Comparison of FACTS Controller for Improvement of Power Quality

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ABSTRACT

Power quality is certainly a major concern in the present era and it becomes an important with the introduction of sophisticated devices whose performance is very sensitive to the quality of power supply. There are different power qualities issues like voltage sag, voltage swell, voltage interruption, harmonic distortion and under voltage and over voltage. Due to increasing use of these sophisticated controllers in almost all modern devices at the industrial and residential consumer level, the voltage sag and swell, which causes severe problems to these devices needs to be analysed. The main objective of this paper is a comparative investigation and mitigation of in the enhancement of voltage sag and voltage swell through unified power quality conditioner (UPQC) and distributed power-flow controller (DPFC). Furthermore, the control circuits are designed for both UPQC and DPFC by using series reference voltages, line currents and these are controlled by external conventional PI controllers. The designed controllers are very efficient to power system for effectively regulating system voltage for different types of faulted conditions. The proposed two control strategies i.e. both UPQC and DPFC are developed in MATLAB 2009b/SIMULINK Environment. The simulation results of Voltage compensation and THD value are observed for both DPFC and UPQC. From the obtained results, it is clearly shown that the proposed methods is able to provide better solution for compensating the power quality problems as compared with the other FACTS controllers. And also, conclude that the distributed power-flow controller (DPFC) give better THD than unified power quality conditioner (UPQC).

KEYWORDS: Power Oscillation Damping, Distributed Power Flow Controller, Unified Power Quality Conditioner, Power Quality Problems.

I. Introduction

With increasing applications of loads and electronically switched devices in distribution systems and industries, power quality problems, such as variation of voltages and faults and distortions. Power Quality problems encompass a wide range of disturbances such as voltage sags/swells, transient changes, steady state changes, dips and interruptions. Voltage sags and swells occur at any instant of time, with amplitudes changes from 0.1 to 0.5 with a short span of time.

Voltage sag and swell can cause system devices either to fail, or shutdown, as well as create a large current unbalance that could blow fuses or trip breakers. In order to meet PQ standard limits, it may be necessary to include some sort of compensation. Modern solutions can be found in the form of active rectification or active filtering. A shunt active power filter is suitable for the suppression of negative load influence on the supply network, but if there are supply voltage imperfections, a series active power filter may be needed to provide full compensation.

Generally, there are many different methods to mitigate voltage sags and swells, but the use of a custom Power device to be the most efficient methods. Switching off a large inductive load or Energizing a large capacitor bank is a typical system event that causes swells. This paper introduces a new method such as DPFC and this result is compared with another custom power device such as UPQC.

2. CONFIGURATION OF UPQC

A unified power-quality conditioner (UPQC) is the extension of the unified power-flow controller (UPFC) concept at the distribution level is one the best solution to make the overall power distribution system more healthy. It consists of combined series and shunt converters for simultaneous compensation of voltage and current imperfections in a supply feeder. The configuration of UPQC is shown in figure 1.

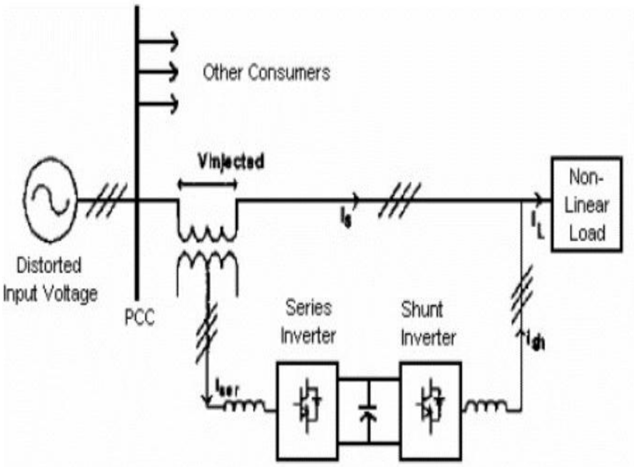

Fig 1: configuration of UPQC

3. CONFIGURATION OF DPFC

The configuration of DPFC system contains elimination of DC-link capacitor and using 3rd harmonic current to active power exchange.

The DPFC consists of shunt and several series connected converters. The shunt converter is nothing but same as STATCOM, while the series converters employ the D-FACTS concept. Each converter within the DPFC is independent and has a separate DC link capacitor to provide the required DC voltage. Fig. 2 shows the structure of DPFC that is used in a transformation system with two parallel lines. The control capability of the UPFC is given by the back-to-back connection between the shunt and the series converters with DC link, which allows the active power to exchange freely. To ensure that the DPFC has the same control capability as the UPFC device, a method that allows the exchange of active power between converters without DC link is the prerequisite. In the DPFC, there is a common connection between the AC terminals of the shunt and the series converters, which is the transmission line. Therefore, it is allows to exchange the active power through the AC terminals of the converters.

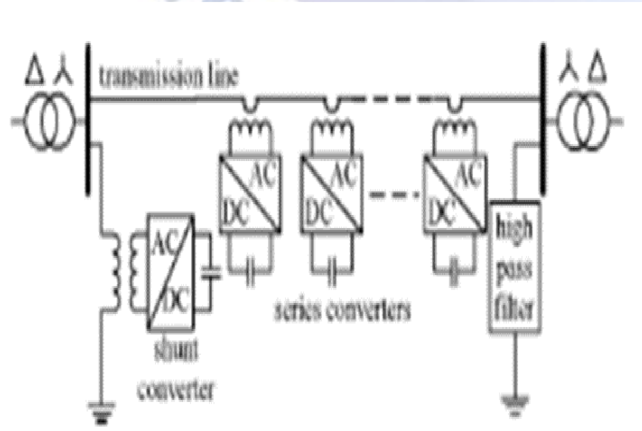

Fig 2: Basic Configuration of DPFC

Merits of DPFC:

The DPFC has the following advantages in comparison with UPQC, such as:

1) High control capability.

The DPFC can control all parameters of transmission network

2) High reliability.

The series converters redundancy increases the DPFC reliability during converters operation. It means, if one of series converters fails, the others can continue to work.

3) Low cost.

The single-phase converters rating, in comparison with three-phase converters is very low. Furthermore, the series converters, in this configuration, no need to any voltage isolation to connect in line. We can use the single turn transformers for series converters hanging.

4. CONTROL CIRCUIT FOR DPFC

According to illustration 2 the DPFC has three types of control strategies: i.e. Main controller, DVR controller and Static controller.

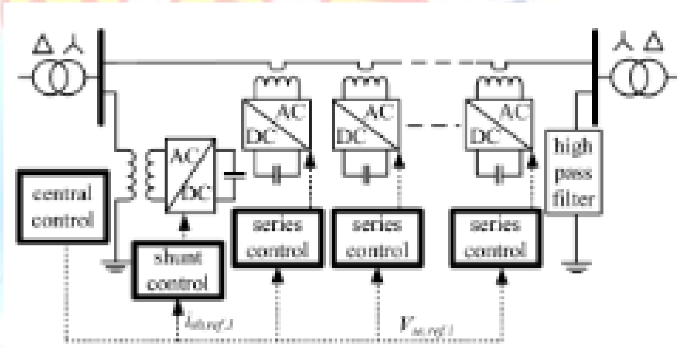

Fig 3: Control Diagram of DPFC

These three controllers are explained as follows:

a. **CENTRAL CONTROLLER:**

The central controller is used to control dvr and static controllers by generation of referral signals (like series voltages and currents).

b. **SERIES CONTROLLER:**

The main purpose of this series controller is to maintain the voltage of capacitor of its own converters and to generate series voltages at the natural frequency. This controller requires inputs as series capacitor voltages, line voltages and reference capacitor voltages in direct and quadrature axis frame. Generally, these series controllers has first order low pass and third order band pass filters to create natural and 3rd order harmonic currents. The control structure for series controller is shown in figure 3.

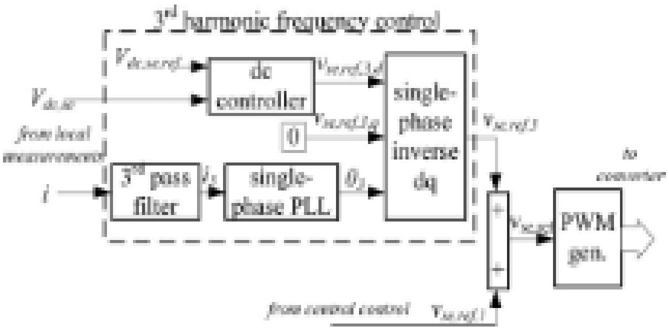

Fig 4: Block Diagram for Series Controller

c. SHUNT CONTROLLER:

The control diagram of the shunt converter is shown in figure 4. Main aim of the shunt control is to insert a 3rd harmonic current into the transmission line to provide active power for the dvr converters. The static converter have three phase converter which is back to back connected with single phase converter. In this the three phase converter absorbs active power from grid and controls Dc voltage of capacitor between this converters.

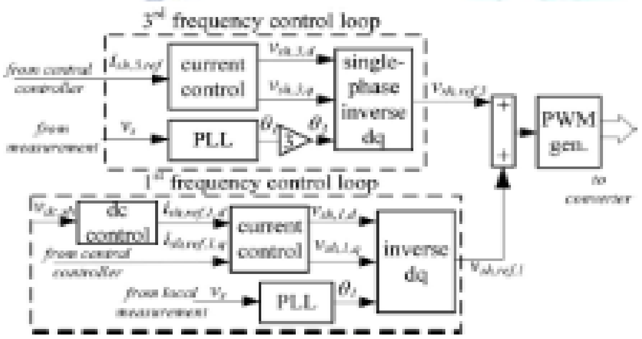

Fig 5: Control Diagram for Shunt Controller

d. SIMULATION DIAGRAM AND RESULTS

The mitigation methods for sag/swell condition is implemented in a single machine system are analyzed and observed the results. The simulation diagram is constructed for both UPQC and DPFC by considering the following basic diagram as shown in figure 3 and figure 4 respectively.

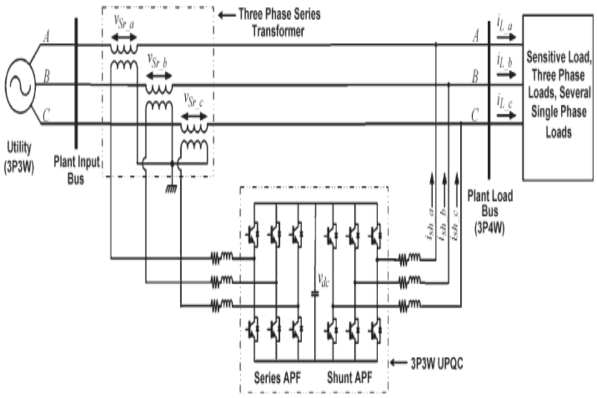

Fig 6: control diagram of UPQC

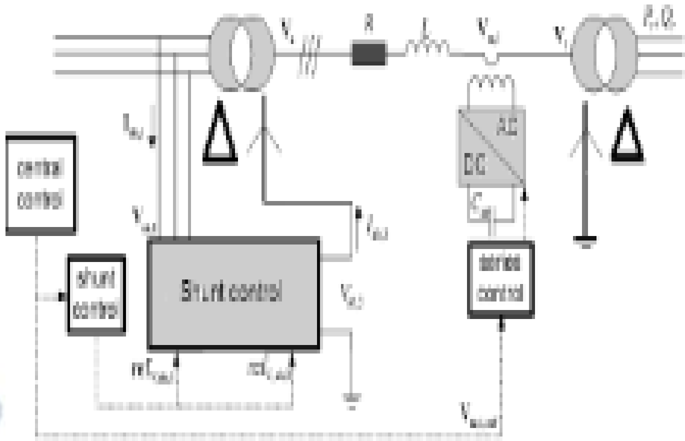

Fig 7: Structure of DPFC

In this paper, the sag is created in voltage about the value of 0.5 per unit and this sags are mitigated by using UPQC and DPFC. The results for both sag condition and mitigation of sag are shown in figure 5 and 6.

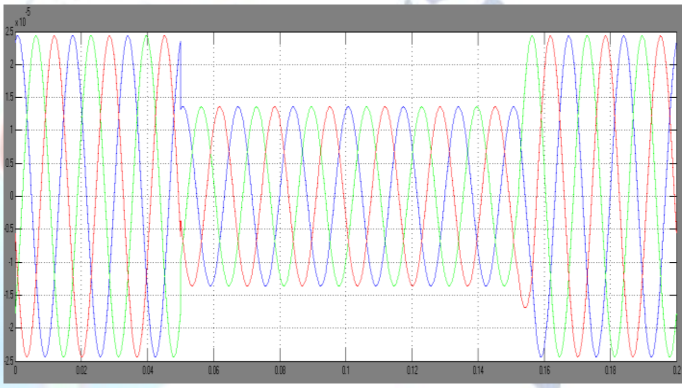

Fig 8: Simulation results for voltage sag condition

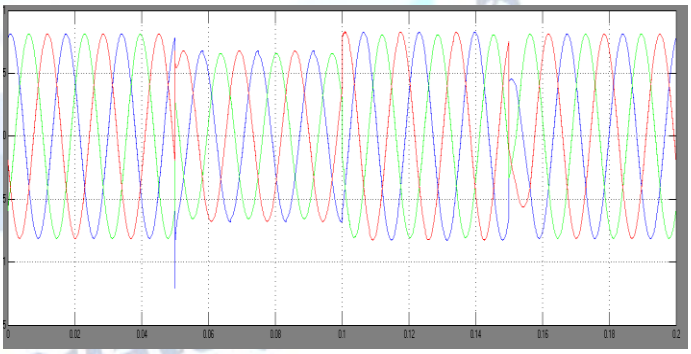

Fig 9: Simulation results for mitigation of Voltage sag.

In this paper, the swell is created in current during fault condition about the value of 0.2 per unit and this swell values are mitigated by using UPQC and DPFC. The results for both swell condition and mitigation of swell are shown in figure 8 and 9.

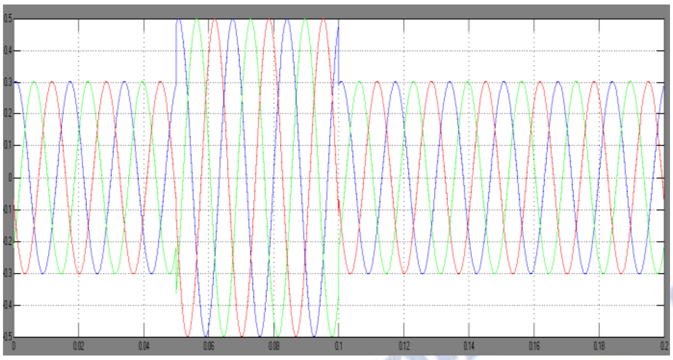

Fig 10: Simulation results for current swell condition

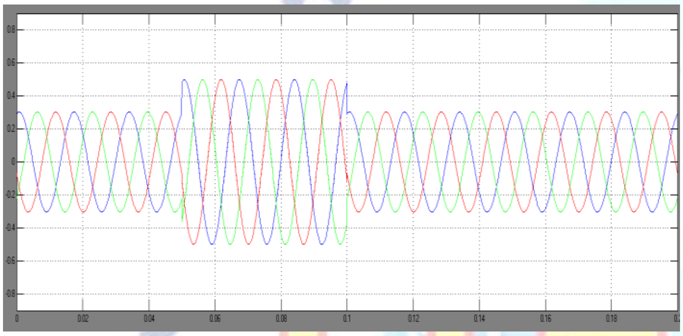

Fig 11: Simulation results for mitigation of current swell.

This paper is also includes comparison of THD values in case of UPQC and DPFC techniques. The THD value obtained in case of UPQC is 7.53% and the THD value obtained in case of DPFC is 5.02%.

CONCLUSION

In this paper a new concept of controlling power quality problems by DPFC controller. The simulation results for sag and swell mitigations are observed in case of both DPFC and UPQC. Out of these two methods the DPFC has good THD value as compared with UPQC. Therefore, the obtained simulation results by DPFC show the effectiveness of power quality enhancement as compared with all other FACTS devices.

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