Loss Reduction Using Optimal Placement and Sizing of Distributed Generator

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Abstract – By harvesting the power at distribution side have its own significant impact on distribution system. These distribution generators (DGs) improve the voltage profile of each bus and reduce the losses of the system if the DGs are places at optimal place on the distribution system and with optimal size of the generation. In order to achieve the optimal place and size, particle swarm optimization (PSO) is proposed in this paper and the performance of proposed algorithm is compared with the genetic algorithm (GA). To test IEEE-38 bus system is taken as the reference system. The observation shows the PSO gives the better optimized values than the GA.

Keywords- Distributed generator, DG placement and sizing, GA, PSO

I INTRODUCTION

The emerging technologies like micro grids and smart grids are going to change the scenario of today's power system and its structure and operation. The penetration of eco-friendly renewable sources will also have the impact on the future structure of the distribution and power systems. As a part of all the upcoming technologies, the distribution generation is significantly gaining the attraction in distribution systems. DGs are small scale generating units that are installed close to load canters to reduce electricity losses and inefficiencies.The best thing about using DG is that it can supply local loads even during grid failure [1].This advantage gives the DG to operate in isolated mode or grid connected mode. The optimal placement and sizing of DGs is formulated based on different objective functions and constraints. Network constraints and voltage stability based DG placement is discussed in [1]. The loss reduction and reliability of system are taken as objective functions in [3], [7] and [8]. The analytical method approach is proposed in [5].

The different types of optimizing techniques are proposed with different objective functions. The mixed integer non-linear programming optimization technique is used in [2], whereas different heuristic techniques are used to optimise the objective function of optimal placement of DGs and sizing [6]-[9]. Artificial bee colony is used to optimize different objective functions of optimal placement and sizing of DG in [6], [8] and [9]. The genetic algorithm based improvement of reliability of distribution system is proposed in [7].

This paper deals with the optimal placement and sizing of DG with voltage profile and loss reduction as the objective functions. Particle swarm optimization is used to solve the multi objective of the problem. The content of paper is presented as follows. The first section, that is, introduction deals with the literature survey. Section II deals with problem formulation. The problem formulation consists of backward forward sweep distribution load flow algorithm, objective function formulation, genetic algorithm and particle swarm optimization. Section III deals with the simulation and results. Section IV deals with the conclusion.

II PROBLEM FORMULATION

A FORWARD AND BACKWARD SWEEP ALGORITHM

Distribution system as unique features compared to power system network. The X/R ratio of distribution system is less compared to power system network. The power flow algorithms which are applicable for power system network model are not suitable for distribution system. Forward and backward sweep algorithm is a distribution power flow algorithm based on linear proportional principle. For a distribution line model containing series impedance or a distribution transformer with different connection types, voltage and current relations between sending and receiving ends can be described by (1) and (2), respectively [2]

$$V_S = A\ V_R + B\ I_R \qquad (1)$$

$$I_S = D\ I_R \qquad (2)$$

Where V_S is the vector of three-phase voltages of the sending end, V_R is the vector of three-phase voltages of the receiving end, I_S is the vector of three-phase line currents of the sending end, and I_R is the vector of three-phase line currents of the receiving end.

By separating real and imaginary parts in equation (2), it is known that the phase voltage at the upstream bus of each feeder branch is determined by the real and imaginary components of the line current, the line impedance, and the downstream bus voltage.

A LINEAR PROPORTIONAL PRINCIPLE

Consider an N-bus resistive network shown in figure 1 with a specified constant voltage, V_S, at bus 1. Before employing the backward sweep to calculate each bus voltage, an initial flat voltage profile at all other busses is firstly assumed. During the backward sweep, the current flowing through the end bus N and the line current between busses N and N-1 are obtained.

According to $I_N = \frac{V_N}{R_N}$ and $I_{N,N-1} = I_N$, respectively. The voltage at any other bus becomes $V_i = I_{i,i+1}\ X\ R_{i,i+1} + V_{i,i+1}$, where $I_i = \frac{V_i}{R_i}$ and $I_{i,i+1} = I_{i+1} + I_{i,i+2}$. Follow this procedure the voltage at bus 1, V_1 can be calculated. Since there is a specified voltage at bus 1, the ratio of the specified voltage to the calculated voltage becomes

$$\gamma = \frac{V_S}{V_1} \qquad (3)$$

Then the final solution of each bus voltage can be determined by the calculated voltage at each bus multiplying with the ratio found in (3) based on the linear proportional principle.

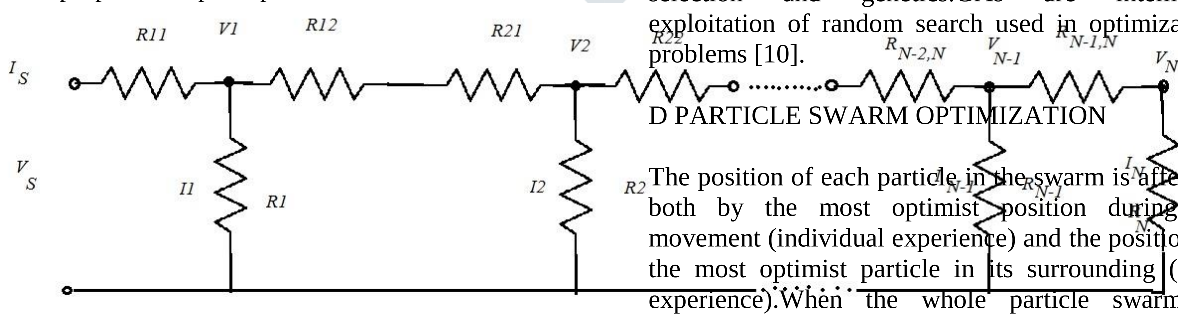

Fig. 1 linear proportional principle

B OBJECTIVE FUNCTION

The problem is formulated as optimization of multiple objective functions. In this the objective functions are system active and reactive power losses and voltage at each bus deviation with respect to a reference bus. The main objective function formulated by weighted sum of sub objective functions as shown in below equations

$$objective\ function = W_1 * APLI + W_2 * RPLI + W_3 * VPI \qquad (4)$$

Where W1, W2 and W3 are objective function weights, such that

$$\sum_{i=1}^{N} W_i = 1 \qquad (5)$$

Where APLI is Active power loss index is given b

$$APLI = \left\{\frac{Total\ Active\ Power\ \ loss\ with\ placing\ the\ DG}{Total\ active\ Power\ \ loss\ without\ placing\ the\ DG}\right\} \qquad (6)$$

Where RPLI is reactive power loss index is given by

$$RPLI = \left\{\frac{Total\ reactive\ Power\ loss\ with\ placing\ the\ DG}{Total\ reactive\ Power\ \ loss\ without\ placing\ the\ DG}\right\} \qquad (7)$$

Where VPI is Voltage profile index is given by

$$VPI = Max_{i=2}^{N}\left\{\frac{V_{Ref}-V_i}{V_{Ref}}\right\} \qquad (8)$$

C GENETIC ALGORITHM

Genetic algorithms (GAs) are main paradigm of evolutionary computing. GAs are inspired by Darwin's theory about evolution-"survival of the fittest". GAs are the ways of solving problems by mimicking processes nature uses like selection, crossover, mutation and accepting to evolve a solution to the problem. GAs are adaptive heuristic search based on the evolutionary ideas of natural selection and genetics.GAs are intelligent exploitation of random search used in optimization problems [10].

D PARTICLE SWARM OPTIMIZATION

The position of each particle in the swarm is affected both by the most optimist position during its movement (individual experience) and the position of the most optimist particle in its surrounding (near experience).When the whole particle swarm is surrounding the particle, the most optimist position of the surrounding is equal to the one of the whole most optimist particle; this algorithm is called the whole PSO. If the narrow surrounding is used in the algorithm, this algorithm is called the partial PSO. Each particle can be shown by its current speed and position, the most optimist position of each individual and the most optimist position of the surrounding. In the partial PSO, the speed and position of each particle change according the following equality

$$V_{id}^{k+1} = V_{id}^{k} + C_1 r_1^k\left(Pbest_{id}^k - X_{id}^k\right) + C_2 r_2^k\left(Gbest_{id} - X_{id}^k\right) \quad (9)$$

$$X_{id}^{k+1} = X_{id}^{k} + V_{id}^{k+1} \quad (10)$$

In this equality, k id v and k id x stand for separately the speed of the particle “i” at its “k” times and the d-dimension quantity of its position; k id pbest represents the dimension quantity of the individual “i” at its most optimist position at its “k” times. K d gbest is the d-dimension quantity of the swarm at its most optimist position. In order to avoid particle being far away from the searching space, the speed of the particle created at its each direction is confined between -vdmax, and vdmax. If the number of vdmax is too big, the solution is far from the best, if the number of vdmax is too small, the solution will be the local optimism; c1 and c2 represent the speeding figure, regulating the length when flying to the most particle of the whole swarm and to the most optimist individual particle. If the figure is too small, the particle is probably far away from the target field, if the figure is too big, the particle will maybe fly to the target field suddenly or fly beyond the target field. The proper fig or c1 and c2 can control the speed of the particle’s flying and the solution will not be the partial optimism. Usually, c1 is equal to c2 and they are equal to 2; r1 and r2 represent random fiction, and 0-1 is a random number.

III RESULTS

To verify the proposed method IEEE 38 bus distribution system is used [10]. Both the algorithms GA and PSO are used to determine optimal location and sizing. The objective function is optimized using GA and PSO, whereas PSO shows better convergence and optimal values than GA. The figure 1 shows the voltages at all the buses of 38 bus distribution system for without any DG placed and with DG placement using GA and PSO. In figure 1 the PSO shows better results than GA when compared voltages of buses of 38 bus system.

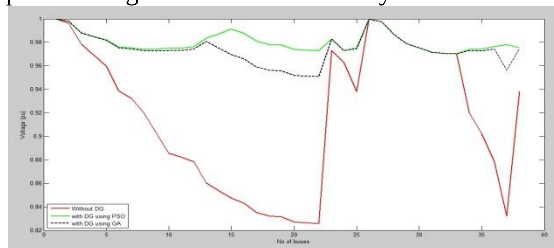

Fig. 2 comparison of voltage profile at each bus without and with DG placement using GA and PSO.

Real and reactive power losses of 38 bus system is shown in table 1. It is observed that the PSO is giving the better optimal points compared to GA.

	Using PSO		Using GA	
Load	Total Real Power Loss(P) (KW)	Total Reactive Power Loss(Q) (KVAR)	Total Real Power Loss(P) (KW)	Total Reactive Power Loss(Q) (KVAR)
Full Load	281.5877	187.9595	282.425	188.225
3/4th Load	150.2769	100.2173	152.452	100.852
½ Load	63.6469	42.4100	64.525	42.756
1/4th Load	15.2185	10.1329	15.675	10.782

Table 1 comparison of losses using PSO and GA

IV CONCLUSION

The proposed optimization of placement and sizing of DGs in distributed system is formulated based on PSO. This is compared with the GA. PSO gives promising optimized values than the GA. voltage profile at each bus is nearly unity by placing the DG at optimal Place and the reactive and active losses are reduced significantly.

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