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# OPTIMAL PLACEMENT AND SIZING OF DISTRIBUTED GENERATION USING SOFTCOMPUTING TECHNIQUES

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***ABSTRACT*** - In this paper an improved non dominated sorting genetic algorithm II (INSGA II) is used for optimal planning of multiple distributed generation (DG) unit. Multi objective functions that take minimum voltage deviation, minimum line loss and maximum voltage stability margin in to consideration have been formed. INSGA II algorithm is used to solve the multi objective planning problem. In order to strength the optimal capability, the mutation and recombination strategies in differential evaluation are introduced to replace the original one. A trade of method is used to obtain the best compromise solution from the Pareto optimal set. The power flows through IEEE 33-bus test case and multiple actual test cases with the consideration of multiple DG units.

***Index Terms***—Distributed Generation (DG), Distribution Network (DN), Multi Objective Optimization (MOO), Improved Non Dominated Sorting Genetic Algorithm–II (INSGA-II).

## I. INTRODUCTION

Distributed Generation (DG) technology has become a heavily researched topic, given increasing global concerns for environmental protection, energy saving issue, photovoltaic power generation, increasing complexities of wind power and other renewable energy technologies. An optimal distributed generation placement and sizing in distribution system is usually done for the purpose of minimization of line losses, minimization of voltage deviation and maximization of voltage stability margin. The research work included by the focuses on using an optimization methodology for identifying proper location and size of DG units. Solution's GA for DG

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units placement and sizing has been developed in terms of parameter selection, to obtain the line losses, voltage deviation are minimized and voltage stability margin is maximized. The performance of this proposed methodology is tested on IEEE 33-Bus distribution system. In this work mathematical model of the optimal DG planning problem is established and solve this optimization problem by the Improved Non dominated Sorting Genetic Algorithm II (INSGA II) with the consideration of line loss, voltage deviation and voltage stability margin. Kassel and Glavitsch (1986) describe the method for online testing a power system is proposed is aimed at the detection of the voltage in stabilities. Based on the basic concept of such an indicator various model are derived which allow predicting a voltage in stability of a collapse. The indicator uses information of a normal load flow [7].

Jasmon and Lee (1991) presented an innovation technique for load flow calculation and voltage instability analysis of distribution networks. In all the calculation, no voltage computation is required as all the voltages are eliminated. This reduced network also enables the fast computation of load flow solutions of distribution networks [5]. Deb et al. (2002) developed the multi objective evolutionary algorithms (MOEAs) that uses non dominated sorting and sharing have been criticized mainly for: Their $O(MN^3)$ computational complexity ,Their by elitism approach and The need to specify a sharing parameter [2]. Gandomkar et al. (2005) presented a new optimization algorithm based on integrating the use of genetic algorithms and tabu search methods to optimal location of dispersed generation resource in distribution networks. This algorithm find how much distribution losses can be reduced if dispersed generation are optimally allocated at the demand of power system [3]. Bhattacharya and Chattopadhyay (2010) developed a hybrid technique combining differential evolution biogeography based on optimization algorithm to solve both convex and non convex economic load dispatch problems of thermal power unit considering the transmission loss, and constraints such as ramp rate limits, Valve points loading and prohibited operating zones [1]. Naderi et al. (2012) developed the deregulation in the power system industry and inventions of new technologies for producing electrical energy have led to innovation in Distribution System Planning (DSP). Distributed generation is one of the most attractive technologies that bring different kinds of advantages to a wide range of entities, engaged in power system [8]. Hejazi et al. (2013) presented the most current regulations allow small – scale electric generation facility to participate in DG with few requirements on power purchase agreements. However in this paper it is shown that distributions companies can alternatively encourage DG investors in to

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DG contracts that can significantly benefit the utility network [4].

Jin et al. (2013) presented the power intermittency and maintenance costs are the major challenges in harvesting wind energy. This work proposes a multi criteria optimization model to design and operate a wind based DG system. The goal is to determine the equipment sizing, setting and maintenance schedules. So that the system cost is minimize while turbine reliability is maximized [6]. Nekooei et al. (2013) presented the new approach using harmony search (HS) algorithm is presented is placing DGs in radial distribution systems. The approach is making use of a multiple objective planning frame work, named and improved multi objective HS (MOHS) to evaluate the impact of DG placement and sizing for an optimal development of the distribution system [9]. Wanxing Sheng et al. (2014) presented an improved non dominated sorting genetic algorithm–II is used for optimal planning of multiple DG unit. First, multi objective functions that take minimum line loss, minimum voltage deviation, and maximal voltage stability margin into consideration have been formed. INSGA II algorithm is used to solve the multi objective planning problem. [10].

## II. METHODOLOGY

### Objective functions

The objective of this work is to minimize the system line losses, minimize the voltage deviation in the distribution system as well as to maximize the voltage stability margin of the system by solving the distributed generator placement and sizing problem when Distributed Generation units considered in the Distribution Network.

### A. Minimum of line losses

The first objective is to minimize system line losses after injection into the distribution network. This objective function as

$$\min f_1(x) = \min \sum_{(i,j)\in B} g_{i,j}\left(v_i^2 + v_j^2 - 2v_i v_j \cos\theta\right) \quad (1)$$

Where B is the set of branches of network and $(i, j) \in B$ denotes that (i, j) are two node of a branch and $v_i$ and $v_j$ are voltage magnitudes of node i and j respectively, $g_{ij}$ is the conductance between node i and j. And $Q_{ij}$ is the difference between nodal phase angles $\theta_i$ *and* $\theta_j$ .

### B. Minimization of voltage deviation

The second objective is to minimize the voltage deviation between nodal voltage and specified voltage magnitude.

$$\min f_2(x) = \min \sum_{i=0}^{N} \left( \frac{v_i - v_i^{spec}}{v_i^{\max} - v_i^{\min}} \right)^2 \quad (2)$$

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Where $v_i$ is the voltage magnitude at the $i^{th}$ bus and $v_i^{spec}$ is the specified voltage magnitude. $V_i^{max}$ and $v_i^{min}$ are the upper and lower limits at the $i^{th}$ bus respectively. N is the number of buses.

C. Maximization of voltage stability margin

The third objective is the maximize steady state voltage margin. Voltage stability margin is the measure of the security level of the distribution system.

$$L_{ij} = 4\left[\frac{(P_j X_{ij} - Q_j R_{ij})^2 + (P_j R_{ij} + Q_j X_{ij})V_i^2}{V_i^4}\right] \quad (3)$$

Where, $L_{ij}$ indicates the extent of branch voltage stability. The branch voltage will be instable if the value of $L_{ij}$ is large. Obviously, the voltage instability of the network is determined by the most instable branch, and its expression is as

$$L = \max(L_1, L_2, \ldots., L_{N-1}) \quad (4)$$

Where the L-index ranges from 0 to1. In order to maximize the voltage stability margin, the corresponding function is as

$$\min f_3(x) = \min L \quad (5)$$

## III. GENETIC ALGORITHM

There are usually three operations in a typical genetic algorithm. The first operator is the 'selection'. Which make one or more copies of any individuals that posses a high fitness value. The second operator is the recombination (also known as crossover) operator. This operator selects two individuals within the generation and a crossover site and carries out a swapping operation of the string bits to the right hand side of the crossover site of both individuals crossover operations synthesize bits of knowledge gained from both parents exhibiting better than average performance, thus the probability of a better than average performance. The third operator is the mutation operator. This operator acts as a background operator and is used to explore some of invested point in the search space by randomly flipping a bit in a population of string. Since frequent application of this operator would lead to a completely random search a very low probability is usually assigned to its activation.

The main Advantages of GA are:

- Optimizes with continuous or discrete variable.
- Simultaneously searches from a wide sampling of the cost surface.
- Deals with a large number of variables.
- Provides a list of optimum variables, not just a single solution.
- Optimizes variables with extremely complex cost surfaces.

 

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- May encode the variables so that the optimization is done with the encoded variables and
- Works with numerically generated data, experimental data, or analytical functions.

## IEEE 33-BUS DISTRIBUTION SYSTEM

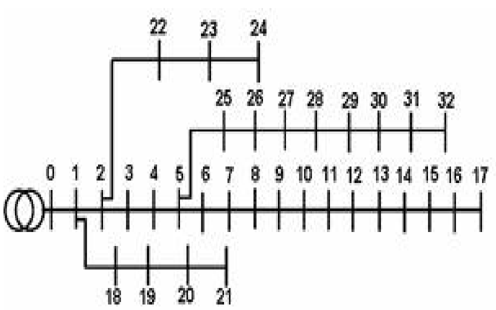


**Fig 1 IEEE 33-bus distribution system**

The Fig 1 shows the bus distribution system in an optimal placement and sizing of distributed generation units in distribution system. A distributed system is a collection of independent computers that appear to the users of the system as a single coherent system. The electric utility system is usually divided into three subsystems which are generation, transmission and distribution. In this distribution plays a very important part as the consumers are directly affected by its efficiency. So proper planning will increase the efficiency and overall performance of the distribution system.

## IV. RESULTS AND DISCUSSIONS

### a) MINIMIZATION OF VOLTAGE DEVIATION

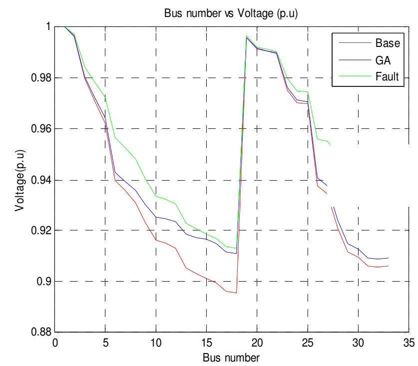


**Fig 2 Minimization of voltage deviation with fault**

Fig 2 shows the response of minimization of voltage deviation with fault.The electrical power is distributed to a load bus. The additional load is installing and the fault is affected. So the DG unit is installed at a certain bus, and the changes of the system voltage, the buses which are sensitive to power losses, voltage deviation are maximization and thus the voltage stability margin minimization. In this work are the selection achieved by developing 4 cases. In each case, are observed. The installed DG unit is assumed to generate constant power 1 MW at unity power factor and the system load demand is taken at peak value. The GA algorithm was applied to solve this problem.

 

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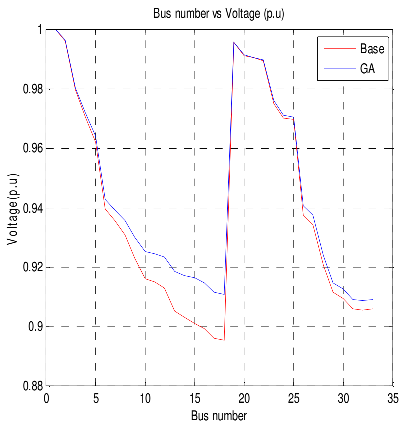


**Fig 3 Minimization of voltage deviation without fault**

Fig 3 shows response of minimization of voltage deviation without fault. The minimization of voltage deviation can help guarantee a better voltage level in distribution power systems. There are usually three operators in a typical genetic algorithm. The first operator is the 'selection' (chromosome) operator. The main idea of the selection is that bigger part of the chromosome should survive to next general. The fitness of the population survives a new generation and the minimum fitness value is to be calculated. The second operator is the recombination (also known as the 'crossover') operator. The fitness of the population survives a new generation and the minimum fitness value is to be calculated. The third operator is the 'mutation' operator. This operator acts as a background operator and is used to explore some of the invested points in the search space by randomly flipping a 'bit' in a population of strings. The fitness value is to be calculated and best calculation is iteration.

### b) MAXIMIZATION OF VOLTAGE STABILITY MARGIN

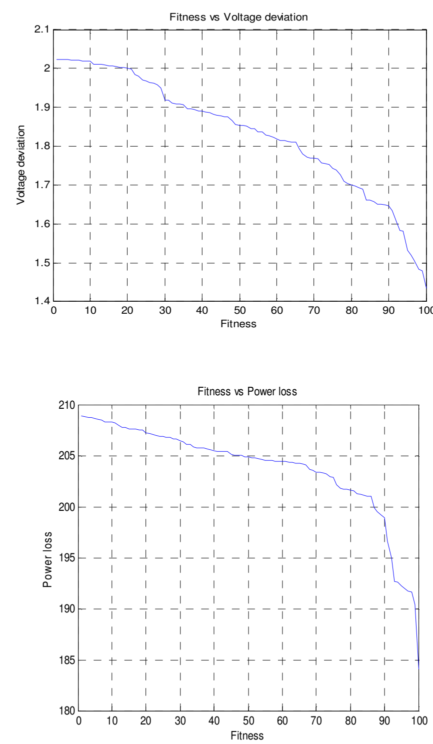


**Fig 4 Maximization of voltage stability margin**

Fig 4 shows the response of maximization of voltage stability margin. Fig 4(a) shows that the relation between the fitness vs. voltage deviation and Fig 4(b) shows the relation between the fitness vs. power loss. DG unit is installed at a certain bus, and the changes of the system voltage are observed. The maximization of voltage stability margin is the measure of the

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security level of the distribution system. Voltage stability analysis is widely used in the planning and daily operation of the power system and online monitoring of the distribution system. Load flow techniques are widely used for voltage stability analysis. The modal analysis method is best method for voltage stability analysis compare to L-index method. Voltage stability analysis is most important factor for highly developed networks. Voltage stability is the ability of power system to maintain steady acceptable voltage at all buses in the system under normal condition. The voltage stability problems are mainly depends up on reactive power variation. The control of reactive power some distributed technologies are used to generate reactive power and improve voltage stability.

### c) MINIMIZATION OF LINE LOSSES

**Table 1 IEEE-33 Bus test**

| **Parameters** | **Multi objective value** |
|---|---|
| Total loss base | 210 |
| Total loss load | 216.6031 |
| Loss (DG (FC)) | 139.1753 |
| DG size (FC) | 91.1842 |
| DG located bus no | 6 |

Table 1 shows the response of IEEE-33 Bus test system. The objective is to minimize system line losses after DG injection into the distribution network. From above tables for the different levels loads the DGs size is change simultaneously with the load levels.

## V. CONCLUSION

The optimal planning of multiple DG units can be derived as the three objectives to consider minimum line loss, minimum voltage deviation, and maximal voltage stability margin can correctly formulate by improving the mutation and crossover procedure, strengthening the non dominated sorting and truncation strategies. The proposed INSGA-II can obtain the best compromise solution for all objectives. Taking IEEE 33-bus systems as test case the comparison of the proposed INSGA-II multi objective optimization algorithm, such as INSGA-II indicate that the proposed method can achieve better precision and diversity.

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