Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 5, Issue 01, January -2018

THE IMPACT OF DISTRIBUTED GENERATION ON IEEE BUS SYSTEM

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ABSTRACT: *Distributed or dispersed generation (DG) is small scale power generation system that is typically connected in the distribution system. It is also known as embedded generation (EG). It is usually connected in the distribution system to improve the reliability, to increase the voltage profile and to reduce the line losses of the system. These impacts could be achieved with optimal allocation and size of DG. Power losses are categorized as real power loss and reactive power loss. The resistance of lines gives rise to the real power loss and reactive power loss is caused due to reactive elements embedded in the system. Power loss in a system could be reduced by controlling the reactive power and regulating the node voltages. In this paper, the investigation is done to study the impact of multi DGs on power losses. The study has been carried out on IEEE bus system. The analysis of the results showed that by increasing the number of DGs in the system to reduce losses is not beneficial. In this paper, it is concluded that the optimal number of DGs are also important parameter to reduce the losses.*

I. INTRODUCTION

The traditional approach in an electrical power system has been to have centralized large Capacity power plants feeding power to distant load centers through an extensive transmission and distribution network. Due to environmental concerns regarding pollution, accidents and loss of forested area Distributed Generators have emerged as a viable alternative to conventional power generation. DG provides electric power there by eliminating the need to upgrade transmission lines and increase the capacity of remote power plants. For conventional radial feeders, without any DG, the power flows only in one direction from the feeding grid towards the loads. Therefore the voltages decrease towards the end of the feeder. When DG is added in a system, we have to consider the situation when the DG exceed the local load and power flows in reverse direction, that is, towards the high voltage grid. Hence, the power flow can either be from the grid toward loads, or vice avers. Then we have two very different load flow situations to consider in the power system analysis. The opposite load flow conditions give totally different voltage distribution in the system. With large interconnection of the electric networks, the energy crisis in the world and continuous rise in prices, it is very essential to reduce the running charges of the electric energy [1]. A saving in the operation of the system of a small percent represents a significant reduction in operating cost as well as in the quantities of fuel consumed. The classic problem is the economic load dispatch of generating systems to achieve minimum operating cost. This problem area has taken a subtle twist as the public has become increasingly concerned with environmental matters, so that economic dispatch now includes the dispatch of systems to minimize pollutants and

conserve various forms of fuel, as well as achieve minimum cost [2]. In addition there is a need to expand the limited economic optimization problem to incorporate constraints on system operation to ensure the security of the system, thereby preventing the collapse of the system due to unforeseen condition. Through the load flow studies we can obtain the voltage magnitudes and angles at each bus in the steady state. This is rather important as the magnitudes of the bus voltages are required to be held within a specified limit. Once the bus voltage magnitudes and their angles are computed using the load flow, the real and reactive power flow through each line can be computed [1]-[2]. Also based on the difference between power flow in the sending and receiving ends, the losses in a particular line can also be computed. Furthermore, from the line flow we can also determine the over and under load conditions. The steady state power and reactive power supplied by a bus in a power network are expressed in terms of nonlinear algebraic equations.

II. IMPACT OF DG IN POWER SYSTEM

Generally, DG helps to decrease current flow in the feeders there by reducing the power losses. In electrical system, the line loss occurs when current flows through distribution systems. The amount of losses depends on current flow and line resistance, which can be reduced by decreasing line current or resistance or both. DG minimizes line loss because it decreases current flow in some part of the network. However, DG may increase or reduce losses, depending on the location, capacity of DG and the size of DG, as well as on the topology of the network and the system configuration [5]. Power loss in a system depends on several factors such, such as level of losses through transmission and distribution lines, transformers, capacitors, insulators etc. DG facilities help to improve grid reliability by placing an additional generation system closer to the load centre. It also helps in reducing the impacts from transmission and distribution (T&D) system disturbances, and peak-period conditions on the local grid, as DG will compensate these impacts. Furthermore, instead of single large central plants, multiple units at a suitable site in the distributed system can increase reliability by dispersing the capacity across several units [3].Optimum DG allocation may improve voltage profile and minimize power loss, but it depends on the size and location of DG at the distribution network. It is very essential aspect in the planning and operation of distribution system. Because DG can provide a portion of real and reactive power to the load close by which helps to improve the voltage profile of the network. The major problem which is noticed in the distribution network is that of voltage drop that must be controlled to keep the voltages at load points within pre-specified limits. The voltage control means reactive power control. The voltage drop difficulty increases due to long distance of between feeder and source. By controlling the reactive power and regulating the node voltages power loss can be controlled and this can be achieved by inserting DG in the system [4]. Power losses are categorized as real power loss and reactive power loss. The resistance of lines gives rise to the real power loss and reactive power loss is caused due to reactive elements embedded in the system. Real power loss reduces the effectiveness of the energy send out to the customers. Reactive power loss is also significant as it affects the system voltage. So, it is necessary to maintain the reactive power flow in the system at a certain level for adequate voltage profile. The intensity of power losses also depend on different types of loads linked to distribution feeders [4]. The objective of this paper is to investigate the effect number of DGs in order to obtain minimum losses in the system. The load flow analysis, the methodology, results and discussion is done in below sections along with conclusion.

III. LOAD FLOW

Generally, there are four quantities associated with each bus in the load flow study, which are listed below:-

- Real Power, P
- Reactive Power, Q
- Voltage Magnitude, V
- Voltage Angle, δ

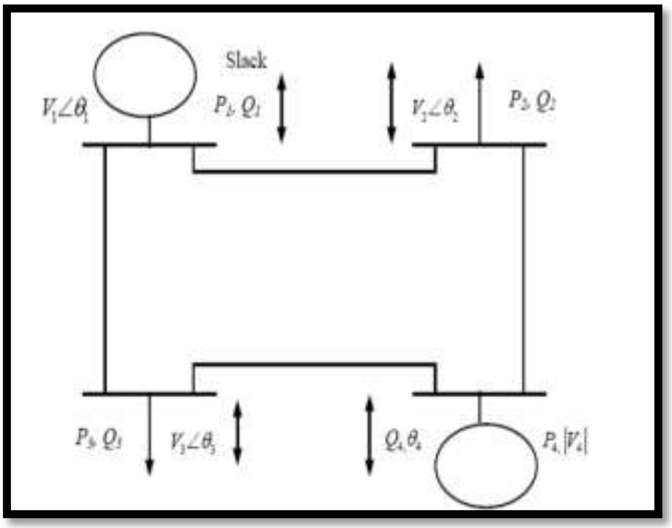

Fig. 1 Basic power distribution system

In every electrical system, two out of these four quantities will be given and the remaining two will be unknowns. Based on this fact, there are three types of line buses: slack bus, generator bus, and load bus. Slack or Swing bus is also known as the reference bus. It is connected to a generator of high rating to the other generators. The voltage of slack bus is always specified and remains constant in magnitude as well as in angle. Thus in slack bus, it the voltage magnitude and voltage phase are known, while real and reactive powers are obtained through the load flow analysis of the system. Mostly, Generator or Voltage Controlled bus is connected to a generator where the voltage is controlled using the excitation and the power is controlled using the prime mover control. In this bus system the voltage magnitude referred as the generator voltage while real power refers to its rating are specified while the reactive power generation and phase angle of the bus voltage are obtained. Sometimes, this bus is connected to a VAR device where the voltage can be controlled by varying the value of the injected VAR to the bus. In Load bus system no generator is connected to this bus. Here, the real and reactive power is specified while the voltage magnitude and phase angle are obtained through load flow solutions. In a three phase ac power system, through complex network of different buses and branches, active and reactive power flow from the generating station to the load centre. The flow of this active and reactive power in the electrical network is known as power flow or load flow. Power flow studies are based on a nodal voltage analysis of a power system. During the planning and operation of power distribution system, power flow analysis is widely used by power distribution professional. Power flow studies provide an efficient mathematical approach for determination of various bus voltages, their phase angles, active and reactive power flows through different branches, generators and loads under steady state condition. There are three methods for load flow studies mainly: Gauss siedel method, Newton-Raphson method, and Fast decoupled method.

IV. METHODOLOGY

In this paper, the investigation was done to study the impact of multi DGs on power losses. The study has been carried out on 14 bus system. Newton-Raphson method was applied for load flow analysis. The investigation started with the insertion of DG at different locations in 14 bus system. By inserting DG1 at different locations, the minima point was found. This minima location was kept fixed for the insertion of next DG and then again the study was carried on with the insertion of DG2 at different locations to find the minima location point. The location was again kept fixed for the next DGs and the process was repeated with total eight DGs. Fig. 2 shows the overall steps of experiment.

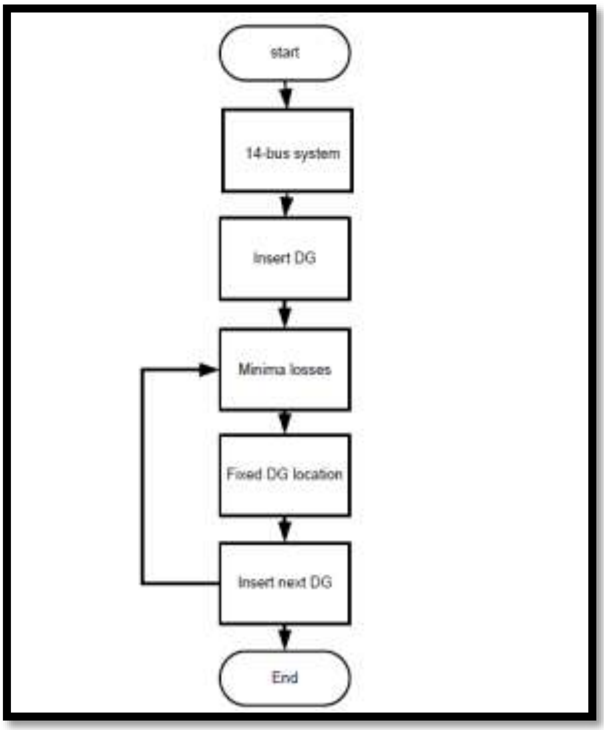

Fig. 2 Overall steps to study impact of number of DGs

V. RESULTS AND DISCUSSION

After inserting DGs overall losses were calculated using Newton-Raphson method. Line Loss Reduction Index (LLRI) and percent decrease was also calculated which is shown in Table I. It could be seen from the table that the line loss reduction was significant up to DG5 and after that insertion of further more DGs, there is no such significant decrease in LLRI. DG6 and DG7 showed small decrease in the LLRI and after adding DG8, there occurred an increase in the losses.

Table I: Analysis were carried out on 14 bus data system to find the impact of multi DGs

DGs	LLRI	Percent decrease
DG1	0.824	17.615
DG2	0.681	31.900
DG3	0.590	40.955
DG4	0.526	47.396
DG5	0.471	52.898
DG6	0.441	55.873
DG7	0.434	56.550
DG8	0.442	55.775

From Fig. 3, it can also be concluded, that with increase in the number of DGs, the percent decrease in the losses was significant up to DG6 and after that insertion of further more DGs didn't show any major decrease in the line losses. As it could be seen in that DG6 and DG7 showed almost same values of the percent decrease and after adding DG8, the percent decrease of losses is decreased. So, from economic point of view as well, it is not beneficial to use a large number of DGs to reduce the losses.

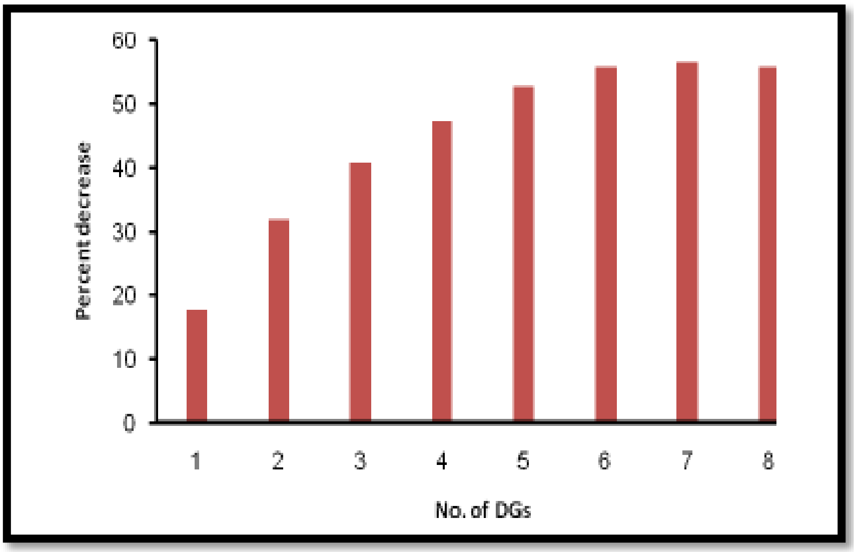

Fig. 3 Impact of number of DGs

VI. CONCLUSION

Investigation was carried out to explore the optimal number of DGs in the 14 bus system. The analysis of the results showed that by increasing the number of DGs in the system to reduce losses is not beneficial. Beside the optimal location and size of DG for the loss reduction in distribution system, number of DG is also very important aspect. Thus In this paper, it is concluded that the optimal number of DGs must also be used to reduce the losses in the system.

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