www.ElitesJournal.ir

مجله نخبگان علوم و مهندسی

Journal of Science and Engineering Elites

جلد ۲- شماره ۶- سال ۱۳۹۶

Coordinate Reactive Power DGs to Reduce Losses with the Algorithm PSO

[1] Mohammad Ahmadi*,[2] Jafar Tahmasebi, [3] Mohammad Reza Norimehr

1-PHD Student Departman of Electrical Engineering Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

2-PHD Student Departman of Electrical Engineering Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

3-Faculty Memberof Department of Electrical Engineering Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

*Mohammad_ahmadi1982@yahoo.com

Received: January 2018 Accepted: February 2018

Abstract

Due to the expansion of free markets of electrical energy, the use of Distribution Generation (DG) units is increasing to provide power in distribution networks. The impact of dispersed productions on losses and the distribution network at the average pressure voltage is the main subject of this research. DG has many beneficial effects, including minimizing losses and operating costs, increasing the power quality and improving the voltage profile on the network. Using the PSO algorithm is to optimization losses and reactive power network. IEC test network includes 26 buses and 5 DG units, which has been implemented in the MATLAB software environment.

Keywords: DG, Optimization Losses and Reactive Power, PSO Algorithm.

1. Introduction

Today, DG resources are widely used in electrical systems due to their high importance in energy production. DG are small energy sources that are easily installed in different parts of the distribution network and do not have the problem of large power plants in finding the location of the installation [1]. Many studies have been presented in the fields of voltage control and active and reactive power in the operation of distribution systems of distributed generation units, and most researches have sought a method to achieve the best response (loss reduction and improvement of voltage profile) [2]. To compensate for reactive power, the most common and widespread solution in distribution networks are capacitor banks that act as a reactive power source and, with proper voltage control, reduce losses. Different methods have been presented for obtaining optimal results in papers [5-3]. Distributed generations can reduce losses by providing local supplementation; and they can be modeled as active power supplies that are able to inject and consume reactive power [6]. Their advantage is that they are uniformly distributed throughout the network, and minimize losses. In many countries, static characteristics are now used to help control local voltages [7]. However, these solutions have limited control facilities due to lack of communication infrastructure. However, there are many questions about reactive power that many have been raised and discussed [8-9]. An article [10], titled DG Optimal Reactive Power Controls for regulating voltage distribution systems using sensitivity analysis. In this paper, the problem of reactive power control, the distributed generation dispersion in (MV), medium

distribution systems to maintain the system voltage in the predefined range. The problem of DGs is to control reactive power as an optimization problem using sensitivity analysis and aims to optimize the problem of returning the system voltage within the permitted range using DGs reactive power in the optimal direction. The simulation results show that the proposed algorithm is capable of maintaining the system voltage within the permitted range.In order to minimize casualties and maximize economic benefits; reactive power play should be controlled when many articles and many different solutions have already been implemented. When the active and reactive power of the loads and generators in the network is continuously monitored and measured by intelligent, these data can be used to generate consistent control of the algorithm.
The purpose of the proposed research is to develop an appropriate control algorithm to minimize operating costs and losses, which is a very simple and effective structure in DG networks. By assigning DGs reactive power and taking into account the costs of reactive power distribution, the minimum cost of operation will be achieved using the PSO algorithm in the 26-bus network.

2. DG resources

DG resources are small power plants that directly connect to the distribution network or consumer side. Increasing subscriber demand for power and reducing the energy resources of fossil fuels and the benefits of using renewable energy have resulted in distribution companies be more willing to install distributed generation units, as shown in Figure 1 of this type of resources [11].

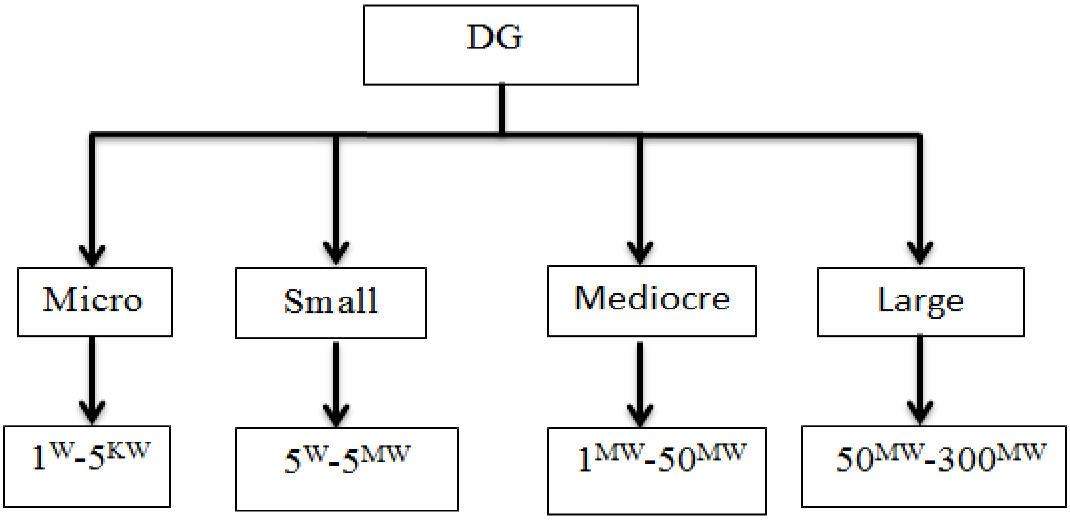

Figure.1. Categorization of capacity of DG resources

Basically; DG is used as an electrical power source to provide some of the active power needed by subscribers. Therefore, according to the definition, there is no mandatory requirement for the generation of reactive power by DG. Nevertheless, in many DG-related technologies, it is possible to generate reactive power directly or indirectly. Given the load and type requirements of the DG, there are various applications for distributed production that are [6]:
1- Feeding supporter to provide critical load capacities, such as specific industrial units, during power outages and to improve reliability level,
2. Feeding loads separately from the network to remote areas, which electricity supply to

them through the network very is expensive due to the presence of the geographic barriers
3. Peak-shaving by providing the required power in peak hours
4. Strengthening the system voltage in rural and remote areas that are connected to the network
5. Producing combined heat and power in order to achieve higher energy efficiency
6. Providing some part of the required power at the base load
7. Postponing the construction and development of the network
8. Reducing environmental pollution, especially for renewable energy based productions
9. Preventing the increase of network capacity and reducing electric losses in the transmission and distribution sector

3. Control and distribution of reactive power

The purpose of the studies of load distribution in power systems is to determine the active and reactive power of the network. The most important cases are the following:
1. Voltage level of buses
2. Compensatory or equilibrium amounts of power
3. Determination of losses in the production and transmission system
4. How to distribute economic burden
5. Optimization of system losses

In order to investigate the extent of changes of distribution network losses in the event of the connection of distributed generation resources to it, the load distribution calculations related to the distribution network must first be conducted [12]. The purpose of the study of the distribution of load in a distribution network with distributed generation sources is to investigate the voltage at each junction, which can easily achieve this voltage increase due to the presence of a synchronous or asynchronous generator or asynchronous generator of distributed generation resources by equation (1), in which X and R are the resistance and reactance of the airline feeder in that location, respectively, and Q and P are active and reactive power, respectively[13]:

$$\Delta V = \frac{PR + XQ}{V} \quad (1)$$

For weak pressure networks, the resistance is more effective than reactance, so the active power is more effective than reactive power in the network. In investigating load distribution of such a distribution network, the effective parameters include the active and reactive power of the output of the distributed generation source and the place of its connection to network, the network load size, the number of resources connected to a line in the network, and the network impedance.
Power losses on the line can be determined using equation (2):

$$Losses_{ij} = \frac{P_j^2 + Q_j^2}{U_j^2} R_{lineij} \quad (2)$$

Where $Pj$and $Qi$are the active and reactive power at the bus bar end, respectively;$Rline\ ij$, line resistance and Uj voltage at j node. As it can be seen in Figure 2a, if the generator activity is high to minimize the losses described above, the reactive power distribution from the generator to the beginning point of the feeder, in which the beginning of the feeder (post) provides the original bus, varies. Figure 2b shows that the lines of reactive power distribution are in the same direction as the line that reaches the node of the generator, the losses are reduced, and in opposite cases, the losses are increased.

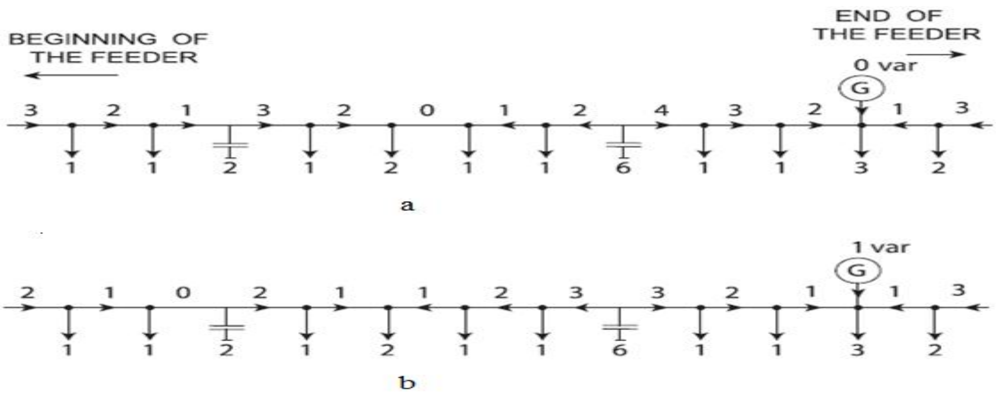

Figure 2 (a) .Reactive power distribution when DG does not minimize company losses
(b) .When the DG reduces the reactive power distribution in the line from the post [13]

The total losses for each line using equation (3) can change losses and determine reduction of losses [13].

$$Losses_{change} \approx \sum_{j=1}^{N} \left(\frac{P_j^2 + Q_j^2}{U_j^2} R_{linej} - \frac{P_j^2 + (Q_j - Q_G)^2}{U_j^2} \right) R_{linej} \qquad (3)$$

4. Optimization algorithm

Optimization is a process to find the best solution. By increasing the use of distributed generation resources and increasing their contribution to supplying power to the power system, we need to look for a way to use these resources properly by planning. The load distribution algorithm is implemented in a coordinated control and determines the optimal work point using a modeled network separately for each unit of generation. The purpose of this algorithm is to minimize losses and optimize distributed generation units. The most common point-to-point classical methods (for example, direct methods and derivative methods) use a computational approach to achieve an optimal solution [14]. However, by increasing the dimensions of the problem and the search space, finding the answer becomes more complicated using classical techniques. Computational intelligence optimization algorithms have been used in a variety of fields, including science, business, and engineering to solve complex optimization problems, due to its easy to use, extensive implementation and overview. Group optimization algorithms generally use a summarized model of the complex social behavior of insect and animal groups. The most popular group smart method is particle swarm optimization (PSO) method [15]. The PSO algorithm is group-based and provides quick search in the method. In the PSO algorithm, the locations are the same particles that change over time. The particles in the PSO move around the search space. Along the movement, each particle encounters its best situation according to its position, which is called $pbest$and with respect to the neighboring particles, which is also $gbest$ figure 3[16].

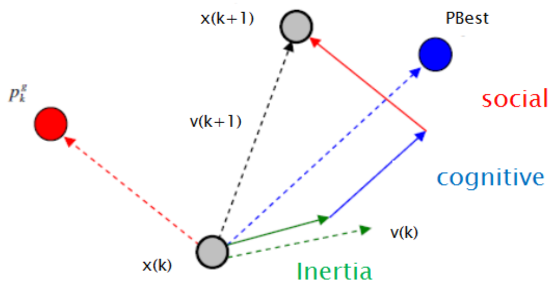

Figure 3.Particle's velocity

After each repetition, the speed and position of the particles are updated. The flowchart of the PSO algorithm is shown in Figures (4) [17-18].

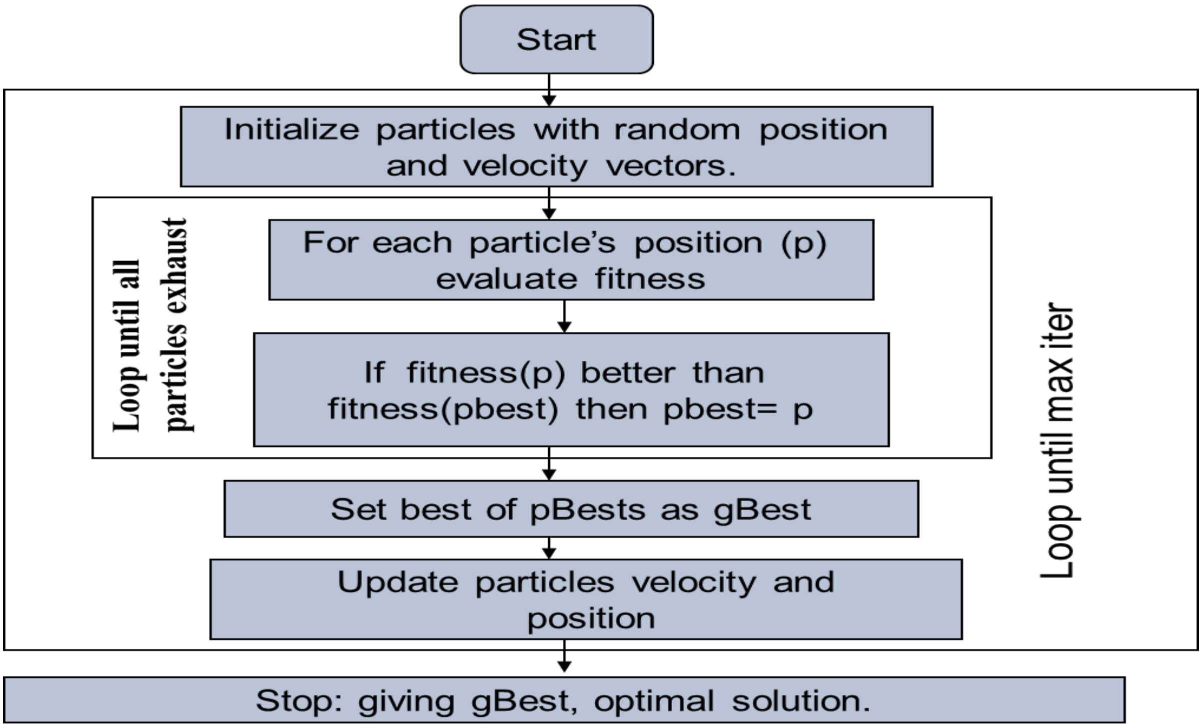

Figure 4.flowchart of the PSO algorithm

5. The studied system

To illustrate some practical implications of the proposed loss minimization algorithm, exploitation is considered on some part of a distribution network model, in which the single-line diagram of the studied system is shown in Figure 5. In Table (1), the location and amounts of distributed generations with high capacity are presented [19-20].

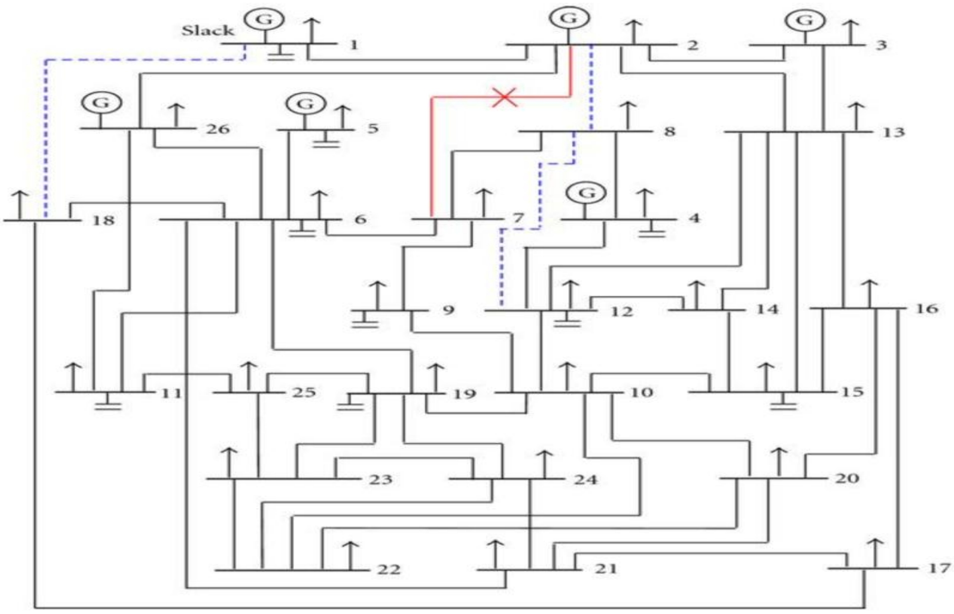

Figure 5 .The single-line diagram of the studied system

Table 1. Location and size range for distributed generation resources

Location of bus DG	Amount of active power (MW)	Amount of reactive power ($Mvar$)
2	40	250
3	40	150
4	25	80
5	40	160
26	15	50

6. Simulation results

We first investigate the study system without coordinating DG resources. In Figure 5, the active and reactive power of the network is shown without resource coordinating for 26 buses. Figure 6 show Convergence curve of the PSO algorithm buses without coordinated distributed resources. The network is shown in the conditions of the unit power coefficient of the losses of the lines in Fig. 6 and the voltage profile is shown in Figure 7, and Figure 8.network voltage profile. In this case, the energy losses with the presence of distributed resources without the coordination of reactive power resources are 15.86 MW

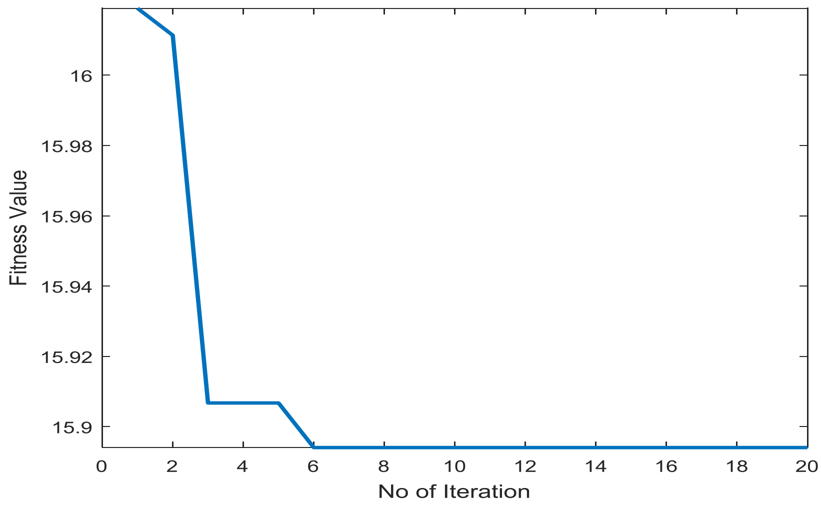

Figure 6 Convergence curve of the PSO algorithm buses without coordinated distributed resources

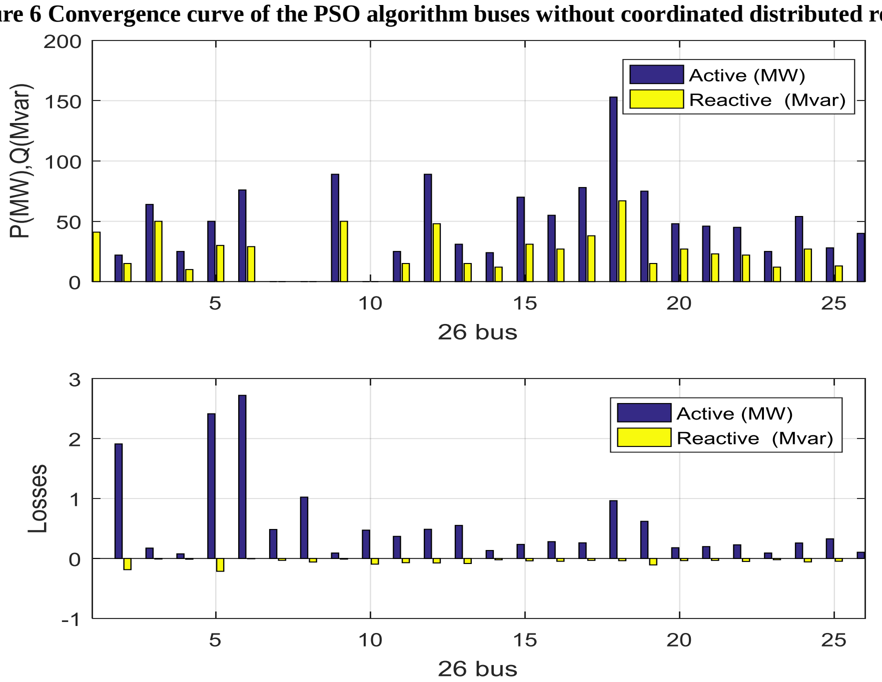

Figure 7 .Active, reactive and losses of buses without resource coordination

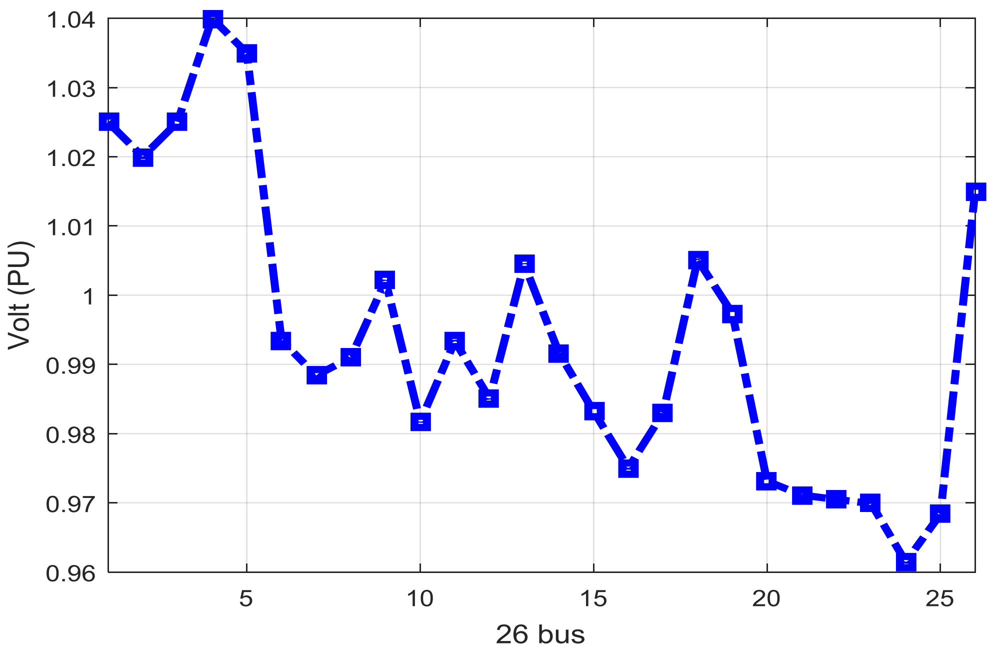

Figure 8.Network voltage profile

Now, by injecting reactive power to DG units of in a coordinated manner and calculating the loss in the adjacent lines according to the flowchart and acquiring reactive power for each unit, it is possible to prevent reactive power rotation in the network by using the PSO search algorithm. In fact, the reactive power generated by five DG power units is achieved according to the flowchart and the most optimal case is with the least rotating losses. In this case, the network losses are reduced to 15.54 MW, and the rate of reduction of losses of lines is obtained. Table 2 shows the range of reactive power inputs injected for the resources that reduce the losses. In Fig. 8, convergence of the algorithm is shown. In Figure (9), coordinated active, reactive power and line losses of the PSO algorithm

Table 2 The range of coordinated reactive power inputs injected for resources with the PSO

Buses of resources	2	3	4	5	26
Coordinated reactive power of resources (MVAR)	153.2	84.48	64.87	126.7	42.83

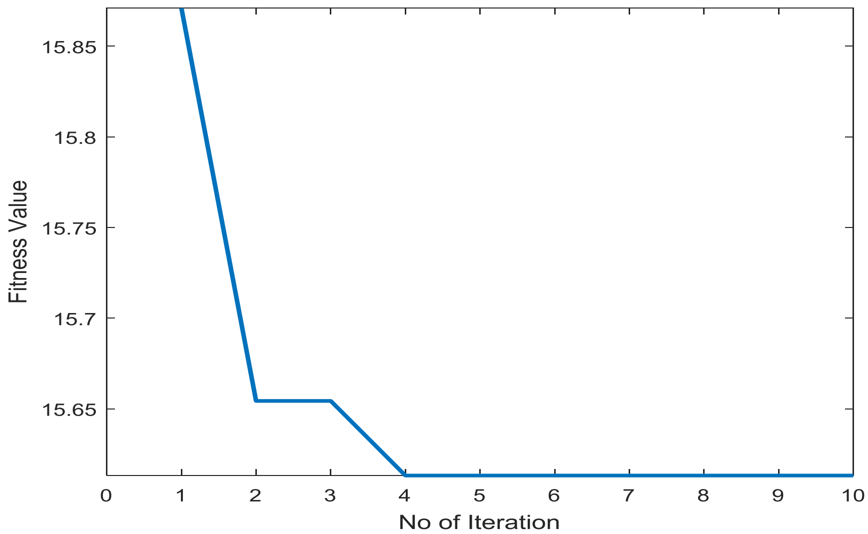

Figure 9 .Convergence curve of the PSO algorithm

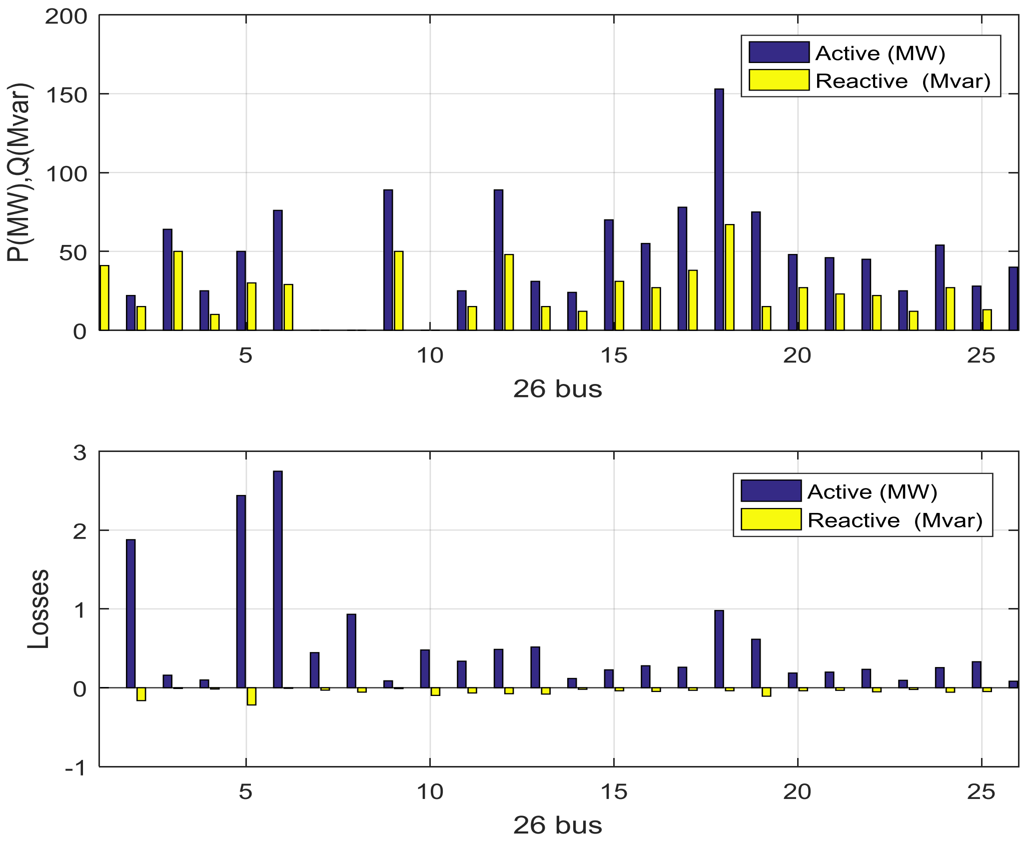

Figure 10 .Coordinated active, reactive power and line losses of the PSO algorithm

7. Conclusion

In this research, the problem of minimizing losses and operating costs in distribution networks with a high DG ratio was investigated. With a proper control of reactive power, DGs can participate in minimizing losses. Smart Implementation will enable the distribution operators to take advantage of the unused capabilities of the reactive power of DG and to have reactive power to participate in emerging markets. The PSO algorithm of coordinated control is presented to determine the point of operation for units based on active and reactive power measurements of smart measurements in order to minimize reactive power with respect to a limited amount of reactive DG power. The results show a reduction in the desired losses and a reduction in operating costs. The research work outlook is presented to develop a methodology that can represent a suitable solution for cost effective smart control and industrial electronic applications to generate electricity distribution systems. Therefore, the proposed method has a simple structure and can easily be implemented in automatic control devices.

8. References

[1] T.Niknam,and B.Bahmani Firuzi,'' A practical algorithm for distribution state estimation including renewable energy sources,''Renewable Energy,Vol.34.No.11,pp.2369-2316.2009.

[2] R.h.liang and Y.S.wang,''Fuzzy-Based Reactive Power and Voltage Control in a Distribution System,''IEEE Transaction on Power delivery, Vol.18.No2, pp.610-618, 2003.

[3] Pooya R, Mehdi V. Discussion of ‘‘Optimal reconfiguration and capacitor allocation in radial distribution systems for energy losses minimization’’ by L.W. de Oliveira et al., International Journal of Electrical Power and Energy Systems 32 (2010) 840–848.. Int J Electr Power Energy Syst 2012;42(1):701.

[4] Smajo B, Mensur H, Mersiha S. One approach for reactive power control of capacitor banks in distribution and industrial networks. Int J Electr Power Energy Syst 2014;60(September):67–73.

[5] Leonardo WO, Sandoval Jr C, Edimar JO, Pereira JLR, Ivo Jr CS, Jeferson SC. Optimal reconfiguration and capacitor allocation in radial distribution systems for energy losses minimization. Int J Electr Power Energy 2010;32(8):840–8.

[6] Ugranlı F. Ersavas_ C. Karatepe E. Neural network based distributed generation allocation for minimizing voltage fluctuation due to uncertainty of the output power. In: Proc IEEE INISTA, June, 2011, Istanbul, Turkey; 2011. p. 415–9.

[7] SODO. Navodila za prikljuc evanje in obratovanje elektrarn inštalirane moci do10 MW (English translation: Electricity DSO. Instructions for connection and operation of power plants installed capacity up to 10 MW), Maribor, Slovenia; 2010.

[8] Kacejko P. Adamek S. Wydra M. Optimal voltage control in distribution networks with dispersed generation. In: IEEE PES ISGT Europe, October2010, Gothenburg, Sweden; 2010.

[9] Shan C, Min-You C. Multi-objective reactive power optimization strategy for distribution system with penetration of distributed generation. Int J Electr Power Energy Syst 2014;62(November):221–8.

[10] B. Bakhshideh Zad, H. Hasanvand, J. Lobry, F. Vallee , “Optimal reactive power control of DGs for voltage regulation of MV distribution systems using sensitivity analysis method and PSO algorithm”, Electrical Power and Energy Systems 68,P.P. 52–60, 2015.

[11] G.Pepermans,J.Driesen,D. Haeseldonckx , R.Belmans ,W.Dhaeseleer ,’’Distributed generation:definition ,benefits and issues’’ ,Energy Policy 2005;33(6),p.p 787-798.

[12] B. Bakhshideh Zad, H. Hasanvand, J. Lobry, F. Vallee , “Optimal reactive power control of DGs for voltage regulation of MV distribution systems using sensitivity analysis method and PSO algorithm”, Electrical Power and Energy Systems 68,P.P. 52–60, 2015.

[13] Marko Kolenc, Igor Papic, Bostjan Blazic“Coordinated reactive power control to achieve minimal operating costs” Electrical Power and Energy Systems 63,p.p 1000–1007,2014.

[14] K. Deb, A. Kumar, Real coded genetic algorithms with simulated binarycrossover: studies on multi modal and multi objective problems, Complex Syst.9 (1995) 431–454.

[15] R.C. Eberhart, J. Kennedy, A new optimizer using particle swarm theory, in: Pro-ceedings of the Sixth International Symposium on Micro Machine and HumanScience, New York, NY, 1995, pp. 39-43.

[16] N. Kumar, U. Nangia, K.Bhushan Sahay, “ Economic Load Dispatch Using Improved Particle Swarm Optimization Algorithms’’, IEEE Transactions,2014.

[17] Jin S. Heo, Kwang Y. Lee and Raul Garduno-Ramirez, “Multiobjective Control of Power Plants Using Particle Swarm Optimization Techniques”, IEEE Transactions on Energy Conversion, Vol. 21, No. 2, 2006.

[18] M., Neyestani, M. M., Farsangi, H. Nezamabadi-pour, “A Modified Particle Swarm Optimization for Economic Dispatch with Nonsmooth Cost Functions,” Eng. Appl. Artif. Intel., Vol. 23, No. 7, pp. 1121–1126, 2010.

[19] Z. Gaing, R.F. Chang, Security-constrained optimal power flow by mixedinteger genetic algorithm with arithmetic operators, in: Proceedings of IEEE Power Engineering Society General Meeting , pp. 1–8, 2006.

[20] Z. Giang, Constrained optimal power flow by mixed-integer particle swarm optimization, in: Proceedings of IEEE Power Engineering Society General Meeting, , pp. 243–250, 2005.