

The Contributions of Custom Power Devices in Improving Voltage Profile of Distribution System

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ABSTRACT: The demand for electric power is increasing day by day resulting in resource, environment and social constraints. Therefore the alternate solution for this problem is increasing generation near the load sectors called distributed generation (DG). The penetration of DG's, power converters, non-linear loads, heavy load variations, etc., into the grid adversely effects on the quality of power intern resulting in huge financial losses and poor operation of the system. Therefore it is very important to improve the power quality of the distribution system. In this proposed work, the various custom power devices are tested with IEEE 6 bus system in the presence of faults using MATLAB/SIMULINK. The contributions of DSTATCOM, DVR and UPQC in improving the voltage profile of the system is analysed by the use simulation results.

KEYWORDS: IEEE 6 bus System, Power quality, Custom Power Devices and MATLAB/SIMULINK.

I. INTRODUCTION

The consumers are connected to a distribution substation through a distribution system. The distribution systems are designed by considering some electrical parameters such as required peak load, voltage, distance to customers, and other local conditions. But due to drastic increase in consumption of electrical power, the distribution system fails to feed the power continuously. Therefore the electrical power is started generating near load side called distribution generation. The power can be generated near the load side by installing wind power plant, fuel cells and solar PV systems

Increase in penetration level of DG's into the grid has a negative impact on stability and power quality of electric power systems. Any deviations in voltage, current and frequency from their standard value resulting in poor power quality. These deviations are adversely affecting the system performance causing huge financial losses for both the consumer and supplier. Because of poor power quality, the system draws more reactive power from the supply system therefore the losses increase. In order to overcome these losses and to improve power quality in concern with the system performance it is very important to supply leading reactive power near to the load sectors.

Many initiatives have been taken by the consumers and as well as the suppliers to improve the quality of the power. Therefore some measurement in this regards must be taken to supply high quality electrical power. The problems related to power quality issues can be mitigated by using various techniques like artificial intelligence, Facts expert controller, genetic algorithm techniques, mathematical techniques etc., the PQ of the distribution system can also be improved by the method of optimal location of DGs.

In this paper, a group of controllers called custom power devices like DSTATCOM, DVR and UPQC are used in an IEEE 6 bus test system in the presence of faults to improve the quality of electrical power thereby to reduce losses. This paper proposes the implementation of custom power devices in a IEEE 6 bus test system. The study has been carried out by using MATLAB/SIMULINK and the results are compared to suggest the suitable custom power device in concern with voltage profile.

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II. RELATED WORK

The analysis on power quality issues both in islanding mode and operating mode using UPQC along with DGs have been successfully done [1]. The location of DGs also plays a very crucial role in maintaining the better voltage profile in the distribution systems.

The Consequences due to low power quality on consumers and electric utility was tested for wind connected grid system with non linear load. The simulation work has been carried out successfully in MATLAB/SIMULINK using STATCOM [2]. The active and passive filters are also connected in parallel with the load as a hybrid power filters to reduce the harmonic levels.

III. MODELLING OF CUSTOM POWER DEVICES

A. DSTATCOM

The Distributed static compensator (DSTATCOM) is a shunt connected custom power device with the distribution system through a reactance. Basically it is a voltage source converter which is coupled to a system through coupling transformer. The DSTATCOM consists of following components are linear transformer, Universal Bridge, Series and Parallel PLC branch, controller and voltage source converter. Fig. 1 represents the schematic simulation model of DSTATCOM used to inject shunt current into the system to avoid the voltage sag by maintaining voltage drops.

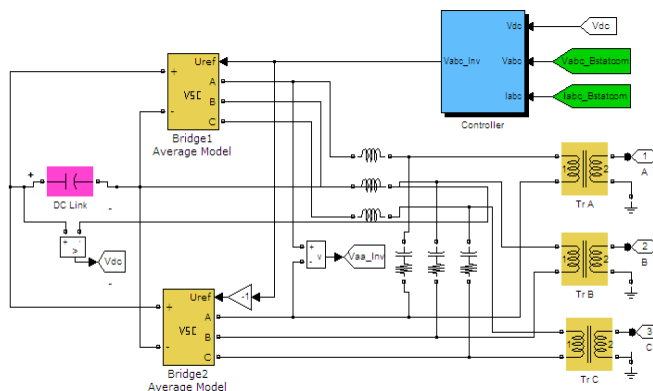


Fig. 1 Model of DSTATCOM

B. DYNAMIC VOLTAGE RESTORER (DVR)

Dynamic Voltage restorer is a solid state device which connected in series with the distribution system. The DVR plays a very crucial role in regulating the voltage at the load side. It injects the voltage into the system to improve the voltage profile. The DVR consists of following components: DC Voltage source, Linear Transformer, Series and parallel RLC branch, universal bridge and controller. The simulink model of DVR system is shown in Fig. 2.

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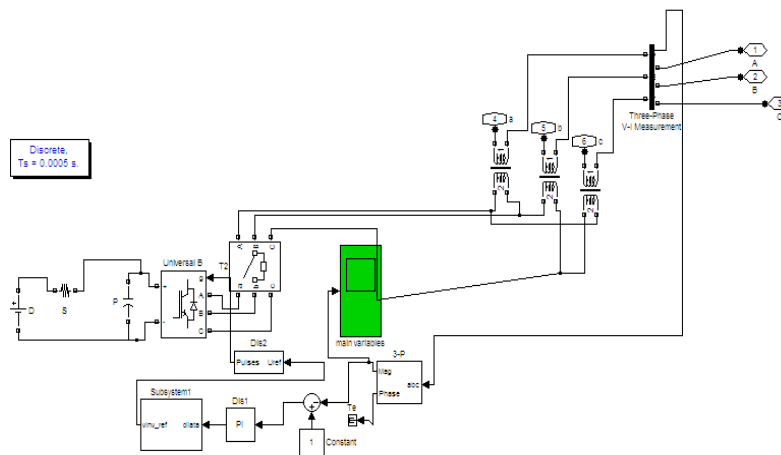


Fig. 2 Simulink Model of DVR

C. UNIFIED POWER QUALITY COMPENSATOR (UPQC):

Unified power quality compensator is a combination of series and shunt solid state device where the shunt active filter compensates the current and shunt active filter compensates voltage. It has various applications in mitigating power quality of the system. The UPQC consists of two voltage source converters which are connected back to back through a DC link. The simulink Model of a unified power quality compensator are shown in Fig. 3.

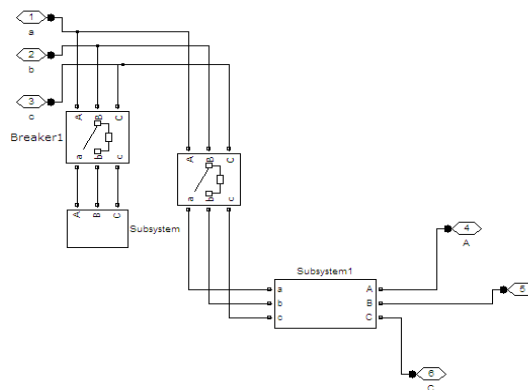


Fig. 3 Modeling of UPQC

IV. IEEE 6 BUS TEST SYSTEM

The performances of custom power devices are evaluated by considering a three phase IEEE six bus test system. It consists of six buses and the voltage profile of this distribution system is analysed. The location of Custom power devices are selected by trial and error method and the CPDs is connected at the 6th bus in order to obtain better voltage regulation and the same is analysed at all the buses using MATLAB/SIMULINK as shown in Fig 4.

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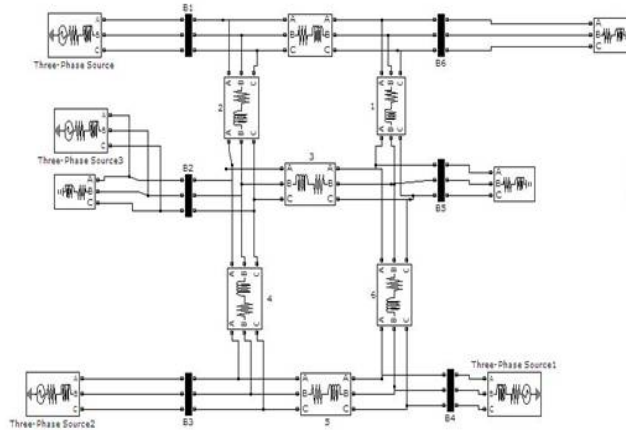


Fig.4 IEEE Six Bus Test System

V. RESULTS AND DISCUSSION

The Test system with different custom power devices like DSTATCOM, DVR and UPQC are analysed using Matlab/Simulink and the results in per unit are shown as follows and the table gives the voltage profile of the test system without and with the aid of different CPDs are given for the purpose of comparison. From the results of the analysis it is clear voltage profile of test system without any CPDs is very poor and with the aid of these devices the voltage profile improved. From the comparison Table 1, it is clear that six bus test system with dynamic voltage restorer (DVR) has a very good voltage profile when compared to the voltage profile of test system with other CPDs. The voltage profile of the system without the aid of any custom power devices are shown in Fig. 5.

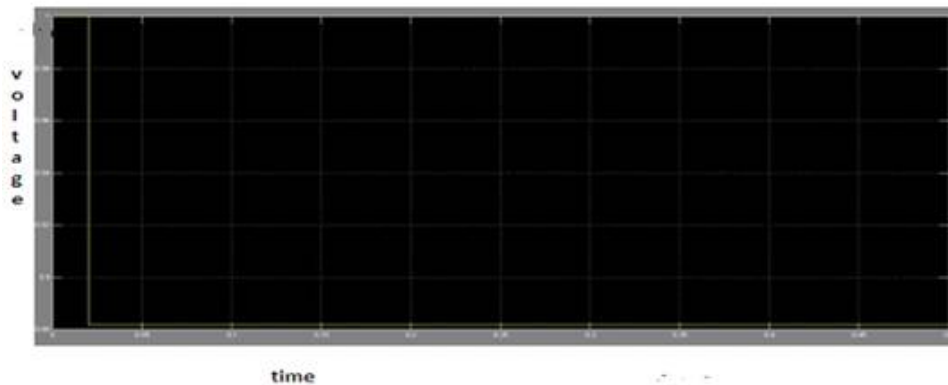


Fig. 5 Voltage profile without CPD's

The voltage profile of IEEE Six bus system can be improved by using different custom power devices. The DSTATCOM is connected to 6th bus and the voltage profile of the system is studied and it is observed that the voltage profile of the system has been improved as shown in Fig. 6.

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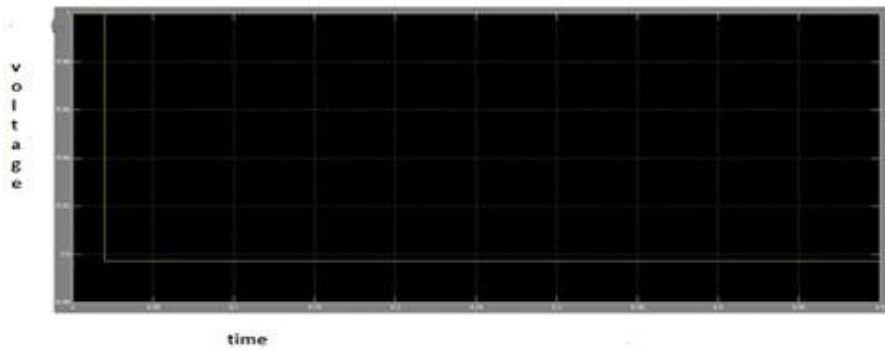


Fig. 6 Voltage profile with DSTATCOM

The DSTATCOM is replaced by another Dynamic voltage restorer and it is found that the voltage profile of the system has been improved as shown in Fig.6 but the contribution of DVR in improving the voltage profile is less compared to DSATCOM

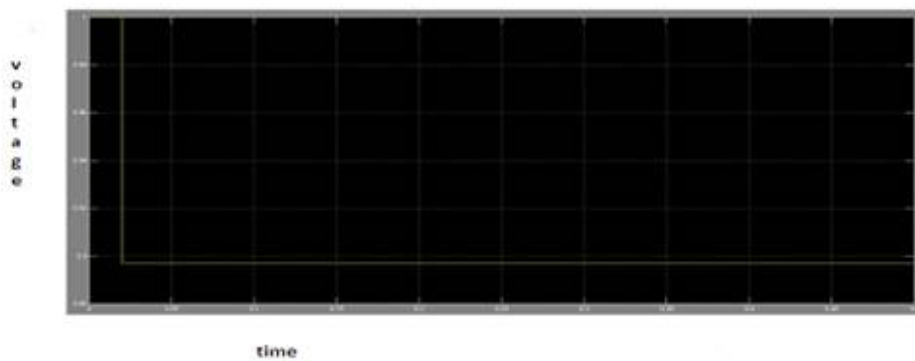


Fig. 7 Voltage profile With DVR

The same IEEE system is simulated with the help of UPQC and it is observed that improving in voltage profile as shown in Fig.8.

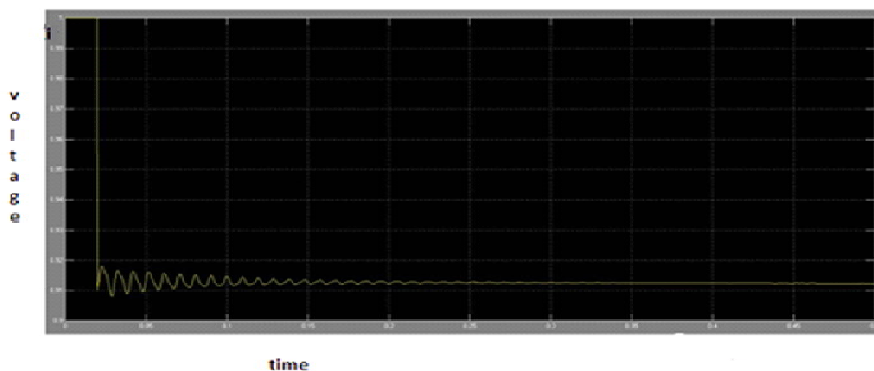


Fig 8. Voltage profile With UPQC

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The Voltage Levels at Different Buses of an IEEE six bus test system with and without custom power devices are analysed for the improvement of voltage profile and it is tabulated in Table 1.

Table 1. Voltage levels with different buses

BUS NUMBER	WITHOUT CPD'S	WITH DSTATCOM	WITH DVR	WITH UPQC
1	0.9015	1.034	0.9136	0.9234
2	0.9025	1.008	0.9123	0.92
3	0.9265	1.005	0.9366	0.9395
4	0.9131	1.003	0.9214	0.9279
5	0.8826	1.001	0.8934	0.9024
6	0.8816	1.062	0.8972	0.9124

VI. CONCLUSION

Voltage sag, Voltage swell, Voltage Flickering, Voltage dip, Harmonic dip and voltage spikes are the main power quality issues which can be addressed using custom power devices such as D-STATCOM, DVR and UPQC.

DSTATCOM is shunt connected custom power device, applied to maintain bus voltage sags at the required level by supplying or receiving of reactive power in the distribution system. It is connected in shunt with distribution feeder with the help of coupling transformer.

DVR is a series connected custom power device, designed to inject a dynamically controlled voltage in magnitude and phase in to distribution line via coupling transformer to correct load voltage and also used to mitigate the flickers.

UPQC is a common operation of series and shunt active compensator. Shunt active power filter capability of the current compensation, series active power filter capability of voltage compensation allow mitigation of various power quality problem like voltage dip, voltage swell etc.

From the results we can conclude that to eliminate voltage flicker series compensator DVR will be used. Similarly to make the system stable with respect to the voltage D-STATCOM and UPQC will be used.

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