Optimal Placement and Sizing Method to Improve the Voltage Stability Margin in a Distribution System using Bio Inspired Fruit Fly Algorithm

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Abstract-Nowadays, a distributed generation (DG) in distribution systems has increased to high penetration levels. The impact of DG units on the voltage stability margins has become significant. Optimization techniques are used to locate and size the DG units in the system, so as to utilize these units optimally within certain limits and constraints. The bio inspired fruit fly algorithm is proposed to be used for optimizing the location and size of the DG units. The main objective of this work is to propose a method for locating and sizing DG units so as to improve the voltage stability margin. The 33 node test system is considered for validating this work.

Index term- Distributed Generation, Voltage stability, Distribution system, Minimization of losses, Voltage profile.

I. INTRODUCTION

The distributed generation (DG) in power system networks has rapidly increased. This increase can be justified by factors such as environmental concerns, there structuring of electricity market and the development in technologies for small-scale power generation. DG units are typically connected so that they work in parallel with the utility grid, and they are placed depending on availability of the resources. Integrating DG units can have an impact on the practices used in distribution systems, such as the voltage profile, power flow, power quality, stability, reliability, and protection [1]. Since DG units have a small capacity compared to central power plants, the impacts are minor if the penetration level is low (1%–5%). However, if the penetration level of DG units increases to the anticipated level of 20%–30%, the impact of DG units will be profound. Voltage instability in distribution systems has been understood for decades and was referred to as load instability. With the development of economy, load demands in distribution networks are sharply increasing. Hence, the distribution networks are operating more close to the voltage instability boundaries. The decline of voltage stability margin is one of the important factors which restrict the increase of load served by distribution companies. Therefore, it is necessary to consider voltage stability with the integration of DG units in distribution systems.

II. DISTRIBUTED GENERATION

Distributed generation is a new trend in electric power generation. The concept permits the electricity "consumer", who is generating electricity for their own needs, to send their surplus electrical power back into the power grid [2].

Distributed generation is an approach that employs small-scale technologies to produce electricity close to the end users of power. DG technologies often consist of modular (and sometimes renewable-energy) generators, and they offer a number of potential benefits. In many cases, distributed generators can provide lower-cost electricity and higher power reliability and security with fewer environmental consequences than can traditional power generators.

In contrast to the use of a few large-scale generating stations located far from load centers--the approach used in the traditional electric power paradigm--DG systems employ numerous, but small plants and can provide power onsite with little reliance on the distribution and transmission grid. DG technologies yield power in capacities that range from a fraction of a kilowatt [kW] to about 100 megawatts [MW]. Utility-scale generation units generate power in capacities that often reach beyond 1,000 MW.Applications of distributed generating systems there are many reasons a customer may choose to install a distributed generator. DG can be used to generate a customer’s entire electricity supply; for peak shaving (generating a portion of a customer’s electricity onsite to reduce the amount of electricity purchased during peak price periods); for standby or emergency generation (as a backup to Wires Owner's power supply); as a green power source (using renewable technology); or for increased reliability. In some remote locations, DG can be less costly as it eliminates the need for expensive construction of distribution and/or transmission lines [3].

III.CHALLENGES ASSOCIATED WITH DISTRIBUTED GENERATING SYSTEMS

There are no uniform national interconnection standards addressing safety, power quality and reliability for small distributed generation systems. The current process for interconnection is not standardized among provinces. Interconnection may involve communication with several different organizations the environmental regulations and permit process that have been developed for larger distributed generation projects make some DG projects uneconomical. Contractual barriers exist such as liability insurance requirements, fees and charges, and extensive paperwork [4].

IV. OPTIMAL LOCATION AND SIZING AND TECHNIQUES

It is an open access market principles are applied to power systems; an increased emphasis is being placed on DG. In most large electrical power systems the power can be generated through generating stations. This is typically done because in past, the cost of produce bulk quantities of electricity is generally much less than cost of produce smaller quantities of electricity. However increased electricity cost, and a growing interests towards environmentally friendly energy source, the incorporation of small scale DG is becoming more popular. In order to prevent network expansion in and to cover new load areas or increased energy to satisfy customer demand. Using the optimal location to implementing the Distributed generation throughout a power system network, providing load electricity to load customers [5].

Over view of optimization

Optimization is simply defined as finding a best solution for the defined problem and it is mathematically defined as minimization or maximization of an objective function f(x) depending on variables x subject to constraints.

Need For Optimization

Today optimization is needed in all platforms of engineering and especially they are well used in the electrical power engineering because of its reliability. Optimization is needed because for any given problem they may have many solutions by the probability, to extract the best solutions of the problem described an optimization technique is required.

Though, this optimization technique is an old technique which uses many older optimization methods. But today, in this fast working world all the things needed are should be in a fast working manner and they have lot of constraints. So the optimization techniques used are also in a fast emerging manner (i.e.) they should obtain best results in fast action. So the developers, develops and optimization technique called bio inspired algorithms.

Bio-inspired Algorithms

The definition of bio inspired algorithms is simple and they are defined as they are the category of algorithms that imitate the way nature performs. They are quite popular because of their unique characteristics called simple and by the reducing the rigorous mathematical approaches. Some of the bio-inspired algorithms are given below, they are,

III. SIMULATION AND RESULTS

Problem formulation

$$f = min(P_L) \quad (1)$$

Where:
P_L: Active Power Loss
The active power loss is obtained from load flow program.

Constraints

The main constraints in the optimization process in the proposed methodology are:

1. Active and reactive power losses constraints
2. Voltage Constraints
3. DG size constraint

Active and reactive power losses constraint:

The losses after installing DG in power grid should be less than or equal losses before installing DGs.
PL with DG ≤ PL without DG
QL with DG ≤ QL without DG
Voltage constraint:

$$V_i^{min} \leq V_i \leq V_i^{max}; i \in N_B \quad (2)$$

DG Size constraint:

To obtain a reasonable and economic solution, the size of generators should not be so small or so high with respect to load value. The DG size is considered not less than one quarter of the load and not more than three quarters of the load as following:

$$25\%L \leq D_{Gi} \leq 75\%L (3)$$

L : Load value
DG_i: DG size

IEEE 33 BUS NETWORK:

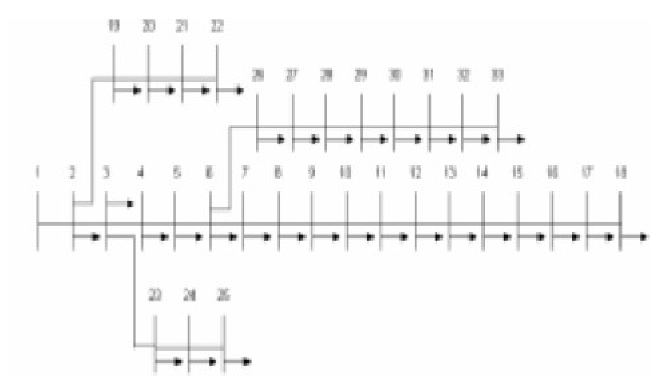


Fig 2 Online diagram of IEEE 33 – bus radial district
6.6.1 PROGRAMING DATA

Input Data

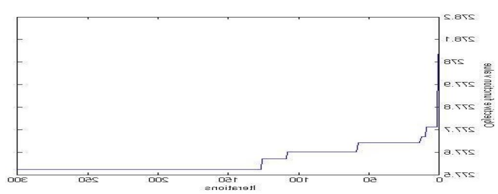
```
line data= [ 1 1 2 0.0922 0.0470
2 2 3 0.4930 0.2511
3 3 4 0.3660 0.1864
4 4 5 0.3811 0.1941
5 5 6 0.8190 0.7070
6 6 7 0.1872 0.6188
7 7 8 0.7114 0.2351
8 8 9 1.0300 0.7400
9 9 10 1.0440 0.7400
10 10 11 0.1966 0.0650
11 11 12 0.3744 0.1238
12 12 13 1.4680 1.1550
13 13 14 0.5416 0.7129
14 14 15 0.5910 0.5260
15 15 16 0.7463 0.5450
16 16 17 1.2890 1.7210
17 17 18 0.7320 0.5740
18 2 19 0.1640 0.1565
19 19 20 1.5042 1.3554
20 20 21 0.4095 0.4784
21 21 22 0.7089 0.9373
22 3 23 0.4512 0.3083
23 23 24 0.8980 0.7091
24 24 25 0.8960 0.7011
25 6 26 0.2030 0.1034
26 26 27 0.2842 0.1447
27 27 28 1.0590 0.9337
28 28 29 0.8042 0.7006
29 29 30 0.5075 0.2585
30 30 31 0.9744 0.9630
31 31 32 0.3105 0.3619
32 32 33 0.3410 0.5302];
6.6.2 .2Bus data= [ 1 0 0 0
2 100 60 0
3 90 40 0
4 120 80 0
5 60 30 0
6 60 20 0
7 200 100 0
8 200 100 0
9 60 20 0
10 60 20 0
11 45 30 0
12 60 35 0
13 60 35 0
14 120 80 0
15 60 10 0
16 60 20 0
17 60 20 0
18 90 40 0
19 90 40 0
20 90 40 0
21 90 40 0
```

22 90 40 0
23 90 50 0
24 420 200 0
25 420 200 0
26 60 25 0
27 60 25 0
28 60 20 0
29 120 70 0
30 200 600 0
31 150 70 0
32 210 100 0
33 60 40 0];

IV. AFTER OPTIMIZATION

MASSOBJ =277.5231
MASSSIZE =10 10
MASSLOC =16 17
vbp =
1.0000
0.9960
0.9770
0.9669
0.9569
0.8886
0.8874
0.8870

V. BEFORE OPTIMIZATION



vbp =
1.0000
0.9960
0.9770
0.9668
0.9568
0.9318
0.9271
0.9205
0.9119
0.9040
0.9028
0.9008
0.8924
0.8894
0.8874
0.8856
0.9320
0.9273
0.9207

0.9122
0.9042
0.9031
0.9010
0.8927
0.8896
0.8877
0.8858
0.8831
0.8823
0.9953
0.9907
0.9898
0.9890
0.9722
0.9633
0.9589
0.9294
0.9259
0.9103
0.8992
0.8944
ans =281.5877

VI. CONCLUSION

In this paper, a method of DG units' allocation is proposed. This method targets utilizing the DG units to minimize the losses. It considers the probabilistic nature of both loads and renewable DG generation. The candidate buses for the DG units' installation are selected based on the sensitivity to the voltage. Simulations results indicate that DG size and location can have positive impacts on reduce cost. Therefore, an optimization method can be used to determine the locations and sizes of the DG units, to achieve the target of reducing loses. Therefore, the DG units with higher rating might be placed in upper stream of a radial distribution system in order to keep the system operating within the allowed minimize the losses.

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