Integration Of DG To Enhance The Efficient Operation Of Distribution Networks

Rudresh B. Magadum, D.B.Kulkarni

Abstract: In the present scenario, the electricity is also playing vital role in development of the country. The expansion of the power systems, interconnections of the different networks and growth in the power demand causing more power losses in the distribution network with dip in the voltage profile. This leads to instability in the network. In this paper, optimal siting with sizing of different types of DG's are tested on IEEE 15 node network using MiPower software. From the obtained results, 60% of the power loss reduction as compared to base case with significant enhancement in the voltage also achieved.

Index Terms: Distribution generation, distribution networks, exhaustive load flow analysis, power loss, power system stability, renewable energy resources and voltage profile.

1. INTRODUCTION

THe electricity gaining more importance due to modernization and changing life style of the people. Every year 8-10% power demand is increasing due to expansion of network, installation of new industry and increase in the consumers [1]. Parallelly, increase in the power generation by integration of renewable energy resources, cogeneration and diesel plants [2-3]. Due to these reasons complexity in the power systems increasing day by day with lack of generation and electrical infrastructure causing severe power quality related issues with 30-40% of T&D losses in the network. These losses can be reduced by optimal placement of DG [4-5]. The distributed generation is generating 10-20% of the total power near to the load centre's [6-7]. This will helps to maintain prescribed voltage level throughout network with minimization of I^2R losses in the transmission lines. Choosing optimal site, size and type of the DG can helps to 41-60% loss reduction with 5-10% boosting in the voltage profile [8]. In this paper, different types of DG's siting and sizing is carried out. The different type of DG like supplying only real power, reactive power and both PQ are tested on IEEE-15 node systems. The obtained result shows the effectiveness of chosen algorithm for power loss reduction.

2 LITERATURE REVIEW

Distributed Generation is one of the most attracted and effective way to support the increased power demand and maintain the good voltage profile throughout the network [9]. Interconnecting DG to present electrical distribution network gives more flexibility to numerous entities. DG helps to improve reliability of the distribution system, power quality, and clipping the peak load to reduce the stress on the network [10-11]. On the other hand the integration of DG into present electrical system has coupled a number of economical and technical issues. Penetration of a generated power by DG into present electrical distribution network has several impacts on the network, with the electrical network security and protection being one of the main issues. DG placement makes the system to lose its radial power flow, in addition with amplified fault level of the network caused due to integration of the DG [12-13].

The optimal placement and sizing of DG plays vital role in enhancement in the voltage with power loss reduction. The fuzzy logic, honey bee method, neuro-fuzzy, artificial neural network (ANN), Grey wolf optimization, Genetic algorithm (GA), Ant Colony Method (ACM), Particle Swarm Optimization (PSO), , Tabu Search (TSM), Exhaustive load flow analysis, evolutionary programming (EP) method etc are used for optimal placement of multiple generators.

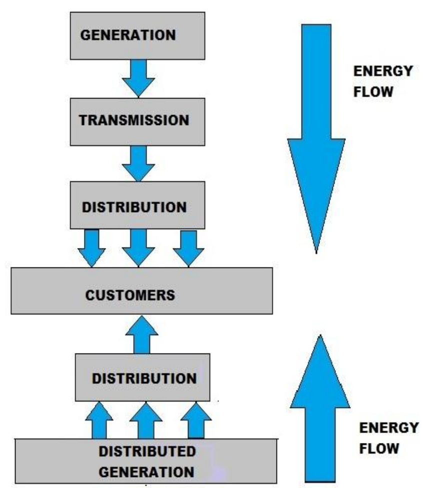

Fig.*1Bidirectional power flow*

Depending on the generation capacity of the DG are classified as micro, small, medium and large is shown in Table.1 [13-14]. The distributed generators are classified in to four types is shown in Table.2 [15]

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TABLE.1

CLASSIFICATION OF DG DEPENDING ON CAPACITY

Sl. No	Details	Capacity
1	Micro DG's	10 Watts to 5kW
2	Small DG's	5kW to 5,000kW
3	Medium DG's	5,000kW to 50,000kW
4	Large DG's	50,000kW to 1,00,000kW

TABLE.2

CLASSIFICATION OF DG DEPENDING ON TYPES

	Function	Resources
Type-1	Supplying only real power	➢ Solar PV ➢ Fuel cells
Type-2	Supplying only reactive power	➢ Super capacitors ➢ Gas Turbines
Type-3	Supplying active & absorbing reactive power	➢ Wind power
Type-4	Supplying both P&Q	➢ Hydro plants ➢ Cogeneration ➢ Gas turbines

Usages of DG [16]

- Provides backup supply
- Improves the network stability
- Peak shaving
- Utility capacity will be enhanced
- Ancillary services
- Efficient use of renewable
- Reduces the emission of gases
- Improves the power quality
- Avoids the T&D investments

3 METHODOLOGY

The main objective of this work is to decrease the power loss in the network with improvement in the voltage profile is given by,

$$P_L = \sum_{m}^{n} I_m^2 * R_m$$

Where,

P_L=Total power loss
N= No. of branches
I^2m= Current flowing through the line k
m= Number of transmission lines
R_m= Resistance of the line m

The enhancement in the voltage profile is given by,

Vmax ≤ Vnew≤Vmin

The Figure.2 shows the flow chart for the siting of different types DG's with optimal size with location. The load flow analysis is carried out with the help of MiPower package.

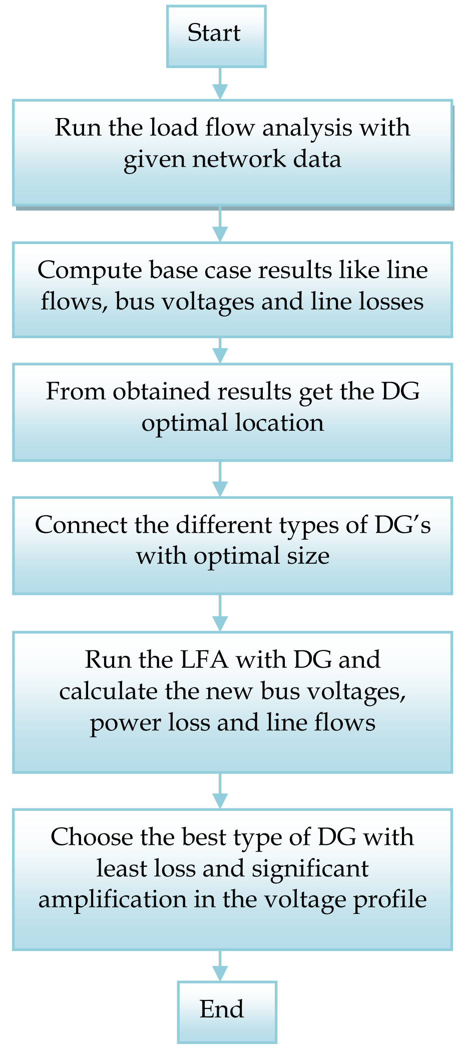

***Fig.2** Flow chart for DG location, type and sizing*

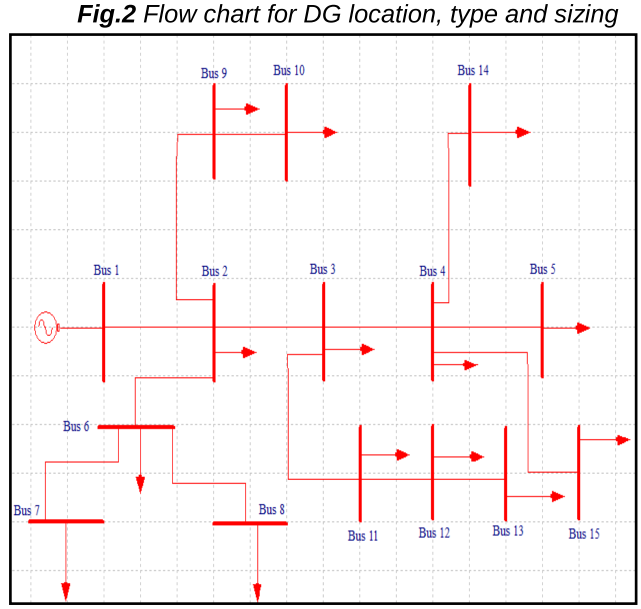

***Figure.3** IEEE-15 Nodes single line diagram*

The Figure.3 shows the SLD of IEEE-15 node network. It consists of one generator coupled at bus one, act as slack bus with voltage 1.0 p.u. The total load of 1.22+1.25j MW load is distributed throughout the network. In the base case it is observed total loss of 61.5KW. From the base case results bus-4 is chosen as optimal location for the further analysis is as shown in the Figure 4. The different types of generators are connected to ensure the effectiveness of the planned methodology.

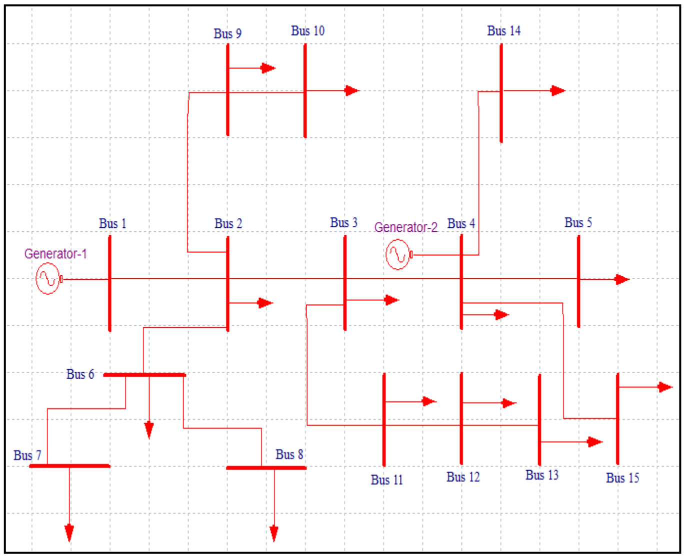

Figure.4 *IEEE-15 bus systems with DG at bus 4*

- The generator type-1 supplying only active power

The generators like solar PV cells, fuel cell can supply only active power; such type of generators with capacity of 3MW is connected at bus-4. Which will helps to reduce the power loss of 38.4KW with 4-6% amplification in the voltage profile.

- The generator type-2 supplying only reactive power

The essential amount of reactive power is supplied from the generator makes improvement in the voltage profile. Which will helps to maintain the voltage stability in the network. 5-10% progress in the voltage profile can be achieved. The over compensation of reactive power causes additional losses in all branches of the network.

- Generator type-3 supplying both P and Q.

The generator like cogeneration, small hydro it will supply real as well as required reactive power which will helps to maintain healthy voltage profile with significant achievement in the power loss minimization. Table.3 shows the voltage and power losses after connecting different types of DG's at bus 4.

TABLE 3

COMPARISON BUS VOLTAGES AND POWER LOSS AFTER INTEGRATING DIFFERENT TYPES OF DG'S

Bus No	Base case	Gen. type-I	Gen. type-2	Gen. type-3
1	1.0000	1.0000	1.0000	1.0000
2	0.9730	0.9849	0.9906	0.9917
3	0.9584	0.9806	0.9933	0.9939
4	0.9527	0.9822	1.0000	1.0000
5	0.9517	0.9813	0.9991	0.9991
6	0.9600	0.9721	0.9778	0.9789
7	0.9577	0.9699	0.9756	0.9767
8	0.9587	0.9708	0.9765	0.9777
9	0.9697	0.9817	0.9873	0.9884
10	0.9686	0.9806	0.9863	0.9874
11	0.9517	0.9741	0.9868	0.9874
12	0.9476	0.9701	0.9829	0.9834
13	0.9463	0.9688	0.9816	0.9822
14	0.9504	0.9800	0.9978	0.9978
15	0.9502	0.9798	0.9977	0.9977
PL in KW	61.5	38.40	62.10	18.10

The Figure 5 shows the voltage comparison after integrating different types of DG's in the network. The generator supplying both P and Q will makes 5-10% overall improvement in the voltage profile. Figure 6 shows the power loss comparison base case with different types of DG.

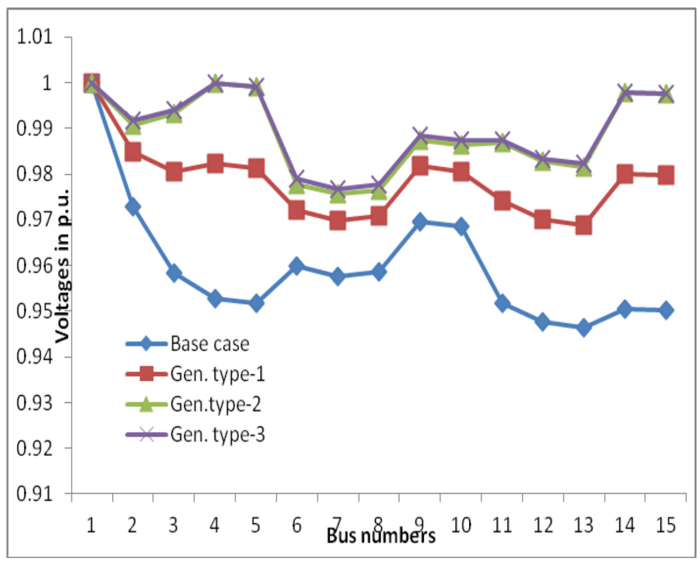

Figure.5 *Comparison of voltage profile*

After connecting generator type-1 at bus 4 leads to the power loss falls from 61.5KW to 38.4KW i.e nearly 30% of the power loss declination can be observed. With generator type-2 it can be observed 5-10% improvement in the voltage profile. After integration with generator type-3 DG the power loss declination came down from 61.5KW to 18.1KW i.e., nearly 60-70% of power loss reduction is achieved. Hence for IEEE-15 bus system generator type-3 can be integrated for efficient operation of the distribution networks.

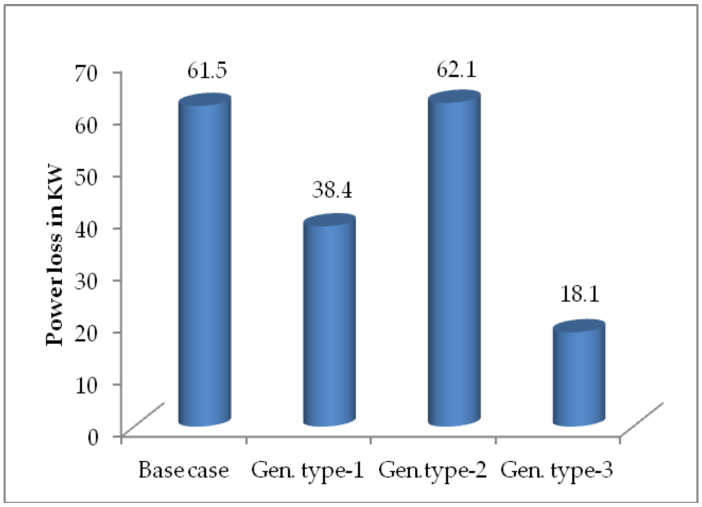

Fig.6 *Comparison of power loss after integrating different types of DG's*

In this paper power loss reduction with enhancement of the voltage profile is tested on IEEE-15 bus network. The 60-70% power loss minimization with 5-10% voltage improvement is achieved by generator supplying both P&Q. Similarly this algorithm can be used for any network for integration of different type of DG to boost the voltage profile with efficient operation of the network.

4 CONCLUSION

In this paper, optimal location with size of different types of DG's are tested on IEEE-15 system using MiPower software. The obtained result shows the importance in selection of DG type for efficient operation of the network. Depending on the given network parameters, choosing optimal location, size and DG type can enhance the voltage profile by 5-10% with 50-60% of the power loss reduction. This will help to stable and efficient operation of the power systems.

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