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Loss Minimization in Distribution Systems Using Multi Distributed Generation

KEYWORDS distributed generation (DG) , load , power loss, power factor, genetic algorithm

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ABSTRACT *The integration of distributed generation (DG) in power system has gained more Importance in today's scenario of depletion of natural energy resources. The Installation of DG reduces power loss and improves voltage profile. Installation of DG units in non optimal places may result in system loss and a bad effect on Voltage profile and other parameters which may lead to increase of cost and Consequently an opposite effect on what is expected. Selecting best places for Installation of DG units is a complex problem. In this paper the optimal Placement of multi distributed generation for different loads i.e. residential, Industrial, commercial is considered for reducing power loss. Two types of DGs i.e. constant power factor and constant voltage types are considered. Genetic Algorithm is utilized to find the location and size of both DGs. The performance Of proposed algorithm is implemented on IEEE-33 distribution system.*

INTRODUCTION

Distributed generation represents a change in standard of electricity generation. DG technologies can meet the needs of a wide range of users with applications in the residential, commercial and industrial sectors. Many studies are performed on distribution power flow with presence of distributed generation. One of main drawback for high DG penetration in distribution feeder is the voltage rise effect which can be rectified by selection of appropriate size and number of DGs. Determining a suitable model for each DG unit in power flow studies requires knowledge of DG operation and type of its connection to grid. Using different combination of sources and conversion devices different output characteristics can be obtained. On the basis of the output power characteristics, DG sources can be modeled as constant power factor source , variable reactive power source, constant voltage source. In this paper constant power factor model and constant voltage model of DGs are used for performing the distribution system power flow with DGs.

Constant power factor model

In this model, reactive power can be controlled by taking power factor as a reference. Synchronous generator is an example for this category. The bus treated as PQ bus and the reactive power is calculated by maintaining ratio between Pgen and Qgen is constant.

$$Qgen = Pgen * \tan(\cos^{-1}(pf))$$

Where Pgen and Qgen are the specified real power output and calculated reactive power output.pf is the specified power factor. This model of DG can be used for controllable DGs where the output reactive power can be adjusted for getting constant power factor.

Constant voltage model

The power flow solution is investigated for this model by a compensation based method to handle all PV nodes in power flow studies.

Load flow method

Because electric distribution system are mainly radial or weakly meshed type with unbalanced distribution load, wide ranging resistance and reactance value, standard Fast-decoupled, Newton-Raphson methods often are not valid. In this paper topological load flow method is used.

After performing load flow using the described models, the optimal size and location of DG is found by using genetic algorithm

Genetic Algorithm implementation for sizing and location of DG units

Genetic algorithm is used to designate optimization algorithms that perform a kind of approximate global search. It rely on the information obtained by evaluation of several points in the search space. Each current point is called an individual. The set of current point is called population. The algorithm keeps this set of current points instead of keeping a single current point as in most optimization algorithms. The population converges to a problem optimum through sequential application of genetic operators.

Problem formulation

The multi objective index for the performance calculation of distribution systems for DG size and location planning considers various performance indices by strategically giving a weight. All impact indices are normalized(values between 0 and 1). The problem is minimization of IMO. Where

$$IMO=(\sigma 1.ILP + \sigma 2.\ ILQ + \sigma 3.\ IC + \sigma 4.\ IVD) \text{ ......(1)}$$

Where ILP and ILQ are real and reactive power loss indices.

$$ILP= [PLDG]/[PL] \text{ .... (2)}$$
$$ILQ= [QLDG]/[QL] \text{ .... (3)}$$

PLDG and QLDG are total real and reactive power losses of distribution system after inclusion of DG.PL and QL are total real and reactive system losses without DG in distribution system.

IVD is voltage profile index .One of advantage of proper location and size of DG is the improvement in voltage profile.

$$IVD = \max_{i=2}^{n} (V1-Vi/V1) \text{ ....(4)}$$

The index IC gives information about the level of MVA flow/currents through the network regarding the maximum capacity of conductors.

These weights are intended to give the corresponding importance to each impact indices for the penetration of DG and depend on required analysis i.e. planning, operation etc.

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CSij=MVA flow in branch i-j without DG unit in distribution. The indices weights are given in table1

Table 1:Indices weights

Indices	σp
ILP	0.40
ILQ	0.20
IC	0.25
IVD	0.15

There is a significant affect of load models on the optimal location and sizing of DG resources in distribution systems. There are various voltage dependent load models such as residential, industrial, commercial. These load models can be mathematically expressed as follows:

$P_i = P_{oi} V_i^{\alpha}$ ……………….. (6)

$Q_i = Q_{oi} V_i^{\beta}$ ……………….(7)

Where Pi and Qi are real and reactive power at bus i , Poi and Qoi are specified active and Vi is the voltage at bus i and α and β are real and reactive reactive power exponents. The values of α and β for different load models are given in table2

Table2: α and β for different load models

Load type	α	β
Constant	0	0
Industrial load	0.18	6.00
Residential load	0.92	4.04
Commercial load	1.51	3.4

$$IC = \max_{i=1}^{nline} (S_{ij}/CS_{ij}) \quad ......(5)$$

Where Sij =MVA flow in branch i-j with DG

Unit in distribution

The following algorithm is followed

1. Read distribution system data, GA Parameters and form Y bus.
2. Enter number of DGs,type of DG model and type of load model.
3. Chromosome length=Chromosome length×number of DGs
4. Set generation count=1
5. Set population count=1
6. Set Pgen(i)=0, Itype(i)=1 for i=1…………Nbus
7. Decode chrosome and get location,size of all DGs.
8. Set load flow iteration count=1
9. Run load flow
10. If &Q ≤0.0001, calculate fitness fit (ii) = (σ1. ILP + σ2 . ILQ + σ3. IC + σ4 . IVD)
11. Arrange the fitness in descending order
12. If (fit (i) = fit (psize), then follow elitism,selection,crossover,mutation.
13. If(gen=max gen) stop otherwise go to step 5.

4.Simulation

The proposed methodology is tested on a test system i.e 33-bus radial distribution system.A computer program has been written in MATLAB 7.1 to calculate optimum sizes of DG at various buses and approximate total losses with DG at different locations to identify the best location. In this paper a general size of DG is considered in the range of 0.0-0.66 p.u. The resuts are shown in following tables 3,4,5,6.

Constant power factor

Single DG case p.f = 0.9

Table 3

Load	Active power loss without DG p.u	Active power loss with DG p.u	Reactive powerloss without DG p.u	Reactive powerloss withDG p.u	DG location	DG size p.u
Constant	0.4247	0.2615	0.1765	0.1882	33	0.66
Residential	0.2550	0.1679	0.1852	0.11872	32	0.66
Commercial	0.2482	0.1656	0.1842	0.11736	32	0.66
Industrial	0.2547	0.1648	0.1846	0.11596	32	0.66
Mixed	0.2968	0.1860	0.2184	0.1331	33	0.66

Constant voltage DG

Single DG case

Table 4

Load	Active power loss without DG p.u	Active power loss with DG p.u	Reactive powerloss without DG p.u	Reactive powerloss withDG p.u	DG location	DG size p.u
Constant	0.42472	0.24445	0.313677	0.18817	28	0.66
Residential	0.25507	0.25134	0.185236	0.18301	20	0.4305
Commercial	0.24923	0.24562	0.18112	0.178966	20	0.4231
Industial	0.2547	0.2508	0.18462	0.1823	20	0.4435
Mixed	0.29682	0.2157	0.21842	0.16594	28	0.66

Simulation results are shown in the following figures.

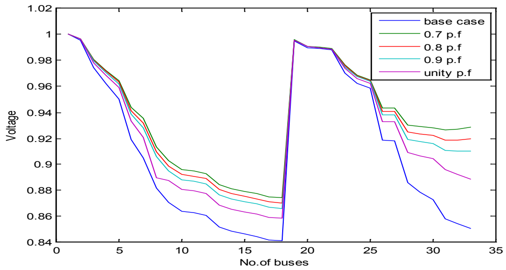

Fig1 : Bus voltages forconstant p.f DG for constant load single DG case

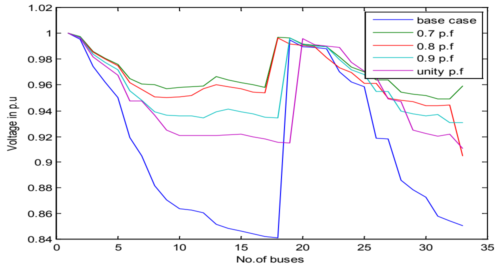

Fig 2:Bus voltages for constant p.f DG for constant load 2DG case

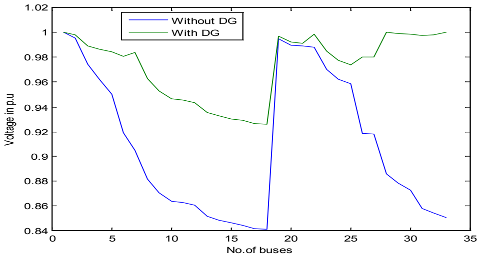

Fig 3:Bus voltages for constant voltage DG for constant load single DG case

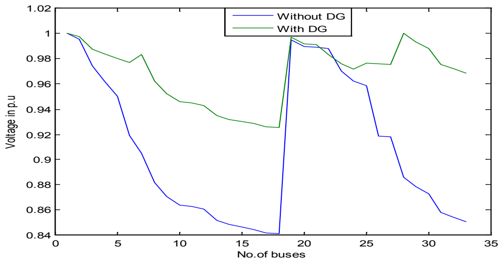

Fig4:Bus voltages for constant voltage 2DG

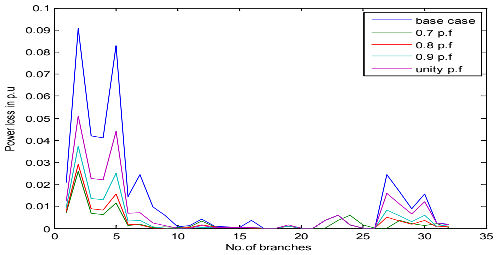

Fig 5: Active power loss for constant p.f. DG for constant load single DG case

CONCLUSION

From the result It can be observed that there is a significant decrease in real and reactive power losses with DG placement. The variation in both real and reactive power losses with generations for both DG models and four load models are presented. The effect of DG units on system voltages for both different DG models and load models is also presented. It is also observed that there is a significant difference in both size and location of DG when different DG models are considered.

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