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Research Article

OPTIMAL PLACEMENT OF VARIOUS TYPES OF DISTRIBUTED GENERATION (DG) SOURCES IN RADIAL DISTRIBUTION NETWORKS USING IMPERIALIST COMPETITIVE ALGORITHM (ICA)

Hadi Abbasi[1,2] and *Mahmood Ghanbari[2]
[1]Department of Electrical Engineering, Golestan Science and Research Branch, Islamic Azad University, Gorgan, Iran
[2]Department of Electrical Engineering, Gorgan Branch, Islamic Azad University, Gorgan, Iran
**Author for Correspondence*

ABSTRACT
In this article we will use the Imperialist Competitive Algorithm for optimal placement and measuring the various sources of distributed generation in radial distribution networks with the purpose of decrease the losses and to improve the network voltage profile. The function of main purpose is considered to optimize, decrease the losses. To evaluate the operation of proposed algorithm we consider it in a 33-bus test network, in three various types of distributed generation sources. Results indicate that using imperialist Competitive algorithm in finding the optimal place and measure of various distributed generation sources will help to solve the optimization problem considerably and in this case the maximum decrease of losses and voltage profile improvement will be obtained.

Keywords: *Imperialist Competitive Algorithm (ICA), Decrease of Losses, Radial Distribution Network, Distributed Generation Sources (DG)*

INTRODUCTION
Since the electrical energy is used in several daily matters so it's necessary to find a way to decrease the losses in its distribution system. One of the methods in decrease the loss in distribution of this energy is to use the energy generation sources adjacent to the consumers. These sources are known as the distributed generation sources, which inject power to the main network where it is installed. Nowadays by changing the power systems from traditional structures to the restructured system and also electrical energy consumers' inclination for receiving the energy in their living place caused that small generation units become important (Brooks, 1988). Distributed generations (DG) are small generation units that are installed on the strategic points of system near the load centers and consist of gas turbine, micro-turbine, fuel cell, solar energy and …, DG can help to provide particular common load separately or provide the common load totally (Borges and Falca˜o, 2008). Distributed generations, generate electricity in the open or closed place for the load centers and in the form of connection to the network (Rawson, 2004). These generations have several advantages and disadvantages (Niknam and Ranjbar, 2002). Among them the standby power, peak shaving, network support and …, can be mentioned. Widespread use of DG in system architecture to generate and exploit the economical electricity is increasing (Bharadwaj and Tongia, 2003). In such a manner that studies indicate that until 2010 the share of these generations in generating energy consists of 25% of total of energy generation (Niknam and Ranjbar, 2002). To decrease the losses using these sources, the suitable place and amount of their generation is important and will have reverse result if it isn't done properly, it means that the losses will increase and the buses voltage will decrease. In this article the optimal place and amount of distributed generation sources types are computed using imperialist Competitive algorithm.

Definition of Distributed Generation Sources
Various definitions are used for distributed generations, but its general and unlimited definition is "the electrical energy source that connects to the distribution network or the consumer's side directly". The nominal amounts of these products are different, but usually their generation capacity is about some kilo watt to 10 mega watt. These units are placed in posts and distribution feeders near the loads (Ackermann *et al.*, 2000). The distributed generation generators, apart from their power generation manner, are

relatively small and their capacity is usually less than 300 MW and they are connected to the distribution network directly (El-Khattam and Salama, 2004). It must be mentioned that CIGRE, proposed the following definition for the distributed generation sources (Garcia, 2004):

1- It must not be programmed centrally. (It must not be programmed in centralized manner).
2- It must not be transferred centrally. (It must not be exploited in concentrated manner).
3- It must be usually connected to the distributed network.
4- It must be smaller than 50 to 100 mega watt.

Some of the available distributed power generation technologies are fuel cells, wind turbines, solar power plants, geothermal power plants, micro-turbines and etc.

The applied DGs are usually three types:

First type: DG is just able to generate the active power.

Second type: DG is able to generate the reactive power.

Third type: DG is able to generate the active and reactive power.

In this article, we will use all of these three types of distributed generation sources to perform simulations.

Problem Modeling

The main purpose of this article, is to find the optimal place and amount for types of distributed generation sources in radial distribution networks with the aim of decrease the losses and improve the network voltage profile and to obtain this purpose we will define a main target function and some limitations and some equal and unequal constraints for this problem. The main target function for optimization is presented as equation (1):

$$min\ f = min(P_{Loss}) \tag{1}$$

whereP_{Loss} is the sum of power losses in the radial distribution network. The equal and unequal constraints which are considered for solving this optimization problem is as the following relations.

Equal Constraints

Power balance is one of the equal constraints of problem that must be observed. In fact the real power of buses must be limited in the form of equation (2):

$$P_{Loss} + \sum P_{Dj} = \sum P_{DGj} \tag{2}$$

Real power of generation in j bus by DG must be equal to the sum of consumed power in j bus and real power losses in that bus and the net injected active and reactive power of each of the buses are obtained from equations (3, 4):

$$P_i = P_{Gi} + P_{Di} \tag{3}$$

$$Q_i = Q_{Gi} + Q_{Di} \tag{4}$$

3.2.unequal constraints

The generative reactive power by the distributed generation sources must be limited as the equation (5):

$$Q_j^c \leq \sum_{j=1}^{n} Q_{Lj} \tag{5}$$

Where Q_j^c and Q_{Lj} are the compensated reactive power in jbus and the consumed reactive power in j bus, respectively. In fact to maintain the quality of power, Q_j^c must be equal or less thanQ_{Lj}. Also the voltage range in each group and voltage range in each branch must be defined in an allowed range in equations (6) and (7):

$$V_{jmin} \geq V_j \geq V_{jmax}, \quad j=1,2,\ldots,N \tag{6}$$

$$|I_j| \leq |I_{jmax}| \qquad j= 1,2,\ldots,N \tag{7}$$

Imperialist Competitive Algorithm (ICA)

The imperialist competitive algorithm is a new algorithm in evolutional calculations that is based upon the social-political evolution of human being.This algorithm, like other evolutional algorithms, is started with some random initial population that each of them are called a country. Some of the best elements are selected as the imperialist and the reminder populations are considered as the colony. In a N_{var} dimensional optimization problem, a country is an order of$1* N_{var}$is defined as equation (8).

$$Country = [P_1 , P_2 , P_3 ,\ldots,P_{N\,var}] \quad (8)$$

The cost of one country through evaluation of f function in return for existing variables in it (P_1,P_2, $P_{3,\ldots,}$ $P_{N\,var}$)will be as equation (9).

$$Cost_i = f\,(country_i\,) = f\,(P_{i1}, P_{i2,} P_{i3}\,,\ldots,\, P_{iNvar}\,) \quad (9)$$

To start the algorithm, amount of $N_{country}$ initial country are generated and N_{imp} of the best members of this population are selected as the imperialist. The reminder of N_{col} countries, form a colonial that each of them belongs to an empire (Atashpaz-Gargari and Lucas, 2007). The imperialist countries attract the colonial countries toward themselves through applying attraction policy, in different directions of optimization. Imperialists attract these colonies toward themselves with equation (10) regarding their power. The total power of each imperial, is determined with calculating the power of both of its constituent parts, that is the power of imperialist country, in addition to a percent of its colonies' average power.

$$T.C._n= Cost\ (imperialist_n) + \xi mean\{\ Cost\ (colonies\ of\ empire_n)\ \} \quad (10)$$

The colony country moves toward the connection line of colony to the imperialist country about X unit and drags to the new position. In figure (1), the distance between the imperialist and colony is shown by d and X is a random number with uniform distribution. In equation (11) for X we have:

$$x \sim U(0, \beta \times d)(11)$$

Where, β is a number more than 1 and near to 2. An appropriate selection can be β=2. Also the movement angle is considered as the uniform distribution (12).

$$\theta \sim U(-\gamma, \gamma)(12)$$

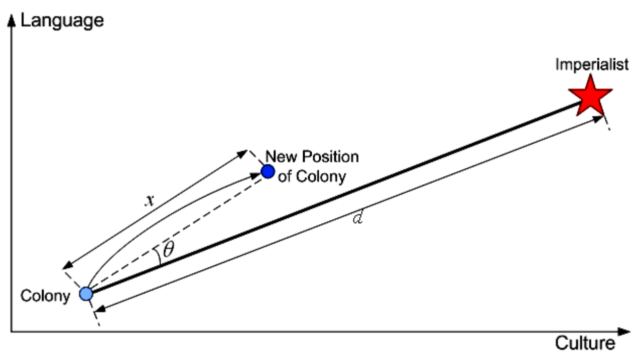

Figure 1: Colonies movement toward the imperialist (Atashpaz-Gargari and Lucas, 2007)

In ICA, the colony moves toward the imperialist's attraction direction with a probable deviation. This deviation is shown with θ angle that θ is chosen randomly and with a uniform distribution. During the movement of colonies toward the imperialist country, may be some of the colonies reach to a position better that the imperialist country, in this case, the imperialist and the colony countries change their places with eachother.

Algorithm of the Proposed Method

After determining the parameters of imperialist competitive optimization algorithm, information of considered network that consists of information of line and information of active and reactive consumption loads are considered as one of the parameters of proposed algorithm. Then by the load distribution algorithm of backward- forward distribution network, we change the raw data of network which consist of lines and buses data to the useful data. In fact after performing the load distribution algorithm, we will obtain the voltage amount and angle of each bus, flow amount and angle of each of the network lines. Now its time to perform the imperial competitive algorithm, after evoking the constant parameters of algorithm, the competence factor of considered problem that is to decrease the losses will be considered.

In fact the imperialist competitive algorithm searches for the most powerful country, in its own search domain, as the imperialist from the viewpoint of the highest decrease in losses. Of course this maximum amount has some limitations which must be considered during 30 decades that are considered for problem. If it placed among the mentioned allowed range such as the range of voltage, flow and active and reactive power balance in the imperial competitive algorithm that is considered as a subprogram in each repetition, the algorithm is continued otherwise the condition will be studied again.

Countries which pass these limitations are known as the most powerful countries or imperialist ones and other countries are known as the colonies or under domination countries. Then the total difference of imperialist with colony is studied with coefficient of calculating the repetitions stop error, if it is more than the threshold of repetitions stop in this case because of complete domination of imperialist power on the colony, in this step the imperialist country will win, and if it is less than the threshold of repetition stop the colony countries will become near to the imperialist country with the attraction factor of colonies (the attraction policy). In the next step, like the genetic algorithm that has the genetic mutation, here a revolution (sudden changes) will occur that is done according to the revolution coefficient of these changes. Finally according to the occurred revolution we go to the first step again and form the empire, that consists of colony and imperial countries, again and this action is repeated until the final answer, that is maximizing the losses decrease, is obtained.

Numerical Results

In this article, connection of some types of distributed generation sources to the network is on the surface of the distribution network and to study the efficiency of proposed algorithm to solve the optimization problem, in an IEEE standard test network, 33 buses will be studied and evaluated before and after installation of distributed generation sources types. In each type of defined distributed generation according to the target function the case of network losses and voltage profile will be studied and at last compared. The data of test networksis obtained from reference (Buhari *et al.*, 2000). The total losses of 33 buses network is equal to 202.68 kilo watt before compensation. To study the proposed operation, three different types of DG are considered for 33 buses network.

The curve of voltage profile and losses in each lines of 33 buses network before placement of DG in the network is as figures (2) and (3).

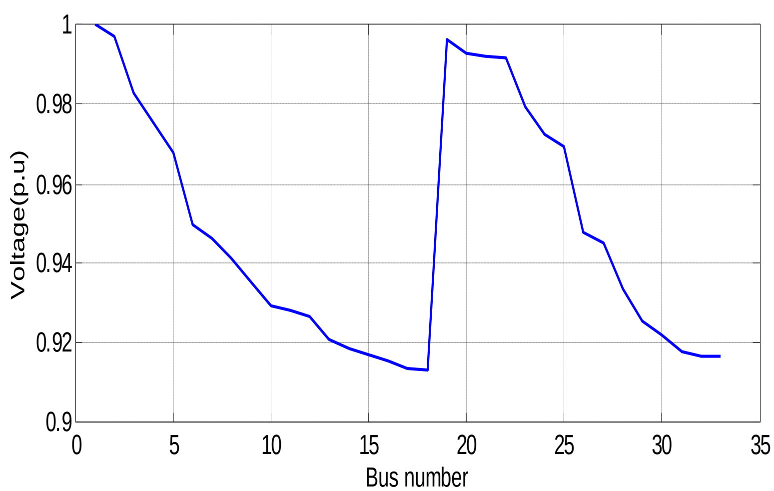

Figure 2: 33 buses network voltage profile before placement of DG

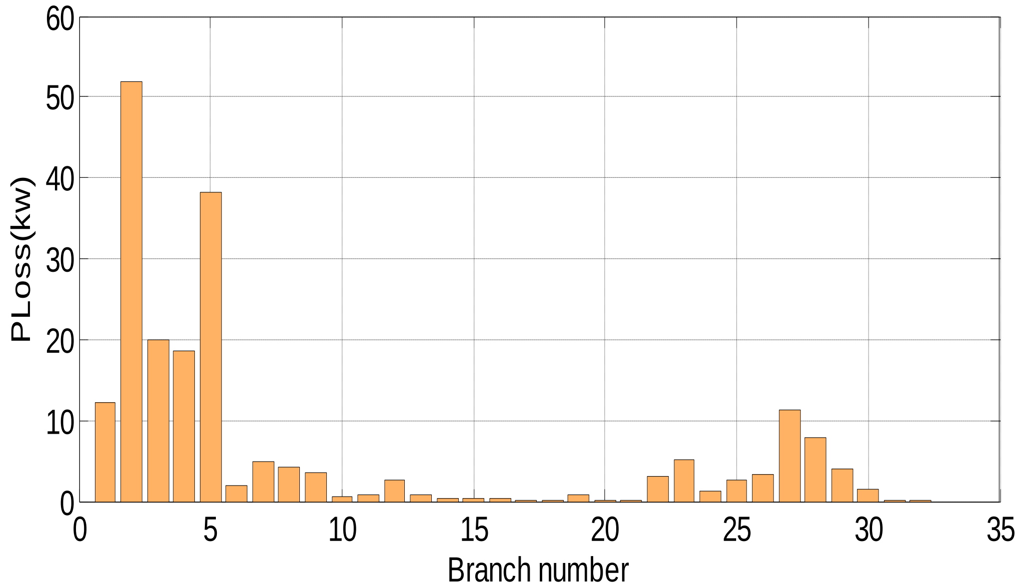

Figure 3: Losses in each line of 33 buses network before placement of DG

Optimal Placement of DG type 1 (Just Generate Active Power)

This type DG just is able to generate active power in the network. Some technologies such as photovoltaic and fuel cells are able to generateactive power. Results obtained from performing the imperialist competitive algorithm in the 33 buses network and DG type 1 is in this form that by installation of DG in bus number 7 with generated active power of 1.8578 mega watt, the network total losses will decrease from 202.68 kilo watt to 110.24 kilo watt. The curve of voltage profile and losses in each lines of 33 buses network after placement of DG type 1 in bus number 7 of the network is as figures (4) and (5).

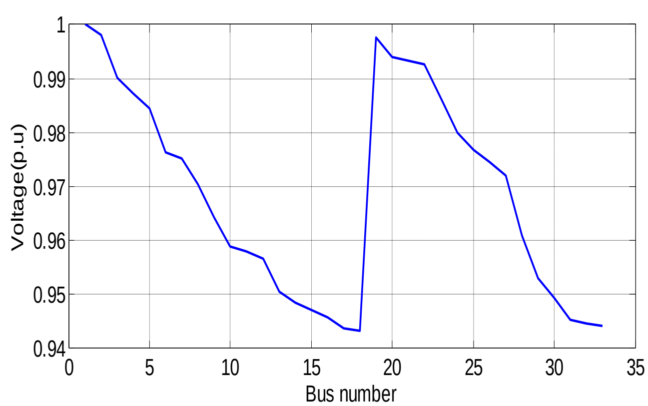

Figure 4: Voltage profile of 33 buses network after placement of DG type 1

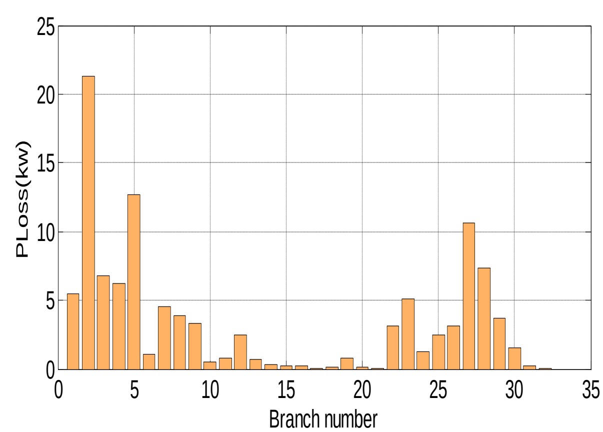

Figure 5: Losses in each line of 33 buses network after placement of DG type 1

Optimal Placement of DG type 2 (Just Generate Reactive Power)

This type of DG is just able to generate reactive power in the network. Technologies such as synchronization and synchronization condenser compensators are able to generate reactive power. Results of performing the imperialist competitive algorithm in 33 buses network and DG type 2 are in such a manner that by installation of DG in bus number 29 with 1.2248 megawatt generative reactive power, the total losses of network will decrease from 202.68 kilo watt to 145.55 kilo watt. The curve of voltage profile and 33 buses network losses after placement of DG type 2 in bus 29 is as the figures (6) and (7).

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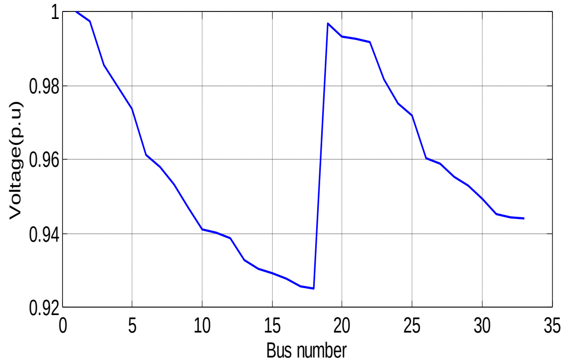

Figure 6: Voltage profile of 33 buses network after placement of DG type 2

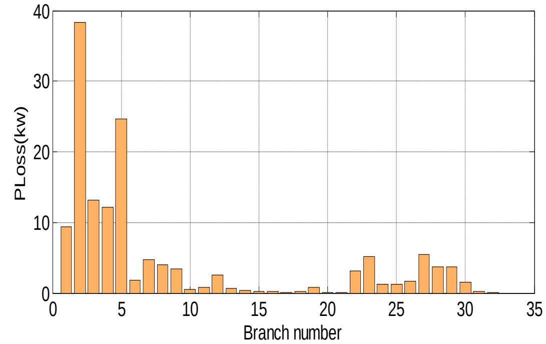

Figure 7: Losses in each line of 33 buses network after placement of DG type 2

Optimal Placement of DG type 3 (Generate Active and Reactive Power)

This type of DG is able to generate active and reactive power in the network. Technologies such as synchronization machines are able to generate reactive and active power. The results obtained from performing the imperialist competitive algorithm in 33 buses network and DG type 3 is in such a manner that by installation of DG in bus number 30 with 1.6 mega watt generative active power and 1.3627 mega watt generative reactive power, the network total losses will decrease from 202.68 kilo watt to 64.75 kilo watt. The curve of voltage profile and losses in each line of 33 buses network after placement of DG type 3 in bus number 29 is as figures (8) and (9).

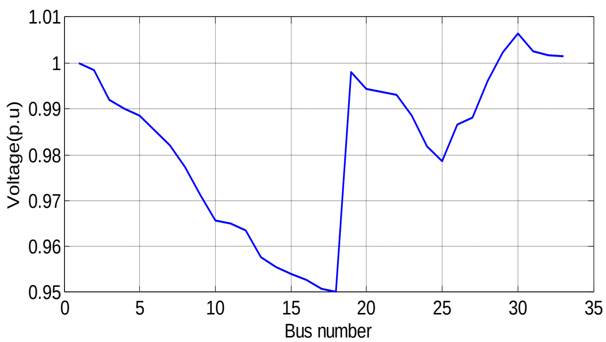

Figure 8: Voltage profile of 33 buses network after placement of DG type 3

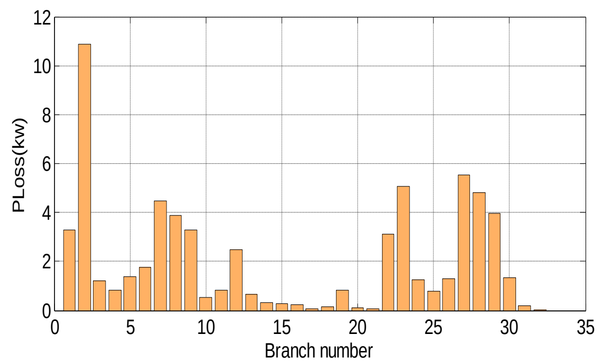

Figure 9: Losses in each line of 33 buses network after placement of DG type 3

To compare and having appropriate analysis of scenario and different conditions and states which are considered in previous sections, the curve of voltage profile with different types of DG are shown in figure (10).

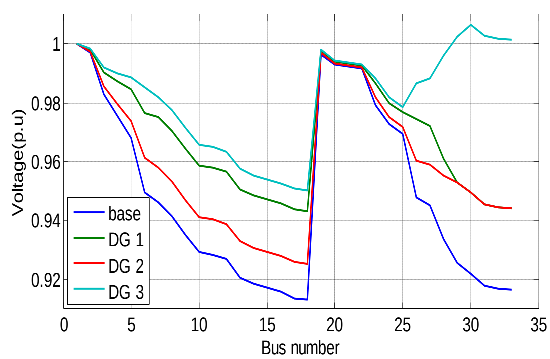

Figure 10: The curve of voltage profile in variousconditions of 33 buses network

CONCLUSION

By observing the curve of voltage profile it is perceived that when DG has the ability of generation both of active and reactive power in the distribution network, the curve of network voltage profile has better situation in comparison with conditions that DG is able to generate one of the active or reactive powers. In examining and considering the network losses it is observed that total network losses will have more decrease by installing DG type 1 in comparison with DG type 2 in the network. Therefore, by installing a DG that is able to generate active and reactive power in the network, it's possible to observe good improvement on aconomical criterion in addition to improvement in the mentioned technical parameters.

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