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# OPTIMAL DG PLACEMENT FOR MINIMUM REAL POWER LOSS USING BFO

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**ABSTRACT**: Power flow analysis is widely used by power distribution professional during the operation and planning of power distribution system. There are three main methods for load flow studies namely Gauss-Seidel method, Newton-Raphson method and Fast decoupled method. Different resources are also be used in distributed generation (DG), such as wind turbines, biomass, micro turbine, photovoltaic, fuel-cells, small hydroelectric plants, etc., and it ranging from sub-kW to multi-MW sizes. DG affects the flow of voltage and power conditions on the system equipment. These may affect themselves either positively or negatively depending on the distribution system operating conditions and the DG characteristics. Bacterial Foraging Optimization (BFO) is inspired by the social foraging behaviour of Escherichia coli. It is having a fast convergence and self adaptability of individual in that group searching activities. BFO is more preferred as compared to Particle Swarm Optimization (PSO) and Genetic Algorithm (GA) because it is derivate free technique. BFO is divided into four main steps chemotaxis, swarming, reproduction and elimination dispersal. In this paper, investigation is done on optimal location of DGs are realize using BFO algorithm.

**Keywords:** Power flow, DG, BFO, Newton-Raphson method.

## I.INTRODUCTION

In a three phase ac power systems reactive and active power flows from the generating station to the load through different networks buses and branches. The flow of reactive and active power is called power flow or load flow. Power flow studies provide a systematic mathematical approach for determination of various bus voltages, phase angle, active and reactive power flows through different branches, generators and loads under steady state condition. Thus power flow study is used to find the steady state operating condition of a power system [1]. Power flow analysis is widely used by power distribution professional during the operation and planning of power distribution system [2]. Power flow analysis or load flow analysis is very important in planning stages of new networks or addition to existing ones like meeting increase load demand and locating new transmission sites and adding new generator sites [3]. Power flow studies are based on a nodal voltage analysis of a power system. Fig. 1 shows the basic power distribution system. The purpose of power flow studies is to plan ahead and account for various hypothetical situations. If a transmission line within the power system properly supplying loads must be taken off line for maintenance [4]. The load flow a problem was first solved using the simplest techniques, soon to be replaced by more sophisticated methods. Load flow analysis is important in planning of new networks or providing addition to existing ones like adding new generator sites, meeting increase load demand and locating new transmission sites. It is helpful in determining the as optimal capacity as well as location of proposed generating station, substation and new lines. A load flow also helps for economic operations. The line should not be overloaded, it means, we should not operate the close to their stability or thermal limits. Load flow analysis is the most important of all network calculations because it concerns the network performance in its normal operating conditions. It is performed to check the magnitude and phase angle of the voltage at each bus and the real and reactive power flows in the system component [5]. There are three main methods for load flow studies namely Gauss-Seidel method, Newton-Raphson method and Fast decoupled method [3]. Different resources are also be used in DG, such as wind turbines, biomass, micro turbine, photovoltaic, fuel-cells, small hydroelectric plants, etc., and it ranging from sub-kW to multi-MW sizes [6]. On basis of the some features of distribution systems such as; radial structure, unbalanced distributed loads, large number of nodes, a wide range of R/X

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ratios; the conventional techniques developed for transmission systems generally fail on the determination of optimum location of distributed generations. The Newton-Raphson load flow algorithm is used in this paper.

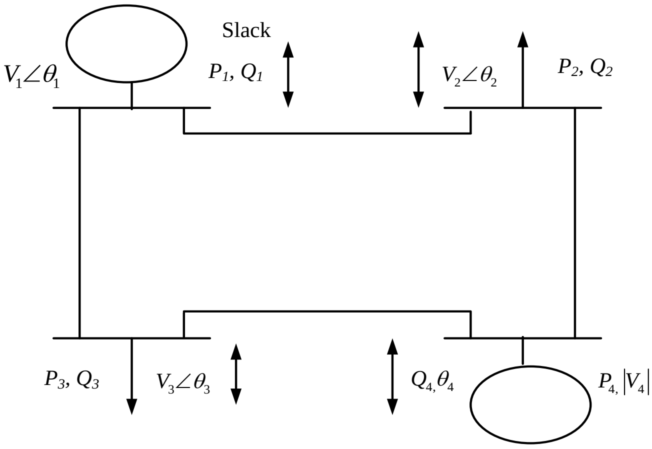


Fig. 1 Basic power distribution system [1]

Dispersed generation (DG) or distributed generation or embedded generation (EG) is small-scale power generation that is usually connected to or embedded in the distribution system. The word DG also indicates the use of technology that is sited throughout a utility's service to lower the cost of service. DG affects the flow of voltage and power conditions on the system equipment. These may affect themselves either positively or negatively depending on the distribution system operating conditions and the DG characteristics [7]. There are many benefits of DG and the reasons for implementing DG are an energy efficiency or rational use of energy, deregulation or competition policy, diversification of energy sources, availability of modular generating plant, of finding sites for smaller generators, shorter construction times and lower capital costs of smaller plants and proximity of the generation plant to heavy loads, which reduces transmission costs. Also distribution generation is accepted by many countries [8, 9]. In the present scenario of vast load growing system, use of DG have become more advantages like reduction of distribution and transmission cost, electricity price, reduction of sound pollution and green house gases. Other benefits include line loss reduction, peak shaving, and better voltage profile, power quality improvement, reliving of transmission and distribution congestion then improved network capacity, protection selectivity and network robustness. The impact of DG on power losses is not only affected by Distribution Generation location but also depends on the network topology as well as on DG size and type. The placement, of DG should be optimal in order to maximize the benefits of it [10]. Different protective schemes are applied to distribution systems, the over current protection and the fuse saving or blowing schemes are the commonly used [11]. The objective of this paper is to investigate the optimal placement of two DGs in order to obtain minimum real powers losses using BFO algorithm. The details of BFO algorithm is given in section II. The methodology is specified in section III, result and discussions in section IV along with conclusions in section V.

## II.BFO

BFO has provided the attention to many researchers, especially due to its biological motivation and its graceful structure. Many researchers are trying to hybridize BFO with different algorithms in order to enhance its local and global search properties individually [12]. Foraging theory explains how to get a patch or amount of food and decide whether to enter and search for amount of food and when to leave that patch. BFO is inspired by the social foraging behavior of Escherichia coli. It is having a fast convergence and self adaptability of individual in that group searching activities. BFO is more preferred as compared to PSO and GA because it is derivate free technique. BFO is divided into four main steps chemotaxis, swarming, reproduction and elimination dispersal. BFO is a new idea which is used to find the best location for placement of DG [13]. During foraging of the bacteria, motion is achieved by a set of tensile flagella. Flagella help an E. coli bacterium to swim, so two basic operations performed by a bacterium at the time of foraging. When they rotate the flagella in the clockwise direction, each flagellum pulls on the cell. That output in the moving of flagella independently and finally the bacterium swings with lesser number of swings whereas in a harmful

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place it swings frequently to find a nutrient gradient. Moving the flagella in the counterclockwise direction helps the bacterium to move or travel at high speed so that bacteria undergo chemotaxis, where they like to move towards a nutrient gradient and avoid noxious environment [14]. Generally the bacteria move for a longer distance in a friendly environment. When they get food in sufficient, they are increased in length and in presence of suitable temperature they break in the middle to from an exact replica of itself. Passino introduce an event of reproduction in BFOA. Due to the occurrence of sudden environmental changes or attack, the chemotactic progress may be destroyed and a group of bacteria may move to some other places. That provides the event of elimination-dispersal in the real bacterial population, where all the bacteria in a region are killed or a group is dispersed into a new part of the environment [15].

## III.METHODOLOGY

IEEE 14 bus data system is considered for study and analysis purposes for best possible position of DGs. For calculating overall minimum losses by using Newton-Raphson method only i.e. by inserting two DGs manually at different locations in the system is a difficult and inappropriate task. To overcome this difficulty a BFO algorithm is used. Overall real losses are calculated by Newton-Raphson method, when no DG is inserted in the system. Fig. 2 shows the overall steps in form of flow chart for finding minima of losses using BFO. Two DGs of same size or capacities are inserted in the system.

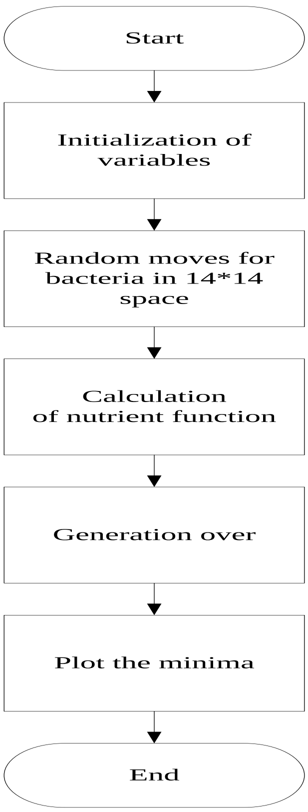


Fig. 2 Flow chart for finding minima using BFO

In BFO, 50 bacteria are selected to travel at different locations. All bacteria move in random direction in search of food (minima in losses). At every selected position of bacteria, loss is estimated. Process is repeated for the bacteria generation which is inspired by passion, to introduce an event of reproduction in BFO. Due to the presence of sudden environmental changes or sudden attack, the chemotactic progress may be destroyed and a group of bacteria which are selected may move to some other places or some other may be introduced in the swarm of concern. This constitutes the event of elimination-dispersal in the real bacterial population, where all the bacteria in a region are killed or a group is dispersed into a new part of the environment. Locations where minima loss is obtained by the bacteria, 3D graph is

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generated. Thus instead of calculating loss at every location of two DGs in 14 bus system, improved system by BFO is implemented. At particular location generated by BFO, overall losses are again calculated using Newton-Raphson method.

## IV.RESULT AND DISCUSSION

Investigations were carried out using 14 bus data system to find the best location for placement of DGs. Fig. 3 represents the location of minima, where x= $\theta_1$ and y= $\theta_2$ represent the locations of $DG_1$ and $DG_2$ in the range from 1 to 14 respectively. While z=J represents value of the real losses and the locations of minima, exposed by valleys in the graph.

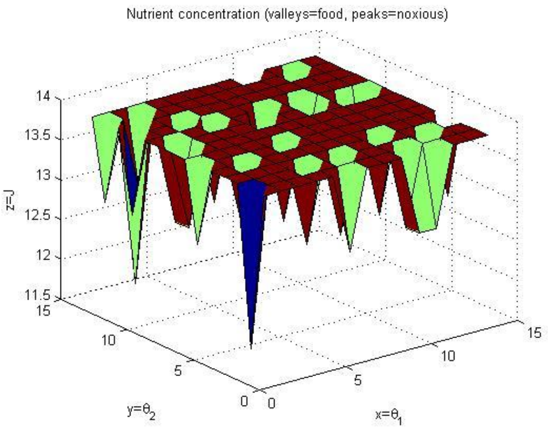

Fig. 3 Represents minima location

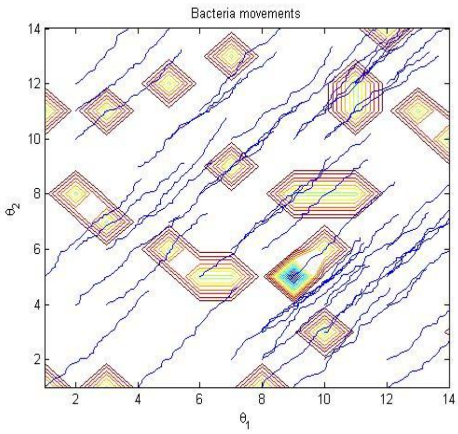

Fig. 4 Bacteria movement for DG location

No peaks in the graphs represents that no bacteria takes noxious value. BFO algorithm is used to find the locations and Load flow calculations are carried out by using Newton-Raphson method to calculate the losses. Location where overall loss is minimum, considered as the best location for the placement of DG. Fig. 4 represents the movement of bacteria which moves to take some values while searching for minima. After getting the best location DG are placed which improves active power, reactive power and reduces real losses and increased efficiency. By using BFO, 20 possible minima are obtained and at every such location losses are calculated which are revealed in the Table I. Loss in 14 bus system without using DG is about 13.81 MVA, and minimum loss with inserting two DG is at location (3, 7) which is about 10.12. $DG_1$ and $DG_2$ must be inserted at third and seventh location respectively. Thus loss reduction is reduced to about 26.72 percent. This can further be reduced by using different capacities of DG.

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Table I: values of real losses in corresponding to the DG locations.

| S.no | Location of DG for 14 bus system | | Real losses |
|---|---|---|---|
| | $DG_1$ | $DG_2$ | (MVA) |
| 1 | 1 | 11 | 12.20 |
| 2 | 2 | 8 | 11.36 |
| 3 | 3 | 1 | 11.76 |
| 4 | 3 | 7 | 10.12 |
| 5 | 3 | 11 | 10.25 |
| 6 | 5 | 2 | 11.57 |
| 7 | 5 | 6 | 11.07 |
| 8 | 6 | 5 | 11.04 |
| 9 | 7 | 5 | 10.77 |
| 10 | 7 | 9 | 10.55 |
| 11 | 7 | 13 | 10.15 |
| 12 | 8 | 1 | 12.11 |
| 13 | 9 | 8 | 10.61 |
| 14 | 10 | 8 | 10.61 |
| 15 | 10 | 3 | 10.14 |
| 16 | 10 | 6 | 10.75 |
| 17 | 10 | 11 | 10.71 |
| 18 | 10 | 12 | 10.69 |
| 19 | 11 | 8 | 10.70 |
| 20 | 13 | 11 | 10.67 |

## V.CONCLUSION

Experiment was carried out to explore the optimal location of DGs in 14 bus system. Location and capacity of DG are the two important parameters for installation of DG in any system. The analysis of the results showed that the DG must be placed in particular location in order to get minimum losses. Two DG of same capacities is inserted in the system. Manually it becomes lengthy and tough procedures to insert DGs in each point and find the losses at each point. The proposed procedure with the combination of BFO and Newton-Raphson method minimizes the labour and provides efficient and effective results in less time with little complexity.

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