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Effects of Integration of Multi Type DGs on Voltage stability and Loss Minimization in the Distribution System

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ABSTRACT

In recent days in distribution system the more importance is giving to Loss minimization techniques since electricity demand is continuously increasing and utility companies are struggling to meet this rapid increase in load due constraints on energy resource to increase the generation. Furthermore, voltage instability phenomena is also playing important role in distribution systems and caused a major blackout in the network. To solve the above problem new technology that is drawing more attention is Distributed Generation (DG). Placing DG in the distribution system inherently reduces the power loss and improves the system voltage. The selection of type of DG, proper placement and sizing of DG plays an important role.

This paper presents an effective methodology to identify the optimum location of multi type DG in the distribution system in order to reduce the losses and improve the voltage. In this work the IEEE 33-Bus system is simulated in Power World Simulator (PWS) and the voltage stability and system losses are analyzed with different types of DGs and combination of different types of DGs are studied. Simulation result shows that optimal placement and sizing of DG will reduce the system losses and improve the voltage profile within the acceptable limits and the loss reduction and voltage profile improvement are depending on the types of DGs and combination of DGs placed in the distribution system.

Index Terms**: Distributed generation, Optimum size, Optimum location, Power loss, Power world simulator, Sensitivity analysis, Types of DG, Voltage stability.**

I.INTRODUCTION

A traditional electrical generation system consists of large power generation plants, such as thermal, hydro, and nuclear. Because these plants are located at significant distances from the load centres, the energy must be transported from the power plants to the loads through transmission lines and distribution systems. These plants, transmission lines, and distribution systems are currently being utilized to their maximum capacity, but the load demand is growing. This increase in load demand requires that new generation power plants be built and that the transmission and distribution systems be expanded, neither of which is recommended from an economic or environmental perspective [1].Therefore, interest in the integration of distributed generation (DG) into distribution systems has been rapidly increasing, distributed generation is defined as small-scale electricity generation fuelled by renewable energy sources, such as wind and solar, or by low-emission energy sources, such as fuel cells and micro-turbines[2].

DG units are typically connected so that they work in parallel with the utility grid, and they are mostly connected in close proximity to the load [3]. DG units have not so far been permitted without a utility grid. However, the economic advantages of utilizing DG units, coupled with the advancements in techniques for controlling these units, have led to the definite possibility of these units being operated in an autonomous mode, or what is known as a micro grid. Hence, distribution systems with embedded DG units can operate in two modes: grid-connected and autonomous mode.

In grid-connected mode, although the voltage and frequency are typically controlled by the grid and the DG units are synchronized with the grid, integrating

DG units can have an impact on the practices used in distribution systems, such as the voltage profile, power flow, power quality, stability, reliability, and protection [4]. Since DG units have a small capacity compared to central power plants, the impact is minor if the penetration level is low. However, if the penetration level of DG units increases the impact of DG units will be profound. Furthermore, if the DG units operate in autonomous mode, as a micro grid, the effects on power stability and quality are expected to be more dramatic because of the absence of the grid support and also it depends on which types of DGs are used in the system [5][6].

Interest in Distributed Generation (DG) in power system networks has been growing rapidly. This increase can be explained by factors such as environmental concerns, the restructuring of electricity businesses, and the development of technologies for small-scale power generation. DG units are typically connected so as to work in parallel with the utility grid, however, with the increased penetration level of these units and the advancements in unit's control techniques, there is a great possibility for these units to be operated in an autonomous mode known as a micro grid.

II.STATEMENT OF THE PROBLEM

The impact of the DG units on stability problem can be further classified into three issues: voltage stability, angle stability, and frequency stability. As both angle and frequency stability are not often seen in distribution systems, voltage stability is considered to be the most significant in such systems [7].The voltage stability problems in the distribution system is due to the following reasons.

a. With the development of economy, load demands in distribution networks are sharply increasing. Hence, the distribution networks are operating more close to the voltage instability boundaries [8].
b. The integration of distributed generation in distribution system introduces possibility of encountering some active/reactive power mismatches resulting in some stability concerns at the distribution level [9][10].

The inappropriate size and allocation of DG can cause low or over voltage in the distribution system leading to voltage instability. Therefore, another goal of our analysis is to check whether the voltage profile remains within permissible limit. So, voltage constraint becomes,

$$V_{min} \leq V \leq V_{max}$$

During this analysis, as per the standard we considered 6% variable voltage as acceptable stable voltage limit i.e. V_{min}=0.94 p.u and V_{max}=1.06 p.u.

III.PROPOSED ANALYSIS METHOD

In our analysis, Based on sensitivity, a new methodology has been proposed to calculate optimum size and location of DG using power world simulator package in order to reduce the losses and improve the voltages at the different buses which improves the voltage stability in the system. The results are tested for 33-bus system with and without DG for optimal location and optimal size required to minimize losses and improve the voltage stability of the system.

IV.FORMULA TO FIND SENSITIVITY

For any distribution system, if DG size is varied from P_{DG1} to P_{DG2} and their corresponding change in power loss is respectively P_{L1} to P_{L2}, then the sensitivity factor becomes,

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

In our analysis, Sensitivity factors are evaluated for each bus using equation and the bus with maximum sensitivity is identified. Only those buses which have sensitivity factors close to the maximum value have been considered in our analysis. Thus solution space is reduced to only a few buses. After that, for each of these buses, power loss has been determined using large step size of DG variation and then graph is drawn using these few samples.

Types of Distributed Generation (DG).

The DG's are grouped into four major types based on the real and reactive power delivering capability [11].
Type1: DG capable of delivering both active and reactive power. DG units based on synchronous machines (cogeneration, gas turbine, etc.) come under this type.
Type2: This type of DG is capable of delivering only active power such as photovoltaic, micro turbines, fuel cells, which are integrated to the main grid with the help of converters/inverters.
Type3: DG capable of delivering only reactive power. Synchronous compensators such as gas turbines and capacitor banks are the example of this type and operate at zero power factors.
Type4: DG capable of delivering active power but consuming reactive power. Mainly induction generators, which are used in wind farms, come under this category. However, doubly fed induction generator (DFIG) systems may consume or produce reactive power i.e. operates similar to synchronous generator

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 loads enter the data.
- Now run the model and observe the voltage at all the buses and total losses in the system without DG.
- Calculate sensitivity of each bus with small penetration of DG and Make list of most sensitive buses
- Select a bus from the list and calculate power loss for large variation of DG size
- Continue until power loss starts to increase and record each sample
- Check whether all sensitive buses have been analyzed
- Find the bus which has minimum power loss and find corresponding DG size
- Find the voltages at all the buses with optimum DG size and location
- Check for voltage stability of the system
- If the voltage stability is not maintained at all the buses then increase the DG size at a optimum location until the voltage stability is maintained.
- Place different types of DG and different combination and repeat the above procedure.

VI.SIMULATION RESULTS AND DISCUSSION

The proposed method has been applied to standard 33-bus systems as shown in fig.1 which have been taken as the bench mark problem in many IEEE papers.

IEEE 33 - BUS TEST SYSTEM

Case A: Voltage Stability and Loss Reduction Analysis with Single DG

- **Type 1 DG**

Proposed method is applied to 33-bus system with type1 DG using power world simulator as shown in fig 2.

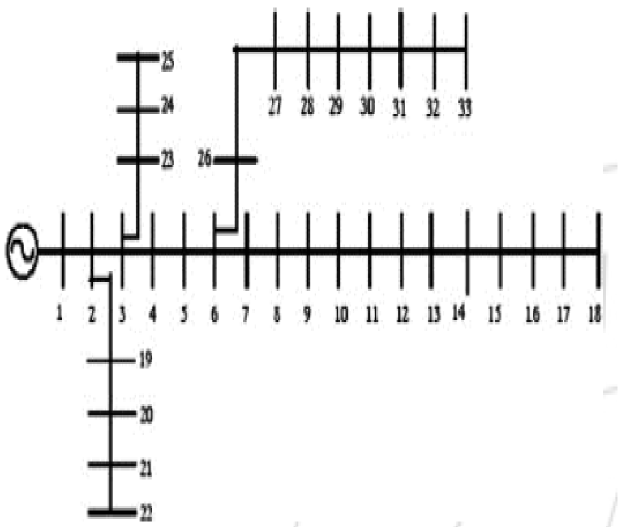

Figure.1. IEEE 33- bus test system

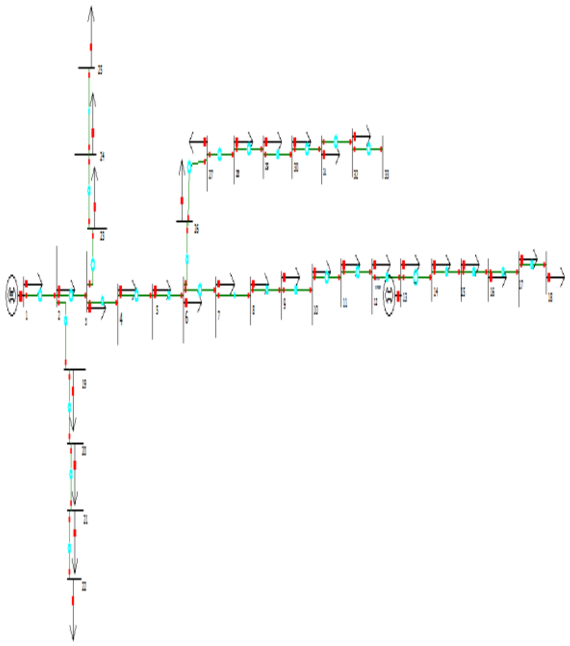

Figure.2.The IEEE 33-bus Test system is Modelled using power world simulator

By applying the proposed method as given in the algorithm the minimum MW loss is occurred when Type1 distributed generation is incorporated at bus 13 and with 50 % of DG at bus -13, all the bus voltages are within the limits [12].

Case B: Voltage Stability and Loss Reduction Analysis with Integration of Multiple DG's

Power loss and voltage stability analysis is done by placing combination of different types of DGs in the 33-bus system. The different case studies are considered with different combination as given below.

Case 1: Combination of type1 and type 2 DG

In this case Type1 DG is placed at bus 13 which is calculated from sensitivity factor method and Type2 DG is placed at bus 33 which is the weakest bus in the system and voltage stability and loss reduction is analysed and is tabulated in table 1.

Case 2: Combination of type1 and type 3 DG

In this case Type1 DG is placed at bus 13 which is calculated from sensitivity factor method and Type3 DG is placed at bus 33 which is the weakest bus in the system and voltage stability and loss reduction is analysed and is tabulated in table 1.

Case 3: Combination of type1 and type 4 DG

In this case Type1 DG is placed at bus 13 which is calculated from sensitivity factor method and Type4 DG is placed at bus 33 which is the weakest bus in the system and voltage stability and loss reduction is analysed and is tabulated in table 1.

Table. 1. Loss Reduction Analysis

DG Type installed	With out DG	DG Type1 & DG Type 2	DG Type1 & DG Type 3	DG Type 1 & DG Type 4
DG location at bus	-	13 &33	13 & 33	13 & 33
Active power supplied by DG in MW	-	1.0130 1.0130	2.0250 0	1.0130 1.0130
Reactive power supplied by DG in MVAr	-	1.26 0	0.6300 0.6300	0.6300 -0.6300
Active power Loss in MW	0.33	0.0707	0.003	0.1983
Reactive power Loss in MVAr	0.22	0.1146	0.0049	0.1519
P Loss Reduction in %	-	78.57	96.09	39.90
Q Loss Reduction in %	-	47.90	97.77	30.95

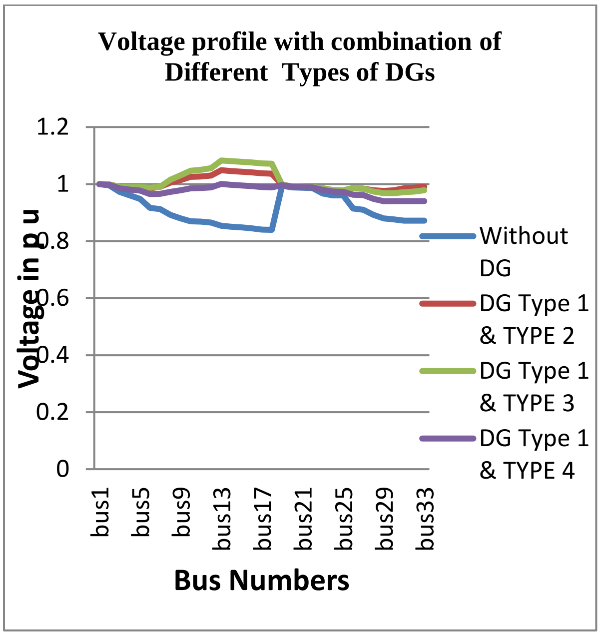

Figure 3. Voltage Profile of 33- bus system with combination of different types of DG

The figure 3 shows the voltage stability analysis with integration of Different combination of Multi type DG.The voltage stability of the system is more for the combination of type1 and type2 DGs then type1 and type3 DGs and less for type1 and

type4 DGs.This voltage stability and loss reduction depends on different combination of multi type DGs. The loss reduction is more for the combination of type1 and type3 DGs as compared to other combination of DGs and it is noted in table 1.

VII- CONCLUSION

The loss minimization and voltage stability improvement in distribution system depends on Proper Size of DG , location of DG,types of DGs and combination of DGs .This paper presented a methodology to be applied to effectively reduce the power loss in a radial distribution network by optimally locating two different types of DGs with proper sizing. In this paper IEEE-33 bus system is taken for analysis and simulation is done using power world simulator software, the results shows that the location of different combination of DGs and its size has a main effect on the power losses and Voltage stability.

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