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Optimal Location and Capacity of UPQC for improvement of Voltage profile and Reducing loss in distribution Network by Data Sharing Algorithm

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Abstract

Voltage profile improvement and loss reduction are two goals that should be considered for providing better service for consumers in the distribution network. Several methods for this goal have been studied before that including capacitor and Custom Power Devices (CPD) installation. However, since these devices are so expensive, we must use them in minimum cost. So, for installation of these devices, the optimal location and capacity of them should be found. The study of this important issue is done in this paper, and we used Unified Power Quality Conditioner (UPQC) for steady state improvement of voltage profile and reduction of power loss. Our method is tested in 33-bus and 69-bus test systems, by using Data Sharing Algorithm (DSA).

Keywords: UPQC, Data Sharing Algorithm, Optimal Location and Capacity, Loss reduction, Voltage profile improvement.

Introduction

Voltage profile improvement and loss reduction are two goals that should be considered for providing better service for consumers in the distribution network. Generation and transmission of power to demand nodes is one of the most important issues in power system. There are several devices such as capacitors and FACTS devices that can maintain the voltage of buses in acceptable limits.

Unfortunately, the reaction of capacitor for improvement of voltage stability is slow. So, in some conditions like voltage sag, the required reactive power for increasing voltage cannot be provided by the capacitors.

One other disadvantage of the capacitor is that it does not have a continuous control on its output. In contrast, the Custom Power Devices (CPD) like Unified Power Quality Conditioner (UPQC) has injection/absorption ability of the reactive power to/from the distribution network. UPQC has not other disadvantages of capacitors. Therefore, UPQC can effectively support the network demands.

The FACTS equipments in distribution network are named CPD. They have structures like FACTS, but their control methods have been changed, in order to support distribution network needs.

Several researchers[1-10] are studied about improvement of power quality with CPD. The D-STATCOM is a CPD device that is in parallel with the network. It usually uses for some power quality goals like[1-2].

DVR is another from them. This device places in series in distribution network. The DVR usually places in network for voltage dip and unbalance elimination[3-5].

The perfect member of this family is UPQC that has two parts, series and parallel. This device is the integration of DVR and D-STATCOM. UPQC can respond dynamically to all of power quality needs of the network like voltage unbalance, voltage dip, voltage flicker and harmonic[6-10].

Tooraji and Abdolamir improved power quality with Unified Power Quality Controller[11].

Our goal in this paper is finding of the optimal capacity and location of UPQC for voltage profile improvement and loss reduction. A method has been proposed by Hosseini et al [12] for gaining this purpose. This reference has some deficiencies which are mentioned below:

First, for determination of optimal UPQC location, in this paper UPQC has placed in all buses, then the location that has the most positive influence on voltage profile, is chosen as its optimal location. Obviously, this method is not effective in large scale networks.

Second, the capacity of UPQC parallel section is considered constant, 2 Mega Var. This allocation is in contrast with optimal capacity determination of UPQC.

For completion of our research the optimal location and capacity of UPQC have been obtained by Data Sharing Algorithm (DSA) for reducing loss and steady state improvement of voltage profile in the distribution network[13].

Problem Formulation

The model of UPQC in steady state: The 2-bus network is shown in figure-1. The phasor diagram of this network is shown in figure 2, too. The voltages of buses of each network generally are close to one. In this paper our goal is to improve buses voltages to one by UPQC.

The buses voltages in 2-bus network have relationship that is as follow:

$$V_{0j}\angle\alpha 0 = V_{0i}\angle\delta 0 - (R + jX)I_{0L}\angle\theta 0 \quad (1)$$

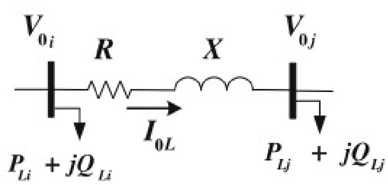

Figure-1
The 2-bus distribution network

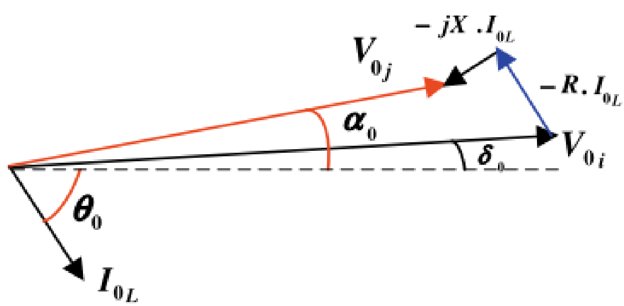

Figure-2
The phasor diagram of 2-bus distribution network

In this paper we suppose that the reactive power only exchange between series and parallel parts of UPQC with network. Our goal from installation of UPQC is that the jth bus voltage reaches to 1. Ith and jth buses voltages after UPQC installations have shown in figure-3. Because, there is no active power exchange, V_{series} is perpendicular to I_{series} , and I_{shunt} to V_{jnew}. The figure 3 has resulted to equation-2.

$$V_{jnew}\angle\alpha new = V_i\angle\delta - (R + jX)I_L\angle\theta - (R + jX)I_{shunt}\angle\left(\alpha new + \frac{\pi}{2}\right) + V_{series} \quad (2)$$

The $V_{jnew}\angle\alpha new$ and $I_L\angle\theta$ are the jth bus voltage and line current after installation of UPQC, respectively. Other figures of UPQC are proposed by Hosseini et al.

The objective function and optimization method: The problem of optimal capacity and location of UPQC for improvement of voltage profile and reducing loss in distribution network has been solved by Data Sharing Algorithm (DSA) in this paper. It has been tried to compensate the buses voltage and reducing loss by minimum capacity of UPQC.

The objective functions are defined according to equations-3 and 4.

$$Max \quad F1 = RUVMN \text{ or } Min \quad F1 = -RUVMN \quad (3)$$

$$Min \quad F2 = Power\ Loss = \sum_{i=1}^{b} R_i.I_i^2 \quad (4)$$

RUVMN in equation-3, indicates the Rate of Under Voltage Mitigated Nodes. In other words, it shows the percentage of buses that are outside of the voltage allowed region and entered into the allowed region after UPQC installation. Equation-4 is power loss of the network. b is the number of branches.

Simulation Results

In order to survey our method, the 33-bus distribution network is chosen (figure 4). The network information is proposed by Hosseini et al.

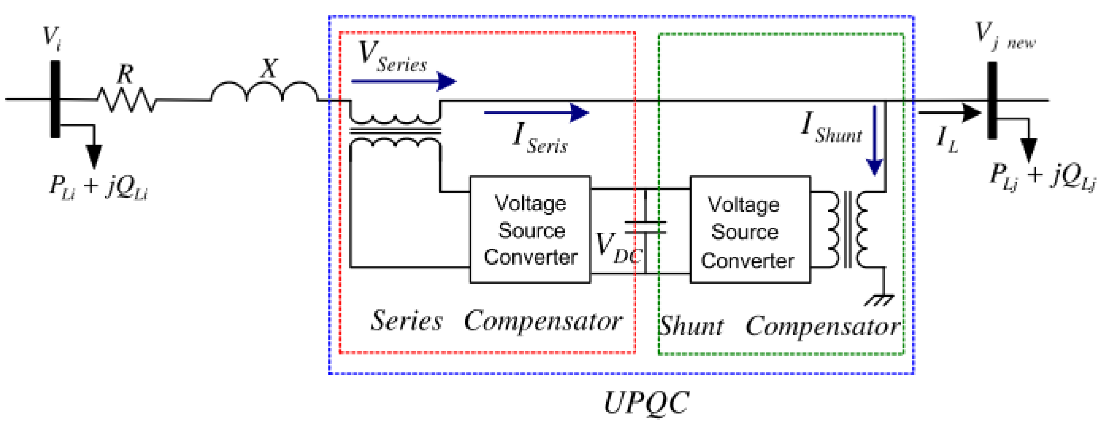

Figure-3
The diagram of two buses distribution network after the installation of UPQC

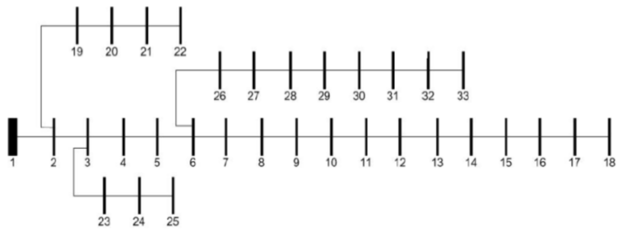

Figure-4
The 33-bus test network

Results of load flow are in table 1 and this results show that before UPQC installation, %63.63 of buses are not in acceptable region. The acceptable voltage limit is considered ±%5. So, if after UPQC installation, RUVMN reaches to %63.63, it means that all buses are in the acceptable region. The flowchart of our proposed method is shown in figure-5. In figure-5, first lines and buses information are entered, and then before UPQC installation the load flow program runs. The numbers of buses outside the allowed region are 21 which are 63.63% of all buses.

Second, the DSA parameters are entered and the initial values of population members are set. These members determine location and capacity of the parallel port of UPQC. Also, the reactive power capacity of series part of UPQC is obtained after running the load flow program. The steps for obtaining this power are too long and we do not write its related equations. These equations completely have been proposed by Hosseini et al.

In the next step, by members encoding and running the load flow program, objective functions for all members are computed. Then a new population is made by DSA operators. This process is continued until the final answer is achieved.

The results of load flow program before UPQC installation are in table-1. As it can be seen, 21 buses from 33 buses are not in the acceptable region. After running of DSA the output of program has been illustrated in figure-6.

The horizontal axis shows the negative percentage of buses that placed in the allowed region after the installation of UPQC, while the vertical axis demonstrates the power loss of the network.

The characteristics of points in figure 6 have been listed in table-2. So our final results are in table-2. Now we implement our method in 69-bus test network that is proposed by Hosseini et al. The results of the simulation are shown in figure-7 and table-3.

What we pursued in this paper was the optimal location and capacity of UPQC for steady state voltage profile improvement and loss reduction in networks. About the figures 6 and 7, we can say that all of the points in these figures are optimal and the operator of the networks can choose one of the points base on his desire.

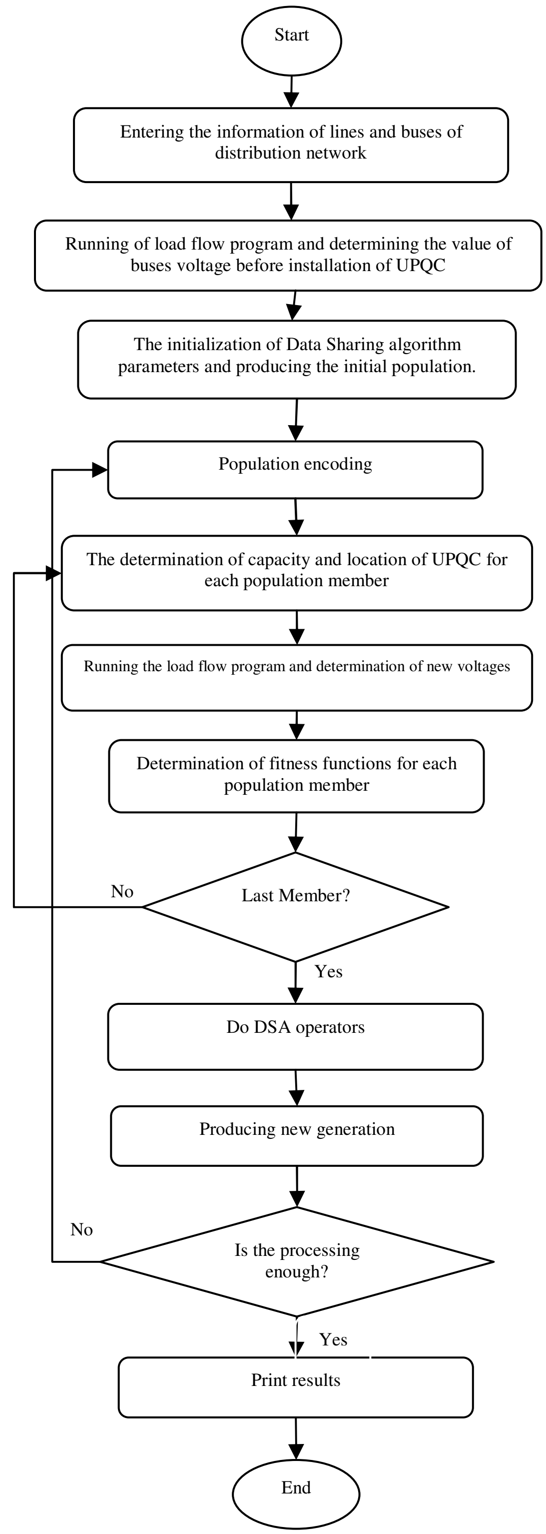

Figure-5
The flowchart of proposed method

Table-1
The characteristics of buses before installation of UPQC

Bus number	Voltage value	Voltage phase	Bus number	Voltage value	Voltage phase	Bus number	Voltage value	Voltage phase
0	1	0	11	0.9269	-0.1772	22	0.9794	0.0651
1	0.9970	0.0145	12	0.9208	-0.2685	23	0.9727	-0.0236
2	0.9829	0.0961	13	0.9185	-0.3472	24	0.9694	-0.0673
3	0.9755	0.1617	14	0.9171	-0.3849	25	0.9477	0.1734
4	0.9681	0.2283	15	0.9157	-0.4081	26	0.9452	0.2296
5	0.9497	0.1339	16	0.9137	-0.4854	27	0.9337	0.3112
6	0.9462	-0.0964	17	0.9131	-0.4950	28	0.9255	0.3891
7	0.9413	-0.0603	18	0.9965	0.0037	29	0.9219	0.4944
8	0.9351	-0.1334	19	0.9929	-0.0633	30	0.9178	0.4100
9	0.9292	-0.1959	20	0.9922	-0.0827	31	0.9168	0.3869
10	0.9284	-0.1887	21	0.9916	-0.1030	32	0.9166	0.3792

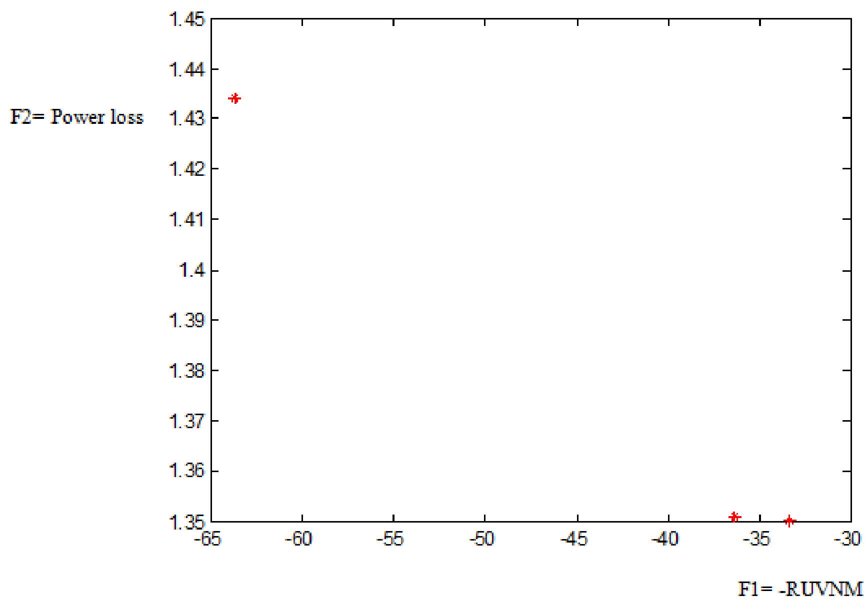

Figure-6
The program output of DSA for 33-bus test network

Table-2
The characteristics of figure 6 points

	1	2	3
F1 (%)	-63.6364	-36.3636	-33.3333
F2 (pu)	1.4339	1.3508	1.3501
Optimal location of UPQC	5	29	29
The exchanged reactive power through UPQC (Kvar)	1693	1371	1324

Table-3
The characteristics of figure 7 points

	1	2	3	4
F1 (%)	-26.08	-20.29	-13.04	-2.898
F2 (pu)	2.3552	2.1324	1.9768	1.8552
Optimal location of UPQC	13	36	38	45
The exchanged reactive power through UPQC (Kvar)	1845	1624	1585	1552

Conclusion

The problem of optimal capacity and location of UPQC for improvement of power quality in distribution network has been investigated in this paper by the DSA. The results of the simulation showed that UPQC can solve the voltage profile and loss reduction problems by exchanging the optimal amount of reactive power.

According to this paper, this optimization method can be used for finding the optimal location and capacity of UPQC for industrial networks that struggle with power quality problems.

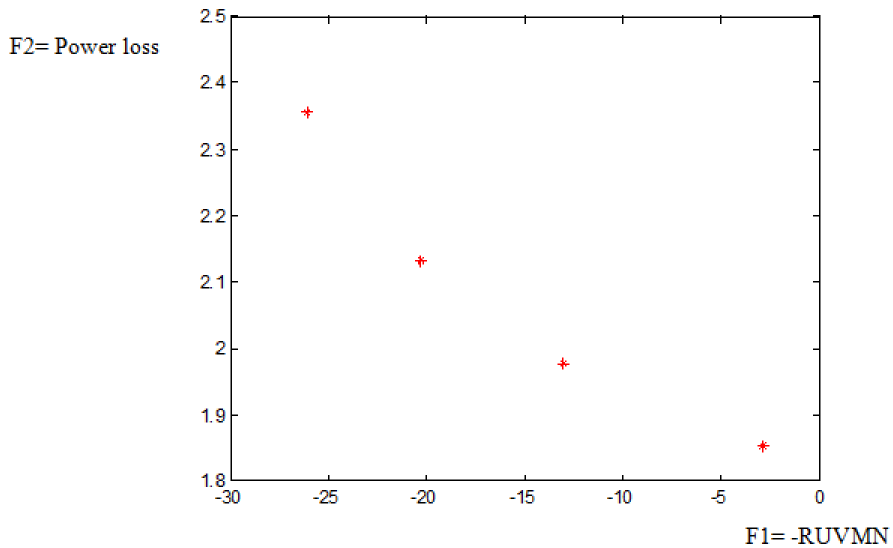

Figure-7
The program output of DSA for 69-bus test network

References

1. Jazebi S., Hosseinian S.H. and Vahidi B., DSTATCOM allocation in distribution networks considering reconfiguration using differential evolution algorithm, *Energy Conversion and Management,* **52(7)**, 2777-2783 **(2011)**

2. Zaveri T., Bhalja B. and Zaveri N., Comparison of control strategies for DSTATCOM in three-phase, four-wire distribution system for power quality improvement under various source voltage and load conditions, *International Journal of Electrical and Energy Systems,* **43(1),** 582-594 **(2012)**

3. Babaei E., Kangarlu M.F., Sensitive load voltage compensation against voltage sags/swells and harmonics in the grid voltage and limit downstream fault currents using DVR, *Electric Power System Research,* **83(1),** 80-90 **(2012)**

4. Ramasamy M. and Thangavel S., Experimental verification of PV based dynamic voltage restorer with significant energy conservation, *International Journal of Electrical Power and Energy Systems,* **49,** 296-307 **(2013)**

5. Hooshmand R.A., Robust control design for multi-functional DVR implementation in distribution systems using quantitative feedback theory, *Electric Power System Research,* **97,** 116-125 **(2013)**

6. Liang Z and Lu B., The decoupled control research of UPQC, *Energy Procedia,* **12,** 303-312 **(2011)**

7. Axente I., Basu M. and Conlon M.F., DC link voltage control of UPQC for better dynamic performance, *Electric Power Systems Research,* **81(9),** 1815-1824 **(2011)**

8. Khadkikar V., Enhancing electric power quality using UPQC: A comprehensive overview, *IEEE Transaction on Power Electronics,* **27(5),** 2284-2297 **(2012)**

9. Mohammed B.S., Rama K.S., Ibrahim R. and Perumal N., Performance evaluation of R-UPQC and L-UPQC based on a novel voltage detection algorithm, *IEEE Symposium on Industrial Electronics and Applications,* 167-172 **(2012)**

10. Kumar G.S., Kumar B.K. and Mishra M.K., Mitigation of voltage sags with phase jumps by UPQC with PSO-Based ANFIS, *IEEE Transaction on Power Delivery,* **26(4),** 2761-2773 **(2011)**

11. Tooraji H.E. and Abdolamir N., Improving Power Quality Parameters in AC Transmission Systems Using Unified Power Flow Controller, *Research Journal of Recent Sciences,* **2(4),** 84-90 **(2013)**

12. Hosseini M., Shayanfar H.A. and Fotuhi-Firuzabad M., Modeling of unified Power quality conditioner (UPQC) in distribution systems load flow, *Energy Conversion and Management,* **50,** 1578-1585 **(2009)**

13. Jalili H., Amirzadeh A., Noorafkan A. and Jalili G., A new evolutionary algorithm based on data sharing concept for solving optimization problems, *Scientific Research and Essays,* **6,** 5082-5090 **(2011)**