Reducing Real and Reactive Power Losses in the Power Distribution System by DFIG Placement and Sizing Using Ordinary PSO and HGAPSO :A Comparison.

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Abstract

Due to the increased importance of DFIGs in optimization of real and reactive power losses and the maintenance of voltage profile, the general methods of DG placement and sizing in the existing literature cannot be of practical importance in DFIG .In this paper a pure PSO method used in general DG is compared with a HGAPSO in the siting and sizing of DFIG with the objective of minimizing power losses .The corresponding Combined participation factors are assigned using the DFIG Domain Distributed Slack Bus Model and a comparison made on the two schemes of loss minimization. The obtained results for the real and reactive power losses and voltage voltage profile illustrate the DFIG need in the modern power system.

Key Words

Distributed Generator (DG), Doubly Fed Induction generator (DFIG), Hybrid GAPSO (HGAPSO),Genetic Algorithm(GA), Particle Swarm Optimisation(PSO).

I. INTRODUCTION

The electric distribution system is the most extensive part of the electrical system, and consequently, it is the mainly responsible for energy losses [1]. Therefore the use of optimization techniques in the design of this subsystem can lead to significant economic gains, obtaining networks which minimize the immediate costs (those related to installation and reconductoring) and further costs (costs related to energy losses and system maintenance) [2–4] It is well known that distribution systems are in constant evolution, subject to load increasing in different places at different times, which leads to the need of successive system expansions [5, 7, 8].

Since the last few years, the interest in the placement of DG in utility network has increased due to its effective role in reducing the power loss of the distribution networks so as to serve remote loads. In recent years, the power industry has experienced significant changes on the distribution power system primarily due to the implementation of smart-grid technology and the incremental implementation of distributed generation. Distributed Generation (DG) is simply defined as the decentralization of power plants by placing smaller generating units closer to the point of consumption, traditionally ten mega-watts or smaller. While DG is not a new concept, DG is gaining widespread interest primarily due to increase in customer demand, advancements in technology, economics, deregulation, environmental and national security concerns.

The distribution power system traditionally has been designed for radial power flow, but with the introduction of DG, the power flow becomes bidirectional. As a result, conventional load flow analysis tools and techniques are not able to properly assess the impact of DG on the electrical system. The presence of DG on the distribution system creates an array of potential problems related to safety, stability, reliability and security of the electrical system. Distributed generation on a power system affects the voltages, power flow, short circuit currents, losses and other power system analysis results. Whether the impact of the DG is positive or negative on the system will depend on the location and size of the DG.This paper will go very specific to study the placement and sizing of the DFIG.

Proper management of DG reduces Green house Gas(GHG) emissions, improves efficiency, helps deferring system upgrades, improves reliability and enhances the energy security. As voltage increases at the end of a feeder, demand supply imbalance during fault condition, decline in power quality, increase in power losses, and reduction of reliability levels may occur, if DGs are not properly allocated [9], [10]. To overcome these problems, solution methodologies and techniques are suggested by various authors to solve the problem of optimal allocation of DGs in the utility network. The exact allocation of DGs is achieved by considering all feasible combinations of sites and sizes of DGs in the system. The number of alternatives could however, be very large as the number of variables of the problem (i.e. number of DGs and number of nodes of the system) increases.

A:GENERAL DG PLACEMENT AND SIZING METHODS:A REVIEW

Distributed generation utilization is an effective alternative for reducing this cost by generation near the load points.In recent years, several studies have considered techniques for locating DG units on distribution systems.

Rau and Wan [22] have used gradient and second order method to minimize loss ,line loading and reactive power requirements in the Distribution network .Willis [23] investigated loss minimization using analytical based 2/3 rule ,assuming a constant power source and a uniformly distributed load.Hybrid and Constraint Based Multi Objective Programming(HCBMOP) and GA method was proposed by Celli et al[24] to minimize the cost of network upgrading ,power losses and energy required by customer.He later used the method to minimize the cost of network upgrading ,cost of energy losses and DG network acceptability index[25] with the DG fully considered as a valid planning alternative.Carpinelli et al [25] used the method proposed in [24] for a peak load with constant growth rate and a constant power source to minimize the cost of losses and to improve voltage quality and harmonic distortions.Kamalnia et al[26] used GA and Multiple Attribute Making Decision (MAMD) approach on a PQ model DG to investigate its technical attributes such as reactive power flows, voltage variation and active loss as well as the economic attributes which include line congestion ,capital cost and emission.

El-khattam et al[27] used an Heuristic Iterative Search method to minimize the cost of investment and operation of DGs,loss and energy required by customers;which Satish et al [28] later applied to minimize DG investment and operation losses and energy purchased from the main grid.

Falaghi and Haghifam[29] use Anti- Colony Optimization(ACO) on a time varying load to minimize investment cost ,operation cost and energy buying from transmission grid. Further Soroudi and Ehsan [30] used Particle Swarm Optimization on a multi- load level to minimize the cost of active losses,investment and operation cost of DG and emission cost.

The other methods used include analytical approach[28],simulated annealing[31,32,58],optimal power flow[33],sensitivity analysis[34], fast sequential quadratic programming [35] and NSGA II and max-min approach [36].All these methods have not take care of the intermittent renewables and therefore in practice they are inaccurate.

GA with decision making approach is used by Carpinelli et al[37] to minimize the cost of power losses and network upgrading for a wind generator with a peak load and constant load growth.Ochoa el al[38] used multi objective optimization with NSGA for a wind generator with a time varying load to maximize the intergration of DG and energy export ;minimizing losses and short circuit level

Several analytical approaches were also proposed in the literature [39-43]. GA based methods and PSO technique was also presented [44,45,48]. EP based method and FL based method are also presented in [49] and [50]. The other methods like probabilistic based MINLP [59], probabilistic based MC simulation [60], ABC [42], DLF [61], and OPF [51, 52, 53] are also presented by various authors. The hybrid based methods, like GA-PSO, GA-TS, and Fuzzy-GA are suggested by [54-56], respectively.

B:DFIG PLACEMENT AND SIZING IMPORTANCE

Distributed generation has been growing rapidly in power systems. Studies by the Electric Power Research Institute(EPRI) and the Natural Gas Foundation indicate that 60% or higher of new generation will be distributed generation by 2030 with 30% being wind based using the commercially viable DFIG [11,12], hence such wind based distributed generation will play an important role in power systems.

Since DFIGs are located close to the load centers,they have the following benefits of Voltage control and support,System reliability enhancement,Real and reactive power losses reduction. Transmission and distribution release and infrastratural expansion deferment and lastly.flexibility in more energy management.In order to achieve these mentioned benefits,the DFIGs must be carefully installed and operated and the behaviours of distribution systems with DFIGs must be accurately analysed. However the inclusion of large number of DFIGs within the distribution systems will change the distribution system analysis ,planning,operation and control presented in the existing literature.

C: OBJECTIVE

The main objective of this paper is to use HGAPSO in the placement and sizing of the DFIG with the aim of reducing real and reactive power losses. The results will be compared with

those of ordinary PSO and the combined participation factors assigned to the various buses using DFIG domain Distributed slack bus model

II:DFIG PLACEMENT AND SIZING USING HGAPSO

A:THE NEED FOR HGAPSO

Particle Swarm Optimization

Swarm Intelligence (SI) is an innovative distributed intelligent paradigm for solving optimization problems that originally took its inspiration from the biological examples by swarming, flocking and herding phenomena in vertebrates. Particle Swarm Optimization (PSO) incorporates swarming behaviors observed in flocks of birds, schools of fish, or swarms of bees, and even human social behavior, from which the idea is emerged [13,14,15]. PSO is a population-based optimization tool, which could be implemented and applied easily to solve various function optimization problems. As an algorithm, the main strength of PSO is its fast convergence, which compares favorably with many global optimization algorithms like Genetic Algorithms (GA)[16] Simulated Annealing (SA)[17,18] and other global optimization algorithms. For applying PSO successfully, one of the key issues is finding how to map the problem solution into the PSO particle, which directly affects its feasibility and performance.

Genetic Algorithm

Genetic Algorithms are a family of computational models inspired by evolution.These algorithms encode a potential solution to a specific problem on a simple chromosome-like data structure and apply recombination and mutation operators to these structures so as to preserve critical information. An implementation of a genetic algorithm begins with a population of (usually random) chromosomes.One then evaluates these structures and allocates reproductive opportunities in such a way that those chromosomes which represent a better solution to the target problem are given more chances to reproduce than those chromosomes which are poorer solutions. This is called *survival for the fittest*.The goodness of a solution is typically defined with respect to the current population.

The genetic algorithm can be viewed as two stage process. It starts with the current population. Selection is applied to the current population to create an intermediate population. Then recombination and mutation are applied to the intermediate population to create the next population. The process of going from the current population to the next population constitutes one generation in the execution construction of the intermediate population is complete and recombination can occur. This can be viewed as creating the next population from the intermediate population. Crossover is applied to randomly paired strings with a probability denoted Pc. A pair of strings is picked with probability

Pc for recombination. These strings form two new strings that are inserted into the next population. After recombination, mutation operator is applied. For each bit in the population, is mutated with some low probability Pm. Typically the mutation rate is applied with less than 1% probability. In some cases mutation is interpreted as randomly generating a new bit in which case, only 50% of the time will the mutation actually change the bit value. After the process of selection, recombination and mutation, the next population can be evaluated. The process of evaluation, selection, recombination and mutation forms one generation in the execution of a genetic algorithm. In this paper, the mutation genetic operator is used to introduce divergence to the PSO so as to escape the local maxima.

Hybrid PSO with GA(HGAPSO)

The drawback of PSO is that the swarm may prematurely converge. The underlying principle behind this problem is that, for the global best PSO, particles converge to a single point, which is on the line between the global best and the personal best positions. This point is not guaranteed for a local optimum[19] .Another reason for this problem is the fast rate of information flow between particles, resulting in the creation of similar particles with a loss in diversity that increases the possibility of being trapped in local optima.A further drawback is that stochastic approaches have problem-dependent performance. This dependency usually results from the parameter settings in each algorithm. The different parameter settings for a stochastic search algorithm result in high performance variances. In general, no single parameter setting can be applied to all problems. Increasing the inertia weight (w) will increase the speed of the particles resulting in more exploration (global search) and less exploitation (local search) or on the other hand, reducing the inertia weight will decrease the speed of the particles resulting in more exploitation and less exploration. Thus finding the best value for the parameter is not an easy task and it may differ from one problem to another. Therefore, from the above, it can be concluded that the PSO performance is problem-dependent. The problem-dependent performance can be addressed through hybrid mechanism. It combines different approaches to be benefited from the advantages of each approach.

To overcome the limitations of PSO, hybrid algorithms with GA are proposed. The basis behind this is that such a hybrid approach is expected to have merits of PSO with those of GA. One advantage of PSO over GA is its algorithmic simplicity. Another clear difference between PSO and GA is the ability to control convergence. Crossover and mutation rates can subtly affect the convergence of GA, but these cannot be analogous to the level of control achieved through manipulating of the inertia weight. In fact, the decrease of inertia weight dramatically increases the swarm's convergence. The main problem with PSO is that it prematurely converges [19] to stable point, which is not necessarily maximum. To prevent the occurrence, position update of the global best particles is changed. The position update is done through some hybrid mechanism of GA. The idea behind GA is

due to its genetic operators crossover and mutation. By applying crossover operation, information can be swapped between two particles to have the ability to fly to the new search area. The purpose of applying mutation to PSO is to increase the diversity of the population and the ability to have the PSO to avoid the local maxima.

There are three different hybrid approaches are proposed [19].In PSO-GA (Type 1) ,the gbest particle position does not change its position over some designated time steps, the crossover operation is performed on gbest particle with chromosome of GA. In this model both PSO and GA are run in parallel.In PSO-GA (Type 2) ,the stagnated pbest particles are change their positions by mutation operator of GA. Lastly,in PSO-GA (Type 3), the initial population of PSO is assigned by solution of GA. The total numbers of iterations are equally shared by GA and PSO. First half of the iterations are run by GA and the solutions are given as initial population of PSO. Remaining iterations are run by PSO.In this paper,the PSO-GA type 2 is preferred since we are interested in changing the siting of the DFIGs optimize the power losses ,taking their capacities as a constant..The cross over genetic operator is not of any importance in this paper since the DFIGs are independent of each other hence PSO-GA Type 1 and Type 3 cannot be used.

PSO, which is stochastic in nature and makes use of the memory of each particles as well as the knowledge gained by the swarm as a whole, has been proved to be powerful in solving many optimization problems. The   hybrid PSO systems find a better solution without trapping in local maximum, and to achieve faster convergence rate. This is because when the PSO particles stagnate, GA diversifies the particle position even though the solution is worse. In PSO-GA, particle movement uses randomness in its search. Hence, it is a kind of stochastic optimization algorithm that can search a complicated and uncertain area. This makes PSO-GA more flexible and robust. Unlike standard PSO, PSO-GA is more reliable in giving better quality solutions with reasonable computational time, since the hybrid strategy avoids premature convergence of the search process to local optima and provides better exploration of the search process.

B:THE DFIG CAPABILITY LIMIT CURVE CURVES

The model of a DFIG used in this paper consists of a pitch controlled wind turbine and an induction generator[20,21].The stator of the DFIG is directly connected to the grid ,while the rotor is connected to the   converter consisting of two back to back pulse width modulated (PWM)inveters,which allow direct control of the rotor currents.

Direct control of the rotor currents allows for the variable speed operation and reactive power control thus the DFIG can operate at a higher efficiency over a wide range of wind speeds and thus help in   providing   voltage support   for the power grid.The

characteristics make the DFIG ideal for use as a wind generator,whose equivalent circuit is as shown in the figure 1.0.
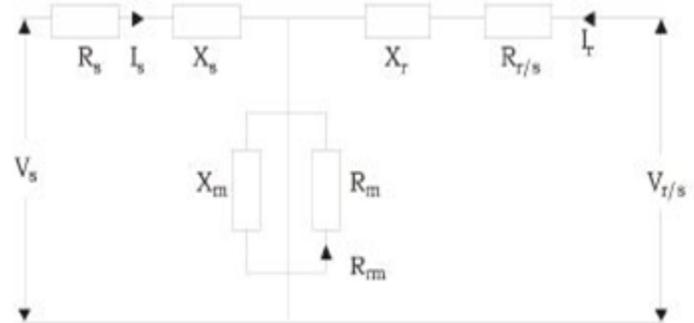

Fig 1:Equivalent circuit of a DFIG [20,21]

The stator active and reactive power can be expressed in terms of the stator and rotor currents as [20,21]

In the PQ plane,the equation (1) represents the circumference

$$P_s^2 + Q_s^2 = (3V_s I_r)^2 \dots\dots\dots\dots\dots\dots\dots(1)$$

$$P_s^2 + (Q_s + 3\frac{V_s^2}{X_s})^2 = (3\frac{X_m}{X_s}V_s I_r)^2 \dots\dots\dots(2)$$

centered at the origin [0,0] with the radius equal to the stator speed apparent power.Equation (2) represents a circumference centered   at $[-3V_s^2/X_s, 0]$ and   radius   equal   to $[3(X_m V_s I_r)/X_s,]$.Therefore given the maximim rotor and stator allowable   currents   limits   , $I_{r\,max}$ and $I_{S\,max}$, the   DFIG capability limits can be obtained.The composed DFIG capability limits   curve   is   shown   in   Figure   2.0   where U_S is used instead of V_S .Taking the steady state stability of the DFIG into account,represented by the vertical line at the $[-3V_S^2/X_S, 0]$ cordinate,it is obvious that the DFIGreal and reactive power capability mainly depends on the maximum allowable roror current.

From the   Figure,the DFIG can operate at any point in the intersecting area within the given limits.when the available active power is far from its maximum,the amount of reactive power is high.The large reactive power control   capability of the DFIG make it possible to use DFIG as the continuous reactive power support to support system voltage control.
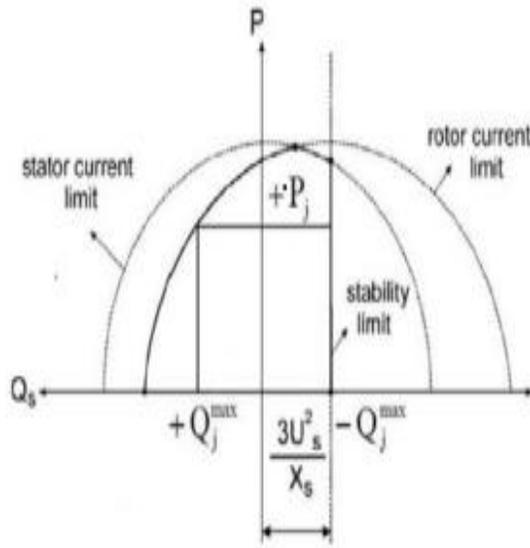
Fig 2:DFIG Capability Limits Curve[20]

C:PROBLEM FORMULATION

The real power loss in the distribution system is very significant from the system operation point of view. The difference between the generated power and the power demand gives the power loss .That is :

$$\sum_{i=1}^{n} P_{DFIGi} = \sum_{i=1}^{n} P_{Di} + \sum_{i=1}^{n} P_{L} \quad \text{(3)}$$

Where

$P_L = \sum_{i=1}^{n} P_{loss}$ Is the total real power loss

$\sum_{i=1}^{n} P_{DFIGi}$ Is the generated power

$\sum_{i=1}^{n} P_{Di}$ Is the power demand

The objective of the placement technique is to minimize the total real power loss. Mathematically, the objective function can be written as:

$$\min imize\ p_L = \sum_{i=1}^{n} P_{loss}$$

with

$$P_L = \sum_{i=1}^{n}\sum_{j=1}^{n} K_i(P_i P_j + Q_i Q_j) + K_t(Q_i P_j - P_i Q_j)\ldots\ldots\ldots\ldots(4)$$

where

$$K_i = \frac{R_{ij}\cos(\delta_i - \delta_j)}{V_i V_j}$$

$$K_t = \frac{R_{ij}\sin(\delta_i - \delta_j)}{V_i V_j}$$

Where

K_i is the real power participation factor,

K_t is the reactive power participation factor

$P_i P_j$,and $Q_i Q_j$ are the net real and reactive power injections in bus " i" and "j" respectively

R_{ij} is the resistance between bus " i" and "j" ,

$V_i V_j$ and $\delta_i \delta_j$ are the voltage and angle at bus " i" and "j" respectively.

In the objective function,the network parameters are absorbed in the loss equation by the real and reactive participation factors formulated in [46]

The objective function is solved subject to the following constraint of DFIG domains and the power distribution system parameters:

(i)Power balance

$$\sum_{i=1}^{n} P_{DGi} = \sum_{i=1}^{n} P_{Di} + P_{L}\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

(ii)DFIG active capability limits

$$P_{DGi}^{max} \leq P_{DG} \leq P_{DGi}^{max}\ldots\ldots\ldots\ldots\ldots(6)$$

(iii)DFIG reactive capability limits

From

$$P^2_{DFIGi}+(Q_{DFIGi}+3\frac{V_s^2}{X_s})^2=(3\frac{X_m}{X_s}V_sI_r)^2 \ldots\ldots(7)$$

Then

$$Q^2_{DFIGi}\le(3\frac{X_m}{X_s}V_sI_r)^2-P^2_{DFIGi}-(3\frac{V_s^2}{X_s})^2 \ldots\ldots(8)$$

$$-Q^2_{DFIGi}\le(3\frac{X_m}{X_s}V_sI_r)^2-P^2_{DFIGi}+(3\frac{V_s^2}{X_s})^2 \ldots\ldots(9)$$

(v)Voltage constraints at the buses

$$V_i^{min}\le V_i\le V_i^{max} \ldots\ldots\ldots\ldots\ldots\ldots(10)$$

(vi)Line thermal limit

$$P_{ij}\le P_{ij}^{max} \ldots\ldots\ldots(11)$$

D:HGAPSO BASED OPTIMIZATION ALGORITHM

The HGAPSO based approach for solving the optimal sizuing and placement of the DFIG is aimed at minimizing the distribution line real and reactive losses.In this paper,the reactive power output is obtained by means of the DFIG power curves after the active power output is known.The total active power output is obtained by the equation(5).Considering the capability limits of the DFIGs,the maximum of the reactive power that each DFIG can generate or absorb,the HGAPSO based approach for solving the problem to minimizes the losses takes the following steps.

Step 1:Input the line and bus data and the bus voltage limit

Step 2:calculate the loss using distribution load flow based on backward forward sweep

Step 3:Randomly generate an initial population (array) of particl;es with random initial positions and velocities on dimensions in the solution space.set the iteration counter $k=0$

Step 4:For each particle,if the bus voltage is within the limits,perform mutation on the particle position ,one by one ,keeping the velocity fixed,then perform mutation on the velocity ,keeping the position fixed.Other n positions and k velocities are obtained.Calculate the total losses as in equation 1 in each case.

Step 5:For each particle,compare its objective position and velocity with the *individual best* .If the objective value is lower than *Pbest* ,set this value as the current Pbest,and record the corresponding particle position.

Step 6:Compare all components of the particle according to their fitness values.Choose the particle associated with the minimum *individual best Pbest* of all the particles and set the value of this Pbest as the current *overall best Gbest*

Step 7:If the iteration number reaches the maximum limit,go to **step 9**.otherwise set iteration index $k=k+1$ and go back to step 4

Step 8:Update the velocity and position of the particle

Step 9:If the particle equals to the population size N,print out the optimal solution of the targeted problem,otherwise set the particle to i=1 and go to **step 3**

Step 10. Assign Combined participation Factors to each particle taking into consideration the DFIG domains[46]

The best position includes the optimal locations and sizes of the DFIGs and the corresponding fitness value represents the minimum total real power loss.

E: 33 BUS RADIAL DISTRIBUTION TEST SYSTEM .

IEEE recommended balanced distribution systems include the radial 16 Bus,30 Bus ,33 Bus 94 Bus 69 Bus and 119 Bus systems[57],with the 33 Bus and the 69 Bus being commonly for most simulations used because they are balanced topologies.

In this paper, the distribution test systems used is the radial 33 bus systems. The system has 32 sectionalizing branches,5 tie

switches , nominal voltage of 12.66KV and a total system load 3.72 MW and 2.3 MVAR. The original total real power loss and reactive power loss in the system are 221.4346 Kw(5.95%) and 150.1784 kVAR(6.53%).The network diagram is as shown in figure 1
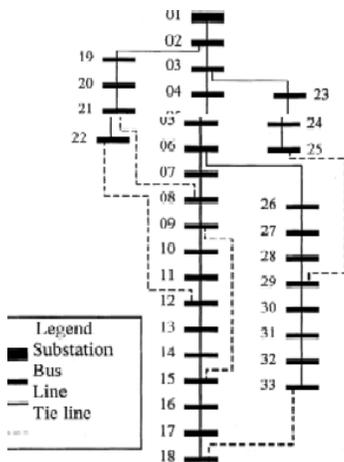

Figure 3:IEEE 33 Bus Radial Distribution System

TABLE I

IEEE 33 BUS RADIAL SYSTEM LOAD DATA

Bus No.	P_L (kW)	Q_L (kVAr)	Bus No.	P_L (kW)	Q_L (kVAr)
2	100	60	18	90	40
3	90	40	19	90	40
4	120	80	20	90	40
5	60	30	21	90	40
6	60	20	22	90	40
7	200	100	23	90	50
8	200	100	24	420	200
9	60	20	25	420	200
10	60	20	26	60	25
11	45	30	27	60	25
12	60	35	28	60	20
13	60	35	29	120	70
14	120	80	30	200	100
15	60	10	31	150	70
16	60	20	32	210	100
17	60	20	33	60	40

TABLE II

IEEE 33 BUS RADIAL SYSTEM BUS DATA

Branch Number	Sending end bus	Receiving end bus	R (Ω)	X (Ω)
10	10	11	0.1967	0.0651
11	11	12	0.3744	0.1298
12	12	13	1.4680	1.1549
13	13	14	0.5416	0.7129
14	14	15	0.5909	0.5260
15	15	16	0.7462	0.5449
16	16	17	1.2889	1.7210
17	17	18	0.7320	0.5739
18	2	19	0.1640	0.1565
19	19	20	1.5042	1.3555
20	20	21	0.4095	0.4784
21	21	22	0.7089	0.9373
22	3	23	0.4512	0.3084
23	23	24	0.8980	0.7091
24	24	25	0.8959	0.7071
25	6	26	0.2031	0.1034
26	26	27	0.2842	0.1447
27	27	28	1.0589	0.9338
28	28	29	0.8043	0.7006
29	29	30	0.5074	0.2585
30	30	31	0.9745	0.9629
31	31	32	0.3105	0.3619
32	32	33	0.3411	0.5302
34	8	21	2.0000	2.0000
36	9	15	2.0000	2.0000
35	12	22	2.0000	2.0000
37	18	33	0.5000	0.5000
33	25	29	0.5000	0.5000

F:RESULTS AND ANALYIS

Simulations were run on the 33Bus Radial distribution Test System.The real and reactive power losses obtained through load flow,PSO and HGAPSO are as shown in the tables III,IV,V,and VI

TABLE III

CASE A:1.5 MW DFIG ON BUS 18

$K = 0.3458 + j0.3189$

METHOD	P LOSS KW	QLOSS KVAR	LOSS REDUCTION %	
LOAD FLOW	221.4346	150.1784	REAL	REACTIVE
PSO	70.9526	57.2155	67.95	61.90
PSO-GA	69.5578	56.2116	68.59	62.57

TABLE IV

CASE B:1.5 MW DFIG ON BUS 8

$K = 0.1856 + j0.1098$

METHOD	P LOSS KW	QLOSS KVAR	LOSS REDUCTION %	
LOAD FLOW	221.4346	150.1784	REAL	REACTIVE
PSO	69.9526	56.3189	68.41	62.50
PSO-GA	68.4589	54.9676	69.09	63.40

TABLE V

CASE C:1.5 MW DFIG ON BUS 3

$K = 0.0234 + j0.0187$

METHOD	P LOSS KW	QLOSS KVAR	LOSS REDUCTION %	
LOAD FLOW	221.4346	150.1784	REAL	REACTIVE
PSO	68.8536	53.8907	68.91	64.12
PSO-GA	66.5578	50.8765	69.94	66.12

% REACTIVE POWER LOSS REDUCTION

Fig 4:% Reactive Power Reduction with installation of DFIG

% REAL POWER LOSS REDUCTION

Fig 5:% Real Power Reduction with installation of DFIG

The load flow method determines the total real and reactive power losses accurately in the 33   bus radial distribution system.The basic PSO   seems to provide better loss reduction than   HGAPSO but this is not accurate enough since the PSO algorithm may have converged   before all the buses are considered.The HGAPSO on the other hand provides a better loss reduction technique compared to the PSO in that the mutation operator ensures no local /premature convergence occur and thus it can be applied in practical distribution systems.

BUS Voltage Profile

The voltage level of all the busses keep the standards level of voltages(+-5%) both with PSO and HGAPSO as shown in the figure 6 .However,the voltage   is more improved by using HGAPSO
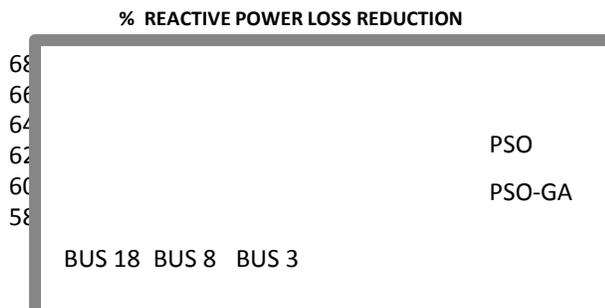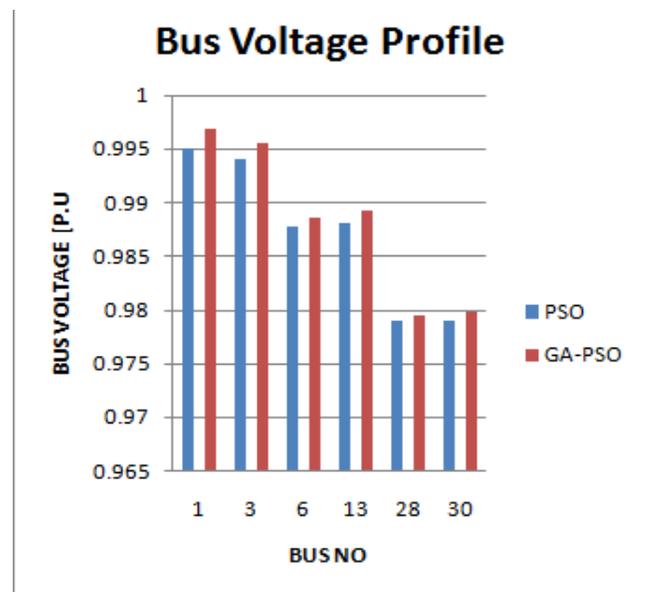

Fig 6:Bus Voltages after DFIG installation using PSO and HGAPS0

III:CONCLUSIONS

The DFIG wind turbines are capable of reducing both real and reactive power losses in a power distribution system ,however they need to be placed at suitable locations. The PSO algorithm is optimally placing the DFIG with the objective of reducing the total real power losses in the primary distribution systems.The PSO is fast and accurate in determining the sizes and the locations.However this ordinard PSO is prone to local minima and premature convergence hence not applicable in solving real life power system optimization problems.

The HGAPSO algorithm performs the optimisation over a larger search space since it escapes from local minima and increases the diversity of variable values using the mutation operator.The HGAPSO optimises in a better way,the real and reactive power losses at the same time giving an improved voltage profile.

The numerical results shows that the intergration of the DFIG wing turbines into the traditional power distribution system is highly effective in reducing real and reactive power losses in the primary distribution System when HGAPSO is used as compared to the ordinary PSO.

In DFIG placement and sizing with the objective of optimizing real and reactive power losses ,the bus to which the DFIG domain Distributed Slack Bus Model assigns a large Combined Participation Factor is considered as the optimal site for the DFIG.

When well applied to a DFIG,the HGAPSO can be used to reduce the real and reactive power losses by 38.10% and 37.43% at the same time giving an improvement of the voltage profile by almost 0.3% .

From the tabulated results,the best locations corresponding to the optimum size for reducing the total real and reactive power losses is in the primary distribution system.

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