DG Installation in Distribution System for Minimum Loss

Anand K Pandey
EE, JSSATEN
Noida,UP

Om Mishra
EE, JSSATEN
Noida,UP

Alat
EE, JSSATEN
Noida,UP

Saurabh Kumar
EE, JSSATEN
Noida,UP

***Abstract*: This paper proposes optimal placement and optimal size of DG system in the distributed system. Earlier proposal gives analytical expression for optimal placement of DG that is capable of delivery real power only. This research paper has proposed two other type of DG system also (type 3 and type 4). 14 test bus systems with standard IEEE data is used. Result shows optimal location for placement of DG and its optimal size with some constraints. The result required less computation and are verified with the help of illustrated graphs.**

***Keywords: Optimal Location, Optimal Size, Power Losses, Distributed Generation*.**

I. INTRODUCTION

The objective of power system is to supply electrical energy to each consumer with rated condition with minimum losses and maximum power transfer along with maintaining stability of the system. There are two types of power technologies: Traditional technologies and Non-traditional technologies. Traditional technologies are non-renewable technologies such as thermal power plant. Non-traditional technologies include fuel cells and renewable energy based technologies such as wind energy, solar energy, geothermal energy, ocean energy.

For increasing demand of energy with minimum cost has led to development of many new technologies. These technologies are also very important because of growing environmental concern around the whole world. The fear of depletion of conventional source of energy has led to the development of non conventional technologies. Among them nowadays DG system has attracted several researchers to find new ideas about how it can be utilised effectively. Among these optimal size and optimal placement of DG system is very important.

DG (distributed generation) is small scale power station whose range may vary from few KW to 50 MW .They are generally placed at the consumer side or at the end of distribution network .There are four types of DG system :

1. Type 1 DG, capable of injecting active power.
2. Type 2 DG, capable of injecting reactive power
3. Type 3 DG capable of injecting active and reactive power.
4. Type 4 DG capable of injecting active power and consuming reactive power.

DG system improves reliability of the system. But has also led to many problems. It has found that if DG is placed at wrong position in the distribution system then effectiveness of DG decreases. Therefore it is very important for one to decide where the DG should be used and it should be what size. This research paper focuses on this problem only taking into consideration of all the four types of DG.

II. LITERATURE REVIEW

In [1] for reducing loss approximate power flow technique was used. As this method is approximate method therefore it can not be used in the practical large distribution system. In [2] single loop method was used for solving network configuration. In [3] “2/3”are “golden rule” is used. This method is very effective for uniform load. But this is applicable to not applicable to non-uniformly distributed load .This rule is simple and easy to apply.

In[4] approach has been made to find appropriate location to place that DG system in radial as well in loop system this method helps in minimizing losses but here optimal sizing is not considered. Because in practical case different sizes of DG are present and due to economic reason sometime it becomes difficult to use DG of same size so this method does not goes well in practical case. In [5] GA method was used to find optimal placement and size of DG it can solve many problem. But it requires lots of computational time. In [6] it used exact loss formula for finding optimal location of DG system in distributed network. Here the two load flow calculation is performed. First of all losses are calculated without the placement of DG .Then the second load flow calculation are performed to find the losses .But this technique gives solution for type 1 DG only. Other technique were also used such as dynamic programming [7], fuzzy expert system which requires lots of analysis and have more computation time [8] and [9] TS technique is used for finding the best location of placement of capacitor only. It does not give solution for inductive loads which is the most common load in distribution system.

III. METHODOLOGY

Before the placement of DG system losses of the distributed system are calculated .Now DG system are placed at different buses and losses are calculated with the help of exact loss formula. Among the various cases the location which gives minimum loss gives the optimal position in the distributed system of particular size. This process is repeated for many sizes within the given constraint The analytical expression is given below.

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N}\left[\alpha_{ij}\left(P_iP_j + Q_iQ_j\right) + \beta_{ij}\left(Q_iP_j - P_iQ_j\right)\right]$$

Where

$\alpha_{ij} = \frac{r_{ij}}{V_i V_j} cos(\delta_i - \delta_j)$;
$\beta_{ij} = \frac{r_{ij}}{V_i V_j} sin(\delta_i - \delta_j)$;

V_i Bus voltage
δ_i load angle
$r_{ij} + x_{ij} = Z_{ij}$ Z bus
P_i Active Power injection at i bus
Q_i Reactive Power injection at i bus
N No of buses

$P_i = P_{DGi} - P_{Di}$
$Q_i = Q_{DGi} - Q_{Di} = aP_{DGi} - Q_{Di}$
$a=\tan^{-1}(Q/P)$

Putting the above two equation in exact loss formula the new equation obtained is:

$$P_L = \sum_{i=1}^{N}\sum_{j=1}^{N}\left[\alpha_{ij}\left((P_{DGi} - P_{Di})P_j + (aP_{DGi} - Q_{Di})Q_j\right) + \beta_{ij}\left((aP_{DGi} - Q_{Di})P_j - (P_{DGi} - P_{Di})Q_j\right)\right]$$

We will differentiate the following equation with respect to P_{DGi}

$$\frac{\partial P_L}{\partial P_{DGi}} = 2\sum_{j=1}^{N}\left[\alpha_{ij}(P_j + aQ_j) + \beta_{ij}(aP_j - Q_j)\right] = 0$$

Finally on substitution and simplification we get

$$P_{DGi} = \frac{\alpha_{ij}(P_{Di} + aQ_{Di}) + \beta_{ij}(aP_{Di} - Q_{Di}) - X_i - aY_i}{a^2\alpha_{ii} + \alpha_{ii}}$$

Where

$$X_i = \sum_{\substack{j=1 \\ j\neq i}}^{n}(\alpha_{ij}P_j - \beta_{ij}Q_j)$$

$$Y_i = \sum_{\substack{j=1 \\ j\neq i}}^{n}(\alpha_{ij}Q_j + \beta_{ij}P_j)$$

With the help of above equation we can estimate the size of DG as follows-

1. Type 1 DG: For type 1 DG value of a=0 because power factor is unity and size is:

$$P_{DGi} = P_{Di} - \frac{1}{\alpha_i}\left[\beta_{ii}Q_{Di} + \sum_{\substack{j=1 \\ j\neq i}}^{n}(\alpha_{ij}P_j - \beta_{ij}Q_j)\right]$$

2. Type 2 DG: In this value of a=∞ because power factor=0:

$$Q_{DGi} = Q_{Di} + \frac{1}{\alpha_i}\left[\beta_{ii}P_{Di} - \sum_{\substack{j=1 \\ j\neq i}}^{n}(\alpha_{ij}Q_j + \beta_{ij}P_j)\right]$$

3. Type 3 DG: Here Q is positive and the value of P_{DG} and Q_{DG} will give the value of total apparent power that determines size of DG.

4. Type 4 DG: The value of Q is negative and here also we can calculate the total apparent power to determine the size of DG system.

With the help of above expression we can not only find the optimal size of DG but also its type which will give minimum loss in the distributed network

IV. ALGORITHM

This research paper uses the standard IEEE 14 test bus system and voltage and load angle of each buses are also present according to IEEE standards. The following steps are followed-

1. Z bus formulation coding has been done to find the Z bus of IEEE standards.
2. 100 MVA base is taken.
3. First of all the total losses of the system is calculated.
4. There is no placement of DG.
5. Many constraints has been taken before the analysis of system such as size of DG.
6. The loop is performed to find position of bus system where minimum losses are present.
7. We first take minimum size of DG and then we place at all the 13 bus except the slack bus.
8. Out of all the 13 position, only that position is located which give minimum loss after placement of DG.
9. This position is saved in the form of variable.
10. The process is again repeated until the maximum limit of the size.
11. Several looping is done to calculate the optimum position of different size of DG.
12. Out of the several size only that size is chosen which gives minimum loss in the distribution system.
13. So we get optimal size and location for type 1 DG.
14. Above process is repeated for two other type of DG also (Type 3 and Type 4 DG).
15. We get minimum losses for all three types of DG.
16. Out of the three cases that DG type is selected which give the minimum loss.

V. THE TEST SYSTEM

IEEE 14 bus system is used to check the validity of proposed work and to find the optimal size and location of DG.

The detail about the test bus system is given in the appendix section from where analysis of DG system is done.

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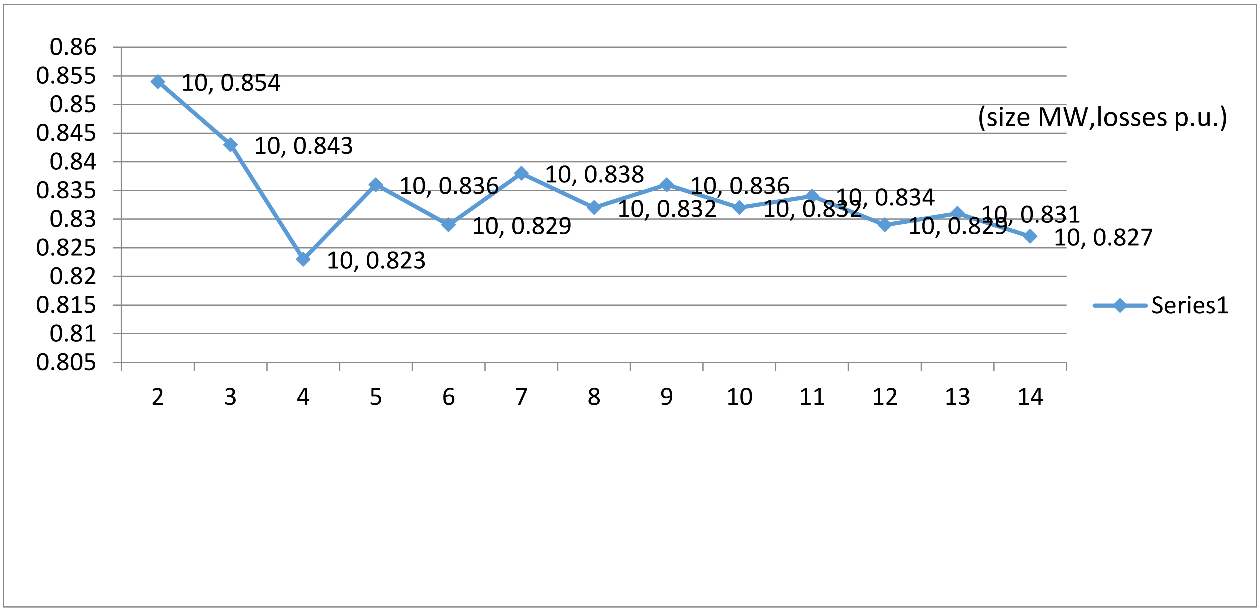
VI. RESULT

The below tables shows the values of losses in per unit and taking 100MVA base and its variation on varying location, size and type of DG and their corresponding graph are given in appendix section.

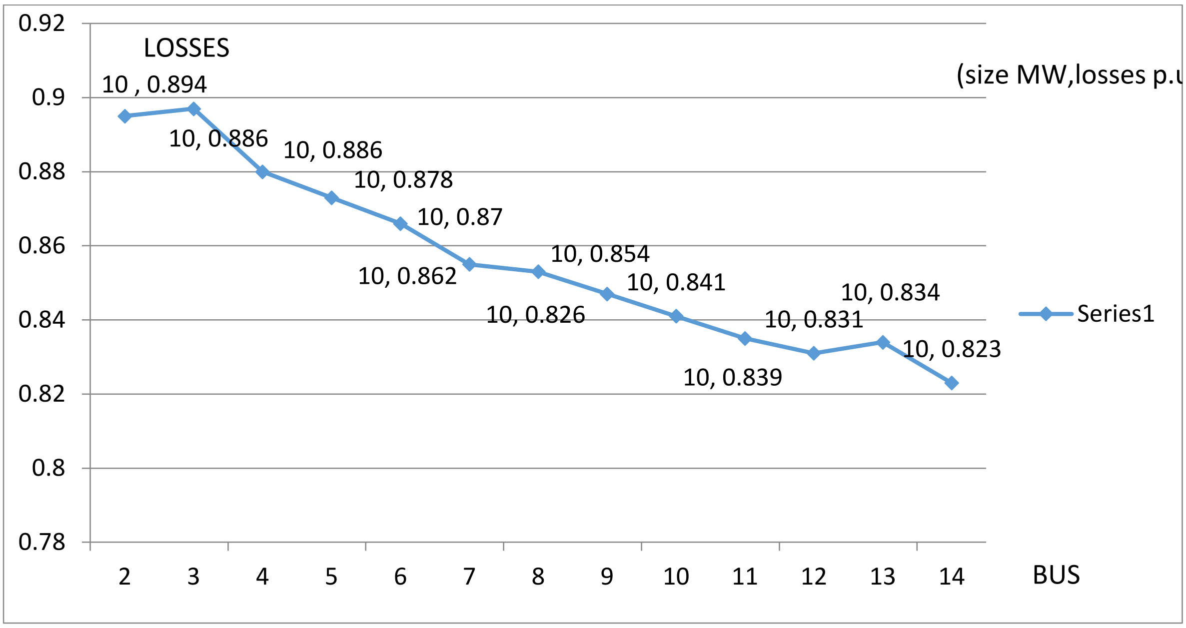
1. TYPE 1 DG

Size (p.u.)	Bus No.												
	2	3	4	5	6	7	8	9	10	11	12	13	14
.01	.898	.896	.894	.896	.895	.896	.8954	.896	.896	.898	.895	.896	.897
.02	.891	.892	.886	.892	.875	.894	.877	.888	.881	.884	.887	.888	.887
.03	.887	.884	.878	.882	.879	.883	.880	.881	.881	.881	.881	.880	.879
.04	.883	.878	.870	.875	.872	.875	.872	.874	.873	.874	.872	.871	.873
.05	.878	.872	.862	.868	.865	.869	.865	.868	.866	.865	.866	.866	.863
.06	.873	.866	.854	.862	.857	.863	.858	.861	.86	.857	.859	.856	.858
.07	.868	.860	.846	.855	.850	.856	.851	.855	.852	.853	.850	.852	.849
.08	.863	.854	.838	.848	.842	.850	.844	.848	.845	.847	.844	.845	.841
.09	.858	.849	.831	.842	.836	.844	.838	.842	.839	.840	.837	.838	.834
.1	.854	.843	.823	.836	.829	.838	.832	.836	.832	.834	.829	.831	.827



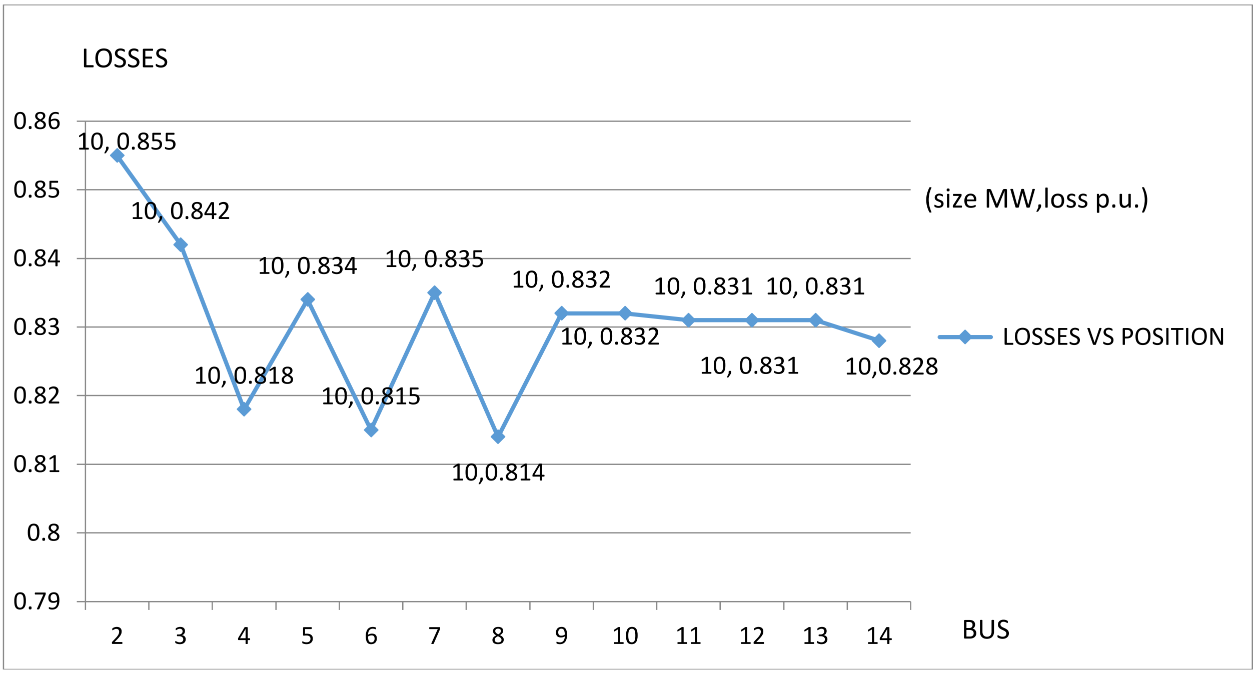
2. TYPE 3 DG

Size (p.u.)	Bus No.												
	2	3	4	5	6	7	8	9	10	11	12	13	14
.01	.898	.897	.8958	.896	.896	.897	.898	.896	.896	.8958	.896	.896	.895
.02	.893	.891	.888	.890	.891	.891	.892	.890	.889	.890	.888	.889	.887
.03	.88	.885	.881	.883	.885	.884	.887	.885	.882	.883	.881	.882	.880
.04	.884	.880	.874	.877	.880	.879	.883	.879	.875	.877	.874	.875	.873
.05	.879	.874	.867	.871	.874	.873	.878	.873	.869	.871	.867	.869	.866
.06	.874	.869	.861	.865	.869	.867	.874	.868	.874	.868	.863	.864	.859
.07	.870	.864	.854	.860	.865	.862	.870	.863	.857	.859	.855	.856	.853
.08	.866	.859	.848	.854	.86	.857	.866	.858	.851	.854	.849	.85	.847
.09	.862	.854	.842	.849	.856	.852	.863	.853	.846	.848	.846	.844	.841
.1	.858	.849	.836	.843	.851	.848	.860	.849	.841	.843	.837	.838	.835



3. TYPE 4 DG

Size(p.u.)	Bus No.												
	2	3	4	5	6	7	8	9	10	11	12	13	14
.01	.898	.896	.894	.896	.894	.896	.893	.895	.895	.895	.895	.895	.894
.02	.893	.890	.885	.888	.884	.888	.883	.887	.887	.887	.887	.887	.886
.03	.887	.883	.881	.887	.881	.873	.874	.879	.879	.879	.879	.879	.878
.04	.882	.877	.867	.874	.865	.874	.864	.872	.872	.872	.872	.872	.871
.05	.878	.871	.858	.867	.856	.867	.855	.865	.865	.865	.864	.865	.863
.06	.873	.865	.850	.860	.848	.860	.847	.857	.858	.858	.857	.858	.855
.07	.868	.859	.842	.854	.839	.854	.838	.851	.851	.851	.85	.851	.848
.08	.864	.853	.834	.847	.831	.847	.830	.844	.844	.845	.843	.844	.841
.09	.860	.848	.826	.840	.823	.841	.822	.838	.838	.838	.837	.838	.834
.1	.855	.842	.818	.834	.815	.835	.814	.832	.832	.832	.831	.831	.828



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VII.CONCLUSION

The loss in the 14 bus system without the use of DG is calculated to be 90.03 MW. Using type 1 DG the loss is calculated to be 82.36 MW and the optimal location is bus no.4 and the optimal size is of 10 MW DG. Using type 3 DG the loss is calculated to be 83.53 MW and the optimal location is bus no.14 and the optimal size is of 10 MW DG. Using type 4 DG the loss is calculated to be 81.46 MW and the optimal location is bus no.8 and the optimal size is of 10 MW DG.
From above cases type 4 DG is suggested at location bus no.8 of size 10 MW which gives minimum loss of 81.46 MW.

VIII. REFERENCES

[1] M. E.Baran and F. F.Wu, "Network reconfiguration in distribution systems for loss reduction and load balancing," *IEEE Trans. Power Del.*, vol. 4, no. 2, pp. 1401–1407, Apr. 1989.

[2] J. Y. Fan, L. Zhang, and J. D. McDonald, "Distribution network reconfiguration:

[3] J. V. Schmill, "Optimum size and location of shunt capacitors on distributionfeeders," *IEEE Trans. Power App. Syst.*, vol. PAS-84, no. 9,pp. 825–832, Sep. 1965.

[4] C.Wang andM. H. Nehrir, "Analytical approaches for optimal placementof distributed generation sources in power systems," *IEEE Trans PowerSyst.*, vol. 19, no. 4, pp. 2068–2076, Nov. 2004.

[5] A. Silvestri, A. Berizzi, and S. Buonanno, "Distributed generation planningusing genetic algorithms," in *Proc. Int. Conf. Electr. Power Eng.(PowerTech Budapest)*, Sep., p. 257.

[6] N. Acharya, P. Mahat, and N. Mithulananthan, "An analytical approach for DG allocation in primary distribution network," *Int. J. Electr. Power Energy Syst.*, vol. 28, no. 10, pp. 669–678, 2006.

[7] T. H. Fawzi, S. M. El-Sobki, and M. A. Abdel-Halim, "A new approach for the application of shunt capacitors to the primary distribution feeders," *IEEE Trans. Power App. Syst.*, vol. PAS-102, no. 1, pp. 10–13, Jan. 1983.

[8] R. A. Gallego, A. J. Monticelli, and R. Romero, "Optimal capacitor placement in radial distribution networks," *IEEE Trans. Power Del.*, vol. 16, no. 4, pp. 630–637, Nov. 2001

IX. APPENDIX

1. STANDARD IEEE DATA

Bus no.	Bus code	Voltage magnitude	Angle degrees	Load		Generator				Injected MVAR
						MW	MVAR	Qmin	Qmax	
1	1	1.06	0	30.38	17.78	40	-40	0	0	0
2	2	1.045	0	0	0	232	0	-40	50	0
3	2	1.01	0	131.88	26.6	0	0	0	40	0
4	0	1	0	66.92	10	0	0	0	0	0
5	0	1	0	10.64	2.24	0	0	0	0	0
6	2	1.07	0	15.68	10.5	0	0	-6	24	0
7	0	1	0	0	0	0	0	0	0	0
8	2	1.09	0	0	0	0	0	-6	24	0
9	0	1	0	41.8	23.24	0	0	0	0	0
10	0	1	0	12.6	8.12	0	0	0	0	0
11	0	1	0	4.9	2.52	0	0	0	0	0
12	0	1	0	8.54	2.24	0	0	0	0	0
13	0	1	0	18.9	8.12	0	0	0	0	0
14	0	1	0	20.86	7	0	0	0	0	0

2. IEEE-14 BUS SYSTEM