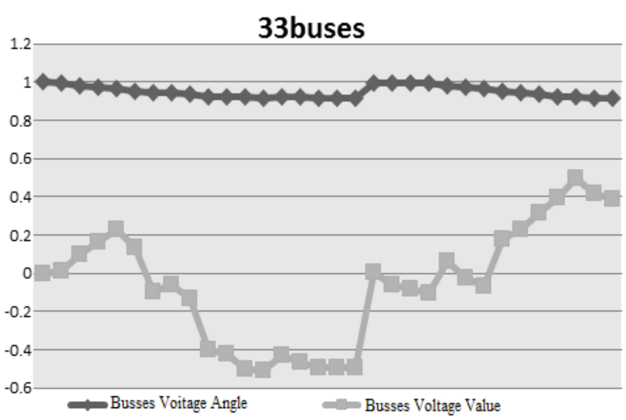


**Fig. 3.** Voltage of 33 bus system

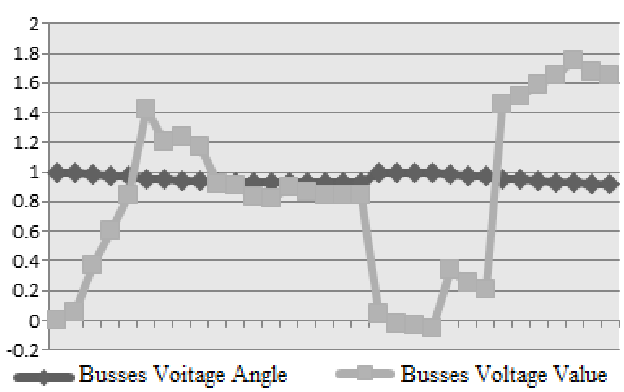


**Fig. 4.** Profiles and voltage angle with the Placement of a DG with active power loss reduction

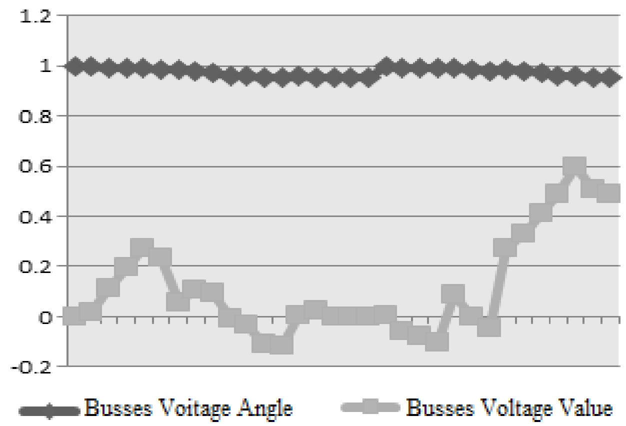


**Fig. 5.** Profiles and voltage angle by placing a DG active power production to reduce the voltage error

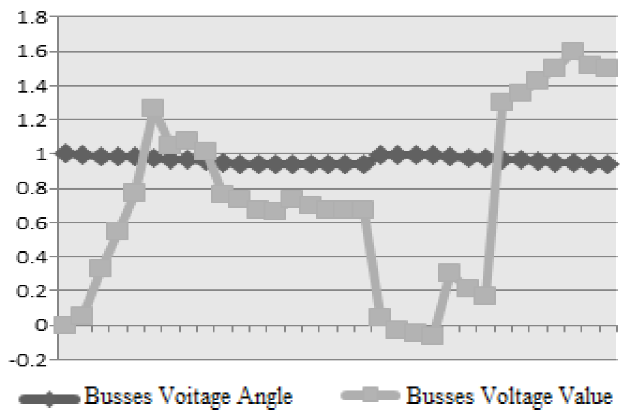


**Fig. 6.** Profile and voltage angle placing a DG with the ability of active power production with aim of voltage errors and loss.

## CONCLUSION

This study has been investigated types of distributed production and introducing and evaluating PSO algorithm method to determine the optimal size and location of dispersed with optimizing the target functions to Improve profiles and angle and voltage loss reduction. Results have been evaluated in four states. In the first case, location and Optimal capacity of a DG with the ability of active power production is considered .in second case, location and optimal capacity of a DG with the ability of active and radioactive power production is considered and in third case, 69 buses system, location and optimal capacity of a DG with the ability of active power production is considered. Finally in fourth case, the system of 69 buses, location and optimal capacity of a DG with the ability of active power production has been investigated. Equations are used, and how it is used in MATLAB to obtain the optimal solution are presented here. It was observed that with the consideration of toll alone, angle and voltage profiles worse situation will find and just by consideration of voltage, losses will be notable .If both of them will be considered simultaneously, both will be optimize reasonably and acceptable results are obtained. It was observed that optimized placement with the ability of active and radioactive power production has been obtained the best values for indicators. DG's optimized placement by aims of losses reduction showed that if losses decrease, profile and voltage angle don't have acceptable chart.

## REFERENCES

[1] A. Moradkhani, M. Haghifam, and M. Mohammadian "Recovery of distribution networks in the presence of distributed generation and Energy saving resources", Iranian Journal of Electrical and Computer Engineering, Year 8 Number 2, 2010.

[2] H. Falaghi, M. Haghifam, and M. Parsa Moghadam, "Distributed generation sources allocation in electrical energy distribution networks in the presence of uncertainties", Journal of Electrical Engineering and Computer Engineering, Year 7, Number 1, 2009.

[3] I. Ghadirian, and R. Ghazi, "Planning of the dispersed generation units (DG) in distribution networks in order to maximize social welfare", Journal of Engineering Islamic Azad University of Mashhad, second edition, 2009.

[4] G. Shahgholian, M. A. Heidari, and M. Mahdavi, "Optimal allocation of dispersed production in distribution networks using ant algorithm", Science–Research Journal of Electrical Engineering, Third Year, Number 1, 2009.

[5] H. Hedayati, S. A. Nabaviniaki and A. Akbarimajd, "A Method for Placement of DG Units in Distributed Networks", IEEE Transaction on Power Delivery, Vol. 23, No. 3, pp.1620-1627, 2008.

[6] M. Mohab Elnashar, El. Shatshat Rabadan, and M. A. Salama Magdy, "Optimum siting and sizing of a large distributed generator in a mesh connected system". Elsevier, Electric power system Research, pp. 690-697, 2009.

[7] A. Naresh, M. Pukar, and N. Mithulananthan, "An analytical approach for DG aiiocation in primary distribution network". Elsevier, electrical power & energy systems, pp.669-678, 2006.

[8] D. Singh, D. Singh and K. S. Verma, "Multiobjective Optimization for DG Planning with Load Models", IEEE Transaction on Power Systems, Vol. 24, No. 1, pp. 427-436, 2009.

[9] IEEE STANDARDS "IEEE-30 bus standard system".