Biogeography Based Optimization Technique for Optimal Siting and Sizing of Distributed Generation System in a Distribution System

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Abstract- In this paper a biogeography based optimization (BBO) technique has been applied for optimal siting and sizing of distributed generation (DG) system in a radial distribution system for the power loss minimization and voltage profile improvement. The objective of the BBO technique is developed to describe the most advantageous real power production and utilization requirements for the best possible sizing and locating the nodes for the siting of DG systems. The BBO technique is implemented using MATLAB software and tested into the IEEE 69 radial distribution system and assessed for voltage variation due to power losses.
Keywords – Distributed Generation (DG), Radial distribution system (RDS), biogeography based optimization (BBO).

I. INTRODUCTION

Distributed Generation (DG) may be defined as a resource of an electric power attached near to the load in the distribution system, represents a clever method both to create and also deliver electric power. Nowadays the need to decrease of Co2 and other toxic discharges on the environment created more attention towards renewable DG as an alternative source for providing electrical power to the customers. Restructuring of existing distribution system, danger with nuclear power, reconstruction of the present distribution system because of lack of power, the new deregulation scheme in market, as well as restraints over the constructions of a brand-new substation and distribution lines had further firmly insisted the value of DG [1]. DG placed near to the loads reduces the Transmission and Distribution (T&D) expenses and losses, together with delayed equipment upgrades, line loss minimization and lowered voltage sags in distribution system. Generally, conventional distribution System is intended to run under radial and unidirectional power flow conditions, but with DG interconnection in the radial distribution system (RDS), the flow of power is no more unidirectional and also thus changes the plan and operation [2]. So the typical structure of the RDS is in danger of termination by the affiliation of DG. The role of existing power plant in an existing power System is to create electric power, at the same time they play a crucial role in controlling voltage, frequency as well as stability of the system. While interconnection of DG with RDS may influence the secure operation, it will certainly not provide the extra solutions offered by existing power plant [3]. So the impacts of DG with RDS cannot be ignored, and detailed studies are needed to make DG a lot more helpful when connected with RDS. Planning of the RDS with DG requires the description of a number of factors such as, the most effective DG modern technology to be utilized, variety of DG devices, DG size, the kind of system link as well as DG placement, and so on. If the DG system are placed ideally the benefits are a lot more, but putting the DG units at non optimal setting and also with incorrect size can increase the distribution line losses, damaging voltage profile, voltage flicker, protection problems, harmonic, as well as the security of the RDS. So an ideal positioning and sizing of DG element can play major duty, to obtain the ideal results in distribution network [4]. The DG innovations can be categorized right into renewable as well as non-renewable. The DG technologies based upon renewable energy resources are: Wind, Photovoltaic, Solar thermal, ocean, small Hydro. DG technologies based upon non-renewable power sources are: combined cycle, Micro turbine, Combustion turbine, steam turbine, internal combustion engine. Fuel cells can be classified as renewable if hydrogen makes use of as well as non-renewable if natural gas or petroleum makes use of as a fuel [5]. Applications of DG are constant power, combined heat and power, peaking power, environment-friendly power, premium power, holding off T&D reformation, reduction of T&D losses. Benefits of DG are client benefits, supplier benefits, national benefits, environmental advantages. The effects of DG when interconnected to the RDS are broadly identified as technical, financial and ecological. DG can provide effective as well as constant power if it is placed in RDS with appropriate technique [6]. Planning of the RDS with DG calls for the numerous factors such as, the best technology to be utilized, number of devices, capacity, financial constraints, placement and also the type of network connection. When DG is adjoined with RDS, the effects have to be considered consists of the area of DG, the size of the recommended DG, kind of DG, electric power losses, stage harmonizing, voltage control, protection issues, harmonics, enhanced fault level and various other issues if any kind of. Amongst the numerous technological impacts of DG in RDS, ideal positioning and sizing of DG, improvement of voltage profile as well as power factor, minimization of electric line losses have taken into consideration [8]. Several techniques have been created for addressing the DG placement as well as sizing problem such as logical techniques, mathematical programming and heuristic or artificial intelligence (AI) based strategies. Analytical technique to place DG in radial and mesh systems for the power loss minimization and voltage profile improvement of the RDS is presented in the past by just maximizing location as well as thought about the size of DG is taken care of. In this work, the biogeography based optimization (BBO) technique from heuristic family is applied for an optimum positioning and sizing issue.

II. PROPOSED ALGORITHM

Among the operating indices for RDS is the total real power losses and voltage profile improvement in various parts of the distribution system. So an optimization issue should be addressed to discover the optimum locations and also size of DG in a distribution feeder. One of the unbiased features in this trouble is the power loss minimization in RDS that can be stated by:

$$f(L) = P_l = \sum_{k=1}^{n} P_k \quad (1)$$

Where, the vector 'L' reveals variables of the optimization issue as well as 'n' is number of buses. Pk is an injected true power in system bus shown in Figure 1.

Pk =PDGk- PLk (2)

Where, PDGk is the recommended values of DG interconnected on the distribution feeder bus are related to Pk according to equation (2). PDGk belongs of control variables as well as PLk show the load power in distribution system buses. The objective feature pertaining to DG sizing and positioning can be resolved subjected to some restraints. These restrictions are split right into two groups specifically equality and inequality restraints. The optimal DG placement and sizing issue can be formulated as a constrained nonlinear integer optimization trouble. Accuracy and flexibility of the DG system placement and sizing method is affected by the load flow evaluation. According to the system features, Newton-Rapson approach for load flow computation in an IEEE 69 bus RDS is utilized. Figure 1, a sample 2 bus system attached with one DG device, where k bus is receiving end bus in which DG system and load are linked [9].

2.1. Objective feature

The unbiased feature is to minimize the real power loss.

$$f(L) = Min \sum_{k=1}^{n} \left(\frac{P_k^2 + Q_k^2}{V_k^2} \right) X r_k \quad (3)$$

Restrictions:

The equal rights restrictions are the three nonlinear recursive power-flow formulas.

Explaining the Pk, Qk and Vk, where k= 0, 1, 2…..n.

The inequality restraints are the system's voltage restrictions, that is, +5% or - 5% of the nominal voltage value.

Vsmin ≤ Vsk ≤ Vsmax (4)

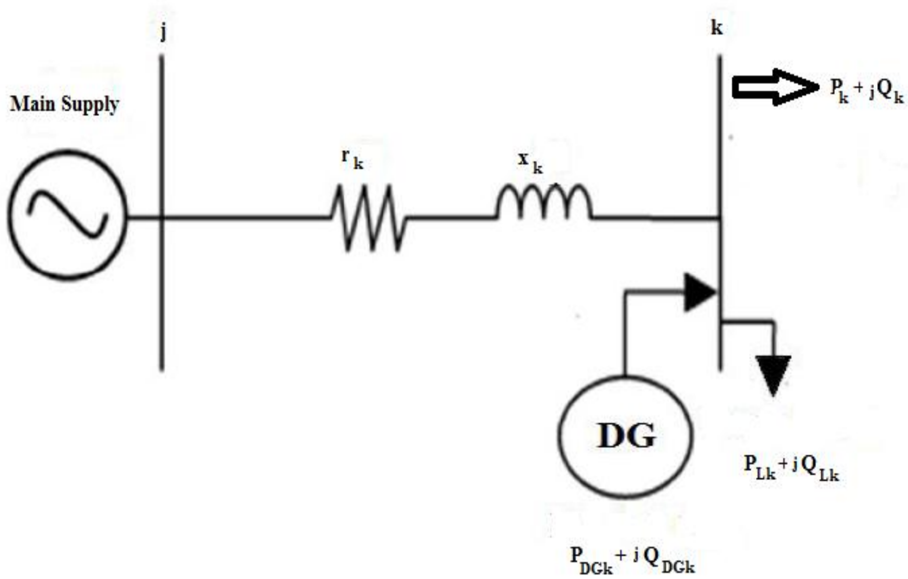

Figure 1 Two bus RDS connected with one DG System

On top of that, the thermal ability limitations of the network's feeder lines are dealt with as inequality restraints.

$Ss\ j,k \leq Sr\ j,k \geq Ss\ k,j$ (5)

The boundary or discrete inequality restraints are the DG-unit's size in MVA and power factor.

$SDGmax \geq SDGk \geq SDGmin$ (6)

The boundary or distinct inequality constraints are the DG-unit's power factor.

$PFDG\ max \geq PFDGk \geq PFDGmin$ (7)

DG device placement area and sizes are recommended and measured by the BBO approach with functional worries.

2.2. Implementation of BBO technique for a IEEE 69 bus RDS

The optimization starts with a mathematical depiction of the recommended BBO technique. In this section, the BBO strategy exists to discover the optimal siting and sizing of the DG utilize the following actions. This study recommended a brand-new strategy based on BBO the formula which is investigated to establish the optimum area as well as the capacity of Distributed generation system which is put on boost voltage account as the major element for power high-quality enhancement as well as lower power losses of the distribution system. The proposed formula's steps are carried out as comply with [10]:

Step 1: Load the data and start the power circulation to review voltage at different nodes and also power losses.

Step 2: Specify penalty features in order to avoid violating constraints.

Step 3: Initialize the BBO parameters including optimal species count, optimal migration rates, and also optimum mutation rate and an elitism parameter.

Step 4: Boot up habitats depending upon environment size within feasible region. Establish the iteration counter m =0.

Step 5: Install the DG and calculate the power flow.

Step 6: Checking network restraints. If the options breach the restraints after that apply the penalty or else go to next Step.

Step 7: Add the counter by 1. Inspect whether it is less than the optimum iteration limitation. If no, publish the result outcomes.

Step 8: If of course, calculate the habitat stability index (HSI) value for the provided immigration & emigration rate as well as Select the optimum HSI value based upon elitism parameters.

Step 9: Customize each non-elite environment utilizing immigration & emigration rate.

Step 10: Look for conceivability. If indeed, HSI is calculated.

Step 11: Species count chance is upgraded as well as recalculated the HSI.

Step 12: Most likely to tip 7 for the next iteration. This treatment can be finished after a conceivable problem option has been discovered.

The complying with BBO criteria have actually been made use of, populace size= 52, Environment Modification Possibility= 1, immigration Likelihood bounds per genetics= [0, 1], elitism specification = 5, step dimension for mathematical integration of likelihoods= 1, maximum λ as well as μ rates for each and every island= 1 and Mutation Possibility= 0.06 [11].

III. EXPERIMENT AND RESULT

We will discuss the performance of our BBO technique and it is tested with IEEE 69 BUS radial distribution system. It consists of one slack bus and 68 load buses. An IEEE 69 BUS RDS is simulated using MATLAB software as shown in figure 2. Analysis of this system is done from the line and bus data available in [12]. The total real power demand 3.624 MW and reactive power demand 2.413 MVAr, respectively. The real power loss is 228.46 kW and minimum bus voltage is 0.9125 pu. Table 1 shows the comparison of various results with BBO technique, with DG and without DG system.

Table-1 Comparison of the results

IEEE 69 Bus RDS	Voltage Profile (V)	Power Loss (Kw)	Power loss Minimization (%)	DG Size (MVA)	DG placed at Bus No.
Without DGs	0.9125	228.46	_	_	_
With DGs	0.9267	225.84	1.14	48	38
With BBO technique	0.9501	195.10	14.60	38	30

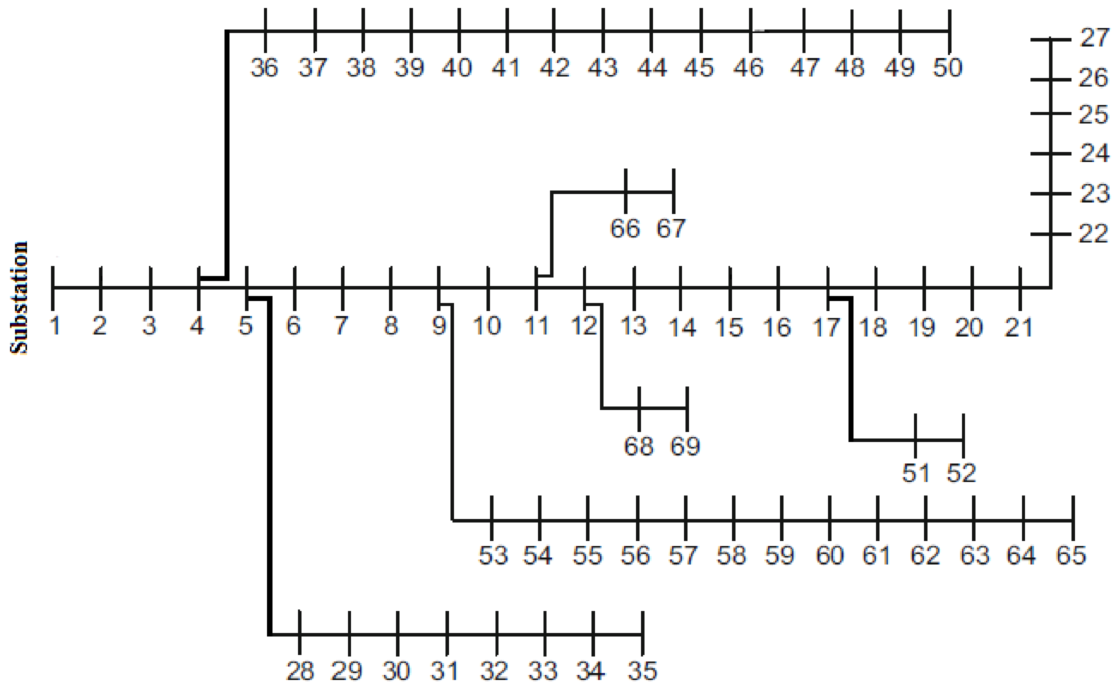

Figure 2. The IEEE 69 Bus Radial distribution system

By the BBO technique the optimal size of 38 MVA DG is connected to the optimal bus 30. BBO technique reduced the DG size by 10 MVA. The power loss obtained from the BBO technique is 195.10 kW, 225.84 kW when connected with DG (Load) and the 228.46 kW without any DG connection (Base Case). The power loss minimized by the BBO technique is by 14.60% as compared to 1.14% by connection with DG. The bus voltage is improving from 0.9125 pu to 0.9501 pu from base model to the BBO technique.

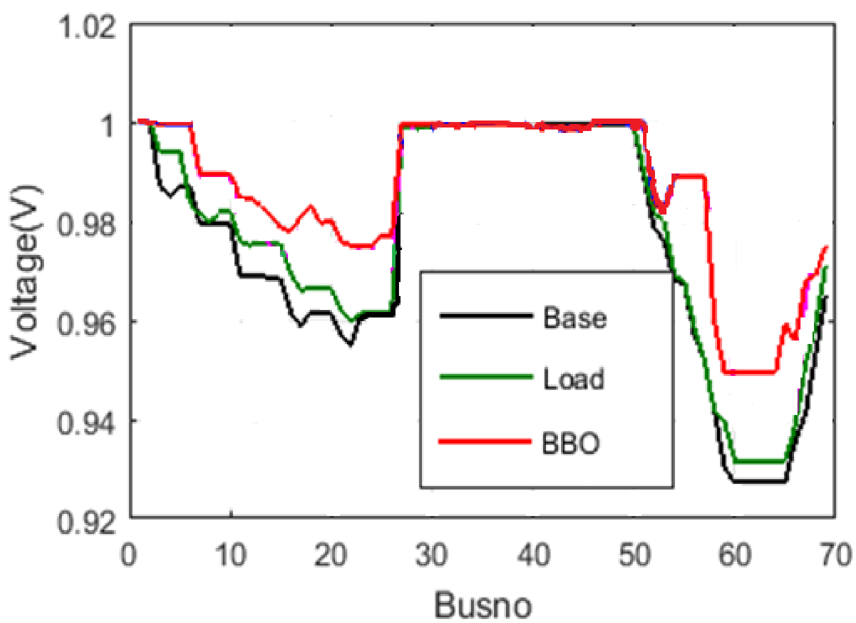

Figure 3. Voltage profile comparison

Figure 3 shows the voltage profile comparison due to the optimal siting of DG system at with BBO technique. The fitness of the BBO is near 72 iterations to reach the optimal results.

IV. CONCLUSION

This paper proposed a BBO technique for optimal siting and sizing of DG system in existing radial distribution system for power loss minimization and voltage profile improvement at the optimal bus where DG system is placed. BBO technique has produced the optimal size and siting location of DG system. This BBO technique is simulated using MATLAB software and tested into the IEEE 69 RDS. The distribution system power loss is evaluated and measured the values and then the maximum power loss bus can place the DG and reduce the power loss. Hence, the optimal siting and sizing of DG system has been successfully done by BBO technique for power loss minimization and improving the voltage profile at the optimal bus.

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