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Optimal sizing and location of Distributed generation (DG)

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ABSTRACT—In this paper, the distributed generators are placed at proper positions using Genetic Algorithm (GA), to overcome the losses which occurs at each bus and then increase the voltages produced. Hence, this paper analyzes the scenarios with and without genetic algorithm. The objective is to use genetic algorithm for finding optimum location where power losses and investment costs are low. These conditions are tested on IEEE-
14 bus system, the study covers why placing of distributed generation (DG) in a system is very important in both economical and performance aspects.
Genetic algorithms help us to analyze and lower the time consumed in identifying the best conditions to place the DG in the bus system[4]. The paper concludes by giving 2 results they are, 1) The relation of voltage in each bus. 2) Total power losses and voltage stability of the system.

Index Terms—Genetic algorithm(GA), Network Admittance matrix, Jacobian Matrix, Newton-Raphson method.

I. INTRODUCTION

Distributed generators at power generating units are placed near load centers to manage consumers' load requirements[1]. They are onsite energy producers rather than relying on the centralized supply. Requirement of building power transformer and distribution station is eliminated. High efficiency and environmental protection: DG's environmental protection per- formance is excellent, it has high energy efficiency up to 65% to 95%.

This project addresses the problem of dg sizing and location and the objective is to use genetic algorithms to enhance and learn about optimum sizing and location of distributed generations (DG), using power flow study which could provide solution for unknown electrical quantities of a larger intercon-nected system[2].

The paper is divided into different sections:- Section-2: Ge- netic Algorithm and power flow, Section-3:-Methodology, Section-4:- Results, Section-5:- Conclusion, Section-6:- Ref- erences.

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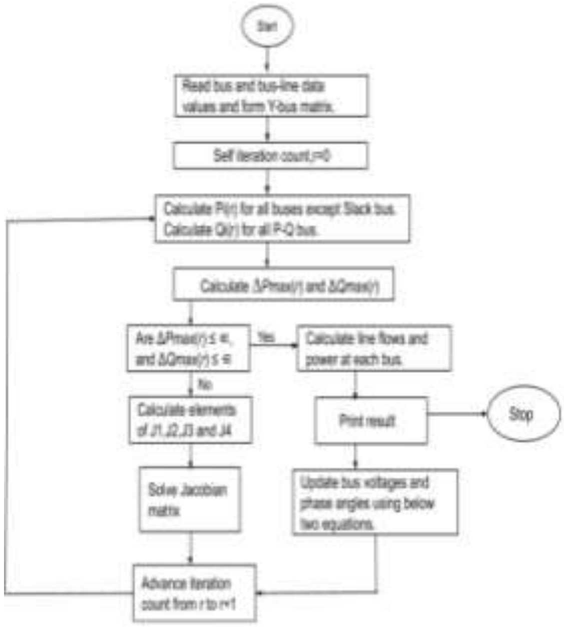

Fig. 1. Optimal sizing and location of DG without GA

II. SECTION

A. GENETIC ALGORITHM AND POWER FLOW

Genetic algorithm are part of evolutionary algorithm, which are inspired from the nature, they work on basis of natural genetics and natural selection[3]. The main phenomenon of genetic algorithm is the survival of the fittest i.e, in the set of data the most compatible is selected if the value has the best chances of giving the best result . Genetic operators exchange information between the peaks, hence reducing the possibility of ending at a local optimum.

Power flow

Fig. 2. Optimal sizing and location of DG with GA

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1. Generate binary string using the input given by the user
2. Calculate the fitness of each string
3. Create offspring by reproduction,crossover and mutation
4. Check the health of each string
5. If the value required received use stop and return the output if not go back to step 3 to start evaluation over.

Features of GA

1. Overcomes the local optimum condition by having multiplesearch path.
2. GAs' work with coding parameters than the parametersthemselves.
3. GAs' use probabilistic transition rules than deterministicrule.

III. METHODOLOGY

Step-1:- Creating a separate function file to assign the values and sizes for each 14-buses (in terms of p.u.) along with their types of buses.

Step-2:- Creating a separate function file to assign the values for transmission lines connected between the buses. (i.e., R, X, Half-line charging capacitance).

Step-3 :- Using the above two functions, create a "Network admittance matrix" of dimension 14x14. Using the formula, (to calculate each element in matrix)

$$Y_{(new)} = Y_{(old)} + (y/(a^2)) + b \; ; \qquad \text{(if from-bus is equal to iteration number)}$$

$$Y_{(new)} = Y_{(old)} + y + b \; ; \qquad \text{(if to-bus is equal to iteration number)}$$

where, b - susceptance; y - admittance; a -transformer tap setting ratio

Step-4:- Creating a Jacobian matrix , using all the data calculated above (in polar form), and along with formulasbelow.

$$P_m = V_m \sum_{n=1}^{nbus} |V_n| [\, G_{mn} \text{Cos} (\delta_m - \delta_n) + B_{mn} \text{Sin} (\delta_m - \delta_n)]$$

$$Q_m = V_m \sum_{n=1}^{nbus} |V_n| [\, G_{mn} \text{Sin} (\delta_m - \delta_n) - B_{mn} \text{Cos} (\delta_m - \delta_n)]$$

The diagonal and off-diagonal elements of J1,

$$\frac{\partial Pm}{\partial \delta m} = [\sum_{n=1}^{nbus} |V_m| |V_n| [-G_{mn} \text{Sin} (\delta_m - \delta_n) + B_{mn} \text{Cos} (\delta_m - \delta_n)] - V^2_m B_{mm} \; ; \quad n=m$$

$$\frac{\partial Pm}{\partial \delta n} = |V_m| |V_n| [G_{mn} \text{Sin} (\delta_m - \delta_n) - B_{mn} \text{Cos} (\delta_m - \delta_n)] \; ; \quad n \neq m$$

The diagonal and off-diagonal elements of J2,

$$\frac{\partial Pm}{\partial |Vm|} = [\sum_{n=1}^{nbus} |V_n| [G_{mn} \text{Cos} (\delta_m - \delta_n) + B_{mn} \text{Sin} (\delta_m - \delta_n)] + V_m G_{mm} \; ; \quad n=m$$

$$\frac{\partial Pm}{\partial |Vn|} = |V_m| [G_{mn} \text{Cos} (\delta_m - \delta_n) + B_{mn} \text{Sin} (\delta_m - \delta_n)] \; ; \quad n \neq m$$

The diagonal and off-diagonal elements of J3,

$$\frac{\partial Qm}{\partial \delta m} = [\sum_{n=1}^{nbus} |V_m| |V_n| [G_{mn} \text{Cos} (\delta_m - \delta_n) + B_{mn} \text{Sin} (\delta_m - \delta_n)] - V^2_m G_{mm} \; ; \quad n=m$$

$$\frac{\partial Qm}{\partial \delta n} = |V_m| |V_n| [-G_{mn} \text{Cos} (\delta_m - \delta_n) - B_{mn} \text{Sin} (\delta_m - \delta_n)] \; ; \quad n \neq m$$

The diagonal and off-diagonal elements of J4,

$$\frac{\partial Qm}{\partial |Vm|} = \sum_{n=1}^{nbus} |V_n| [G_{mn} \text{Sin} (\delta_m - \delta_n) - B_{mn} \text{Cos} (\delta_m - \delta_n)] - V_m B_{mm} \; ; \quad n=m$$

$$\frac{\partial Qm}{\partial |Vn|} = |V_m| [G_{mn} \text{Sin} (\delta_m - \delta_n) - B_{mn} \text{Cos} (\delta_m - \delta_n)] \; ; \quad n \neq m$$

Step-5:- Calculating real and reactive power at each bus, usingNewton-Raphson method .

Step-6:- Then, calculate all the losses and store them in one file.

Step-7:- Related to Genetic Algorithms.

→ In the algorithm, the positions of buses and their sizes are taken. For the selected buses(3,4,8 and 14) position and its sizes, the power losses, rank, cost are calculated.

→ Depending upon the cost and rank, it tries to take such a type of bus position and values where less cost and losses are obtained.

→ The algorithm changes the bus values repeatedly and run the whole process through multiple iterations in the program, as many specified by the user.

→ Based upon these algorithms, the voltage at each bus graphis plotted for both with and without DG.

→ For least losses it fixes the values of the buses considered.
→ Calculating losses at each bus(based on load flow analysis), summing it up. Then, display total power losses and stability
index of total 14-bus DG unit.
→ Similarly, we are writing a program without DG units and calculating the total power losses and stability. To compare the losses with proper DG unit installation and without DG unit.
→ At last we call all these functions in one main program and run along with the genetic algorithm functions involved in it.

IV. RESULTS

The Fig(3). represent a conclusive evidence on how geneticalgorithm solved issues of power loss of the system.

According to conditions with and without dg the values re- spectively are 10.6kW and 4.3kW showing how the algorithm helped in lowering the losses.
Stability index of the algorithm and DG locations of the DG selected by the user.
Fig(4) shows the voltage vs 14 bus condition.
At bus-3 both have minimum voltage and as progress the red line(without GA) shows lower voltage at buses than the green line(with GA) i.e, evident at bus 10 where the maximum voltage difference can be seen, voltage of 1.11pu versus 1.09 pu.

```
POWER_LOSSES_WITHOUT_GA =

   10.5990


STABILITY_INDEX_WITHOUT_GA =

    2.0477


DG_LOCATION =

     3     4    13     8


DG_UNIT_SIZE =

    0.5023    0.0084    0.0207    0.0696


POWER_LOSSES_WITH_GA =

    4.3203


STABILITY_INDEX_WITH_GA =

    0.9577
```

Fig. 3. Results of power losses and stability index with and without GA

V. CONCLUSION

We addressed the problem of optimal DG location andsizing in a distribution network.
Using genetic algorithm we generated comparison between systems with DG and without DG, produced relationship between voltage and buses for the system
Also focusing on lowering power losses and installment costs.The network used for tests is the IEEE 14-bus distribution. Also deduced that there is 44percent improvement in lowering power loss with using DG.
DG can serve as a solution to major power system issuesbut they are followed with multiple drawbacks like,

1. Since these work on fossil fuels till an better alternative fuel source they pose a risk to consumers health.
2. Protection of unit as well as the network.
3. Impact on system voltage - When there are

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large capacity DG in Power system, the introduction of DG will have a greater impact on system voltage, short circuit current, active and reactive power flow and other characteristics.

4. Impact on grid planning.

VI. SECTION

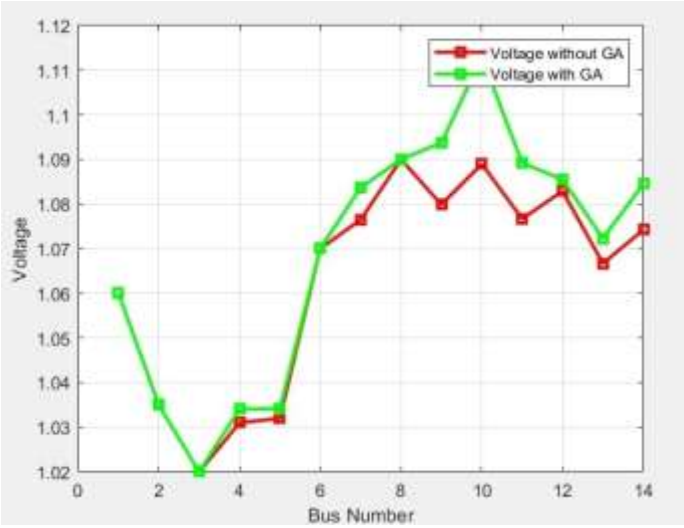

Fig. 4. Comparison of graph plotted between Bus voltages v/s Number ofbuses w.r.t both with and without GA

A. Future scope

1. This paper has dealt with how genetic algorithm is used for optimum sizing and location of DG's.
2. Even though GA have helped in better computations, hold many problems like the computation time is very high and as the number of inputs(buses) increase the time and load on the system to generate increases.

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