Impact of DG Integration in Distribution System on Voltage Stability and Loss Reduction for Different Loading Conditions

Rudresha S. J., Shekhappa G. Ankaliki, T. Ananthapadmanabha

Abstract: One of the modern and important techniques in the electrical distribution systems is to solve the networks problems service availability, high loss, improve system voltage and reliability, these can be resolved by accommodating small scaled de-centralized generating stations in networks, which is known as Distributed Generation (DG).Distributed generation (DG) units placed at the consumer end will minimize electric power losses, improve reliability and voltage profile in the system. This paper, presents a method to determine the proper size and location of DG in a distribution system to reduce the losses and improve the voltage stability for different loading conditions. The IEEE 33-Bus system is used to simulate in Power World Simulator (PWS) software and the voltage profile and losses in the system are analyzed. The Simulated result shows that proper placement and sizing of DG will reduce losses in the system and improve voltage profile within the allowable limit and there by improve the voltage stability.

Index Terms: Distribution system; Distributed generation; Optimisation; Power loss; Sensitivity factor; voltage stability.

I. INTRODUCTION

The present traditional electrical power system includes power generating plants mainly, hydro, thermal and nuclear. These power plants are placed far away from the consumer end and the electricity is transmitted from the generating end to the consumer end through long transmission and distribution lines. The power plants, transmission and distribution systems are used to maximum extant and there is no possibility to load it further and overloading of the system may cause the voltage drop which may leads to complete block out of the system. The option to meet this growing in load demand is by increasing the generation and expansion of transmission and distribution system which is not economical and not environmental friendly. [1].

Therefore, the other alternative to solve the above problem is to generate the electricity at the consumer end that is called as distributed generation (DG).The distributed generation is a small-scale electricity generation by using energy sources, such as wind energy, solar, fuel cells and micro-turbines [2][3]. The DG units can be connected directly to supply the load without the support of utility grid or it can also be connected to operate in parallel with the utility grid.

When it is operating alone like micro-grid care should be taken about voltage stability and power quality and reliability due to uncertainty of renewable sources like wind and solar. When it operating in parallel with the central grid care should be taken to synchronize with the grid and also it affects the voltage profile and losses.[4][5]

If The DG units is of small capacity when it is compared to central power grid , then its impact is less but if its size is more then its effects on the system is more [6].

II. STATEMENT OF THE PROBLEM

Introduction of distribution generation into the distribution systems causes lot of changes in the power system i.e. voltage, power quality, stability, reliability, power flow and power system protection. The effects of the DG on stability means, its effects on voltage stability, frequency stability and angle stability. Out these the voltage stability is more important in the distribution system. [7].

In the distribution system if the generation is equal to load plus losses i.e active and reactive power are balanced then there is no problem in its normal operating conditions. However, some unexpected situation such as drastic increase in the load may leads to abnormal condition. The common abnormal conditions are reduction in voltage at the buses which leads to voltage instability in the system [8][9].

The placement of inappropriate DG size and location can increase the losses in the system and also decrease or increase in voltage level at some buses in the distribution system leads to voltage instability[10][11].Therefore, the objective of our analysis is to minimise the losses and to verify whether the voltage profile is within acceptable limit. So that voltage stability is maintained in the system with the connection of DG into the distribution system. The voltage constraints are, given by

$$V_{imin} \leq V_i \leq V_{imax}$$

During this analysis, as per the standard we considered 6% variable voltage as acceptable stable voltage limit i.e. V_{imin}=0.94 p.u and V_{imax}=1.06 p.u. The following section will give details of how proper size and location of DG affects the voltage stability in the distribution system.

III. METHODOLOGY

In this paper, the analysis is done using loss sensitivity factor and a new method is given to find the optimum size and location of DG using power world simulator software package to reduce losses and improve voltages at the different buses that improves voltage stability in the distribution system.

Revised Manuscript Received on January 10, 2020.

***** Correspondence Author

Rudresha S. J.*, Research Scholar,Electrical & Electronics Engineering department, SDMCET Dharwad, Visvesvaraya Technological University, Belgaum.,Karnataka, India.

Dr. Shekhappa G. Ankaliki, Electrical & Electronics Engineering department, SDMCET, Dharwad, VTU, India.

Dr. T. Ananthapadmanabha, Electrical and Electronics Engineering department, NIEIT, Mysuru, VTU,India.

The method is applied for 33 bus system and results are verified with and without DG to find optimum location and size required to minimize losses and improve voltage stability of distribution system for different loading conditions.

IV. FORMULA TO FIND SENSITIVITY

In distribution system, if DG size is changed from P_{DG1} to P_{DG2} then the change in its in power loss is P_{L1} to P_{L2}, and then the sensitivity factor is given by,

$$\frac{dP_L}{dP_i} = \frac{P_{L1} - P_{L2}}{P_{DG1} - P_{DG2}}$$

In this method, Sensitivity factors are calculated at all buses by using above equation and the bus which is having maximum sensitivity is noted. In remaining buses, only buses which are having sensitivity factors close to the maximum value are chosen so that system calculation is minimised only to a few buses. Then, at all of these buses, power loss is calculated by placing the large step size of DG and graph is drawn using above
Selected values.

In the graph the minimum value indicates the minimum loss, for a particular DG size which is the optimum DG size and the bus at which this minimum loss occurs is the optimal location of DG.

V. STEPS TO CARRY OUT SIMULATION USING POWER WORLD SIMULATOR

The following steps are carried out to model the test system in the power world simulator

- Draw the buses and enter the data.
- Draw the transmission lines and enter the data as given in the test system.
- Draw the generators and enter the data.
- Draw the load and enter the data.
- Now run the model and observe the voltage at all the buses and total losses in the system without DG.
- Find the sensitivity factor at each bus with small penetration of DG and note the most sensitive buses.
- Choose a bus from the above list and find the power loss by varying DG in large size.
- Follow the same step until power loss starts increasing and note down each value. Continue same procedure at all the sensitive buses.
- Choose a bus at which power loss is minimum and its corresponding DG size.
- Find the voltages at all the buses with optimum DG size and location
  and check for voltage stability in the system
- If the voltage profile and hence the stability is not maintained at all the buses then increase the DG size at a optimum location until the voltage stability is maintained.

VI. SIMULATION RESULTS OF THE TEST SYSTEM

The above method is applied to a standard 33 bus system which has been taken as the bench mark problem in many IEEE papers.

Ieee 33 – Bus System

The above method is applied to 33-bus system using power world simulator.

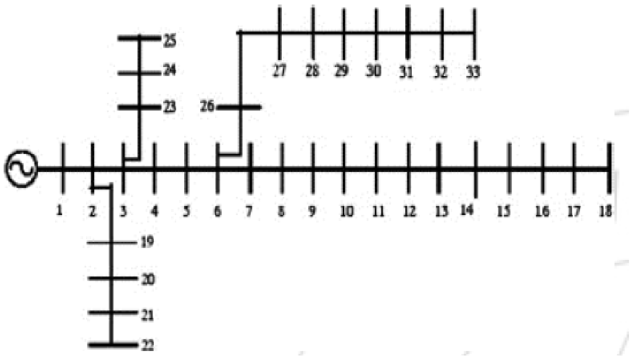

Figure.1. IEEE 33- bus test system

The total load in the system is 3.72 MW and 2.3 MVAR.By applying proposed method as given in the algorithm the minimum MW loss is occurred when distributed generation is incorporated at bus 13 with 30 % of generation and it is given in table-1 and shown in figure 2.

Table-1

% of Distributed generation at Bus 13	Distributed MW generation	MW losses
20	0.8100	0.1494
29	1.1745	0.1493
30	**1.2150**	**0.1473**
31	1.2555	0.1493
40	1.6200	0.1772
50	2.0250	0.2316

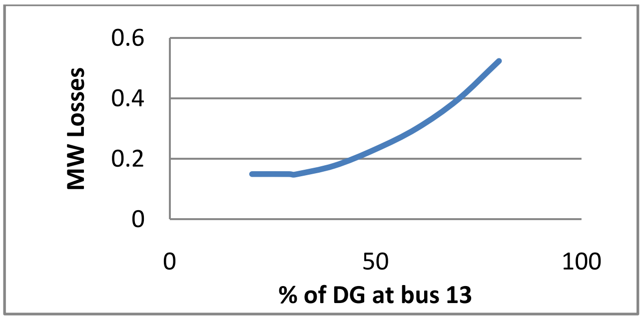

Figure 2. MW loss v/s % of DG at bus 13

Therefore the bus -13 can be chosen as optimum location due to minimum losses with 30% DG at bus -13

The voltages at bus -13 with this 30% DG are not within the limits therefore to obtain the voltage at all the buses within the limits and to maintain the voltage stability in the system % DG is increased at bus -13 till the voltages at the all the buses are within the limits. In this case for 50% of DG at bus -13, all the bus voltages are within the limits.

The comparison of voltages at the various buses with and without DG is shown in figure .3

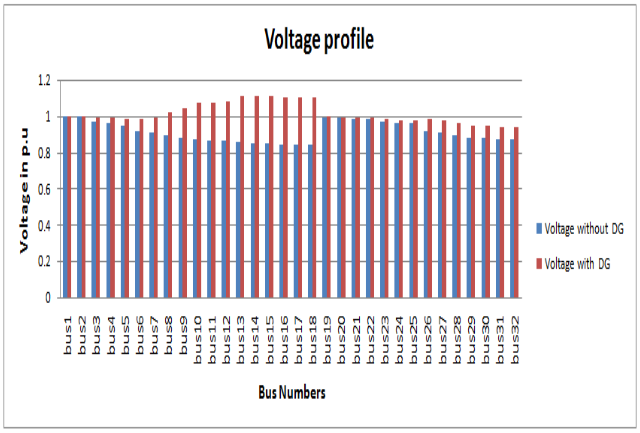

Figure. 3. Voltage Profile of 33- bus system before and after placement of DG

Effects of Load Change on Losses and Voltage Stability

In power system load is not constant but it continuously varies, so it required to study the effects of load change on losses and voltage stability of the distribution system. In this work the load change effects is studied in IEEE 33- bus standard test system with and without placing the DG.

Effects of Load change on Losses and voltage stability in 33-Bus test system with and without placing the DG

The losses and voltage stability is analyzed with and without DG for 75, 85, 95,105,115 and 125 percentage of load in 33-bus test system. The optimal location of DG obtained is at bus 13 which is obtained from proposed Sensitivity factor method.

The voltage profile with and without placing the DG for different load level is analyzed and it is shown in figure 4.

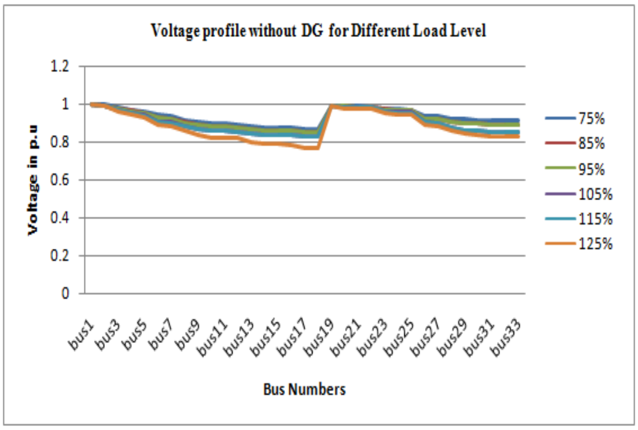

Figure 4. Voltage Profile of 33-bus system without DG for different load level

After placing the DG at bus 13 with different DG size for various load level the voltage at all the buses are improved as shown in figure 5.

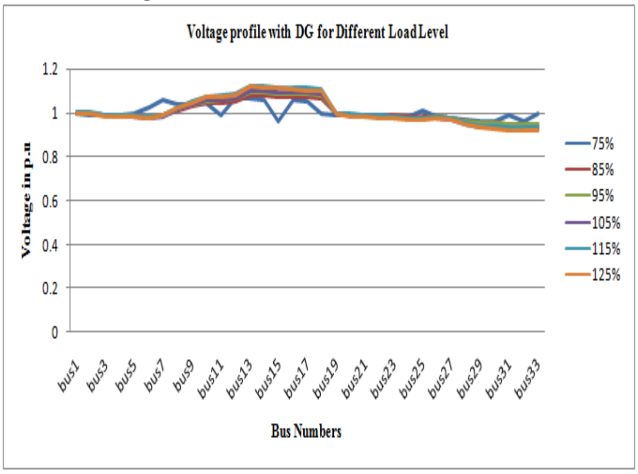

Figure 5. Voltage Profile of 33-bus system with DG for different load level

DG size for different load level in 33-Bus system

DG size required for different load level to maintain voltage stability in the 33-Bus system is different and is tabulated in table-2.

Table-2

Load Level in %	75	85	95	105	115	125
Active Power supplied by DG in MW	1.485	1.705	1.905	2.145	2.355	2.615
Reactive Power supplied by DG in MVAr	0.925	1.065	1.185	1.340	1.470	1.635

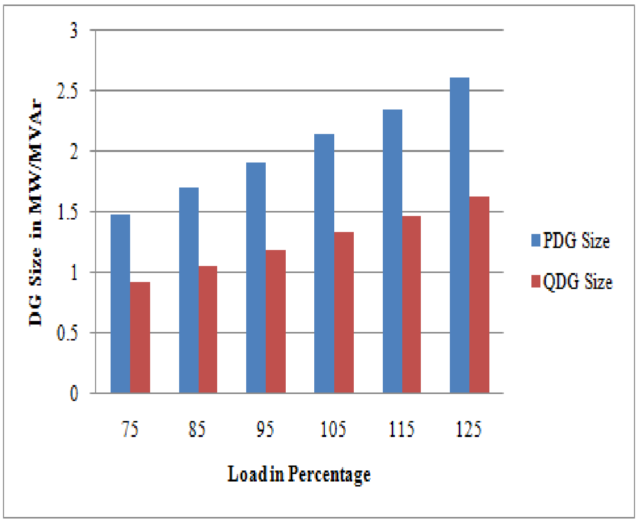

Figure. 6. DG size for different load level in 33-Bus system

It is observed from the figure 6 that as load level increases the DG size required also increases to maintain the voltage stability in the system.

The Power Loss with and without placing DG in 33-Bus system

The active and reactive power loses with DG and without DG for 33-Bus system for different load level is tabulated in table-3

Table-3

Load Level in %	75	85	95	105	115	125
Active Power Loss in MW without DG	0.180	0.248	0.276	0.384	0.432	0.580
Active Power Loss in MW with DG	0.070	0.108	0.156	0.234	0.302	0.310
Reactive Power Loss in MVAr without DG	0.125	0.175	0.185	0.265	0.295	0.395
Reactive Power Loss in MVAr with DG	0.035	0.045	0.065	0.185	0.225	0.235

The active power loses with DG and without DG for 33-Bus system for different load level is shown in figure 7 and the reactive power loses with DG and without DG is shown in figure 8.

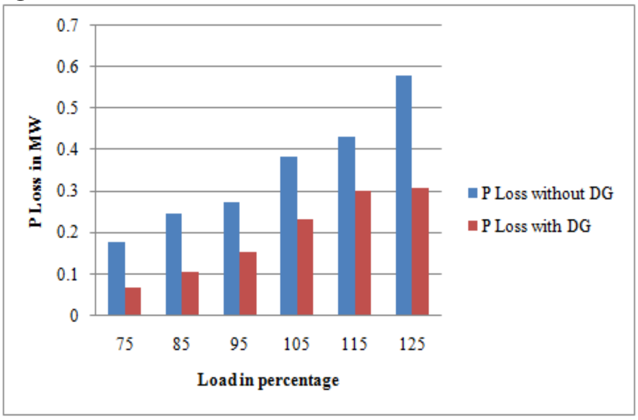

Figure. 7. Active power loss with and without DG in 33-Bus system

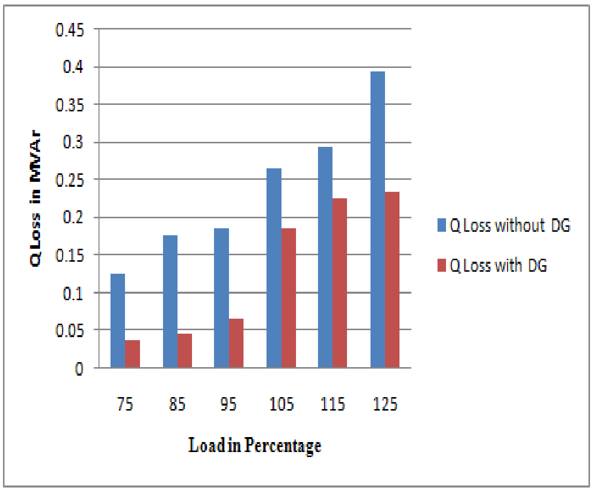

Figure.8. Reactive power loss with and without DG in 33-Bus system

The percentage reduction in loss is tabulated in table-4

Table-4

Load Level in %	75	85	95	105	115	125
P Loss reduction in %	61.11	56.45	43.47	39.06	30.09	46.55
Q Loss reduction in %	72	74.28	64.86	30.18	23.73	40.50

It can be observed from the table-4 that with DG at optimal location 20 to 70 % of losses can be reduced.

VII- CONCLUSION

The DG size and location plays a very important role in the application of DG to minimise the losses and improve voltage stability in the system. In this paper an algorithm is given to find the optimum location and size of DG to reduce the total power losses and improve the voltage profile in primary distribution system and the voltage stability analysis is done for different load level. The IEEE-33 bus system is taken for analysis and simulation is done using power world simulator software, the results shows that the optimal location of the DG can reduce power losses and Voltage stability can be improved by selecting proper size of DG at a selected optimal location which improves overall performance in the distribution system.

REFERENCES

1. Ackermann, T. Andersson G.Soder, L. "Distributed generation: a definition," Electric Power System Research, Vol. 57, pp. 195-204, 2000
2. J.Momoh, G.D.Boswell, "Improving power Grid Efficiency using Distributed Generation" Proceedings of the 7th international conference on power system.pp.11-17, Jan-2007
3. P. Dondi, D. Bayoumi, C. Haederli, D. Julian, and M. Suter, "Network integration of distributed power generation," J. Power Sources,vol. 106, pp. 1-9, 2002.
4. Rudresha S J , Dr. Shekhappa G. Ankaliki, Dr.T.Ananthapadmanabha "Voltage stability Analysis with integration of dg into the distribution system" IJSDR, Volume 3 Issue 7, July-2018
5. N. Hadjsaid, J. F. Canard, and F. Dumas, "Dispersed generation impact on distribution networks," IEEE Comput. Appl. Power, vol. 12, pp. 22-28, 1999.
6. P.Sindhu Priya and N.Chaitanya kumar reddy "Optimal placement of the DG in radial distribution system to improve the voltage profile". International Journal of Science and Research, ISSN :2319-7064,2015.
7. Rudresha S J, Dr. Shekhappa G. Ankaliki and Dr.T.Ananthapadmanabha "Loss minimization and Voltage Stability improvement with integration of Multiple DG's into the distributed System" IJSER, Volume 10 Issue 5, May-2019.
8. V.V.S.N. Murty, Ashwani Kumar "Optimal placement of DG in radial Distribution systems based on new voltage stability index under load growth" Electrical Power and Energy Systems journal.pp.246–256, 2015

9. Somashekar D.P, Shekhappa G. Ankaliki, Ananthapadmanabha T, Ramya N.S **"**Impact of Distributed Generation on Network Reconfiguration for Power Loss Minimization in Radial Distribution System by Hybrid Algorithm" ", IJRTE, Volume-8 Issue-3, sep-2019, pp.8020-8025.
10. Vericherla N Malleswari, K. Chandra Sekhar "Voltage Stability Assurance Based Optimal Location and Sizing of Distribution Generation in Radial Distribution System" IOSR Journal of E and E Engineering, Volume 13, Issue 4, Jul. –2018, PP 46-50.
11. Arulraj Rajendran,Kumarappan Narayanan "Optimal Installation of Different DG Types in Radial Distribution System Considering Load Growth" Electric Power Components and Systems, pp.739–751, 2017

AUTHORS PROFILE

Mr. Rudresha S. J., is currently working as assistant professor in the department of EEE in PESITM Shimoga. He obtained his B.E, M.Tech from Visvesvaraya Technological University, Belgaum, and Karnataka. Presently he is pursuing his ph.D in Power System at SDMCET under VTU. He is having 9 years of teaching experience and he has published more than 8 papers in various international and national conferences and journals.His field of interest includes distribution system reliability analysis, distributed generation, voltage stability analysis, power quality and energy system.

Dr. Shekhappa. G. Ankaliki, is currently working as a Professor and HOD, Department of Electrical Electronics Engineering in SDM college of Engineering, Dharwad. He obtained his B.E, M. Tech. from Mysore University and Ph. D. From Visvesvaraya Technological University, Belgaum, and Karnataka. He is a life member of ISTE, ISWE and MIE. He has published number of papers in National and International Journals and Conferences. His research interest includes AI application to Power Systems, Power System Security, distribution system automation, distributed generation resources for power system
Energy Audit, Energy Management and Demand Side Management

Dr. T. Ananthapadmanabha, received his B.E. degree in Electrical and Electronics Engineering, M.E degree in Power System Engineering and Ph.D degrees in 1982, 1986 and 1997 from Mysore University, Mysore, Karnataka, India. He was with faculty of Electrical and Electronics engineering department at PES College of Engineering, Mandya, Karnataka, former professor and head in department of Electrical and Electronics Engineering at The National Institute of Engineering, Mysuru, Karnataka. And, also he was a principal at NIE Institute of Technology, Mysuru. He is having 32 years of teaching experience and published more than 160 numbers of various international and national conferences & journals. He is a life member of IEEE and also a member of Institution of Engineers (India). His current research areas include artificial intelligence techniques on power system applications; knowledge based expert systems, distribution system operational planning, service restoration, distribution system automation and distributed generation resources for power system.