International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Optimal Allocation of DG Considering Loss Minimization and Voltage Profile Using PSO

A. Apparao[1], K. Bhashna[2]

[1]Department of Power Engineering, GMRIT, Rajam, Srikakulam district AP, India

[2]Electrical and Electronic Engineering, GMRIT, Rajam, Srikakulam district AP, India

Abstract: ***Distributed Generation integration in distribution system is one of the options which give many benefits like loss minimization, peak saving, over load relieving, voltage profile improvement, power quality and improved reliability. The installation of DG units at non-optimal places can result in an increase in system losses, damaging voltage state. In this paper, objective function is designed for optimally determining the location of distributed generation, distribution system for power loss reduction and voltage profile improvement are presented. Newton Raphson's Power flow method with particle swarm optimization algorithm (PSO) is used and the effectiveness of the proposed method is tested on IEEE 33- bus radial distribution systems to demonstrate the performance and in the presence of distributed generation (DG).Results show the efficiency of the proposed algorithm in reducing power losses, improving voltage profile.***

Keywords: Distributed generation, Real power loss, Voltage profile, PSO

1. Introduction

In the present scenario electrical power demand is increasing rapidly, and generation can't reach to the existing demand so we need extra power or emergency power which has to be connected in the distribution system. The performance of distribution system becomes inefficient due to the reduction in voltage magnitude and increase in distribution system losses.

Placement of DG units on the distribution network has been continuously studied in order to achieve different aims and objectives with different types of DG in different test systems are studied in literature review. Analytical approach for real power loss minimization in power distribution system has been presented to size and site DG in [1]. Optimum location & optimum size of DG unit for voltage profile improvement & minimizing power losses using ETAP [2]. Firefly algorithm is presented [3] with the objective of determining the optimal location and size of distributed generation (DG) in radial distribution network. PCLONALG method used in [4] Khoda-Bande-Loo distribution test feeders of Tehran city. A load flow base algorithm for reducing line loss and improving voltage profile [5]. Load flow algorithm is combined appropriately with GA [6]. Planning and operation of active distribution networks, with respect to placement and sizing of Distributed Generators are discussed with the help of a fuzzy logic methodology in [7] Renewable energy source DG location based on voltage sensitivity index [8] ANN technique [9] optimal DG unit and capacitor placements in distribution systems are studied [10] two innovative mathematic models are proposed to solve OPF problems and other methods like Bacterial Foraging Algorithm (BFA), bus-injection to branch-current (BIBC) and branch-current to bus voltage (BCBV) and Shuffled Frog Leaping Algorithm (SFLA) [11-13] these algorithm have come into existence and almost succeeded in getting optimal or near optimal solution with operating constraints. But the problem associated with these techniques is increase in computational time with the improper selection of control parameters.

Many approaches are proposed for allocation of Dispersed Generators and they are still in research and enlargement stage. Different types of the DG's can be characterized as [14]
Type I: DG capable of injecting 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 improve the voltage profile 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 used in the wind farms. Type-I DGs are frequently used. In this study, DGs capable of supplying both real and reactive power are considered by satisfying the all the constraints by the proposed method.

2. Distribution Generation

DG can be defined in many ways practically, a general Definition of distributed generation given in [15] as DG is an electric power source connected directly to the distribution network or on the customer site of the meter. These Distributed Generators are also called as embedded or dispersed generation and ranges from few KW to MW [16]. The purpose of distributed generation is to provide a source of electric power. The definition of the location of the distributed generation plants varies among different authors. Most authors define the location of DG at the distribution side of the network, some authors also include at the customer side, and Technologies that utilizes conventional energy sources includes gas turbines, micro turbines and combustion engines. Currently, the ones that show promises for DG applications are wind electric conversion systems, geothermal systems, solar-thermal–electric systems, photovoltaic systems and fuel cells [17] while today's typical wind turbine is rated at 2 to 3 MW, It has several benefits economical and operationally. Power electronics has been representing a major enabler in supporting the growth of renewable energy sources [18] it is extensively used on the consumer side and is a core technology for the new smart grid. Use of electronic converters improved the efficiency of energy harvesting through dedicated controls and also made possible in the connection of renewable energy generators to the legacy power systems.

2.1 Importance of DG

The main motive behind integration of DGs in the power distribution is an effective energy solution, particularly for emergency power, uninterruptible power requirements under certain conditions. The optimal location of DGs in power systems is very important for obtaining their maximum potential benefits like [19]

Technical benefits: Reduced line losses, Voltage profile improvement, increased overall energy efficiency, Enhanced system reliability and security, improved power quality.

Economical Benefits: Deferred investments for upgrades of facilities, Enhanced productivity. Reduced health care costs due to improved environment, Reduced fuel costs due to increased overall efficiency, Reduced reserve requirements and the associated costs, Lower operating costs due to peak shaving, Increased security for critical loads.

Environmental benefits: Reduced carbon dioxide emissions by 41% in 1999, reducing fossil fuel consumption, increase its diversity of energy sources. In addition to providing benefits, DG can also have negative impacts on network. These impacts include frequency deviation, voltage deviation and harmonics on network [20]. The increase of power losses is another effect that may occur [21]. Thus proper considerations need to be taken for allocation of DGs in distribution systems.

3. Problem Formation

The aim of the proposed work is to minimize the designed objective function (Eq.3) to reduce power loss (Eq.1), voltage profile improvement (Eq.2) with optimal location and fixed DG size.

3.1 Objective Function

$$F_1(x) = P_L = \sum_{i=1}^{N} R_i \times |I_i|^2 \tag{1}$$

$$F_2(x) = V_P = \sum_{i=1}^{n} |V_i - V_{i,ref}| \tag{2}$$

$$f_{(min)} = W_1 * F_1 + W_2 * F_2, \sum_{i=1}^{n} W_i = 1 \tag{3}$$

Where N= number of branches
n=number of buses
I_i=Branch current
R_i=Resistance of the branch
V_i=Voltage magnitude of bus i
$V_{i\ ref}$=Voltage magnitude of slack bus
W_1, W_2=Weight factors

3.2 Constraints

Equality Constrain: For each bus, to meet demand and supply the following load balance equations should be satisfied

$$\sum_{i=1}^{n} P_{DGi} \le \sum_{i=1}^{n} P_{Di} \tag{4}$$

In Equality constrain: Voltage limits for each bus, there should be an upper and lower voltage bounds

$$|V_i|^{min} \le |V_i| \le |V_i|^{max} \tag{5}$$

$$0.93p.u \le V_i \le 1.07p.u$$

Where V_{min} the minimum is bus voltage and V_{max} is the maximum bus voltage

4. Particle Swarm Optimization (PSO)

Particle Swarm Optimization (PSO) applies to concept of social interaction to problem solving. It is based on the movement and intelligence of swarms and it was developed in 1995 by James Kennedy and Russell Eberhart [22]. It has been applied successfully to a wide variety of search and optimization problems. In PSO, a swarm of n individuals communicate either directly or indirectly with one another search directions.PSO is a simple but powerful search technique.

A. Advantages of PSO [23] over the other conventional techniques are:

1) PSO is based on the intelligence. It can be applied into both scientific research and engineering use.
2) PSO has no more operators and it requires few particles to be tuned. The search can be carried out by the speed of the particle. During the development of several generations, only the most optimist particle can transmit information onto the other particles
3) The calculation in PSO is very simple. Compared to the other techniques, it gives faster convergence to a solution close to the optimal, by balancing the local search and global search and has less computational time.

4.1 Algorithm for solving DG location problem using PSO:

Step1: Read the input data
(a) Line data
(b) Bus data
(c) Limits
(d) DG size

Step2: Select the parameters of PSO

(i)population size
(ii) acceleration constants
(iii) inertia weight (ω)

Step 3: Calculate the voltages and losses by NR method

Step4: location of the particle is (x).

$$x(i,j) = x_{min} + (x_{max} - x_{min})$$

Step5: Initialisation of population of particles for finding the location with random Positions. Set the iteration count k=0

Step6: Initialisation of random velocities of the particles

Step7: Check the power balance constraint

Step8: Check the voltage constraint

Step9: Calculate the total loss and voltage in each bus by using the objective function

Step 10: Evaluate the fitness function

Step11: Finding the local best and global best values

Step12: Updating the velocity of each particle following the equation,

$$S_i^{k+1} = \omega S_i^k + c_1 r_1 \left(P_{besti}^k - X_i^k\right) + c_2 r_2 \left(g_{besti}^k - X_i^k\right)$$

Step13: Check whether the updated velocities are within the limits or not

$$\left[-S_i^{max}, +S_i^{min}\right]$$

Step14: Now the position of each particle will be modified as,

$$X_i^{k+1} = X_i^k + S_i^{k+1}$$

Step15: calculate the new fitness values .If this values are better than previous Values then assign the current values as local best

Step16: If stopping criteria is reached, when the iteration number reaches the maximum value, go to step 17. Otherwise, set the iteration count k=k+1, and go back to step 7

Step17: The latest global best is the optimal solution to the target problem. The best position is optimal location of DG and corresponding values are the minimized loss and improved voltages.

Table 1: PSO Parameters

Parameter	Value
Population size	50
Maximum iterations	100
Constriction factor c_1, c_2	2
Inertia weight factor (W_{max})	0.9
Inertia weight factor (W_{min})	0.4

5. Results and Discussion

To check the validity of the proposed method, IEEE-33bus Radial Distribution System (RDS) shown in Figure 1 was considered with a total load of 3.715 MW and 2.3 MVAR is tested and Having following characteristics: Number of buses=33; Number of lines=32; Slack Bus no=1; Base Voltage=12.66KV; Base MVA=100 MVA; and the line and bus data are taken from [24-25] The size of the distributed generation unit considered here is 0.5840MVA which is approximately 16 % of real power demand. A computer program is written in MATLAB 13 to find the optimal location of DG, the voltage at each bus and approximate total real power loss with DG at various locations to find out the best location using PSO.

Further, two more cases were analyzed, case I and case II. Case I is the reference case i.e., the system without DG unit using Newton Raphson's Power flow method, Case II determines the optimal location with a single DG unit using PSO optimization technique. The results of the proposed test system are shown below:

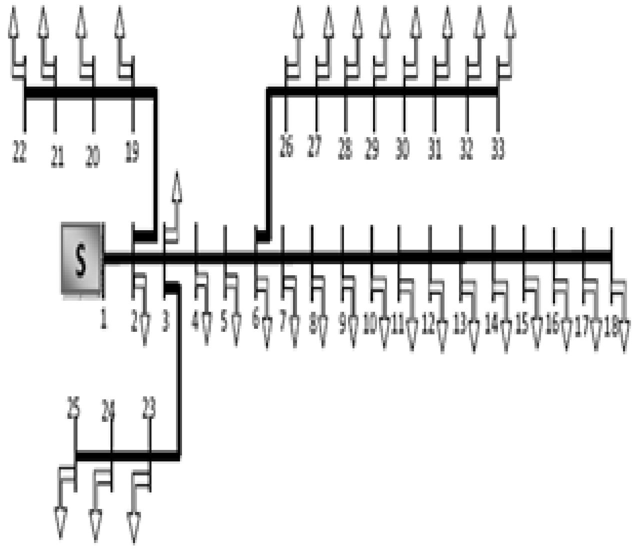

Figure 1: Single Line Diagram of IEEE 33-Bus Radial Distribution System

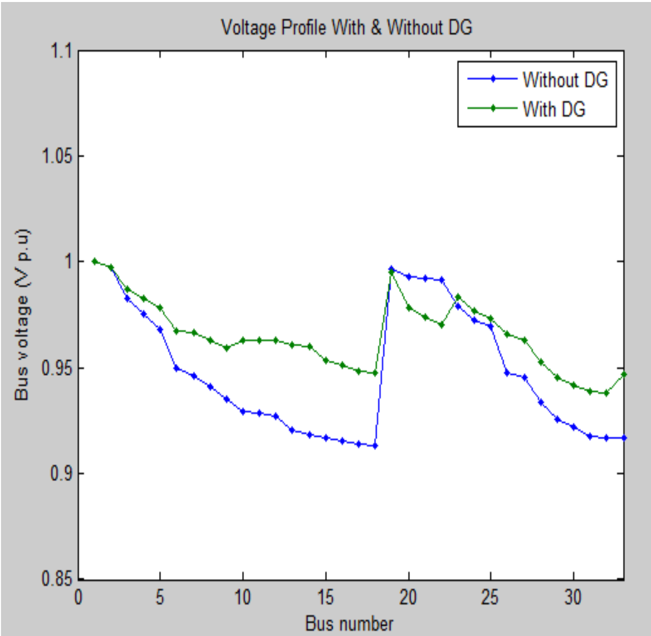

Figure 2: Voltage Profile Improvement With and Without DG Unit

The voltage profile before and after DG installation is shown in Figure 2. The lowest voltage occurred at the Bus 18 in the case I with of 0.9130 p.u and and maximum voltage occurs at Buses 1,2,20. for the case II lowest voltage occurs at Bus 32 0.9378 p.u, and maximum voltage occurs at Buses 1,2,19.The comparison graph in figure 2 shows the voltage profile improvement takes place from case I to case II .

Table 2: Voltages with and without DG

Bus No	Case I Without DG	Case II With DG	Bus No.	Case I Without DG	Case II With DG
1	1.0000	1.0000	18	0.9130	0.9475
2	0.9970	0.9971	19	0.9965	0.9951
3	0.9829	0.9870	20	0.9929	0.9782
4	0.9754	0.9825	21	0.9922	0.9736
5	0.9680	0.9781	22	0.9916	0.9701
6	0.9496	0.9673	23	0.9793	0.9834
7	0.9462	0.9667	24	0.9727	0.9768
8	0.9413	0.9626	25	0.9693	0.9735
9	0.9350	0.9592	26	0.9477	0.9655
10	0.9292	0.9627	27	0.9452	0.9632
11	0.9284	0.9628	28	0.9337	0.9526
12	0.9269	0.9631	29	0.9255	0.9451
13	0.9207	0.9605	30	0.9219	0.9419
14	0.9185	0.9597	31	0.9178	0.9385
15	0.9170	0.9532	32	0.9169	0.9378
16	0.9157	0.9514	33	0.9166	0.9472
17	0.9136	0.9485			

Table 3: Comparison of losses

Case	DG size (MVA)	Bus location	Real Power loss(MW)
I Without DG	-	-	0.2027
II With DG	0.5840	33	0.0731

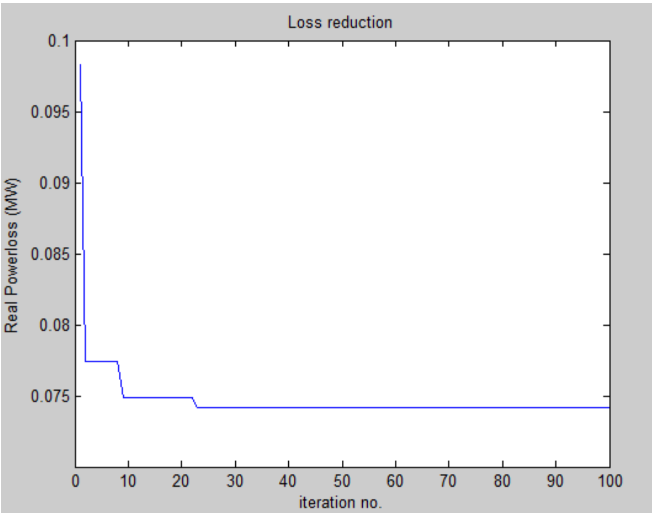

Figure 3: Convergence graph

From figure 5 Convergence graph drawn between real power losses and iteration number it show that the Real Power losses reduced gradually from 0.2027MW to 0.0731MW and remained constant after 22nd iteration.

6. Conclusion

Integration of DG is the crucial factor in application of loss minimization and voltage improvement. This paper presents a load flow based programming with PSO algorithm to find out the optimal location of DG unit for voltage profile improvement and minimizing power loss in IEEE 33 Bus distribution system. The methodology used is capable of analyzing the influence on some system characteristics of DG allocation can be very useful for the system planning engineer when dealing with the increase of DG penetration that is happening nowadays. The proposed algorithm can identify the best location for single DG placement in order to improve the voltage at all buses & to minimize total power losses. This method is so fast and efficient. At the same time it's so accurate in determining the losses, voltage stability with 0.5840 MVA DG size at 33 bus location.

References

[1] Gopiya Naik. S, D. K. Khatod, M. P. Sharma "Sizing and Siting of Distributed Generation in Distribution Networks for Real Power Loss Minimization Using Analytical Approach" 2013International Conference on Power, Energy and Control (ICPEC).

[2] Nibedita Ghosh, Sharmistha Sharma ,Subhadeep Bhattacharjee "A Load Flow based Approach for the Optimum Allocation of Distributed Generation Units in Distribution Network for Voltage Improvement and Loss Minimization" International Journal of Computer Applications (0975 – 8887) Volume 50 – No.15, July 2012.

[3] Ketfi Nadhir, Djabali Chabane and Bouktir Tarek "Distributed Generation Location and Size Determination to Reduce Power Losses of a Distribution Feeder by Firefly Algorithm" International Journal of Advanced Science and Technology Vol. 56, July, 2013.

[4] M. Sedighizadeh, M. Fallahnejad, M. R. Alemi1, M. Omidvaran1, D. Arzaghi-haris "Optimal Placement of Distributed Generation Using Combination of PSO and Clonal Algorithm"2010 IEEE International Conference on power and energy (PECon2010), Nov 29-Dec 1, 2010, Kuala Lumpur Malaysia.

[5] A.Kazemi, and M.Sadeghi"Distributed Allocation for Loss Reduction and Voltage Improvement Generation" IEEE DOI: 10.1109/ APPEEC. 2009. 4918287 Power and Energy Engineering Conference.

[6] G.V.Nagesh Kumar, R.SR Krishnam Naidu , Sarada Busam,Snigha Hota "Multi objective Optimization of Radial Distribution System with multiple Distributed Generation Units using Genetic Algorithm" International conference on Electrical, Electronics, Signels,Communication and Optimization (EESCO)-2015.

[7] S. Kumar Injeti, Dr. Navuri P Kumar" Optimal Planning of Distributed Generation for Improved Voltage Stability and Loss Reduction" International Journal of Computer Applications (0975 – 8887) Volume 15– No.1, February 2011.

[8] Gopiya Naik. S 1, D. K. Khatod 2, M. P. Sharma "Optimal Allocation of Distributed Generation in Distribution System for Loss Reduction" IPCSIT vol. 28 (2012) © IACSIT Press, Singapore.

[9] Partha Kayal and Chandan Kumar Chanda "A simple and fast approach for allocation and size evaluation of distributed generation" International Journal of Energy and Environmental Engineering 2013.

[10] Minnan Wang and Jin Zhong "A Novel Method for Distributed Generation and Capacitor Optimal Placement considering Voltage Profiles" IEEE Transactions On Power

and Energy Society General Meeting, 978-1-4577-1002-5/11/$26.00 ©2011

[11] Vahid Rashtchi, Mohsen Darabian "A New BFA-Based Approach for Optimal Sitting and Sizing of Distributed Generation in Distribution System" International Journal of Automation and Control Engineering Vol. 1 Iss. 1, November 2012.

[12] Ram Singh1, Gursewak Singh Brar2 and Navdeep Kaur3 "Optimal Placement of DG in Radial Distribution Network for Minimization of Losses" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 1, Issue 2, August 2012.

[13] E. Afzalan1, M. A. Taghikhani, and M. Sedighizadeh1 "Optimal Placement and Sizing of DG in Radial Distribution Networks Using SFLA" International Journal of Energy Engineering 2012, 2(3): 73-77.

[14] Duong Quoc Hung, Nadarajah Mithulananthan, R. C. Bansal "Analytical Expressions for DG Allocation in Primary Distribution Networks" IEEE Transactions On Energy Conversion, Vol. 25, No. 3, September 2010

[15] Thomas Ackermann, Go¨ran Andersson , Lennart So¨der" Distributed generation: a definition" Electric Power Systems Research 57 (2001) 195–204

[16] V. Selve "Optimal Allocation of Distributed Generation to Minimize Loss in Distribution System" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering Vol. 3, Special Issue 4, May 2014.

[17] W. El-Khattam, M.M.A. Salama "Distributed generation technologies, definitions and benefits" Electric Power Systems Research 71 (2004) 119–128.

[18] Frede Blaabjerga & Dan M. Ionelbc "Renewable Energy Devices and Systems – State-of-the- Art Technology, Research and Development, Challenges and Future Trends Department of Electrical and Computer Engineering, Marquette University, Milwaukee, WI, USA Electric Power Components and Systems Published online: 12 Jul 2015.

[19] Rajkumar Viral n, D.K. Khatod "Optimal planning of distributed generation systems in distribution system:A review" Electric Power and Energy System 16 (2012) 5146–5165.

[20] El-Ela A.A.A., Allam, S.M. and Shatla, M.M., 2010. "Maximal Optimal Benefits of Distributed Generation Using Genetic Algorithm." Electric Power Systems Research, 80: 869-877.

[21] Carmen L.T.Borges, and Djalma M. Falcao, , 2006. "Optimal Distributed Generation Allocation for Reliability, Losses and Voltage Improvement." Electric Power and Energy System, 28: 413- 420.

[22] James Kennedy and Russell Eberhart "Particle swarm optimization," .Proc of IEEE International conference on Neural Network, Perth, Australia December 1995:1942-1948.

[23] Qinghai Bai "Analysis of Particle Swarm Optimization Algorithm" computer and information science vol.3, No.1,February 2010

[24] M. E. Baran and F. Wu, "Network reconfiguration in distribution system for loss reduction and load balancing," IEEE Trans. Power Delivery., vol. 4, no. 2, pp. 1401–1407, April 1989.

[25] Rayapudi Srinivasa Rao, Sadhu Venkata Lakshmi Narasimham, Manyala Ramalinga Raju, and A. Srinivasa Rao "Optimal Network Reconfiguration of Large-Scale Distribution System Using Harmony Search Algorithm" IEEE Transactions On Power Systems, Vol. 26, No. 3, August 2011.

Author Profile

Mr. A. Apparao Rao is currently associated as an Associate professor with the Department of Power Engineering (PE) at GMR Institute of Technology, Rajam, AP, India. He has a total 15 years of academic experience. Pursuing Ph.D from GITAM University Visakhapatnam

K. Bhashna, presently pursuing M.Tech in Power and industrial drives (PID) in the Department of Electrical and ElectronicsEngineering (EEE) at GMR Institute of Technology, Rajam, AP, India.