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Adaptive Optimal Size and location Determination of Distributed Generation in Radial Distributed System

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Abstract-- **Distributed Generation (DG) has gained more attention as it uses renewable and non-renewable small energy sources. Distributed generators are neither centrally placed nor dispatch able. It is scattered within the distribution system at or near load Centre. Distributed generation playing important role in the field of the electricity generation whereas Different issues related to power quality when DG is integrated with the existing power system has been discussed in the report. Distributed Generation is the best way to bridge the gap between supply and demand by reducing losses and carbon foot prints. Rural and remote areas can be electrified by these technologies.**

1. Introduction:

Distributed generators have gained more attention as it uses renewable and non-renewable small energy sources. Distributed generators (DG) can be 1) renewable energy sources, such as: Wind turbines, Solar photovoltaic, Biomass energy sources or 2) non-renewable energy sources such as: Diesel generator, Small turbines. Distributed generators are neither centrally placed nor dispatchable. It is scattered within the distribution system at or near load Centre. Incorporation of DGs in distribution system results in increase in the capacity of the feeder, higher reliability, lowers system losses, improves voltage profile and improves voltage stability of the system and lowers the peak demand resulting into increase in the life of system equipment and hence more number of customers can be served. To avail these merits one has to find out the appropriate capacity and location of DG, otherwise higher DG capacity results into higher power losses and increase of system voltage.

The size of DG should be such that it is equal to the total load of the system plus the total system losses. Higher capacity of DG results into reverse power flow from substation to the source node. In the literature three methods are adopted to find the optimum size of DG, they are: analytical, heuristic and optimization techniques. Analytical method requires repetitive derivation of current and voltage after placement of DG, which requires more time. Heuristic methods are simple but the results obtained from heuristic algorithms are not guaranteed to be optimal. Optimization techniques can give the best solution within short duration of time for a given distribution network. A study by the Electric Power Research Institute (EPRI) indicates that by 2010, 25% of the new generation will be distributed, a study by the Natural Gas foundation concluded that this figure could be as high as 30% [1]. The European Renewable Energy Study (TERES), commissioned by the European Union (EU) to examine the feasibility of EU CO2-reduction goals and the EU renewable energy targets, found that around 60% of the renewable energy potential that can be utilized until 2010 can be categorized as decentralized power sources [2].The parameters for distributed generation (DG) used in the literature, however, are not consistent. This paper presents a discussion of the relevant aspects of DG and provides the required parameters.

Distributed generation is a new approach in the electricity industry and as the analysis of the relevant literature has shown there is no generally accepted parameter of distributed generation yet (see particular [35]).In the literature, a large number of terms and parameters is used in relation to distributed generation. For example, Anglo-American countries often use the term ‘embedded generation’, North American countries the term ‘dispersed generation’, and in Europe and parts of Asia, the term ‘decentralized generation’ is applied for the same type of generation. In addition, in regards to the rating of distributed generation power units, the following different parameters are currently used:

1. The Electric Power Research Institute defines distributed generation as generation from ‘a few kilowatts up to 50 MW’ [4];
2. According to the Gas Research Institute, distributed generation is ‘typically [between] 25 and 25 MW’ [5];
3. Preston and Rastler define the size as ‘ranging from a few kilowatts to over 100 MW’ [3];
4. Cardell defines distributed generation as generation ‘between 500 kW and 1 MW’ [6];
5. The International Conference on Large High Voltage Electric Systems (CIGRE´) defines DG as ‘smaller than 50–100 MW’ [8]; And because of different government regulations, the parameter of the rating of each distributed power station also varies between countries, for example (also[35]):

1. In the English and Welsh market, DG plants with a capacity of less than 100 MW are not centrally dispatched and if the capacity is less than50 MW, the power output does not have to be traded via the wholesale market [7]. The term distributed generation is, therefore, predominantly used for power units with less than 100 MW capacities;

2. Swedish legislation gives special treatment to small generation with a maximum generation capacity of up to 1500 kW, [8, 9]. Hence, DG in Sweden is often defined as generation with up to 1500 kW. But under Swedish law, a wind farm with one hundred 1500 kW wind turbines is still considered DG, as the rating of each wind energy unit, and not the total wind farm rating, is relevant for the Swedish law. For hydro units, in comparison, it is the total rating of the power station that is relevant. Some of the proposed offshore wind farms for Sweden have a maximum capacity of up to 1000 MW. This would still be considered DG as they plan to use 1500 kW wind turbines [10]

2. Related Work:

Pola Kishore Kumar, 2013 [1] presented way of properly selecting the location and size of multiple distributed generations. The approach which is used here is Kalman filter algorithm. Increase in power consumption can cause serious stability problems in electric power systems if there are no ongoing or impending construction projects of new power plants or transmission lines. Additionally, such increase can result in large power losses of the system. In costly and environmentally effective manner to avoid constructing the new infrastructures such as power plants, transmission lines, etc., In response to the recently increased prices of oil and natural gas, it is expected that the electric power industry will undergo considerable and rapid change with respect to its structure, operation, planning, and regulation. Moreover, because of new constraints placed by economical, political, and environ- mental factors, trends in power system planning and operation are being pushed toward maximum utilization of existing electricity infrastructure with tight operating margins.

A. A. Chaudhary 2013 [3] determined a method for selecting the optimal locations and sizes of multiple distributed generations (DGs) to minimize the total power loss of system. To deal with this optimization problem, the Kalman filter algorithm was applied. When the optimal sizes of multiple DGs are selected, the computation efforts might be significantly increased with many data samples from a large-scale power system because the entire system must be analyzed for each data sample. The proposed procedure based on the Kalman filter algorithm took the only few samples, and therefore reduced the computational requirement dramatically during the optimization process. Prior to the implementation and connection to an electric power grid, this study can be used as a decision-making process in the power system operation and planning for selecting the optimal locations and sizes of multiple DGs based on the renew- able energy resources such as fuel cell, photovoltaic, micro-turbines, wind powers, etc.

Y. G. Hegazy,2007 [7] according to them the effect of load models on distributed generation (DG) planning in distribution system is investigated in this work. It is shown that load models can significantly affect the DG planning. Normally a constant power (real and reactive) load model is assumed in most of the studies. Such assumptions may lead to inconsistent and misleading results about deferral values, loss reduction, payback period, and other subsequent calculations. It has been demonstrated that DG planning based on such assumptions would not be effective after implementation. It is shown that load models can significantly affect the optimal location and sizing of DG resources in distribution systems. A comparative study of real and reactive power loss, real and reactive power intake at the main substation and MVA support provided by installing DG resources for different type of loads models has been performed. Load models significantly affect the DG planning. It is established that DG planning based on constant power load models is not effective after implementation on actual systems

Power system deregulation and the shortage of transmission capacities have led to increased interest in distributed generation (DG) sources. Proper location of DGs in power systems is important for obtaining their maximum potential benefits. **Devender Singh, 2004 [8]** presented analytical methods to determine the optimal location to place a DG in radial as well as networked systems to minimize the power loss of the system. Simulation results are given to verify the proposed analytical approaches.

The electric power industry to adapt to new technologies, market and environment has been deregulated. The most advantages of it is reducing carbon, increasing energy efficiency, improving power quality. Distribution network is the most expensive section in power system. Voltage regulation is one of the usual problems. Due to this problem there is some way to solve that. **[15] S. Pazouki , (2012)** worked at first the distribution generation (DG) and the advantages of that are explained and the traditional solution such as shunt capacitor is presented then the effect of Distribution Generation like fuel cell on the network is discussed. By using the MATLAB software the simulation results shows the effect of DG on a feeder in distribution network. At end, conclusion debates the comparison between the impact of installing DG and shunt capacitor on the distribution network.

3. Methodology:

In general, existing power plants are located far from consumer areas, and this condition results in a large amount of power loss on the power system. Installation of DGs can reduce the power loss if their proper locations are selected. To determine the optimal locations of multiple DGs, the IEEE benchmarked 31-bus system shown in Fig. 1 is used as a test system [1], [16]. The system in Fig. 1 is now analyzed for two different cases with respect to generator or load [17]. In other words, powers flow from the *k*th generator to numerous loads in the first case, and they flow from several generators to the *l*th load in the second case. These two conditions are shown in Figs. 2 and 3, respectively. The associated parameters are defined as follows:

1) P_k: power supplied by the *k*th generator in a power network;
2) P_l: power consumed by the *l*th load in a power network;
3) $P_{k,l}$: power flowing from the *k*th generator to the *l*th load;

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4) Fjl,k: power flowing from the kth generator to the lth load through bus j connected to the lth load;
5) Fkj,l: power flowing from the kth generator to the lth load through bus j connected to the kth generator.

In a combination of two cases described previously, the system in Fig. 1 can be expressed by the simplified circuit shown in Fig. 4 with the consideration of only power generations and load consumptions.
The branch between buses i and j in Fig. 4 can be represented with the simplified unit circuit as shown in Fig. 5. Then, the total power loss of the entire system can be calculated by summing the losses of all branches whenever the DG is connected to any bus [1]. In other words, the system in Fig. 4 can be simplified as a circuit in Fig. 5 by focusing on the relationship between the DG and the power loss. In the same manner, the entire power system (Fig. 1) can also be simplified

In DAPSO2, if there were many particles far away from the global best position, then the velocities should be given a larger value. If there were many particles near the global best position, then the velocities should be given a smaller value. DAPSO1 only adjusts the velocity of the certain particle, but in DAPSO2, the velocities of all particles are adjusted together.

The general flow of DAPSOs and the flowchart of DAPSO are shown as follows.

Step 1. Initialization of a population of particles with random positions and velocities

Step 2. Evaluation of particles.

Step 3. Calculate the distance from each particle to the global best position and save the farthest distance in the memory.

Step 4. Adjust particle's velocity according to its distance from itself to the global best position.

Step 5. Update particle's position by the adjusted velocity.

Step 6. Repeat Step.2~Step.5 until termination criteria are met.

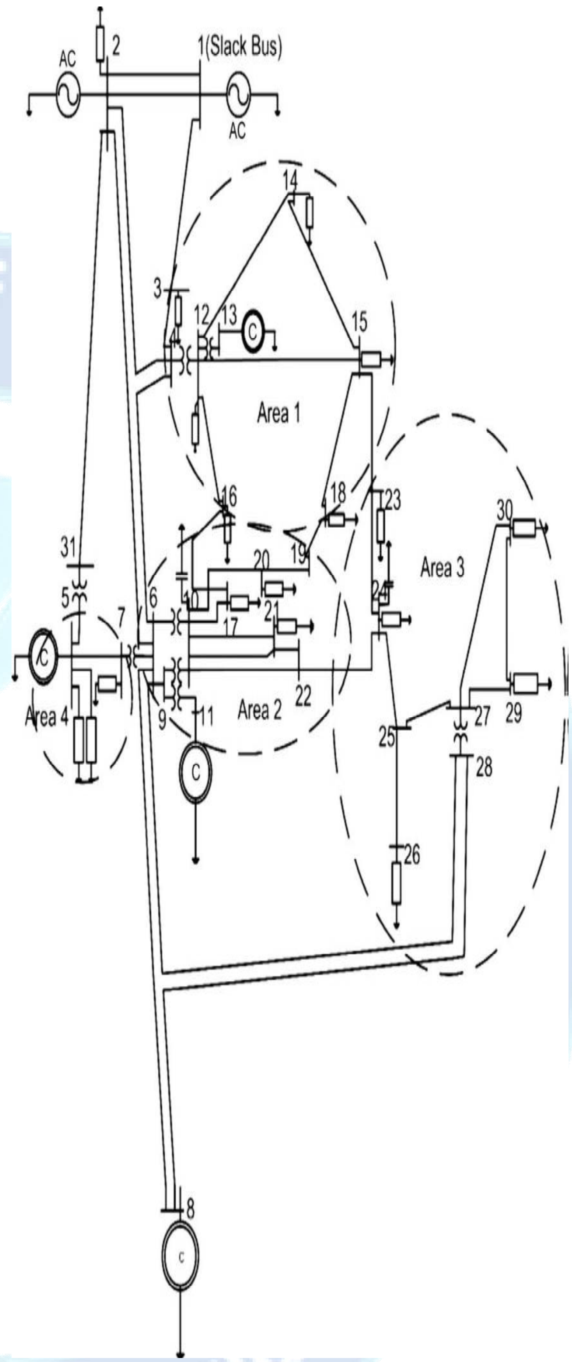

Fig. 1. IEEE benchmarked 31-bus system.

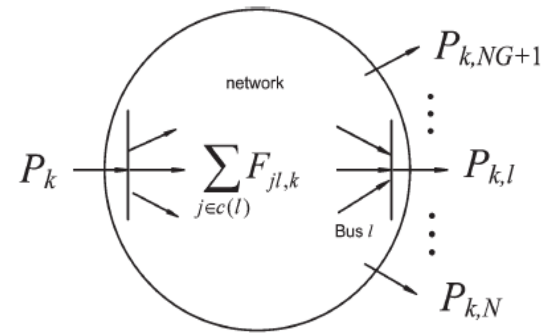

Fig. 2. Power flow from the *k*th generator to the several loads.

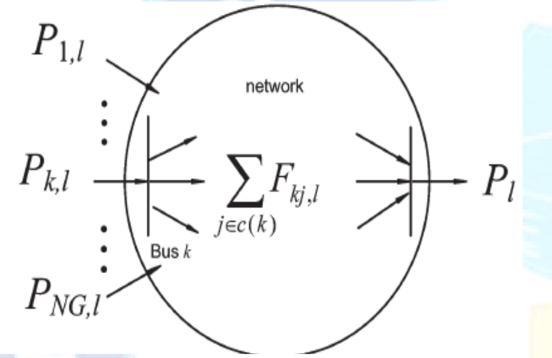

Fig. 3. Power flow from the several generators to the *l*th load.

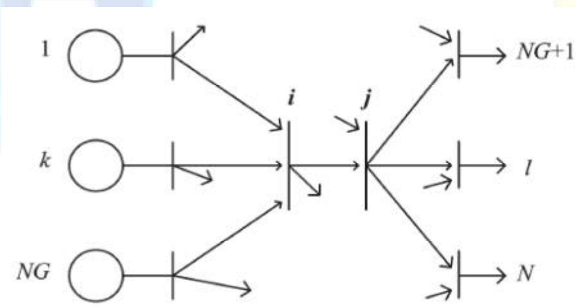

Fig. 4. Simplified circuit with only power generations and consumptions.

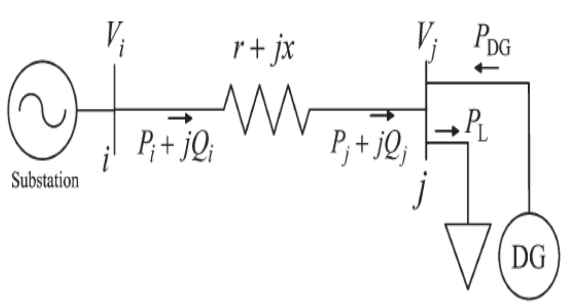

Fig. 5. Simplified unit circuit between two buses.

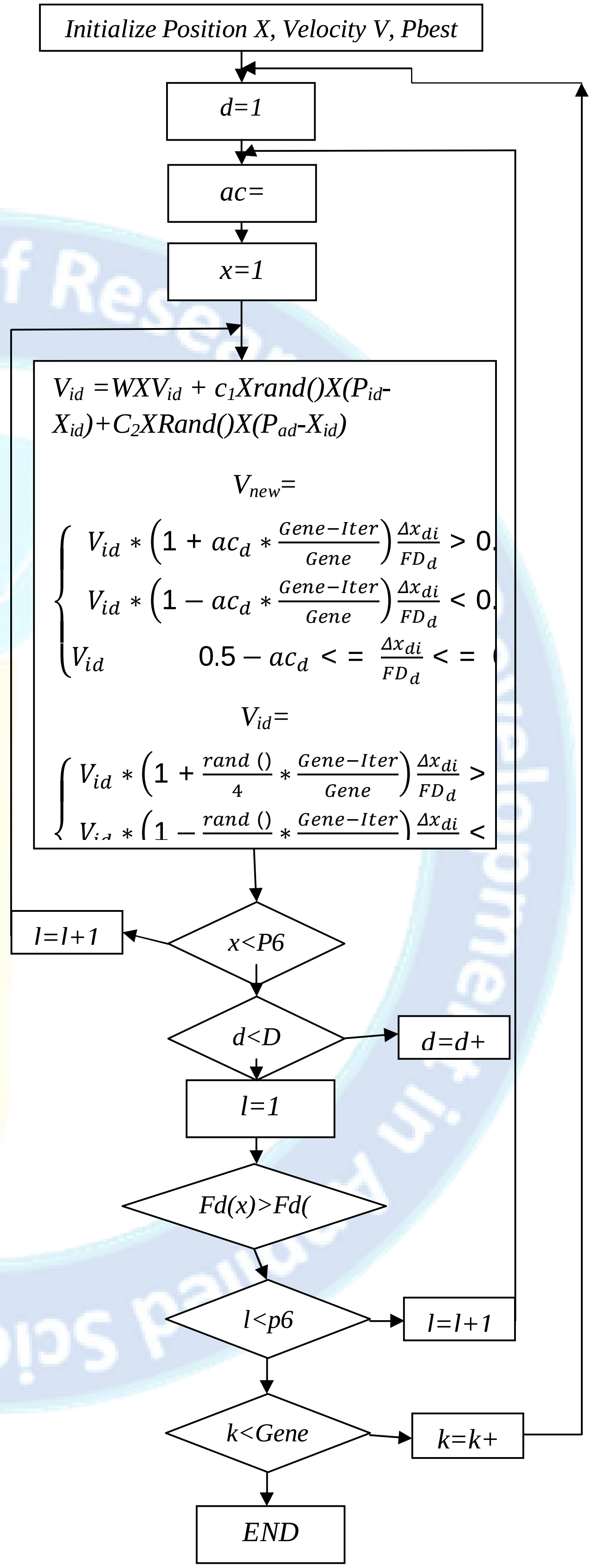

Fig. 6: Flowchart of DAPSO.

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4. Result and Discussion:

Optimized parameter value:

Line no. 66.00

Distance from line: 0.25

Voltage : 1.28 pu

Power: 15.00 MW

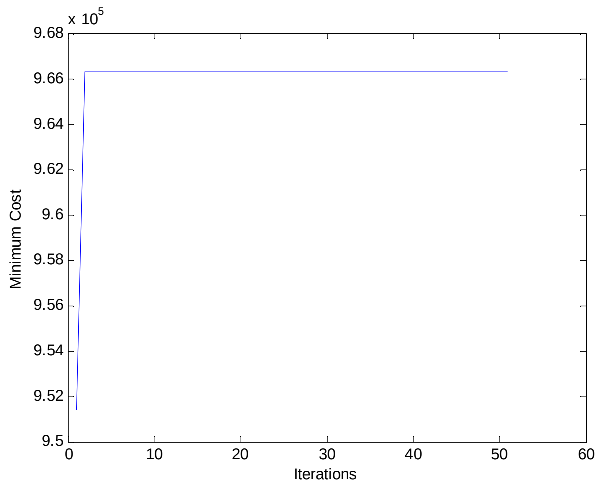

Figure 7: Minimum cost vs. iterations

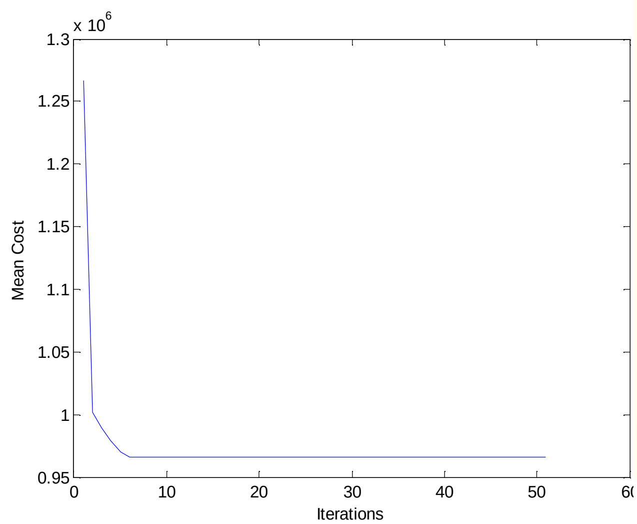

Figure 8: Convergence Plot

Table 1: Comparative result	
Cost of generation in original 57 bus: 950685.6 $/h	**Cost of generation in optimized 58 bus:** 941390.08 $/h
Losses: 27.394MW and -85.925MVAR	**Losses:** 27.394MW and 263.95MVAR

5. Conclusion:

The PSO based optimum DG parameter estimator is designed using MATLAB programming algorithm. It has been proved that this optimization algorithm is quite effective for rapidly finding the changes required in insertion of additional DG's location, voltage and power rating in both the simulated and real-world power system scenarios considered. The new optimization method has demonstrated an ability to not only rapidly find large changes to power system modes, but has also been able to identify the mode which has changed. Multisite measurements can be also used to provide greater confidence in the detection alarming. This has significant implications for power utility intervention strategies. Importantly, the method is computationally efficient and can easily be implemented in real-time.

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