Science Arena Publications
Specialty Journal of Engineering and Applied Science
ISSN: 2520-5943
Available online at www.sciarena.com
2019, Vol, 4 (3): 110-116

Optimal Placement of Demand Response Program to Improve the Voltage Profile using the TLBO Algorithm

Abolfazl Akram[1]*, MohammadHosein Adel[2]

[1] Electrical Distribution Company, Yazd, Iran.
[2] Department of Electrical Engineering, Faculty of Sharif, Abarkooh Branch, Technical and Vocational University (TVU), Yazd, Iran.

***Corresponding Author**

Abstract: *The demand response program, which is in fact the response of consumers to reduce their consumption, is one of those tools that can be useful in improving the network voltage profile to an acceptable level. Therefore, in this research, these tools have been utilized in order to improve the network voltage profile. In this study, as to improve the objective functions under consideration, the normal state of the grid has been considered. Normal state means the normal situation of the network wherein the network supplies the load in its stable state without any breakdown in equipment. In this research, the improvement of objective functions has been taken into account separately by employing the demand response program. The algorithm through which the optimization is carried out in this study is the TLBO algorithm. The simulation results showed that the best position for the demand response program in order to improve the network voltage profile is the bus number 18.*

Keywords: *Demand Response Program, Voltage Profile, TLBO Algorithm.*

INTRODUCTION

By the augmenting growth of load in power networks, in particular, the increment of those loads which are sensitive to changes in the parameters of the power delivered by network, we realize an indispensable need to define new resources of electrical energy with the capability of fast reaction in case of power network emergency more than any other time. Thus in addition to paying special attention to distributed generation resources, considering the consumption management, and demand response programs can be an interesting subject to bear in mind (Kirschen et al., 2000).

By revolutionizing the power industry and establishment of electricity market, the electricity consumption management programs encountered serious challenges and threats. So they started to search for techniques that can be used in order to reuse the electricity usage management programs in accordance with market operations so that they encourage the consumer to show an active presence in market and they do not reduce the reliability of market. These methods are called demand response by the international energy agency (IEA, 2004-2009).

Implementation of demand response programs can be very useful for both the network and consumers to a great extent. We can mention that improvement in reliability and reduction in cost of exploitation are the most important advantages of this program execution for power network. Also some benefits, which concerns the electrical energy consumers, can be cited such as the capability of transferring, the consumption from expensive-hours to cheap-hours and improvement in energy efficiency (Staff, 2006).

Some studies have also been carried out in this field. (Rezaei and Kalantar, 2015) has presented a new approach to provide network security. This reference has used the microgrid and demand response program at the same time so as to maintain the network security. The demand response programs have had a remarkable impact on improvement of network security. (Moreno-Munoz et al., 2010) focused on the influence of distributed generation resources presence on power quality factor such as voltage profile in distribution networks. (Basu, Das and Dubey, 2007) has fulfilled the control approaches of FACTS devices and has presented two control approaches for UPQC for the sake of improvement of power quality and voltage profile . In another reference, a model has been demonstrated for series-parallel FACTS devices distribution in load division case (Hosseini et al., 2009). (Jalili et al., 2011) has studied the problem of finding the optimum location and capacity of distributed generation resources on behalf of making the voltage profile better and reduction in losses. (Lahaçani, Aouzellag and Mendil, 2010) has accomplished the problem of utilizing the FACTS devices like SVC in wind farms and has studied its impact on network voltage amplitude and angle. The goal of (Saeidpour et al., 2008) is to implement a new method in order to design a fuzzy logic controller for STATCOM to make voltage profile better. The purpose of this research is expanding the researches which have been done in finding the optimum location and capacity of demand response program so as to improve the network parameter such as the voltage profile of distribution network by using the TLBO optimization algorithm.

Procedure

The value of the network bus voltage in a steady and stable state is defined as the voltage profile of that network bus. This research tends to make the value of network buses voltage come close to one per unit thus defining some indexes and objective functions to assist this aim is mandatory. In order to do so, various indexes have been introduced in different papers. These functions have been shown in relations (1) and (2)

(1) $F_1 = \sum_{i=1}^{n} \left| V_{ref} - V_i \right|$

(2) $F_2 = \sum_{i=1}^{n} (V_{ref} - V_i)^2$

In relation (1), the number of network buses and the value of network buses voltage have been indicated by variables n and V_i respectively. V_{ref} is meant to be an ideal voltage *acquisition* of which is the goal. Number one per unit has been taken into consideration for this variable whereas the whole attempt of the network exploiter is to make the profile of network buses come as close to this value as possible.

1-TLBO algorithm

This idea is the foundation of the TLBO algorithm in solving optimization problems. The mechanism of the TLBO algorithm contains two parts whereas the first part is teacher's contribution in promoting the scientific level of class and the second part is the interaction level and the review of lesson by the students of the same class.

I) Teacher's contribution

A good teacher is the one who makes the knowledge level of the people of a class become closer to his own level. In practice, the knowledge level of the students does not run to the knowledge level of the teacher and only comes close to it. The amount of this approachment depends on the ability level of the class. This part has been modeled as the following relationship

(3) $\overline{X_{diff}^{k}} = rand\,() \times (T^k - R_t \times M^k)$

Wherein, T^k is teacher in kth iteration, M^k is class average in kth iteration, R_t is teaching coefficient which is zero or one and its value is chosen randomly in each iteration. Also $\overline{X_{diff}^{k}}$ is the difference between the knowledge level of teacher and students. The population in the next iteration is built as the following.

(4) $\overline{X_{new}^{k+1}} = \overline{X_{old}^{k}} + \overline{X_{diff}^{k}}$

Where in this relation $\overline{X_{old}^{k}}$ is the same member of the population in the previous iteration and $\overline{X_{new}^{k+1}}$ is the member of the population in new iteration. Here, a cost-function is defined for the new member of the population and the value of its cost-function is compared with the cost-function value obtained from the same member of the population in the previous iteration, $\overline{X_{old}^{k}}$, and if it was lesser, the new member would be substituted for the old one.

II) Student's contribution

Students raise their knowledge level with two techniques, one is through attending class and benefiting from teacher's knowledge and another technique is via reviewing the lesson with each other. For modeling this section, we postulate that each student interchange views with another student randomly and its mathematical model is as the under-mentioned relation.

(5) $\overline{X_{new}} = \overline{X_{old}} + rand() \times (\overline{X}_i - \overline{X}_j)$

Wherein, $\overline{X}_i$ and $\overline{X}_j$ are the ith and jth members of the population respectively, $\overline{X_{old}}$ and $\overline{X_{new}}$ are the old member and new member of the population respectively. After calculating the new member of the population, the value of its cost-function is compared with the cost-function value of the same member of the population in the previous iteration. In case the new value was lesser, the new member is superseded. This method is iterated for a specified number of times (Zareshahri et al., 2013).

Simulations flowchart

Figure (1) has considered determining the optimum location and capacity of demand response program so as to improve the voltage profile in network.

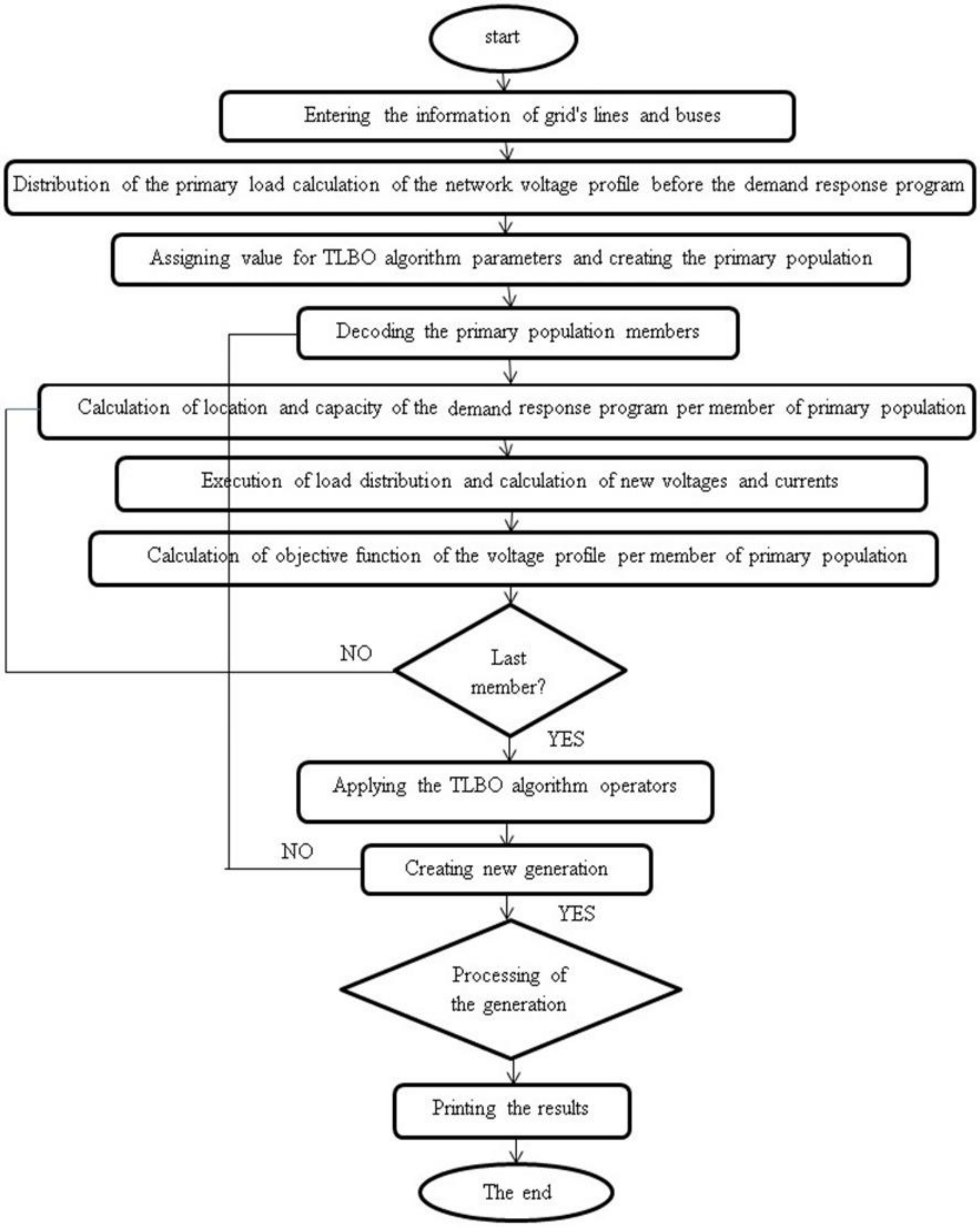

Figure 1. Flowchart of the placement program of the demand response program in order to improve the voltage profile by utilization of the TLBO algorithm

First the optimum location and capacity of demand response program has been determined in order to make the network voltage profile better. In this section the location and the active and reactive powers per which the minimum amount of the objective function of voltage profile is being achieved, has been acquired and has been introduced as the optimum response.

The network under consideration is the third feeder of the sub-transmission microgrid of Abarkooh which has been depicted in figure (2). The characteristics of the algorithm used have been exhibited in table (1) as well.

Table 1. Characteristics of the TLBO algorithm utilized

Number of population members	80
Number of engendering times	100
Algorithm input	Location and percentage of employing the demand response program
Algorithm output	Optimum Location and percentage of employing the demand response program and objective functions of the problem
Objective functions	Voltage profile

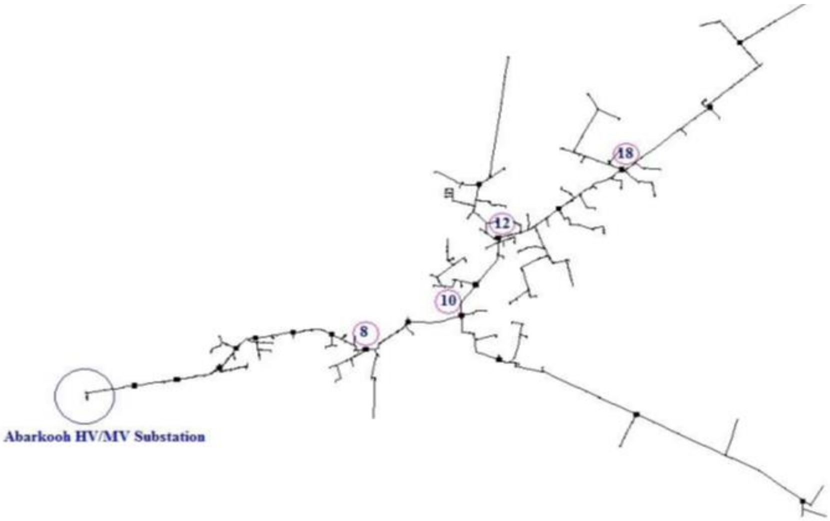

Figure 2. schematic of the feeder under consideration

Findings

The flowchart used for solving the problem of optimal placement of the demand response program in order to improve the voltage profile had been demonstrated in research method section. Input of this program (primary population) is the location and capacity usage of the demand response program which is located in primary population members and moreover, output of the program is the optimum location and capacity usage of the demand response program and the optimum quantity of objective function of the voltage profile. The results of program execution have been shown in figure (3) and table (2).

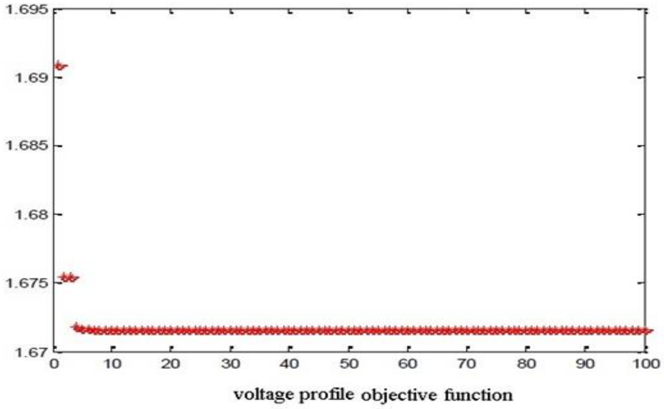

Figure 2. Output of the uni-object TLBO algorithm with voltage profile objective function

Table 2. Characteristics of output point of the voltage profile objective function minimization program by utilization of the TLBO algorithm

Value of voltage profile objective function after employing the demand response program	Value of voltage profile objective function before employing the demand response program	Optimum capacity of the demand response program	Optimum location of the demand response program
1.6716 per unit	1.7009 per unit	10%	Bus. 18

As can be seen in table 2, applying the demand response program could amend the network voltage profile. The best bus for making use of this program is bus 18 and the best capacity which was obtained for making use of this program is 10% of the bus 18. Network voltage profile was also improved up to 0.0293 per unit. Consequently, the simulation of this section proves that the demand response program has the ability to improve the network voltage profile.

Moreover, there was a logical argument for this topic. The meaning of the demand response program utilization in bus 18 is the load reduction of this bus. By the reduction of bus's load, the current passing through the network lines to supply the existing load in this bus is also reduced and the voltage drop in lines is decreased subsequently. By the lines voltage drop being diminished, the network buses voltage is improved which in turn results in improvement of the network voltage profile indicator. Hence, according to the expectation, simulations verified that the demand response program is effective in improving the network voltage profile.

Conclusion

Voltage profile is one of the most significant factors which is required by the power network to provide its consumers with load continuously. Steady voltage profile is regarded as one of the power quality indicators. On the other hand, population growth and industry development oblige the government to invest further in network expansion, in order to be responsible for ever-increasing increment in consumption. But the point which merits the most attention (the point which is worth mentioning) is that the development of network demands major investment then it has to be deferred as much as possible. Demand response programs are means by making use of which, the network voltage profile can be improved to a desirable degree. In this study, we concentrated on finding the optimum location and capacity of the demand response program so as to improve the power system's technical indicators like voltage profile. Simulations results displayed that the best place of the demand response program to improve the network voltage profile is the bus number 18.

Reference

1. Basu, M., Das, S. P., & Dubey, G. K. (2007). Comparative evaluation of two models of UPQC for suitable interface to enhance power quality. Electric Power Systems Research, 77(7), 821-830.
2. H Jalili, H., Karamizadeh, A., Foroughi, M. J., Pazhoohesh, M., & Jalili, M. (2011). Optimization of distributed generation location and capacity for improving voltage profile and reducing loss using genetic algorithm (SPEA) with proposing a new index. Scientific Research and Essays, 6(20), 4421-4427.
3. Hosseini, M., Shayanfar, H. A., & Fotuhi-Firuzabad, M. (2009). Modeling of unified power quality conditioner (UPQC) in distribution systems load flow. Energy Conversion and Management, 50(6), 1578-1585.
4. IEA, "Strategic plan for the IEA demand side management program 2004-2009," Available at: http://www.iea.org.

5. Kirschen, D. S., Strbac, G., Cumperayot, P., & de Paiva Mendes, D. (2000). Factoring the elasticity of demand in electricity prices. IEEE Transactions on Power Systems, 15(2), 612-617.
6. Lahaçani, N. A., Aouzellag, D., & Mendil, B. (2010). Contribution to the improvement of voltage profile in electrical network with wind generator using SVC device. renewable energy, 35(1), 243-248.
7. Moreno-Munoz, A., De-la-Rosa, J. J. G., Lopez-Rodriguez, M. A., Flores-Arias, J. M., Bellido-Outerino, F. J., & Ruiz-de-Adana, M. (2010). Improvement of power quality using distributed generation. International Journal of Electrical Power & Energy Systems, 32(10), 1069-1076.
8. Rezaei, N., & Kalantar, M. (2015). Stochastic frequency-security constrained energy and reserve management of an inverter interfaced islanded microgrid considering demand response programs. International Journal of Electrical Power & Energy Systems, 69, 273-286.
9. Saeidpour, E., Parizy, V. S., Mohammadi, A., Abedi, M., & Rastegar, H. (2008, September). Integrated and simultaneously design for STATCOM fuzzy controller with genetic algorithm for voltage profile improvement. In 2008 40th North American Power Symposium (pp. 1-6). IEEE.
10. Staff, F. E. R. C. (2006). Assessment of demand response and advanced metering. Federal Energy Regulatory Commission, Docket AD-06-2-000.
11. Zareshahri, A., (2013). Development Planning of Transmission Network using TLBO Algorithm. Electricity Engineering Conference and Sustainable Development.