OPTIMAL DISTRIBUTED GENERATION PLACEMENT IN RADIAL DISTRIBUTION SYSTEM

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***Abstract-** Recent years, distribution generators have been increasingly installed in distribution system in many parts of the worlds. Depending on their characteristics and locations, Distribution generators could significantly affect the voltage profile and network losses in distribution system. This paper studies the influences of distributed generators (DG) placement in radial distribution systems. The purpose is to minimize losses and increase the voltage profile. In this study the optimal DG placement was simulated using power system simulation programme for planning, design and analysis of distribution system (PSS/Adept) software. The proposed technique was tested on the IEEE 33- bus distribution test system and IEEE 69-bus distribution test system where variation of loading condition was being considered.*

***Index Term-** Distribution generators(DG), PSS/Adept , loss minimization ,voltage stability improvement.*

I. INTRODUCTION

Rapid industrialization process and population growth has resulted in an escalation in the electrical power consumption. The limited areas and slow progress in network expansion has also caused areas with high load densities. At the same time, rural electrification are experiencing poor network performance in terms of large voltage drop and high distribution losses along the lines[1]. There is currently a great deal of interest in distributed power system in both environmental and public policy perspective. Proper placement will also free available capacity for transmission of power and reduce equipment stress[2-3]. Moreover, cost savings can be expected by deferring transmission and distribution upgrades Dispersed, or distributed generation (DG) will affect the electric power system at the system and, more directly, at the distribution level. This study investigates transmission and distribution losses based on location. Simulations will show that proper placement of the units will reduce losses normally seen by the system while improper placement may actually increase system losses. By integrating DG into the utility's power grid, line upgrades can be postponed, and there exists the possibility of greater efficiency of power delivery. Power flows should be reduced, and thus, losses minimized. In particular, heavily loaded feeders or transmission corridors can be relieved. It may also be an opportunity to improve power quality allowing customers and utility equipment more years of usage [3].

Placing DGs to minimize loss based upon a single load point, such as the peak load, may not provide the same optimal solution as when the entire time varying load pattern is considered, therefore time-varying loads are taken into account. Applying DGs to a distribution system may also contribute to improving system reliability. Thus maximizing reliability can also be a criterion for seeking optimal DG location. [4]

This paper studies the influence of location and capacity sizing of distributed generation (DG) towards the radial bus system. The analysis is being implemented on a IEEE 33-bus test system.The test was simulated using power system simulation programme for planning, design and analysis of distribution system (PSS/Adept).[5] The design of IEEE 33-bus distribution test system[6] was being studied for its effect without DG, and with the implementation of DG. To ensure the program accuracy in obtaining the result this program was also tested with IEEE 69-bus test system[7].

II. METHODOLOGY

Figure 1 below, shows the flow of the step being used to obtain the result of the optimal placement of DG in a radial distribution system. The IEEE 33-bus test system and IEEE 69-bus test system will be implemented to test this method.

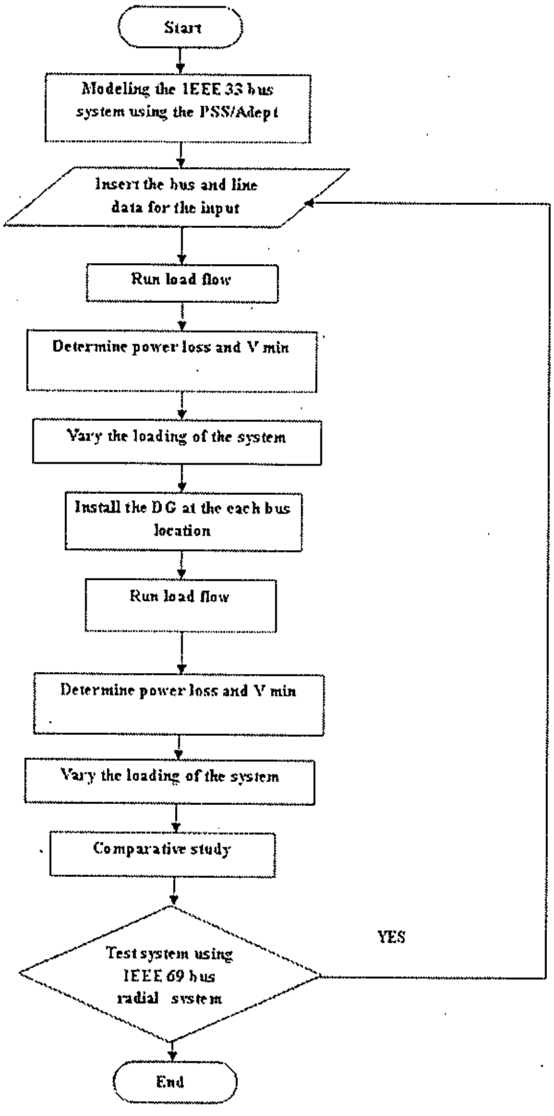

Figure 1 : shows the flow chart of the analysis to obtain the optimal DG placement in distribution system.

The method of this study is more towards the analysis of the placement of the DG on each bus location. In order to determine the optimal DG placement we used heuristically method.The impact on DG placement on each bus location towards reducing the total losses and increasing the minimum voltage was analyzed. The PSS/Adept was used to analyze the system. The initial total power loss was obtained from analyzing the load flow of the IEEE 33-bus test system. The system needs to be model accordingly, with all the bus data and line data of the system needs to be inserted in the modeling system. Figure 2 and figure 3 shows the IEEE 33-bus test system and the IEEE 69-bus test system respectively.

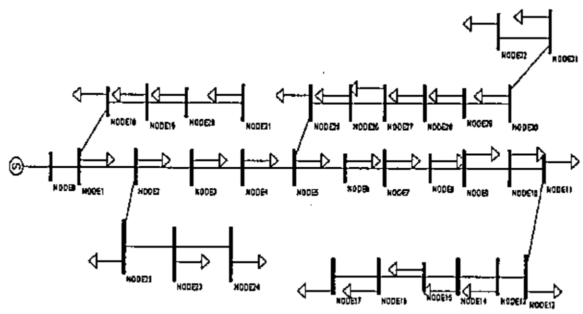

Figure 2: IEEE 33-bus system modeling in The PSS/Adept software.

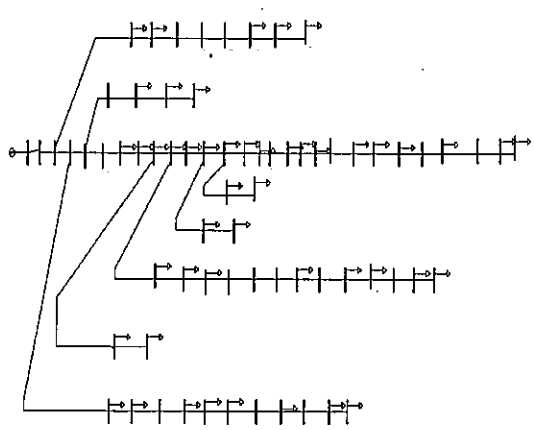

Figure 3: The IEEE 69 bus radial bus system modeling in the PSS/Adept software

The insertion of DG will be place at each bus location one at a time, in order to study the effect of the losses and minimum voltage. The DG was represented as negative load and in PSS/Adept software. The DG was modeled as source in the test system as shown in figure 4.

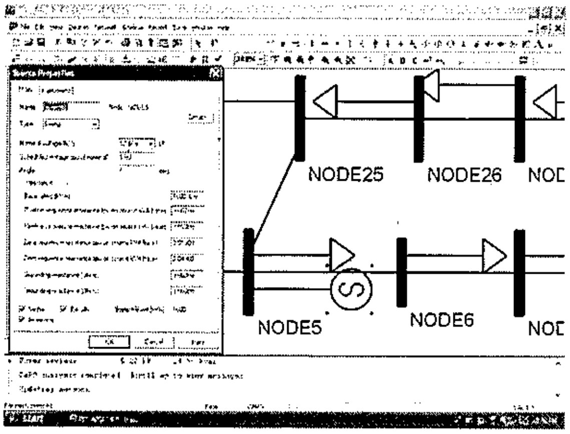

Figure 4 : The source is being used as DG, and the source data is similar to the actual source of the system.

Apart from the study of of DG placement using PSS/Adept, There is also a method to estimate the size of DG that being locate at the bus system. The sizing of DG can be calculated by assuming there is only line losses occurred at the bus system. These equation were used [8]:

$$\sum Pin = \sum Pout \quad (1)$$

$$P_{DG} = P_{Source} - P_{Losses} + P_{load} \quad (2)$$

$$\sum Qin = \sum Qout \quad (3)$$

$$Q_{DG} = Q_{Source} - Q_{Losses} + Q_{load} \quad (4)$$

Therefore the above formula was being used to obtain the size of DG at every bus where it is located. In this test the source being used are negative load.

After the completion of all of this method, the system load was being varied to analyze the effect of loading variation towards the whole system. The result obtained with DG at optimal location was compared to the without DG test system in terms of P_{loss} and V_{min}. The purpose of this comparison is to test the method reliability to use on every radial bus system.

III. SIMULATION RESULT AND DISCUSSION

The IEE 33-bus test system and IEEE 69 bus test system were used in all the simulation. Various location of DG placement was being applied towards the test system. After all the relevant data has been collected, we need to determine the size of DG being installed at each bus, base on the formula given; we tabulated the size of DG due to the effect of installing DG at each bus location .

Table 1: Table showing the overall DG size, power losses, V min when DG being installed at each bus.

DG at bus location	P DG	Size DG	P Loss	V min
Without DG	-	-	19,979.57	0.9773
1	3,268,791	3254908.79	13,882.21	0.9814
2	2,245,191	2466819	10,982.00	0.9848
3	2,122,821	2759368.71	9,010.29	0.9874
4	2,060,712	2936766.88	7,144.12	0.9900
5	1,076,419	2109354.61	5,322.39	0.9924
6	1,340,770	2639014.44	5,909.56	0.9908
7	1,322,572	2839301.09	6,542.91	0.9893
8	1,333,731	3039467.91	7,256.09	0.9882
9	1,239,945	3099607.83	7,846.17	09873
10	1,170,772	3159722.81	8,359.19	0.9866
11	1,105,899	3204819.43	8,814.57	0.9859
12	1,069,288	3264892.86	9,248.14	0.9853
13	1,042,895	3324948.05	9,669.95	0.9848
14	1,080,306	3444973.33	10,156.67	0.9844
15	1,064,716	3504988.79	10,623.21	0.9840
16	1,054,819	3564995.76	11,079.24	0.9835
17	1,049,618	3624999.17	11,527.83	0.9833
18	1,685,659	3354954.88	16,363.12	0.9795
19	1,184,106	3444981.03	17,265.97	0.9788
20	955,749	3534992.73	17,785.27	0.9785
21	836,720	3624995.1	18,157.90	0.9783
22	1,721,353	2784661.31	12,597.69	0.9828
23	1,363,291	2874930.43	13,304.57	0.9818
24	1,429,515	3294997.85	14,183.15	0.981
25	1,468,042	2793233.1	5,689.90	0.9938
26	1,310,758	2853727.1	5,886.92	0.9928
27	1,200,115	2914174.78	5,998.22	0.9921
28	1,120,622	2974581.66	6,064.34	0.9915
29	1,117,024	3094901.88	6,214.12	0.9910
30	1,198,035	3294970.8	6,924.20	0.9902
31	1,236,394	3444998.25	7,684.75	0.9894
32	1,335,872	3655000	8,561.00	0.9888

From table 1 it is shown that the when the DG is installed at the early lines and at the ending line of the radial system, the total power losses are higher compared when the DG installed at the middle of the system and at the branch starting from the middle. The results of other DG that being located at other bus are also shown. From the result, it is shown that the installation of DG at other location also indicated lower total power losses compared without installing DG. However the minimum total losses occurred at bus 5.Therefore we chose bus 5 as the optimal location. For comparisons, bus 2 and bus 25 were also chosen, as the location of DG. Bus 2 represents the DG location at average power losses where as bus 25 represent the second best location for the DG.

The graph in figure 5 and figure 6 illustrates the loss minimization and minimum voltage profile respectively when DG was installed at various locations. The loading was being increased to show the loss minimization effect on the system.

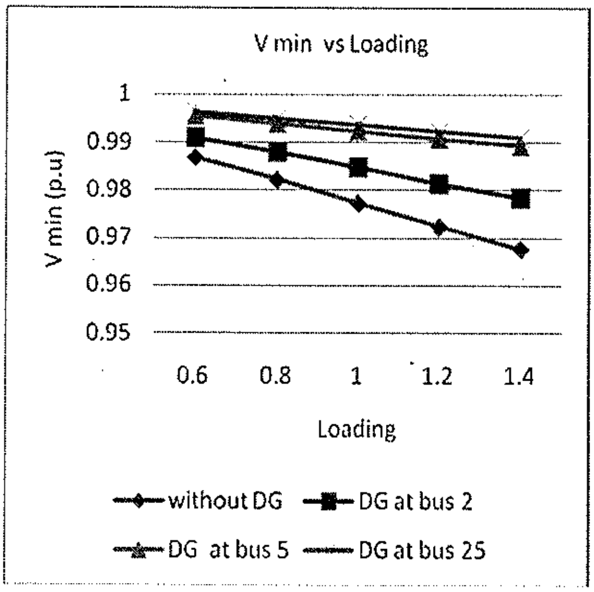

Figure 6: The V min result with overall load increase on the 33-bus radial distribution system

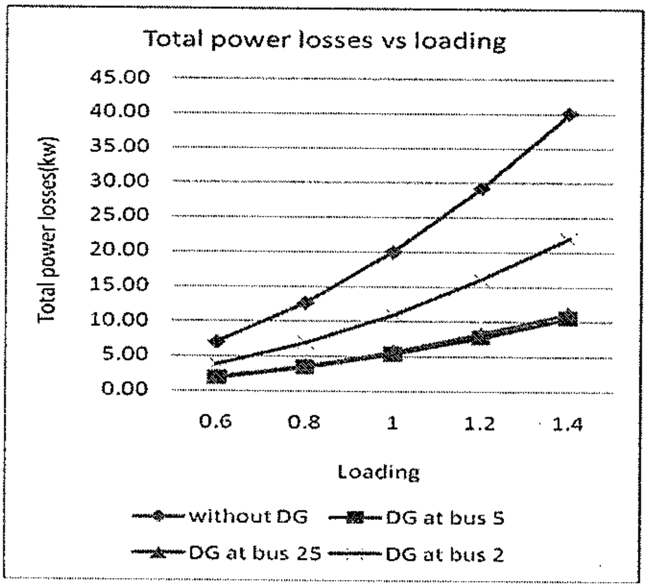

Figure 5: The total power loss minimization result with overall load increase on the 33 bus radial distribution system

From the graph at figure 5, it is shown that the installation at the various location of DG, it would affect the total power loss of the system. From the analysis when DG is installed at bus 5, it produced the minimum loss comparing when there is no DG installed. From the graph at figure 6 it is shown that the installation of DG does not only affect the total power loss but also affect the V min, or voltage profile. It helps to increase the V min of the system. After installing DG at bus 5, the lowest V min of the system was able to produce a slight increase comparing before installing DG.

From the result obtained it shows that when the loading increase the total power loss was also increased, where as when the loading increased the minimum voltage profile was decreased.

The similar analysis was also implemented on IEEE 69- bus test systems. The purpose is to prove the reliability of the method used, in order to determine the losses minimization and increasing minimum voltage profile technique used.

Table 2: Table showing the overall DG size, power losses, V min when DG being installed at the selected bus.

DG at bus location	P DG	Size DG	P Loss	V min
Without DG	-	-	65,047.42	0.9718
Bus 9	155,365	1244306.3	44,161.67	0.979
Bus 50	277,237	2239933.8	6,919.15	0.9913
Bus 51	1,492,649	3483962.7	7,552.29	0.9912

From table 2 it shows the three selected bus where DG were located. From the result, it is shown that the installation of DG at other location also indicated lower total power losses compared without installing DG. However the minimum total losses occurred at bus 50.Therefore we chose bus 50 as the optimal location. For comparisons, bus 9 and bus 51 were also chosen, as the location of DG. Bus 9 represents the DG location at average power losses where as bus 51 represent the second best location for the DG.

The graph in figure 7, and figure 8 illustrates the loss minimization and voltage increment when DG was installed at various location, comparing without installing DG. The test was implemented on IEEE 69 bus test system. The loading was being increased to show the loss minimization effect on the system.

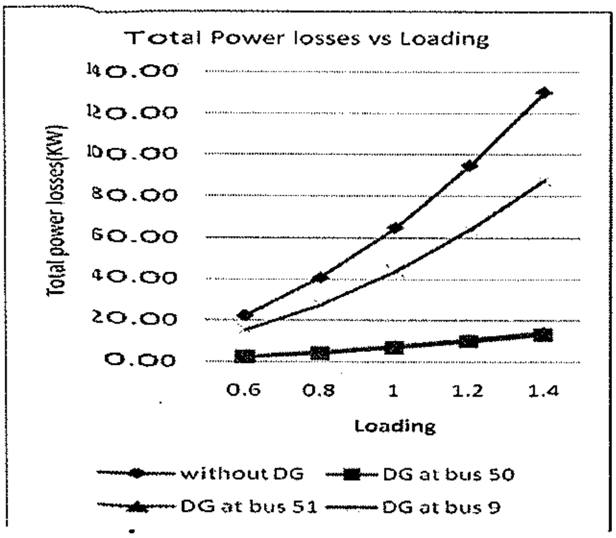

Figure 7: The total power loss minimization result with overall load increase on the 69- bus radial distribution system.

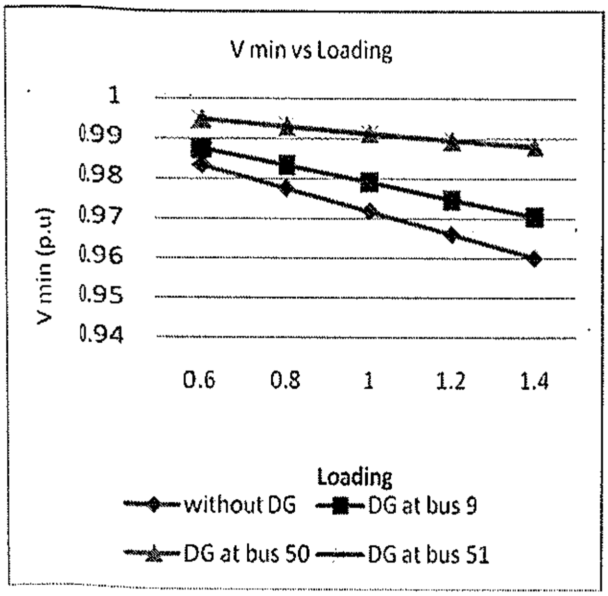

Figure 8: The V min result with overall load increase on the 69-bus radial distribution system

From the graph at figure 7, it is shown that the installation at the various location of DG, it would affect the total power loss of the system. From the analysis when DG is installed at bus 50, it produced the minimum loss comparing when there is no DG installed. The results of other DG that being located at other bus are also shown. From the result, it is shown that the installation of DG at other location also indicated lower total power losses compared without installing DG. However the minimum total losses occurred at bus 50. Therefore we chose bus 50 as the optimal location. Therefore it is proven that the methods used are suitable to minimize the total power loss of the radial distribution systems.

From the graph at figure 8 it is shown that the installation of DG does not only affect the total power loss but also affect the V min, or voltage profile. It helps to increase the V min of the system. After installing DG at bus 50, the lowest V min of the system was able to produce a slight increase comparing before installing DG. Therefore it is also proven that the methods used are suitable to increase the voltage min of the radial distribution systems.

From the result obtained it shows that when the loading increase the total power loss was also increased, where as when the loading increased the minimum voltage profile was decreased.

IV. CONCLUSION

In this paper, the benefit of implementing Distributed Generation (DG) in terms of minimizing the power loss and improving voltage profile condition were analyzed. The optimal location of DG is determined by using heuristically method. The method is by analyzing the impact of DG placement at every bus location. The total power losses in terms of P(KW) and Voltage stability in terms of p.u were being considered during the optimization process. The objective of the optimization is to reduce the total power losses and voltage stability improvement at the system. The test was implemented on IEEE 33- bus test systems and IEEE 69-bus test system.

The simulation was carried out using software PSS/Adept with various loading condition. The results obtained were compared with the system without DG. From the numerical simulation, the presence of DG at the proposed location and sizing are able to produce the best results in terms of voltage profile improvement and power loss minimization at various loading condition.

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