Future Generation of Communication and Internet of Things (FGCIOT)

Journal homepage: http://fgciot.semnaniau.ac.ir/

Research paper

Power management in the network consisting of renewable resources and electric vehicle using soft open point switches by improved imperialist competitive algorithm

M. M. Erfani Majd[1], R. Davarzani[1], M. S. Moghaddam,[*,2], A. A. Shojaei[3], M. Vahedi[1]

[1]Department of Electrical Engineering, Sha.C., Islamic Azad University, Shahrood, Iran

[2]Department of Electrical Engineering, Da.C., Islamic Azad University, Damghan, Iran

[3]Department of Electrical Engineering, Ne.C., Islamic Azad University, Neyshabur, Iran

Article Info

Article History:
Received: 15 October 2024
Revised 14 December 2024
Accepted 27 December 2024

Keywords:
Soft open point (SOP) switch, imperialist competitive algorithm, voltage imbalance, electric vehicle, solar panel

[*]Corresponding Author's Email Address: samiei352@iau.ac.ir

Extended Abstract

Background and Objectives: Today, serious concerns about the reduction of greenhouse gas emissions, the need to use clean resources, and government incentive plans have increased the penetration level of using renewable resources and using electric cars. In the meantime, the share of energy produced by solar photovoltaic panels is increasing significantly around the world. However, the expansion of the use of solar panels and electric vehicles on a large-scale causes problems such as voltage imbalance, excessive increase in its range and reverse power distribution, which makes the power quality indicators in the distribution network face serious risks.

Methods: In this study, the effects of the use of solar panels and the entry of electric vehicles into the distribution network have been evaluated in the percentage of different intrusions for a part of the distribution network in the city of Mashhad in Iran, and then soft open point (SOP) switches have been used to manage power distribution. In order to determine the optimal position of using SOPs, the imperialist competitive algorithm based on chaos has been used by MATLAB software, and DIgSILENT Power Factory software is used to evaluate the amount of violations in the voltage profile of network buses.

Results: The results of using SOPs show that there is a significant improvement in the voltage range, so that in the case of 60% penetration, it equals 4.7%, for 80% penetration, it equals 5.4%, and for 100% penetration, it equals 7.8% from the increase in voltage amplitude changes is reduced. In fact, by using this method, up to 100% penetration coefficient, the voltage range remains within its permissible range and the voltage imbalance does not exceed the threshold value.

Conclusion: According to the obtained results, by applying the mentioned control methods, it is not only possible to reduce the voltage profile range by more than 7%, but also help its stability by reducing the imbalance of the network.

Introduction

Distribution networks have an inherent imbalance due to the asymmetric three-phase structure and the presence of single-phase loads with different natures, which worsens with the presence of renewable resources [1]. Intermittent power generation sources consisting of wind turbines, solar arrays, and controllable loads such as electric vehicles, which have significant uncertainty in spatial and temporal distribution, cause disruptions in control systems, increase power losses, and exacerbate

Doi:

network instability problems. As the power quality indicators get worse, the modeling of network performance without taking into account characteristics such as the level of voltage fluctuation and the amount of imbalance, does not have practical results [2]. On the other hand, voltage fluctuation in the power network is one of the types of disturbances that can have adverse effects on the reliability of the network and is considered as one of the main reasons for unwanted outages.

On the other hand, voltage fluctuation in the power network is one of the types of disturbances that can have adverse effects on the reliability of the network and is considered as one of the main reasons for unwanted shutdowns. In this situation, the development of power electronics technology such as soft open points (SOPs) have provided opportunities to improve the level of power distribution management in distribution networks. SOP devices are controllable power electronic equipment that can replace normally open points (NOPs) in distribution networks and create a flexible connection between feeders in the distribution network. Compared to the traditional switching structure, an SOP can accurately control the power distribution in the three-phase network and quickly act to compensate the reactive power. To reduce the voltage fluctuation level from its nominal value, switchable capacitor banks or static reactive power compensators are traditionally used to regulate reactive power. However, voltage fluctuations in distribution networks are also affected by active power distribution, so compensation of voltage violations is not efficient only based on reactive power regulating equipment [3-4]. Methods such as the distribution network reconfiguration (DNR) cannot be considered as a sustainable approach due to the slow response of switching operations and high security risks. In this situation, the use of SOPs can create a balance in the power distribution of different feeders and increase the level of power quality in power systems [5]. So far, several designed strategies have been implemented for their optimal performance, including minimizing energy losses [6], reducing annual network expenses [7], load balancing [8], improving voltage profiles [9] and increasing the service capacity of renewable resources in distribution networks pointed out. Fig. 1 shows a schematic of SOP integration in the distribution network.

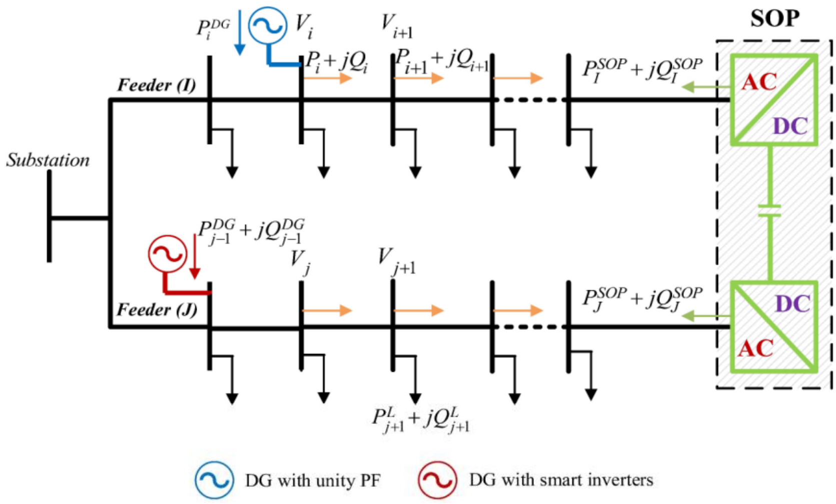

Fig. 1: Schematic of SOP integration in a distribution network [12]

In [10], a multi-objective optimization problem has been formulated to minimize power losses, balance load and maximize the penetration level of distributed generation resources (DG) using Pareto optimizer. To achieve this goal, the size of 4 DG units has been optimized separately using 3 objective functions. However, the presented objectives are not coordinated with each other simultaneously using Network Reconstruction (NR). In [11], a single-objective optimization problem is presented in the form of a second-order compound integer problem in order to minimize both the operating costs of the distribution network and the investment costs of energy storage systems (ESS). The strategies presented by them include restructuring the network hour by hour, using SOPs and determining the position of DGs. In Table 1, there is an overview of the research done on the function of SOP in distribution networks.

As it can be seen from the review of the articles, so far, the issue of managing the voltage imbalance and the violation of its range from the standard allowed range when using solar panels and electric vehicles at the same time has not been comprehensively studied. Therefore, in this study, the imperialist competitive algorithm based on chaos has been used to manage the performance of SOPs in order to control the voltage fluctuation and prevent its range from exceeding the allowed range.

Table 1: An overview of the research work done in the field of SOP exploitation

Ref. No.	Objective function	Optimization method	Description
[6]	Min. of annual costs & power losses	Advanced linear	Finding the optimal position of DGs, circuit breakers and SOPs
[7]	Minimizing annual costs and power losses	programmin g Interior point search method	Sensitivity analysis based on the Jacobian matrix to exploit SOPs
[8]	Mini. Of annual costs and power losses	Improved PSO	Optimum positioning of SOPs in different DG penetration percentages
[9]	Maximizing service capacity	Enhanced second-order planning	Identification of optimization gaps in order to maximize the service capacity
[13]	Min. of cost of storage resources	Advanced convex programing	Determining the optimal location & size of ESS, SOP and DG
[14]	Minimizing power losses	Particle swarm optimization	Converting a 33kV dual-circuit AC circuit to DC in order to improve service capacity
[15]	Max. of DG influence	Ant colony optimization	maximize the level of DG penetration

Among the most important achievements of the mentioned article, the following can be mentioned:

- Management of power distribution in the distribution network to improve the profile and level of voltage imbalance and reduce the violation of the standard range with the help of SOPs.
- Determining the optimal location of the SOP with the help of the novel meta-heuristic algorithm based on chaos in order to achieve a suitable answer in the specified time frame.
- Modeling the effect of using solar arrays and electric vehicles in different penetration percentages on a part of the distribution network of Mashhad in Iran.

Modeling of components

A. Soft open point switches

The idea and concept of SOP connection was first proposed by English researchers in 2010. From a practical point of view, SOP is a power-electronic device that replaces the traditional switch and is able to control the distribution of power on its corresponding feeder quickly and accurately. Furthermore, as compared to the regular mode, SOP can eliminate the safety risk caused by repetitive switch operation, which considerably improves the flexibility and speed of active distribution network operation control. Indeed, efficient SOP integration can aid in the reduction of energy losses, reactive support, feeder load balance, improved power supply dependability, and the expansion of the penetration range of distributed generation resources.

In fact, SOPs control the distribution of active power/reactive power between adjacent feeders to manage grid voltage. Furthermore, these devices allow for immediate fault isolation between interconnected feeders as well as quick repair of supply lines. As a result, SOPs can increase distribution network performance while simultaneously facilitating the wider use of low-carbon technologies in the distribution network [16]. They are compatible with three alternative distribution network topologies (back-to-back voltage source converter, static series synchronous compensator, and unit power distribution controller) [17]. The SOP control variables include active and reactive outputs of two three-phase converters that are controlled independently, and the governing equations for modeling their performance are expressed in 1 to 4.

$$P_{j,i}^{SOP} + P_{j,j}^{SOP} + P_{j,i}^{SOP,loss} + P_{j,i}^{SOP,loss} = 0 \tag{1}$$

$$P_{j,i}^{SOP,loss} = A_i^{SOP} . \sqrt{\left(P_{j,i}^{SOP}\right)^2 + \left(Q_{j,i}^{SOP}\right)^2} \tag{2}$$

$$\underline{Q}_{j,i}^{SOP} \le Q_{j,i}^{SOP} \le \bar{Q}_{j,i}^{SOP} \tag{3}$$

$$\sqrt{\left(P_{j,i}^{SOP}\right)^2 + \left(Q_{j,i}^{SOP}\right)^2} \le S_{j,i}^{SOP} \tag{4}$$

B. PV array modeling

The type of PV panel considered for this simulation is Sharp ND_250QCS. The output power of this panel is obtained through 5 [18]. In this regard, I_T indicates the intensity of ambient radiation w/m^2, T_{cell} indicates the temperature of the cell (°C), the nominal capacity of each panel is equal to Y_{PV} = 250 W, the depreciation ratio f_{pv} = 5%, the temperature coefficient α = -0.485%⁄°C, intensity The standard solar radiation is considered to be I_s = 1000 w/m^2 and the standard temperature is T_s = 25°C. Solar radiation data for Mashhad city was obtained from NASA website. The annual average of solar radiation for different months of the year is also shown in Table 2. Considering that this study has been conducted in the city of Mashhad in Iran, the months in the Table 2 are based on the solar Hijri instead of the Gregorian calendar.

$$P_{pv} = Y_{pv} . f_{pv} . \frac{I_T}{I_S} . \left[1 + \alpha \left(T_{cell} - T_s \right) \right] \tag{5}$$

Table 2: Average monthly solar irradiation of Mashhad

Month	Wind speed (m/s)	Month	Wind speed (m/s)
Farvardin	2.66	Mehr	7.07
Ordibehesht	3.51	Aban	6.580
Khordad	4.40	Azar	5.60
Tir	5.40	Dey	4.33
Mordad	6.53	Bahman	2.47
Shahrivar	7.23	Esfand	3.05

C. Electric vehicle modeling

In this study, a Nissan Leaf model car was used, which has an energy consumption of 0.34 kilowatt hours per mile, which is equal to 1227 kilojoules per kilometer. Such a car can use up to 80% of the energy stored in its batteries [17]. This car is a 5-door hatchback car, the second generation of which was launched in October 2017. This car has an urban use and is almost identical to the Nissan Mica car, which is a type of car with an internal combustion engine.

Optimization method

Like many meta-heuristic algorithms, the implementation of this algorithm begins with the formation of an initial population. Some of the best answers (countries) in the initial population are selected as colonizing countries and the rest as colonized countries. All the colonial countries are distributed among the colonizing countries based on their power. The power of an empire has an inverse proportion with its costs, and the cost of each country is a function of variable N (by 6) [19]. For the formation of early empires, it is necessary to normalize the costs of colonizers (7). Next, the power of each empire is normalized by 8. Over time, colonial countries try to improve their colonial domain. This is done through the movement of the colonies towards the colonial countries.

$$Cost = f(country) = f(p_1, \dots, p_N) \tag{6}$$

$$C_n = c_n - max\{c_i\} \tag{7}$$

$$P_n = \left| \frac{C_n}{\sum_{i=1}^{N_{imp}} c_i} \right| \tag{8}$$

To search around the colonial country, a random number is used to deviate the movement path. While moving towards the colonizing country, if the colonizing country reaches a position that has a lower cost than the colonizing country, then the positions of the two countries are swapped. After some time, all but the most powerful of the colonizing countries are destroyed and all countries come under the control of a colonizing country. In this situation, there will no longer be any differences not only among the colonies, but also between the colonies and the colonizers. At this stage, the operation of the algorithm is terminated and convergence is achieved.

A. Chaos based solver

Participating chaotic mappings in the main structure of heuristic algorithms is done in order to improve the process of generating random numbers to create a population and by using the rules of chaotic movement, the probability of reaching the global optimal point is improved. At the same time, a fundamental challenge for chaos producers is the limitation of their performance, which is solved by the scaling method. The four main characteristics of chaos-based optimization algorithms are as follows:

- Convergence to the global optimal point: Chaos-based optimization algorithms converge to the global optimal point because they do not use completely random variables and are able to test almost the entire search area.
- - Low computing time: since gradient calculation is not done in these algorithms to detect the direction of the objective function, they need little computing time to reach the optimal point.
- - Non-regularity: systems based on chaos do not follow any specific rules.
- - The impossibility of long-term estimation: due to the sensitivity of chaos-based systems to the initial conditions, it is practically impossible to accurately estimate the output results for a long-term period, but it can only be done in a certain range.

B. Structure of proposed approach

Considering the equations of AC power distribution and the limitations of using SOPs, the challenge of unbalanced operation presented with the help of SOPs becomes highly non-linear and non-convex, and this causes the computational time to solve the problem to increase exponentially with the increase in the dimensions of the problem [20-21]. In the conditions of moving normal switches to SOPs, the active and reactive output powers of the two three-phase converters used in SOPs can be controlled independently, and in this condition, it is simply not possible to obtain the global optimal working point among the local optimal points. Considering the high volume of calculations and the need to obtain the desired answer in a short period of time, the use of meta-heuristic algorithms can be a solution. In this study, a dual-purpose approach is used as the objective function to minimize the voltage imbalance and improve the voltage profile. In traditional distribution networks without the presence of PV, electric power flows only from the power substations to the consumers. In this situation, the use of PVs causes a change in the direction of power distribution, and thus the amount of voltage drop in the network can be calculated through equation (9) [22]. In this regard, R and X are the resistance and inductive reactance of the network conductor, V_1 and V_2 are the source and destination side voltages, P and Q are the amount of active and reactive power injected into the network, respectively. In this situation, with the injection of power by PV, the difference between active and reactive power on the demand side and the supply side is reduced, therefore, it brings an increase in the bus voltage in the network.

$$\Delta V = V_1 - V_2 = \frac{(P-P_{pv}).R+(Q-Q_{pv}).X}{V_2} \quad (9)$$

According to 1, the amount of PV power generation capacity, line impedance and inverter power factor are among the effective factors on changes in the voltage profile level in the network [23]. According to the definition of the National Energy Agency, the imbalance index is obtained through 10 and 11. According to the EN-50160 standard, the value of the permissible range of unbalance is defined as less than 2% in more than 95% of the 10-minute intervals during a week [24]. In these equations, $\Delta|V_i|$ shows the absolute value of the voltage difference between two network lines, and V_i^{ave}also shows the average value of the voltage of the three phases of bus i.

$$LUVR = \frac{max\{\Delta|V_i^{AB}|, \vee\Delta|V_i^{BC}|, \vee\Delta|V_i^{CA}|\}}{|V_i^{ave}|} \quad (10)$$

$$V_i^{ave} = \frac{|V_i^{AB}+V_i^{BC}+V_i^{CA}|}{3} \quad (11)$$

In this study, the goal is to minimize profile changes and voltage imbalance levels by managing the performance of SOP switches in such a way that both the effect of electric vehicles and solar panels are taken into account and the conditions of network operation are met. For this purpose, the desired objective function is defined as 12. The first expression on the right side of this relation expresses the amount of voltage changes which is calculated through 13. The weight coefficients w1 and w2 also help the user to adjust the importance of each term in the objective function. The N parameter indicates the total number of network buses and the value of the violation limit of voltage imbalance is equal to 2% (14). The considered voltage limit is equal to 10% which is expressed in 15.

$$\min o.f = w_1.V\cdot\mathrm{D} + w_2.LUVR \quad (12)$$

$$V\cdot\mathrm{D} = \frac{\sum_{i=1}^{N}|V_i-1|}{N} \quad (13)$$

$$LUVR \le 0.02 \quad (14)$$

$$V_i^{min} \le V_i \le V_i^{max} \quad (15)$$

Results and Discussion

To implement the desired approach, first the network characteristics, the amount of load demanded by the subscribers, the production power level of the solar panels in each time period and the penetration percentage of electric vehicles are considered as inputs and then with the help of the imperialist competitive algorithm based on the chaos theory The location of the SOP and the method of implementation are determined by MATLAB software in such a way that the two goals of the violation of the voltage range from the nominal value and the creation of an imbalance between the phases of each bus are minimized. In the modeling, the limitations of the distribution network are considered and the optimal structures for different percentages of EV and PV penetration have been evaluated. After determining the application location and performance specifications of the SOP, DigSilent software has been used to simulate the conditions of the voltage profile of all network buses and calculate the exact amount of violations in all distribution network buses under study. In the following, the results obtained under different scenarios are presented.

A. Case study

In Fig. 2, an aerial image of a part of the radio network of Mashhad city is shown, obtained by GIS software. In this figure, the parts of residential units, the location of the distribution network route, the number of branches and the place of installation of the transformer are specified. This information has been extracted from the database archive of the Mashhad distribution company. In the following, the obtained results are expressed in the form of different scenarios.

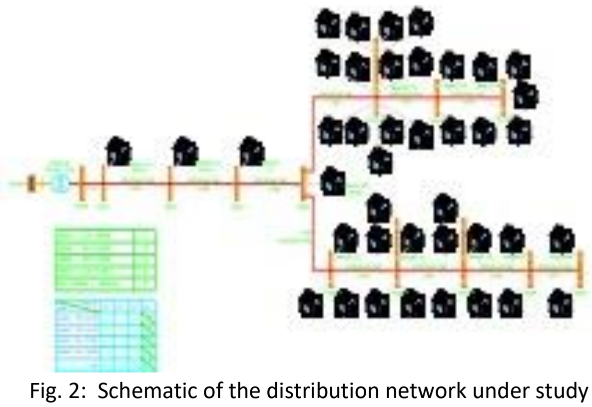

Fig. 2: Schematic of the distribution network under study

B. Scenario 1: Evaluation of voltage variation (W/O PV)

In this section, renewable sources and electric vehicles are not used and the voltage profile for the normal load of the network is evaluated. The graph of the voltage profile of bus No. 8 on Mordad 1, 1397 is shown in Fig. 3. As can be seen in this figure, the lower voltage limit has exceeded its lower limit value (0.95 P.U.) for some hours of the day and night. The voltage profile of all the days of August for bus C is also shown in Fig. 4. Considering that this study has been conducted in the city of Mashhad in Iran, the months are based on the solar Hijri instead of the Gregorian calendar.

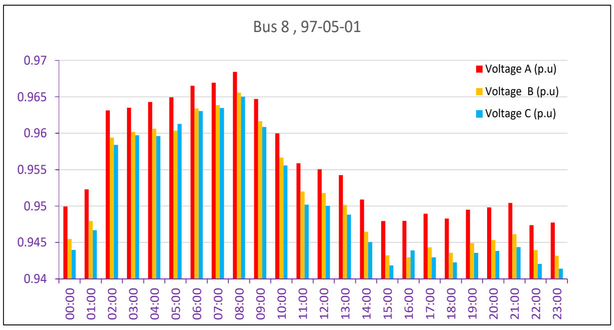

Fig. 3: Changes in the voltage profile of bus No.8 (15/06/1397)

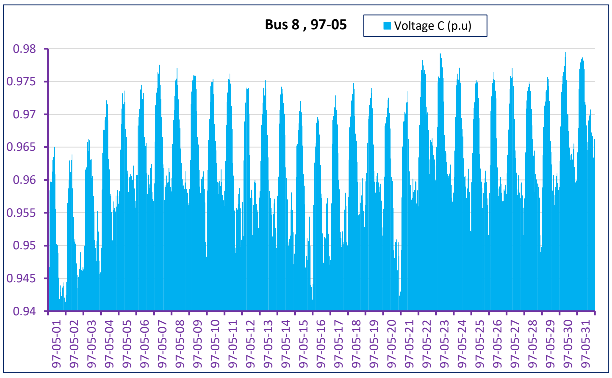

Fig. 4: Changes in the voltage of phase C (bus 8) (Mordad 1397)

C. Scenario 2: Evaluation of voltage variation (with EV)

In this section, the effect of electric vehicle (EV) load on the distribution network is shown. At first, it is assumed that the electric vehicle battery is charged between 12:00 PM and 7:00 AM the next day, and the result obtained for bus 8 is shown in Fig. 5.

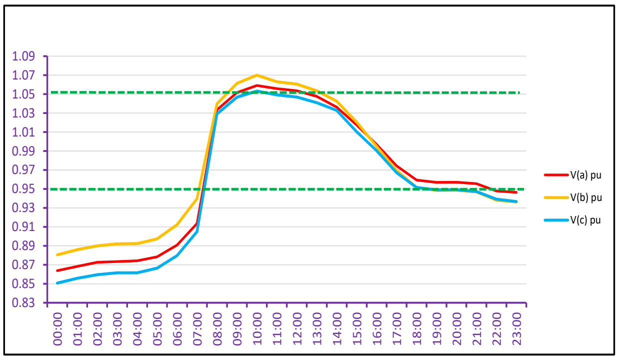

Fig. 5: Voltage profile of bus 8 with 100% EV penetration

In the following, it is assumed that the charging of the electric vehicle will take place between 17:00 and 23:00. The results obtained in this case for bass number 8 are presented in Fig. 6.

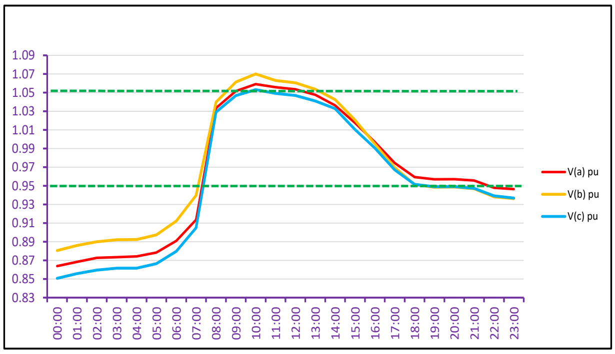

Fig. 6: Voltage profile of Bus 8 (100% pen.) (31/4/1397)

D. Scenario 3: Evaluation of voltage variation (with PV)

In this section, the effect of using solar arrays on the network voltage profile has been investigated. At first, the percentage of PV penetration is considered equal to 50% and the amount of voltage imbalance for bus number 8 is shown in Fig. 7. In this situation, for peak hours of power consumption, an unauthorized increase in the voltage range with imbalance and extreme voltage fluctuations is quite possible. Next, the penetration percentage of solar panels (PV) in Bus 8 has been increased to the maximum possible value (100%) and the voltage profile changes of all days of Mordad month for Phase C of Bus 8 are also shown in Fig. 8. Next, the amount of three-phase imbalance for Bus 8 with 100% penetration percentage has been investigated, and the results for the first day of Mordad month are presented in Fig. 9.

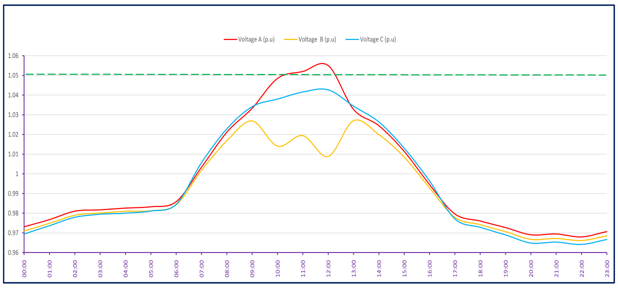

Fig. 7: Level of voltage imbalance in bus 8 (50% PV)

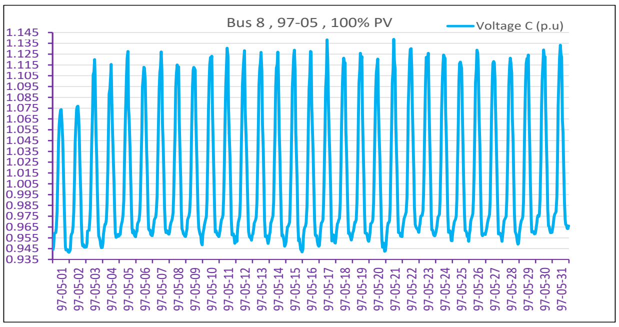

Fig. 8: Variation in the voltage of phase C of bus 8 (100% Pen.) (Mordad 1397)

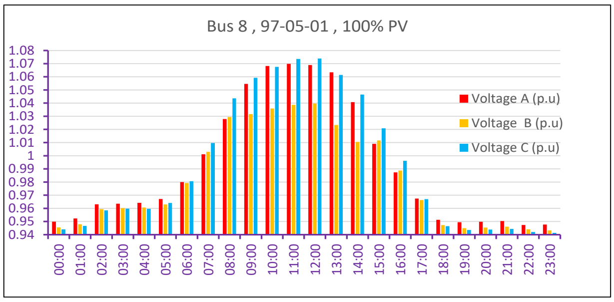

Fig. 9: Level of voltage imbalance of bus 8 (100% Pen.) (1/5/1397)

E. Scenario 4: Voltage regulation by SOP management

By using SOP switches, a significant improvement in the voltage range is created. In fact, by using this method, with 100% penetration coefficient of electric vehicle and PV, it is possible to maintain the voltage range within the allowed range and to prevent the violation of the voltage imbalance criterion. The results of using SOP in terms of maximum penetration percentage for Bus 8 are presented in Table 3.

Table 3: The avg. voltage range of Bus 8 in Dey 1397

100% EV penetration and with SOP control			100% EV penetration and without SOP control			Without EV presence		
Phase C	Phase B	Phase A	Phase C	Phase B	Phase A	Phase C	Phase B	Phase A
1.0311	1.0356	1.0200	1.0379	1.0431	1.0333	0.953	0.940	0.945

Next, the numerical results obtained through the use of SOP on the average amplitude of all network buses are presented in Table 4. By using SOP at 50% penetration factor of electric vehicle, more than 1.2% of the overvoltage value is reduced. According to the obtained results, by using SOP, the amount of voltage increase can be reduced to considerable amounts. On the other hand, the voltage range exceeds the allowed standard value by expanding the use of solar panels to more than 60%. According to the obtained calculations, in fact, with the proper application of SOP, up to 100% penetration factor of the solar array, the same voltage range remains within its allowed range. Since the results stated in this table are made for the worst voltage violation situation and are completely satisfactory, therefore, for lower penetration percentages, more favorable results are definitely obtained.

Table 2: Ave. voltage range of network buses (100% EV+PV Pen.)

Phase A	Phase B	Phase C	Network status
0.975	0.972	0.974	W/O EV
1.075	1.086	1.120	100% Pen. (EV+PV) & without SOP
1.035	1.044	1.043	100% Pen. (EV+PV) & with SOP

Conclusion

The integration of distributed production sources with the national grid can expand the capacity of energy producing sources, increase power quality, improve reliability and reduce environmental pollution. On the other hand, the unplanned connection of electric vehicles and solar arrays to the distribution network causes significant changes in the network voltage profile and several effects on its power quality. In this situation, the proper management of voltage profile changes can reduce power losses and free up the capacity of network lines, which increases efficiency in power distribution. In order to keep the changes of the voltage profile within the allowed range due to the increase in the penetration percentage of EVs and PVs, SOP has been used in this study. In this regard, first, based on the topology of the network under study and the amount of load consumed in the network, the location of the SOP in the network is determined by using the imperialist competitive algorithm with the help of MATLAB software, and then the effect of its application on the level of network voltage probability is determined with the help of soft DigSilent software is simulated. According to the obtained results, by applying such a control approach in the distribution network, not only can the percentage of penetration of EVs and solar panels be increased up to 100% (without any violation of the standard intervals), but also by reducing the amount of losses, the capacity of the network lines can be freed and thus Improve the level of network efficiency. According to the results obtained by using SOP at 50% penetration factor, more than 1.2% of overvoltage is reduced. On the other hand, without the use of control methods, the voltage range will exceed the allowed value of the standard by expanding the penetration of EVs to more than 60%. According to the obtained calculations, in fact, by using this method, up to 100% penetration coefficient, the voltage range remains within its permissible range.

Conflict of Interest

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

Abbreviations

$P_{j,i}^{SOP}$	SOP injected active power on phase ø in node i
$P_{i,j}^{SOP}$	SOP injected active power on phase ø in node j
$P_{j,i}^{SOP,loss}$	SOP active power loss on phase ø in node i
A_{i}^{SOP}	SOP loss coefficient on phase ø in node i
$\underline{Q}_{j,i}^{SOP}$	The lower limit of reactive power of SOP on phase ø in node i
$\bar{Q}_{j,i}^{SOP}$	The upper limit of reactive power of SOP on phase ø in node i
$S_{j,i}^{SOP}$	Apparent power of SOP on phase ø in node i

References

[1] W. Chengshan, G. Song, P. Li, H. Ji, J. Zhao, and J. Wu. "Optimal siting and sizing of soft open points in active electrical distribution networks." Applied energy 189 (2017): 301-309.

[2] L. Hong-ze, S. Guo, C. Li, and J. Sun. "A hybrid annual power load forecasting model based on generalized regression neural network with fruit fly optimization algorithm." Knowledge-Based Systems 37 (2013): 378-387.

[3] A. Thomas, S. Cherevatskiy, T. Brown, R. Eriksson, A. Samadi, M. Ghandhari, L. Söder et al. "Smart modeling of optimal integration of high penetration of PV-Smooth PV." Final Report for Smooth PV Project under PV ERA NET Call (2013).

[4] L. Chao, J. Wu, L. Thomas, and N. Jenkins. "Optimal operation of soft open points in medium voltage electrical distribution networks with distributed generation." Applied Energy 184 (2016): 427-437.

[5] C. Wanyu, J. Wu, N. Jenkins, C. Wang, and T. Green. "Benefits analysis of soft open points for electrical distribution network operation." Applied Energy 165 (2016): 36-47.

[6] B. Saeid, and H. K. Fathy. "Cost-optimal charging of plug-in hybrid electric vehicles under time-varying electricity price signals." IEEE Transactions on Intelligent Transportation Systems 15, no. 5 (2014): 1958-1968.

[7] Z. Hua, R. Lu, C. Zhu, and Y. Zhao. "On-line measurement of internal resistance of lithium ion battery for EV and its application research." International Journal of u-and e-Service, Science and Technology 7, no. 4 (2014): 301-310.

[8] https://pushevs.com/2018/01/29/2018-nissan-leaf-battery-real-specs

[9] A. M. Sawkat, M. Haque, and P. Wolfs. "A review of topological ordering based voltage rise mitigation methods for LV distribution networks with high levels of photovoltaic penetration." Renewable and Sustainable Energy Reviews 103 (2019): 463-476.

[10] P. Piyadanai, and S. Kanprachar. "Voltage level management of low voltage radial distribution networks with high penetration of rooftop PV systems." GMSARN Int. J.11, no. 1 (2017): 16-22.

[11] O. Vazquez, M. A. "Optimal scheduling of electric vehicle charging and vehicle-to-grid services at household level including battery degradation and price uncertainty." IET Generation, Transmission & Distribution 8, no. 6 (2014): 1007-1016.

[12] Y. Cheng, C. Zhou, J. Yu, K. Xu, P. Li, and G. Song. "A sequential optimization method for soft open point integrated with energy storage in active distribution networks." Energy Procedia 145 (2018): 528-533.

[13] https://commons.wikimedia.org/wiki/File:Nissan_Leaf_2018_(31874639158)_(cropped).jpg#/media/File:Nissan_Leaf_2018_(31874639158)_(cropped).jpg

[14] L. Chao, J. Wu, L. Thomas, and N. Jenkins. "Optimal operation of soft open points in medium voltage electrical distribution networks with distributed generation." Applied Energy 184 (2016): 427-437.

[15] Z. Mehdi, M. E. H. Golshan, and J. M. Guerrero. "Voltage quality improvement in low voltage distribution networks using reactive power capability of single-phase PV inverters." IEEE transactions on smart grid10, no. 5 (2018): 5057-5065.

[16] J. Haoran, C. Wang, P. Li, F. Ding, and J. Wu. "Robust operation of soft open points in active distribution networks with high penetration of photovoltaic integration." IEEE Transactions on Sustainable Energy 10, no. 1 (2018): 280-289.

[17] P. Yael. "Plug-In Electric Vehicles: What Role for Washington?." (2010): 806-808.

[18] M. T. H. Yang, and L. Lu. "A feasibility study of a stand-alone hybrid solar–wind–battery system for a remote island." Applied Energy 121 (2014): 149-158.

[19] A. Gargari, and C. Lucas. "Imperialist competitive algorithm: an algorithm for optimization inspired by imperialistic competition." In 2007 IEEE congress on evolutionary computation, pp. 4661-4667. IEEE, 2007.

[20] L. Doudou, and A. K. Raji. "Decision-making between a grid extension and a rural renewable off-grid system with hydrogen generation." International journal of hydrogen Energy 43, no. 20 (2018): 9535-9548.

[21] Z. Chengming, H. Cheng, L. Liu, H. Zhang, X. Zhang, and G. Li. "Coordination planning of wind farm, energy storage and transmission network with high-penetration renewable energy." International Journal of Electrical Power & Energy Systems 120 (2020): 105944.

[22] H. Carsten, P. Fortenbacher, A. Fuchs, and G. Andersson. "PV-integration strategies for low voltage networks." In 2016 IEEE International Energy Conference (ENERGYCON), pp. 1-6. IEEE, 2016.

[23] Y. J. H. Chin, J. Wong, Y. Seng Lim, and J. H. Tang. "Assessment on various allocations of energy storages systems on radial distribution network for maximum PV systems penetration." In 2018 International Conference on Smart Grid and Clean Energy Technologies (ICSGCE), pp. 89-94. IEEE, 2018.

[24] P. Rung, W. Ongsakul, and U. Schmidt. "Impact of high solar rooftop PV penetration on voltage profiles in distribution systems." In 2014 International Conference and Utility Exhibition on Green Energy for Sustainable Development (ICUE), pp. 1-7. IEEE, 2014.