TELKOMNIKA Telecommunication, Computing, Electronics and Control
Vol. 19, No. 3, June 2021, pp. 1039~1049
ISSN: 1693-6930, accredited First Grade by Kemenristekdikti, Decree No: 21/E/KPT/2018
DOI: 10.12928/TELKOMNIKA.v19i3.15223

Distribution power loss minimization via optimal sizing and placement of shunt capacitor and distributed generator with network reconfiguration

Mohammed B. Essa[1], Lubna A. Alnabi[2], Abbas K. Dhaher[3]
[1]Electrical Techniques Department, Al Suwaira Technical Institute, Middle Technical University, Iraq
[2]Computer Techniques Engineering, Al-Mustafa University College, Iran
[3]Electric Power Engineer, Ministry of Oil, Iraqi Drilling Company, Iraq

Article Info

Article history:

Received Jan 8, 2020
Revised Nov 30, 2020
Accepted Dec 7, 2020

Keywords:

Distribution generation
Radial distribution system
Reconfiguration power loss
Shunt capacitor

ABSTRACT

The population is speeding up and the demands for electrical energy are clearly increasing, this growth in load leads to higher power loss and Voltage drop. This paper is focused on a method to decrease the power losses and voltage profile improvement. The first suggested technique binary particle swarm optimization (BPSO) is utilized for solving the problem of the power loss minimization in network distribution. This work based on optimum position and sizing of the distribution generation (DG) units, shunt capacitor (SC) with network reconfiguration is applied to show the improvement of the network distribution efficiency. The MATLAB programming part and software package MATPOWER7 are used to simulate 69-bus and 33-bus test system with three different cases of loads and different number of DG and SC. The result showed a positive impact on system efficiency in comparison with other previous studies. This paper showed that increase of DG and capacitor does not usually give the best result although the increase of system cost, maintenance, and the units' distance for gas supplying.

Corresponding Author:

Mohammed B. Essa
Electrical Techniques Department, Al Suwaira Technical Institute
Middle Technical University
Baghadad, Iraq
Email: Moh.Bahlol@mtu.edu.iq

1. INTRODUCTION

The distribution network linked the transmission network to consumer loading points. The distributed network configuration is ordinary a closed-loop, although the process is radial. The distribution network of includes both tie and sectionalizing switches. Though the two switches are basically alike, the network tie-switches are the one which stay open in order to preserve the network's radial nature [1]. Any of the sectionalizing switches (typically closed) of basic configuration of the network may be opened throughout the reconfiguration, which is why, it will become a tie switch. The optimum re-configuration specifies the suitable switches opening of which impact the minimal losses of the real power. The procedure would make sure that none of the consumers is separated and the radially of network is attained. DGs such as solar photo-voltaics (PV), diesel generators, small wind turbines, and others. And shunt capacitors are added as well to radial distributed network for boosting of the capacity, minimizing system losses and improving the voltage profile. None-the-less, SCs and DGs require being sized and placed optimally for sufficient system operation [2].

There has been an increased tendency for the automation of the system of distribution. It became possible installing the operating center of distribution for monitoring and controlling the networks of distribution, in addition to the reconfiguration of the distributed system for reducing the losses of the real power and balancing the loads in the case of the normal operating conditions. The distribution system operation control are performed with 2 switch types, which are the sectionalizing switches normally close and the tie switches normally open. The system of distribution shall operate in a manner that has to be radial, the operating cost have to be maximally low, all loads are serving and the node voltages have to be in the permitted limit [3].

Improving the technical losses in distribution system is a solution which was taken under consideration in efficient planning and modeling of the power system. Reducing the power losses will enhance the system's power quality, thereby it will increase the electrical components' life like distribution lines and transformers in the system. An efficient distribution system will be transmitting the electric power to consumer in a flexible way, maintaining protection of the feeders and the equipment throughout the contingencies [4]. One another basic reason of the distribution reconfiguration is eliminating the overload on the components of the network. The load on the distribution system's feeders is typically combined from industrial, residential, commercial and those loads are capable of decreasing or increasing in various day or night times.

Therefor peak load on feeders, sub-station and transformers it happens in various day times; which might result in the systems having light or heavy loads throughout the day times [5]. Kanase [6] a multi-objective adaptive fuzzy-genetic approach presents for improving the efficiency of radial electric distribution system through reducing real power losses and node voltage deviation. Multiple objectives considered are minimizing node voltage deviation and minimizing the actual power loss, depending on the structure of the radial system where all loads have to be energized.

Abubakar *et al.* [7] proposed a method developed which dependent on enhanced genetic algorithm for the determination of the optimal position of tie and sectionalizing switches, and to provide the network with optimal efficiency. Muhtazaruddin *et al.,* [8] proposed a solution for solving system reconfigurations, SC coordination (this means the size and the location) and DG coordination (this means the size and the location), in a simultaneous manner. The suggested solution is going to be found through the use of the artificial bee colony (ABC). Difference case studies have been published for viewing the effects on the testing system, concerning the voltage profiles improvement and the power loss reduction as well. As a result, in this paper, the reconfiguration is applied using Newton Raphson (NR) method based on binary particle swarm optimization (BPSO) with three different cases of loads, constant and variable loads with regulation ratio (nominal load 100%, light load 50%, and heavy load 160%).

2. LITERATURE SURVEY

In this paper introduses the reconfiguration distribution network with the distributed generation simultaneous allocation. The load fluctuation uncertainties prior to the reconfiguration of the distribution network are also considered. Three optimum goals, including minimum energy estameted not to be supplied, minimum cost of switch operation and minimal line loss cost are investigated. Where two cases are included in the proposed network reconfiguration process. The first case is to construct a viable topology network using BPSO. Then the DGs Allocation problem is overcome by using the harmony search algorithm (HAS) and sensitivity analysis [9].

In this work presented a summary of the various methods used for the study of load flow effects using the NR method. The problem of power flow, also referred to as the problem of load flow, has been solved. The load-flow solution gives complex voltages to all the busses and complex power flows in the feeders. The fast decoupled load flow method, Gauss-Seidel method and the Newton Raphson method were discussed in detail. Gauss-Seidel load flow solution tends to be useful in smaller systems, but as the system size increases, the computation time increases. Thus, the fast decoupled load flow and the Newton Raphson methods are more common methods in large systems. A comparison of various requirements, such as reliability, speed, storage, convergence, computational time characteristics proposed, and are tested on IEEE 30-bus and IEEE 57-bus distributed system [10].

In this work gived an effective approach focused on the BPSO presented to identify the switching operation plan for network reconfiguration. Typical IEEE distribution systems consisting of 16 buses are used in order to provide the benefit of the proposed approach. The result of simulation shows that the presented method which applied to feeder reconfiguration problems is more effective and stable compared with other existing methods [11].

In this work, the reconfiguration of distributed system is achieved by altering the close/open location of two types of switches: normally open tie-switches, and sectional-switches are usually closed. They present the implementation of the novel discrete improved BPSO algorithm of the distributed system reconfiguration to improve the voltage profile and minimize real power loss. The algorithm is applied on a16-bus, 69-bus and 33-bus system with various loading conditions. The results of simulation show that the proposed technique can achieve optimal reconfiguration and substantially minimize power losses on the supply system and improve the voltage profile [12].

Essallah *et al.,* [13] introduces a BPSO based approach to system reconfiguration. The method was designed to boost the voltage profile and power losses minimization while satisfying system constraints and preserving the radial distribution network structure. Three various load cases are considered during the re-configuration of the network to estimate the performance of the suggested technique. Simulation is performed with the IEEE 33-bus test system. The results give a clear description of the efficiency and effectiveness of the suggested method [13].

3. RESEARCH METHOD

Power flow analysis methodology applied to transmission systems is mainly comprised by the Gauss-Seidel, Newton-Raphson. These power flow methods are typically used assuming a balanced system, consequently using a single-phase representation of the 3-phase system. Another study of the forward/backward methods (a popular power flow method applied to distribution systems) are capable of performing power flow analysis, however, it is limited to radial networks and does not have the ability to consider the influence of distributed generation, On the other hand, NR method typically can deal with any topology type (i.e. radial, weakly meshed and meshed) and can consider the influence of distributed generation, the formulation and origin of the NR approach has been dated back to the late 1960's [14].

NR an iterative approach approximating a group of simultaneous nonlinear equations to a group of the simultaneous linear equations with the use of the expansion of Taylor series and terms are limited to the 1st approximation. It is the most iterative approach which is utilized for load-flows due to the fact that its properties of the convergence are quite more powerful in comparison with other methods [15]. The main attribution to the success of NR method in distribution systems is the representation of the Jacobian matrix, which is created, based on the nature of the network topology [16].

In addition to NR, we use one of the types of artificial intelligence to determine the optimal location and size of DGs, SCs, and network reconfiguration there are many approaches used to evaluate the value of the switches, the position and the size for both DGs and SCs. Improper estimation of these parameters will lead to local optimal solution, which is not the better solution. As the combination of these methods is difficult and complex to solve, BPSO is therefore chosen on the basis of robustness. Some population-based examples are as follows: genetic algorithm (GA), particle swarm optimization (PSO), binary particle swarm optimization (BPSO), artificial bee colony (ABC), firefly algorithm (FA) and ant colony system (ACS), [4]. The PSO has been successfully implemented to optimize various problems of the continuous function optimization. However, it has not been designed for the problems of the discrete function optimizations. Luckily, they have presented a new and enhanced PSO version, which has been referred to as the BPSO which may be utilized for solving the problems of the discrete function optimization. In this BPSO, the typical PSO improved to solve the minimization losses problem for more detail on BPSO see the works in [11, 17, 18].

In this work, two standard test systems used with four cases for number of SC and DG and after determine the optimal results, and then the performance of the system tested after optimal results in light and heavy loads conditions to ensure that the optimization is suitable with the natural variation of loads. The rest of the work in the paper, problem formula for simultaneously network reconfiguration and Representation of DGs and SCs in Load Flow in section 4 and section 5 provides details of the cases analysis that performed in this work the algorithm and its Simulation results and comparisons. Finally, finish with the conclusion in section 6. MATPOWER7 software used where network data read and determin system power losses by NR method then BPSO parameters and k (iteration number) set to reach the optimum solution of the network reconfiguration problem as shown in the Figure 1 [13].

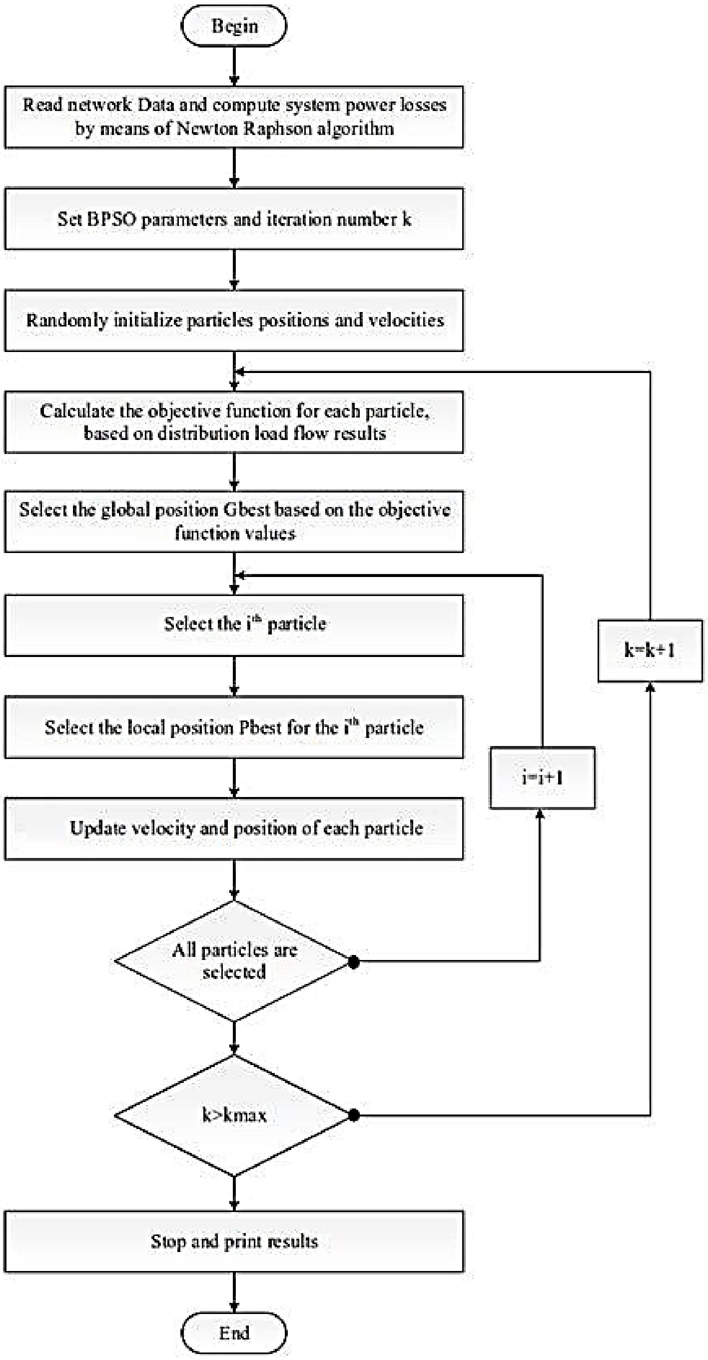

Figure 1. Block diagaram of BPSO based on Newtoon Raphson method [13]

4. MATHEMATIC FORMULATION

The goal of this study is to determine optimal network reconfiguration along with optimal location and size of SC and DG in the radial distributed network. In the following two parts, the first part 4.1 explains the network reconfiguration and the second part 4.2 explains the mathematical representation for finding the location and size of each of the DG and SC in the distribution network. With the clarification of the constraints that cannot be overcome during the improvement process for network system.

4.1. Network reconfiguration

Figures 2 and 3 shown in basic configurations for 69-bus and 33-bus systems, normally open tie-switch described in dotted line. Buses are numbered inside the circles as a first step to implement an algorithm for optimal reconfiguration, all network sectionalization and tie-switches are closed. This process generates a number of loops in the network labeled as Loop1 to Loop5 in the diagrams.

Thereafter, every single switch (either tie or sectionalization) in the loop is opened to preserve the radial nature of the network. The switch must be specific for each loop, and the switch opening mustn't separate any bus from the network when the switch is openedBPSO performs multiple iterations to arrive with the switch numbers, opening which decrease power loss. It should be taken into account that this operation and position of SC and DG are simultaneous. BPSO output solutions are proposed switches for opening along with the optimal sizes and positions of SCs and DGs that reduce network power loss.

4.2. Representation of DGs and SCs in load flow studies

Power flow computing is done using NR load-flow approach algorithm where the admittance matrix is used to write equations for currents entering a power system more detail about NR method in [19, 20], after deriving several equations down to equations of computing the active Power Pi and the imaginary Power Qi.

$$P_i = G_{ii}\,|V_i^2| + \sum_{j=0}^{n-1} |V_i||V_j|\,(G_{ij}\cos\Theta_{ij} + B_{ij}\sin\Theta_{ij}) \quad (1)$$

$$Q_i = B_{ii}\,|V_i^2| + \sum_{j=0}^{n-1} |V_i||V_j|\,\left(G_{ij}\sin\Theta_{ij} - B_{ij}\cos\Theta_{ij}\right) \quad (2)$$

Then Jacobian matrix Created. The difference between the schedule and calculated values known as power residuals for the terms Δpi and ΔQi for all i=1, 2, 3… (n-1);

$$\Delta P_i = P_{i.spec.} - P_{i.cal.} \quad (3)$$

$$\Delta Qi = Q_{i.spec.} - Q_{ii.cal.} \quad (4)$$

Total active power losses of network is specified with adding all line section losses of the feeder. Total active power losses of feeder;

$$(\text{PT Loss}) = \sum_{i=0}^{n-1} P_{LOSS}(i.i+1) \quad (5)$$

In the present work, the DG is merely modelled as a constant real P and imaginary Q power source of generation. The characterized DG model values are imaginary QDG and real PDG power output of DG. It has been noted that the DGs of the Fuel cell type may be modeled as a model of the negative PQ-load. The load at bus - i with a unit of DG will be updated:

$$P_{load.i} = P_{load.i} - P_{DG.i} \quad (6)$$

$$Q_{load.i} = Q_{load.i} - Q_{DG.i} \quad (7)$$

The shunt capacitor SC is modelled as a constant imaginary Q power generating source the load at bus-i with capacitors will be altered as well:

$$Q_{load.i} = Q_{load.i} - Q_{c.i} \quad (8)$$

During the optimization action, following constraints must be fulfill with:

$$V_{min} \leq V_i \leq V_{max}$$

$$/I_i/ \leq I_{i.(max)}$$

$$P_{DGi\,min} \leq P_{DGi} \leq P_{DGi\,max}$$

$$Q_{DGi\,min} \leq Q_{DGi} \leq Q_{DGi\,max}$$

System should be radial.

$$Q_{Capacitor\ total} \leq Q_{demand\ total}$$

In the presented research, we have considered V_{max} 1.05 p.u and V_{min} 0.90 p.u, respectively as the maximum and minimum acceptable ranges of the voltage for the network nodes [21, 22].

5. RESULTS AND ANALYSIS

The function of minimizing the power loss and improvement of the voltage profile, four different cases within two standards are studied in the present research to investigate the authority of the suggested approach: a 33-bus IEEE Standard for light, normal, and heavy load and for 69-bus IEEE standard as well. The suggested approach has been applied on IEEE 69-test system of the bus radial distribution which consists of 5 tie-lines as can be seen in Figure 2 at standard system 1. The nominal system voltage is 12.66 kV. At the normal conditions of the loading, the test system has provided a total amount of 2.69459 KVAR reactive loads and 3.80219 kW active loads. [23]. and for standard system 2 the suggested method is applied on the test system of IEEE 33-bus radial distribution which consists of 32 line and 5 tie-lines from (33-37) as can be seen from Figure 3 [24]. At the normal conditions of the loading, the test system has provided a total amount of 2300 KVAR reactive loads and 3715 kW active loads with 12.66 kV system voltage [25].

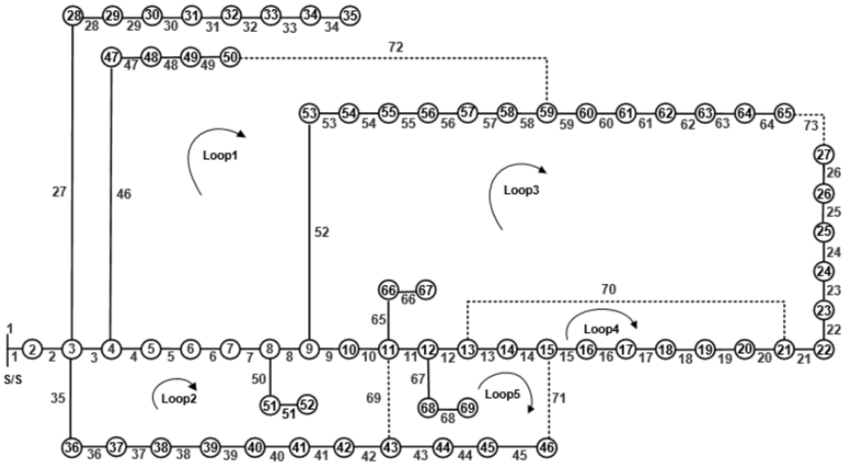

Figure 2. IEEE 69-bus radial distribution system [2]

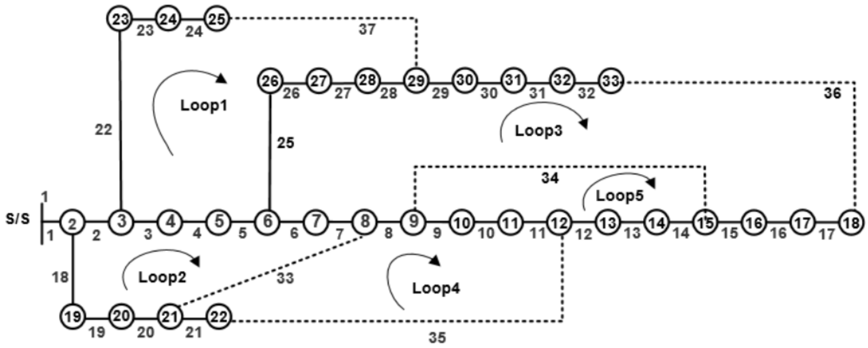

Figure 3. IEEE 33-bus radial distribution system [2]

5.1. Case study

The system test is implemented and compared with some studies as shown in Tables 1 and 2. the results presented an improvement regards the voltage profile and the power loss. Two Standard systems proposed for IEEE 33-bus and IEEE 69-bus with different number of DG and SC as shown at Table 3.

- Case 1: Network reconfiguration technique is used with 1DG and 1SC for the power loss minimizing.
- Case 2: Network reconfiguration technique is used with 2DG and 2SC for the power loss minimizing.
- Case 3: Network reconfiguration technique is used with 3DG and 3SC for the power loss minimizing.
- Case 4: Network reconfiguration technique is used with 4DG and 4SC for the power loss minimizing.

In this work, BPSO gives better results than DE and AGPSO through the results shown in Tables 1 and 2 it is clear that the results of the 33-bus system are good with capacitor size of 1814 KVAR instead of 2300 KVAR, compared to reference [2]. As for the results of the 69-bus system, we also obtained good results with the size of DG 2250 kW and SC 2170 KVAR, compared to reference [2] and [25]. In both systems we got voltage profile improvement and power losses reduction obtained from Table 1 and Table 2 with less number of DG and CS compared with other research that show the importance of reconfiguration and their effect on the system. The results compared in the Tables 1 and 2 with case3 only as the references used case 3 only for the same number of DGs and SCs in this case, but this work contains other cases as shown in Table 3. Table 3 show voltage and losses for both systems at base case and four cases of reconfiguration and allocation of DG and SC at nominal load level. Table 4 illustrate 69-bus optimal results using nominal load level for all cases. Table 5 illustrate loads variation results after network reconfiguration and allocation of DG and SC that slelcted at nominal load as shown in Tables 3 and 4. A comparison is made for the base case and with the reconfiguration of four cases with different number of DG and SC as shown in Figures 4-9. The result shows the effect of Improvements, where the load flow run with NR method based on BPSO, figures of voltage profile at varies load level with two difference standard system IEEE 69-bus and IEEE 33-bus listed.

Table 1. Results comparison for 33-bus using nominal load level (Relate Case3), two level for maximum rating of DG and SC seeking for optimal solution

Maximum rating of DG and SC	Algorithm	Open Switches	Distributed Generator: DG Size in kW (bus number)	Total kW	Shunt Capacitor: SC Size in KVAR (bus number))	Total KVAR	Power loss (kW)	Vmin (p.u)
2000 kW and 2000 KVAR	DE [1]	7, 11, 12, 17, 26	557 (15) 813 (25) 630 (32)	2000	703 (3) 399 (9) 1198 (30)	2300	15.63	0.9891
	Proposed	7, 35, 10, 36, 26	700 (15) 600 (31) 700 (25)	2000	382 (14) 1013 (30) 419 (24)	1814	15.47	0.9887
1750 kW and 1050 KVAR	DE [2]	7, 9, 14, 32, 37	680 (16) 670 (30) 420 (32)	1770	280 (17) 510 (30) 280 (32)	1070	36.5	0.9800
	Proposed	7, 10, 28, 8, 36	650 (15) 600 (25) 500 (31)	1750	650 (30) 230 (15) 170 (31)	1050	25.4	0.9820

Table 2. Results comparison for 69-bus using nominal load level (Relate Case3)

Algorithm	Open Switches	Distributed Generator: DG Size in kW (bus number)	Total kW	Shunt Capacitor: SC Size in KVAR (bus number))	Total KVAR	Power loss (kW)	Vmin (p.u)
AGPSO [23]	69, 17, 71, 58, 73	50 (747) 12 (795) 61(1633)	3175	50 (300) 12 (600) 61 (1050)	1950	3.895	0.9954
DE [2]	14, 17, 69, 72, 73	394 (12) 200 (21) 1656(61)	2250	528 (12) 934 (49) 1228 (61)	2690	4.82	0.9956
Proposed	25, 14, 55, 10, 69	350 (11)	2250	450 (12)	2170	4.42	0.9939

Table 3. 33-bus optimal results using nominal load level for all cases

Case	Open Switches	Distributed Generator: DG Size in kW (bus no)	Total kW	Shunt Capacitor: SC Size in KVAR (bus no.)	Total KVAR	Power loss (kW)	Vmin (p.u)
Original System	33, 34, 35, 36, 37	----	----	----	----	208.5	0.9108
Case1	11, 14, 24, 33, 34	2000 (29)	2000	1390(30)	1390	32.49	0.9779
Case2	9,12, 24,33, 34	1000 (29) 1000 (33)	2000	1270(30) 480(6)	1750	22.46	0.9829
Case3	7, 35, 10, 36, 26	700 (15) 600 (31) 700 (25)	2000	382(14) 1013(30) 419 (24)	1814	15.47	0.9887
Case4	7, 10, 26, 35, 36	450 (32) 650 (15) 410 (29) 490 (25)	2000	400 (15) 990 (33) 230 (6) 400 (24)	2020	14.48	0.9867

Table 4. 69-bus optimal results using nominal load level for all cases

Case	Open Switches	Distributed Generator DG Size in kW (bus no)	Total kW	Shunt Capacitor SC Size in KVAR (bus no.)	Total KVAR	Power loss (kW)	Vmin (p.u)
Original System	69, 70, 71, 72, 73	-----	----	----	----	225	0.9092
Case1	12, 71, 55, 72, 69	1790 (61)	1790	1270(61)	1270	11.85	0.9902
Case2	25, 15, 55, 17, 69	1700 (61) 550 (12)	2250	1240(61) 450 (12)	1690	5.17	0.9932
Case3	25, 14, 55, 10, 69	350 (11) 300 (21) 1600(61)	2250	450 (12) 530 (49) 1190(61)	2170	4.42	0.9931
Case4	24, 14, 72, 10, 69	1370 (61) 410 (12) 180 (11) 290 (64)	2250	980 (61) 460 (12) 600 (49) 210 (64)	2250	3.53	0.9959

Table 5. 69-bus and 33-bus for (light, nominal, and heavy loads)

System	Case	Light load (50%) Power loss (kW)	Light load (50%) Power loss reduc.	Light load (50%) Vmin (p.u)	Nominal load (100%) Power loss (kW)	Nominal load (100%) Power loss reduc.	Nominal load (100%) Vmin (p.u)	Heavy load (160%) Power loss (kW)	Heavy load (160%) Power loss reduc	Heavy load (160%) Vmin (p.u)
33-bus	Original System	48.53	------	0.957	208.5	------	0.911	589.4	------	0.849
	Case1	8.02	83.5%	0.989	32.49	84%	0.978	155.1	74%	0.925
	Case2	5.55	88.6%	0.992	22.46	89%	0.983	149.1	75%	0.911
	Case3	3.83	92.1%	0.994	15.47	93%	0.989	112	81%	0.951
	Case4	3.58	92.6%	0.993	14.48	93%	0.987	109.9	81%	0.948
69-bus	Original System	51.61	-------	0.957	225	------	0.909	652.5	------	0.845
	Case1	2.94	94.3%	0.995	11.85	95%	0.99	163.8	75%	0.886
	Case2	1.29	97.5%	0.997	5.17	98%	0.993	60.04	91%	0.949
	Case3	1.1	97.9%	0.997	4.42	98%	0.993	64.52	90%	0.949
	Case4	0.88	98.3%	0.998	3.53	98%	0.996	81.12	88%	0.948

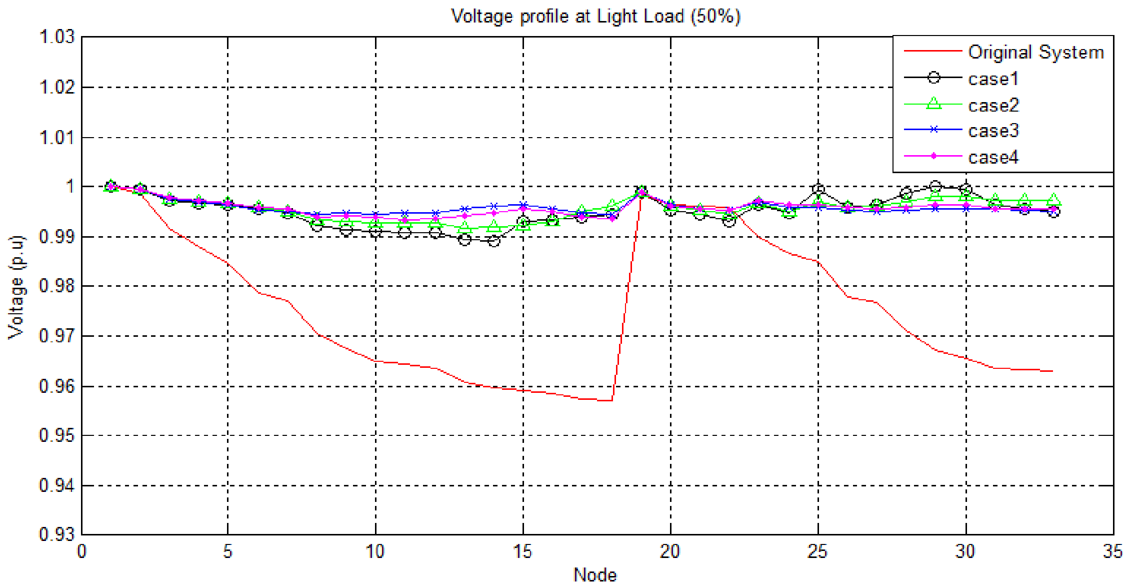

Figure 4. Voltage profile at light load for 33-bus system

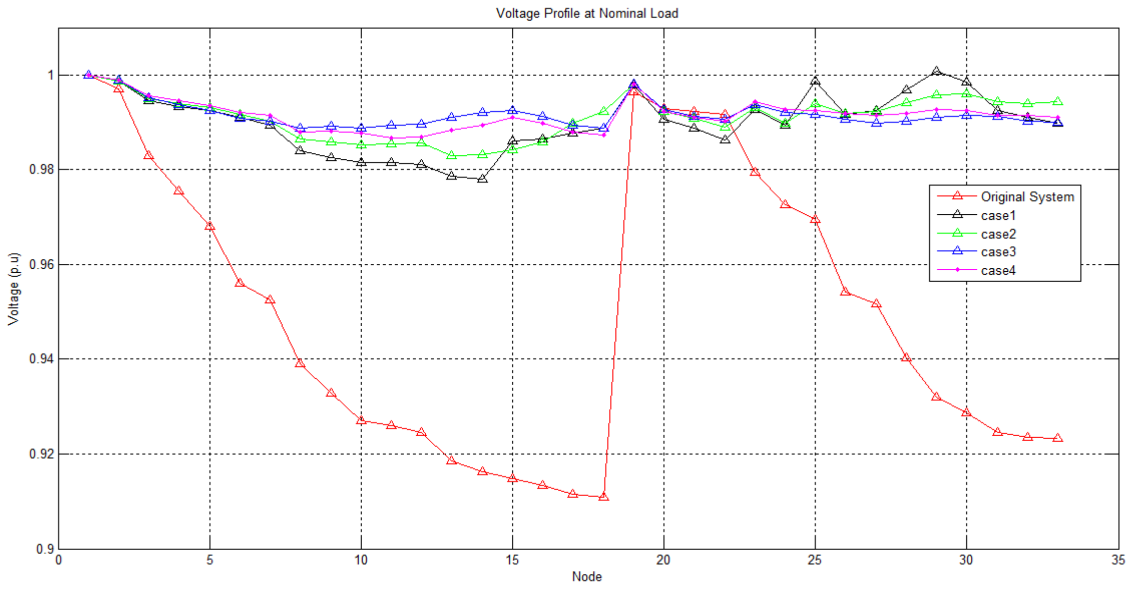

Figure 5. Voltage profile at nominal load for 33-bus system

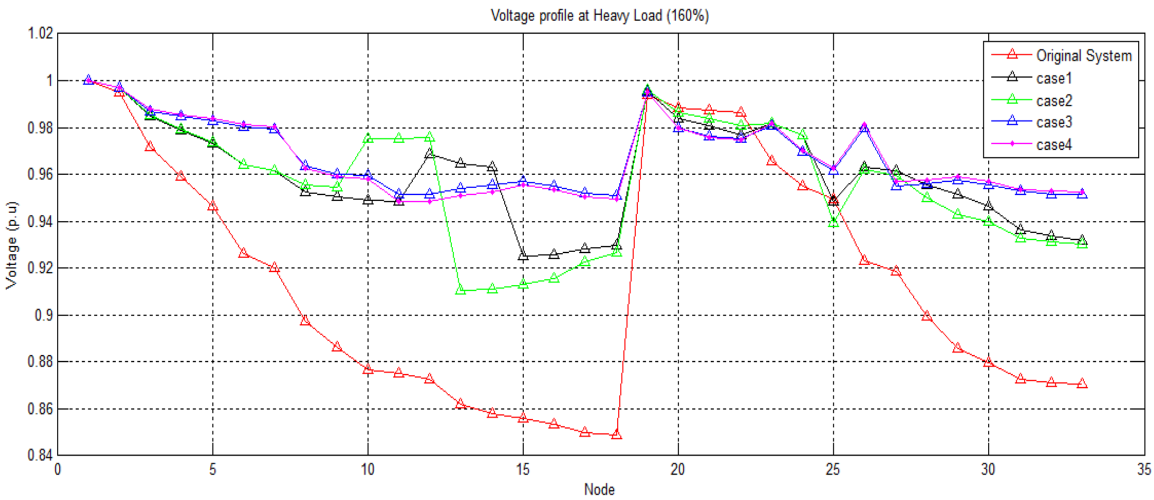

Figure 6. Voltage profile at heavy load for 33-bus system

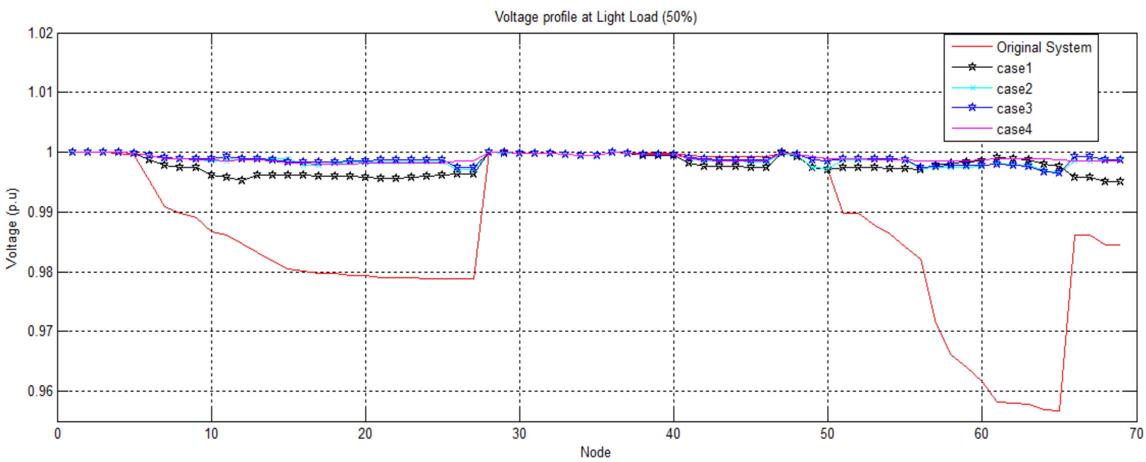

Figure 7. Voltage profile at light load for 69-bus system

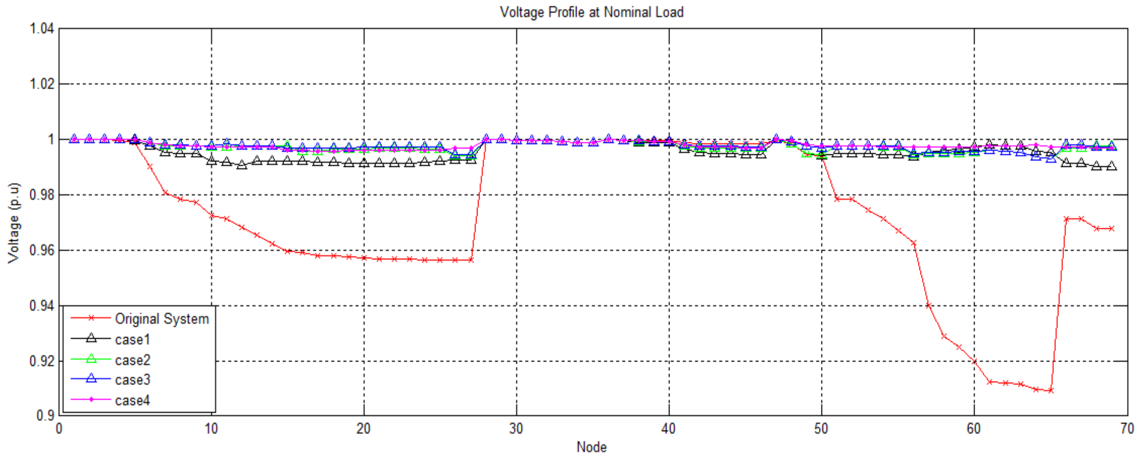

Figure 8. Voltage profile at nominal load for 69-bus system

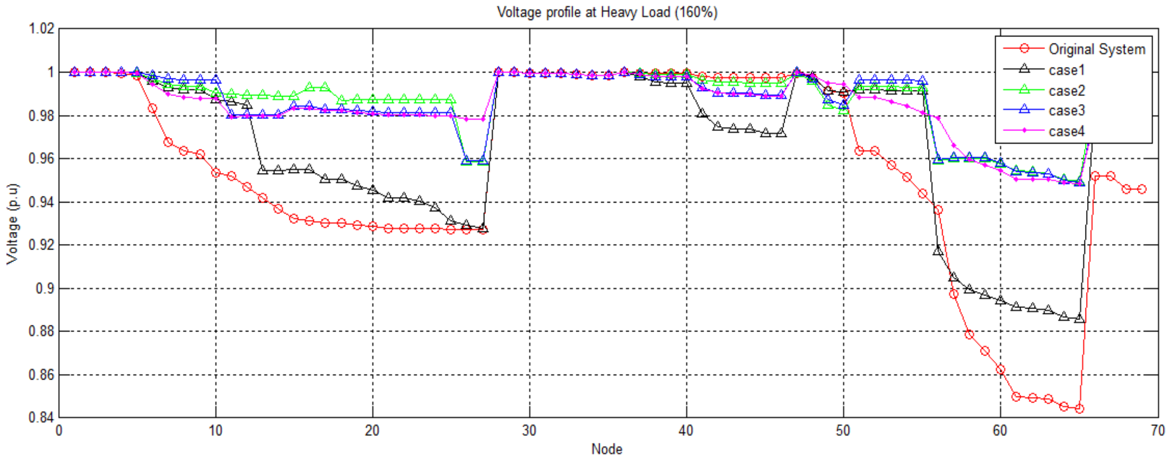

Figure 9. Voltage profile at heavy load for 69-bus system

6. CONCLUSIONS

This research discussed the use of MATPOWER7 software in minimizing active power loss in distribution systemfs and BPSO was successfully implemented. In addition to that, the network operation is presented to set the most sufficient option in the case where the reconfiguration is combined with the allocation of SC and DG in a simultaneous manner. The proposed method results in the minimum active loss of power amongst the equivalent papers. The total allowable installed SC and DG capacities were entirely and effectually used. Also, it is showed that increase of DG and capacitor does not usually give the best result though the increase of system cost, maintenance, and the units' distance for gas supplying.

REFERENCES

[1] A. N. Hussain, W. K. Shakir Al-Jubori, and H. F. Kadom "Hybrid Design of Optimal Capacitor Placement and Reconfiguration for Performance Improvement in a Radial Distribution System," *Hindawi Journal of Engineering*, vol. 2019, pp. 1-15, 2019.
[2] Partha P. Biswas, P. N. Suganthan, Gehan A. J. Amaratunga, "Distribution Network Reconfiguration together with Distributed Generator and Shunt Capacitor allocation for Loss Minimization," *2018 IEEE Congress on Evolutionary Computation (CEC),* 2018.
[3] S. Nawaz, S. Singh, S. Awasthi, "Power Loss Minimization in Radial Distribution System Using Network Reconfiguration and Multiple DG Units" *European Journal of Scientific Research*, vol. 148, no 4, pp. 474-483, 2018.
[4] S. A. Jumao, "Optimal Radial Distribution Network Reconfiguration using Modified Shark Smwll Optimization," Thesis of Pan Afrian Unversity Institute for Basic Sciences Technology and Innovation, 2018.

[5] T. Ackermann, G. Andersson, L. Söder, "Distributed generation: adefinition. Electr Power System," *Electric Power System Research*, vol. 57, no. 3, pp. 195-204, 2001.
[6] A. Kanase, "Fuzzy-Genetic Approach for Reconfiguration of Electric Distribution Network," *Journal of Emerging Technologies and Innovative Research,* vol. 4, no. 12, pp. 60-66, 2017.
[7] A. S. Abubakar, K. R. Ekundayo, A. A. Olaniyan, "Optimal Reconfiguration of Radial Distribution Networks Using Improved Genetic Algorithm," *Nigerian Journal of Technological Development*, vol. 16, no. 1, 2019.
[8] M. N. Bin Muhtazaruddin, N. A. Bani, S. A. Mohd Aris, S. Zura A. Jalil, "Distribution Power Loss Minimization via Distributed Generation, Capacitor and Network Reconfiguration," *Indonesian\Journal of Electrical Engineering and Computer Science*, vol. 5, no. 3, pp. 488-495, 2017.
[9] K. yan Liu, W. Sheng, Y. Liu, X. Meng, "Network Reconfiguration Method Considering Data Uncertainties in Smart Distribution Networks," *Energies,* vol. 10, no. 5, 2017.
[10] D. Kaur Mander, G. S. Virdi proposed "Result Analysis on Load Flow by Using Newton Raphson Method," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,* vol. 6, no. 7, pp. 5835-5844, 2017.
[11] E. M. Ali, A. A. ElDesouky, G. AbdulAzim, "Binary PSO for Distribution Network Reconfiguration," *International Journal of Scientific & Engineering Research,* vol. 9, no. 7, pp. 1187-1191, 2018.
[12] S. G. Kamble, K. Vadirajacharya, U. V. Patil, "Distribution System Reconfiguration for Loss Minimization and Voltage Profile Enhancement by using Discrete-Improved Binary Particle Swarm Optimization Algorithm," *International Journal of Recent Technology and Engineering (IJRTE)*, vol. 8, no. 2S11, pp. 900-906, 2019.
[13] S. Essallah, A. Khedher, "Optimal Distribution System Reconfiguration for Loss Minimization using BPSO Algorithm," *International Renewable Energy Congress*, IEEE, 2019.
[14] Aroop B., Satyajit B., Sanjib H., "Power Flow Analysis on IEEE 57 Bus System Using Mathlab," *International Journal of Engineering Research& Technology (IJERT)*, vol. 8, no. 23, pp. 1-9, 2014.
[15] Glover J. D., Sarma M. S., "Power System Analysis and Design," *3rd Edition, Brooks*/Cole, Pacific Grove, 2002.
[16] A. Landeros, "Smart Reconfiguration of Electric Power Distribution Networks for Power Loss Minimization and Voltage Profile Optimization," Thesis, Master of Science (M.Sc.) in Sustainable Energy Engineering, May2018.
[17] J. Kennedy and R. C. Eberhart, "A discrete binary version of the particle algorithm," *IEEE International Conference on Systems Man and Cybernetics*, 1997.
[18] T. M. Khalil, Hosam K. M. Youssef, M. M. Abdel Aziz, "A Binary Particle Swarm Optimization for Optimal Placement and Sizing of Capacitor Banks in Radial Distribution Feeders with Distorted Substation Voltages," *AML 06 International Conference*, 2006.
[19] Hadi S., "Power System Analysis," *3rd Edition*, PSA Publishing, North York, 2010.
[20] D. K. Mander and G. S. Virdi, "Result Analysis on Load Flow by Using Newton Raphson Method," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering,* vol. 6, no. 7, pp. 5833-5844, July 2017.
[21] C. Yammani, S. Maheswarapu, S. Matam, "Optimal Placement of Multi DGs in Distribution System with Considering the DG Bus Available Limits," *Energy and Power* 2012, vol. 2, no. 1, pp. 18-23, 2012.
[22] B. Sereeter, K. Vuik, C. Witteveen, "Newton Power Flow Methods for Unbalanced Three-Phase Distribution Networks," *Energies*, vol. 10, no. 10, pp. 1-20, 2017.
[23] *T*. Lantharthong, N. Rugthaicharoencheep, "Network Reconfiguration for Load Balancing in Distribution System with Distributed Generation and Capacitor Placement," *International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering,* vol. 6, no. 4, pp. 563-567, 2012.
[24] W. M. Dahalan, H. Mokhlis, A. H. Bin Abu Bakar, J. J. Jamian, "The simultaneous application of optimum network reconfiguration and distributed generation sizing using PSO for power loss reduction," *Przeglad Elektrotechniczny,* vol. 89, no. 4, pp. 137-141, 2013.
[25] G. Srinivasana, S. Visalakshi, "Application of AGPSO for Power loss minmization in Radial Distribution Network via DG units, Capacitors and NR," *1st International Conference on Power Engineering, Computing and Control*, 2017.