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Performance Investigation of Series Part of UPQC

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ABSTRACT

This paper presents a new Unified Power Quality Conditioner for enhancement of power quality. The proposed UPQC system can improve the power quality at the point of common coupling on power distribution systems under unbalanced and distorted load conditions. The main problem in the power distribution system is voltage sag, voltage swell and harmonics, to compensate these problems we are using in this project a power electronic device i.e., UPQC (Unified power quality conditioner).UPQC is a flexible ac transmission system. It is combination of series and shunt converters. Computer simulation by MATLAB/ SIMULINK has been used to support the UVTG controller based control method presented in this paper.

KEYWORDS

Active power filter (APF), Power quality (PQ), Unified Power Quality Conditioner (UPQC), Voltage sag and swell, current harmonics compensation, Unit Vector Template Generation (UVTG).

1. INTRODUCTION

The term Power Quality are most important part of any power delivery system today .Because of low quality power it affects electricity consumers in many ways. Also the lack of quality power can cause loss of production, increased power losses, interference with communication lines, and damage of equipment or appliances. The main aim of electricity companies is to provide supply uninterrupted sinusoidal voltage of constant magnitude to their customers. Custom power devices are used to improve the quality of power. The thought of custom power is first explained by Hingorani in1995 [7]. Here are the number of custom power units which are Distribution Statcom (D-STATCOM), Dynamic Voltage Restorer (DVR), Unified power quality conditioner (UPQC), Active Power Filters etc. Also for that reason we use the power electronics based equipment which are widely use now a days, has produced a significant impact on quality of electric power supply by generating harmonics in voltages and currents. One of the most common power quality problems today is voltage dips. Voltage sag is a small time (10 ms to 1 minute) duration event which is nothing but the reduction in r.m.s. voltage magnitude occurs. Voltage sag is set only by two parameters, magnitude and duration. The range of magnitude of voltage sag is from 10% to90% of nominal voltage .Therefore, it is very important to maintain a high standard of power quality .For Conventional power quality mitigation we use passive elements and do not always respond correctly as nature of power system condition change. Also the term active power filter (APF) is a widely used terminology in the area of power quality improvement. In that there is one modern solution that deals with both load current and supply voltage problems is the UPQC.

To improve power quality of electrical distribution system many researchers was studied the eventual method i.e. Unified power quality control [1]. The function of unified power quality conditioner is to compensate supply voltage flicker/imbalance, reactive power, negative-sequence current, and harmonics. In other words, the UPQC has the capability of improving power quality at the point of common coupling on power distribution systems or industrial power systems. So that the UPQC is expected to be one of the most powerful solutions to large capacity loads sensitive to supply voltage flicker/imbalance [7]. The UPQC is nothing but the combination of a series active power filter (APF) and shunt APF.It can also compensate the voltage interruption if it has some energy storage or battery in the dc link [6].The shunt APF is usually connected across the loads to compensate reactive power

2. LITERATURE SURVEY

Today power quality has become the most important factor for both power suppliers and customers due to the deregulation of the electric power energy market. Efforts are being made to improve the power quality. The acceptable values of harmonic contamination are specified in IEEE standard in terms of total harmonic distortion. The concept of custom power was introduced by **N.G.Hingorani** [8]. Power electronic valves are the basis of those custom power devices such as the state transfer switch (STS), active filters and converter based devices [9]. The active filter technology is now mature for providing compensation for harmonics, reactive power, and/or neutral current in ac networks. Active filters are also used to regulate terminal voltage, suppress voltage flicker, eliminate voltage harmonics and improve voltage balance in three-phase systems. The active filter technology is used to provide compensation for harmonics, reactive power, and/or neutral current in ac networks. Active filters are also used to regulate terminal voltage, suppress voltage flicker, eliminate voltage harmonics and improve voltage balance in three-phase systems.[4] This is also can be used as individually or in combination, depending upon the requirements and control strategy and configuration. **Bhim Singh** et al. [4] suggested a simple control algorithm for the dynamic voltage restorer (DVR).Which is used to mitigate the power quality problems in terminal voltage. Two PI controllers are used each to regulate the dc bus voltage of DVR and the load terminal voltage respectively. The fundamental component of the terminal voltage is extracted by using the synchronous reference frame theory and control signal for the DVR is obtained indirectly from the extracted reference load terminal voltage.

V.Khadkikar et al. [2] proposed a control technique for Unified Power Quality Conditioner (UPQC).It is a combination of series APF and shunt APF. A control strategy based on unit vector template generation (UVTG) is discussed in this paper. Which focused on the mitigation of voltage harmonics present in the utility voltage. In [10] the authors present the steady state analysis of unified power quality conditioner (UPQC). The analysis is based on active and reactive power flow through the shunt and series APF .The series APF can absorb or deliver the active power whereas the reactive power requirement is totally handle by shunt APF. The relationship between source current and percentage of sag/swell variation shows shunt APF playing an important role in maintaining the overall power balance in the entire network. The digital simulation is carried out to verify the analysis done. . This analysis can be very useful for selection of device ratings for both shunt and series APFs.

Metin Kesler et al. [7] suggested a new control method to compensate the power quality problems through a three-phase unified power quality conditioner (UPQC). Under unbalanced load conditions. The performance of proposed control System was analyzed. The UPQC system can improve the power quality at the point of common coupling (PCC) on power distribution system under unbalanced load conditions.

Shazly A. Mohammed et al. [11] describes the DVR, its functions, configurations, components, operating modes, voltage injection methods and closed-loop control of the DVR output voltage along with the device capabilities and limitations.

S. R. Naidu et al. [12] described a software phase-locked loop (SPLL) for custom power devices. The phase angle and frequency of the estimated positive sequence component are tracked. Performance of a dynamic voltage restorer incorporating the proposed phase locked loop (PLL) has been presented under unbalanced and distorted utility conditions.

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3. UNIFIED POWER QUALITY CONDITIONER

Fig.(1) shows a basic system configuration of a general UPQC. Unified Power Quality Conditioner is a multifunction power conditioner that can be used to compensate various voltage disturbance of the power supply, to prevent harmonic load current from entering the power system and to correct voltage fluctuation. It is nothing but a custom power device which is designed to mitigate the disturbances that affect the performance of sensitive and/or critical loads. It consisting of the combination of a series active power filter and shunt active power filter.

UPQC consists of two voltage-source inverters with a common dc link designed in single-phase, three-phase three-wire, or three phase four-wire configurations. One inverter is controlled as a variable voltage source in the series active power filter (APF) and the other inverter is controlled as a variable current source in the shunt active power filter (APF). The series APF can compensates the voltage supply problems (e.g., including harmonics, imbalances, negative and zero sequence components, sag, swell, and flickers). The shunt APF, it can compensates for load current distortions (e.g., caused by harmonics, imbalances) and reactive power, and perform the dc link voltage regulation. The aim of the series active power filter is to isolate harmonics between a sub-transmission system and a distribution system, it has the capability of voltage flicker/ imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer point of common coupling (PCC). The aim of shunt active power filter is to absorb current harmonics, which compensate for reactive power and negative-sequence current, and also regulate the dc-link voltage between both active power filters.

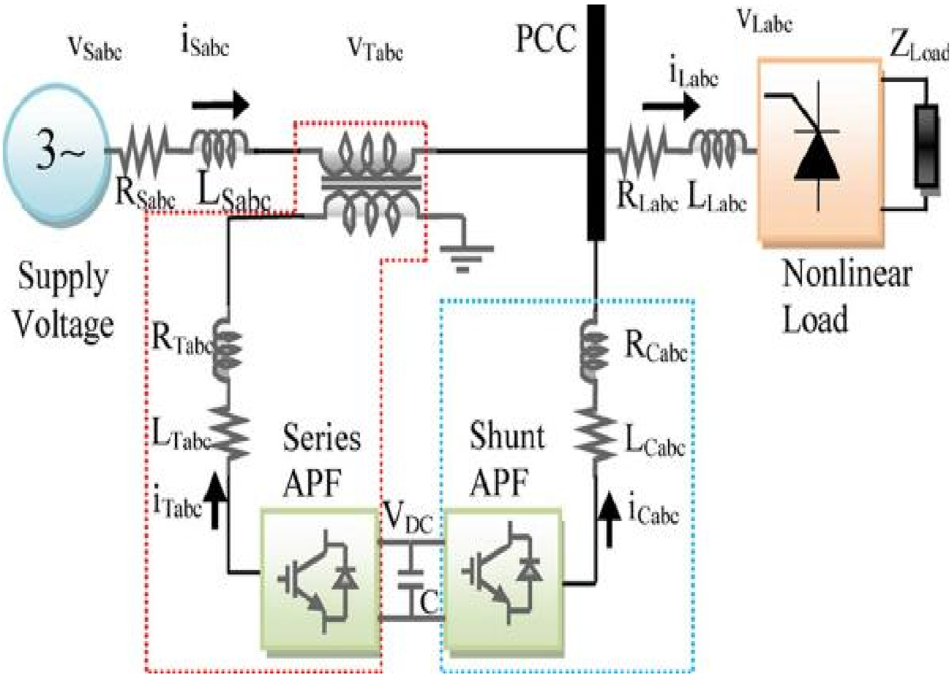

Figure 1 Basic Configuration of UPQC

Figure (1). Shows the basic configuration of the UPQC. The UPQC has two distinct parts:

- Power circuit formed by series and shunt PWM converters.
- UPQC controller

The series PWM converter of the UPQC acts as a controlled voltage source, that is, it behaves as a series APF and the shunt PWM converter acts as a controlled current source, as a shunt APF. No power supply is connected at the DC link. It contains only a relatively small DC capacitor as a small energy storage element.

4. BASIC CONFIGURATION OF SERIES APF

UPQC is the combination of series and shunt APFs for simultaneous compensation of voltage and current. The series APF inserts a voltage, which is added at the point of common coupling (PCC). Such that the load end voltage remains unaffected by any voltage disturbance. The series active power filter can compensate the supply voltage related problems by injecting voltage in series with line to get distortion free voltage at the load end. The series inverter of the UPQC can be represented by following equation:

Vinj (ωt) = VL (ωt) – VS (ωt) ……. (1)

Where,

Vinj(ωt) = series inverter voltage

VL(ωt) = load voltage

VS(ωt) = actual source voltage.

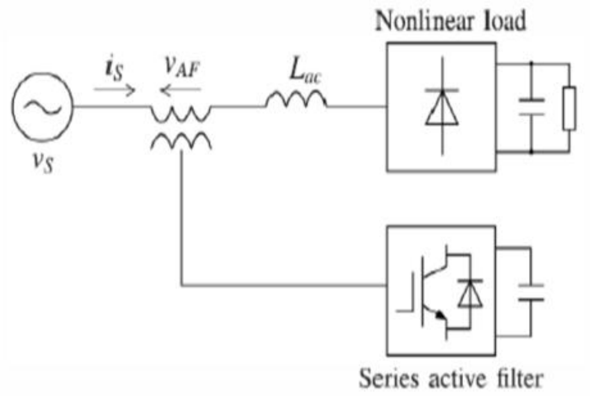

Figure 2 Basic Configuration of Series APF

5. PROPOSED CONTROL STRATEGY OF SERIES APF

There are various types of control techniques which are used in series active power filter. From that we use UVTG technique in this paper, to control the series active power filter [6]. Figure (3) shows the reference voltage signal generation for series active power filter. In this the phased locked loop (PLL) is used to achieve synchronization with supply voltage. By using unit vector template generation (UVTG) the extraction of three-phase voltage reference signal for series active power filter is achieved.

By using phased locked loop (PLL) is given by equation (2):

Ua = sin(ωt)

Ub = sin(ωt - 120º)

Uc = sin(ωt + 120º) ….….(2)

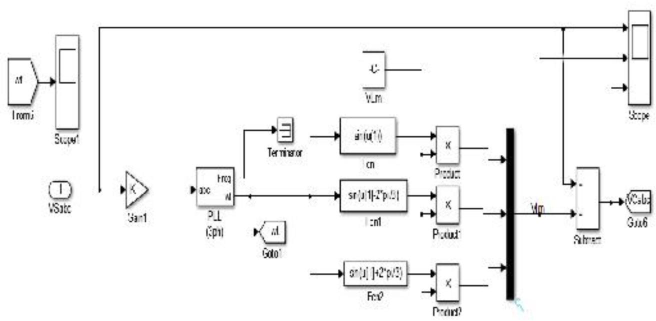

Figure 3 Control Scheme of Series APF

Then the computed three in-phase unit vectors are multiplied with the desired peak value of the PCC phase voltage (V*lm), after that which becomes the three-phase reference load voltages as from equation:

[VLabc*] = [VLm*] [Uabc] .... (3)

According to equation (3) the load voltage must be equal to the computed reference voltages so that we get distortion less load voltage .To generate injected voltages, supply voltage signals are compared with these reference signals and these signals are then given to the hysteresis controller along with the sensed series APF output voltages. The figure of hysteresis controller for series APF is shown below.

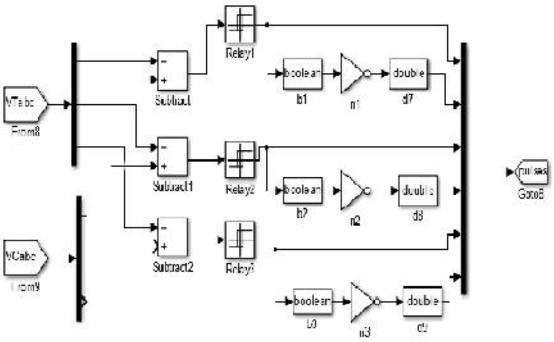

Figure 4 Hysteresis controller

The output of the hysteresis controller controls the six switches of the VSI of the series APF. The hysteresis controller generates the switching signals such that the voltage at the load becomes the desired sinusoidal reference voltage. Therefore, the injected voltage across the series transformer through the ripple filter cancels out the harmonics and unbalance present in the supply voltage.

6. SIMULATION DIAGRAM OF SERIES APF

The series active filter shown in figure (4).It is a voltage controlled voltage source inverter (VSI), which is connected in series with series injection transformer. Series active power filters are used to compensate the voltage related problems.

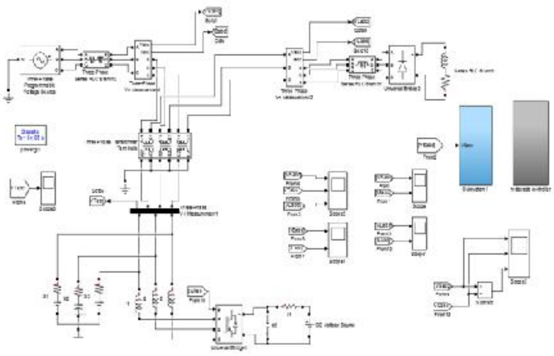

Figure 5 the series APF Simulink model

7. SIMULATION RESULTS

In the given proposed control technique, the series APF has been simulated using Simpower system block which is set in MATLAB/SIMULINK[6].The figure(6),(7) and (8) shows the result for voltage sag voltage swell and the condition for voltage sag and swell. Simulation results for series active power filter are obtained by applying parameter and values shown in TABLE-1.

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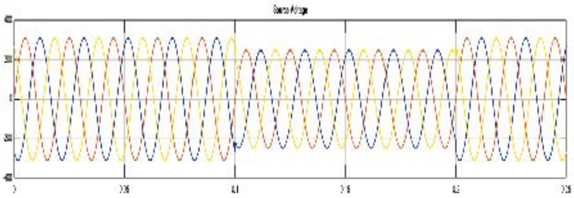
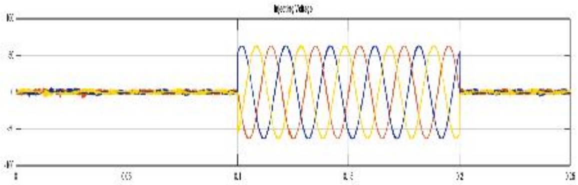
(a)SOURCE VOLTAGE



(b)INJECTING VOLTAGE



(C)LOAD VOLTAGE

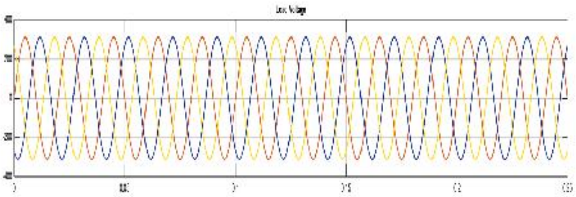
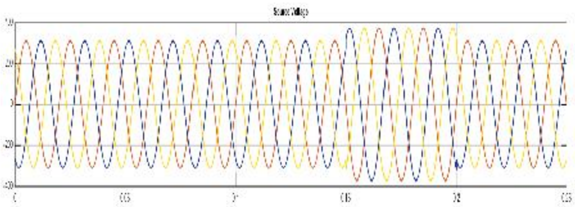
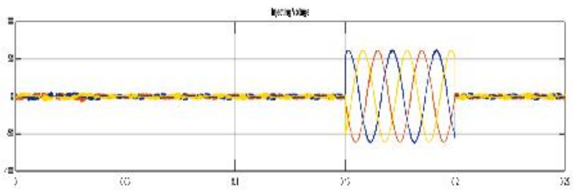


Figure 6 Simulation results for voltage sag

(a)SOURCE VOLTAGE



(b)INJECTING VOLTAGE



(c)LOAD VOLTAGE

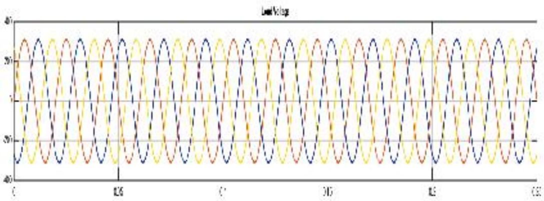


Figure 7 Simulation results for voltage swell

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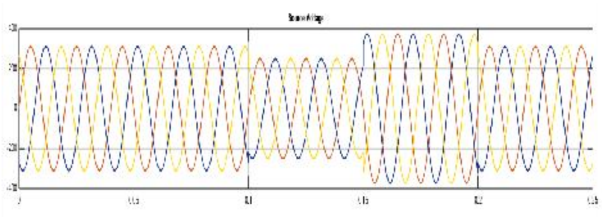
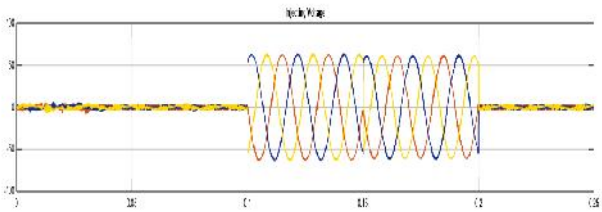
(a)SOURCE VOLTAGE



(b)INJECTING VOLTAGE



(c)LOAD VOLTAGE

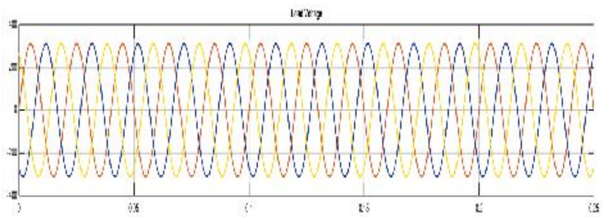


Figure 8 Simulation results for both voltage sag

TABLE-1: Various Parameter Applied to Series Active Power Filter.

System Parameter	Value
Ac voltage supply	380 V
Line Frequency	50Hz
Series Transformer	50KVA 1:1 Turns ratio
DC voltage	700V
Voltage sag	20%
Voltage swell	20%
Load(Diode rectifier with RL load)	R=30Ω L=10Mh
Series LPF	Lse=25mH Rse=5 Ω

8. CONCLUSION

In this paper, a Unified Power Quality Conditioner has been investigated for power quality enhancement. Unified power quality conditioner is an advanced hybrid filter that consists of a series active filter (APF) which can compensate voltage disturbances and shunt active power filter (APF) for eliminating current harmonics and distortion. This paper presents control technique based on unit vector template generation (UVTG) for series APF. A Simulink model has been prepared and simulation results shows that the voltage sag & swell can be compensated by proposed control strategy. During voltage sag and swell conditions the

load voltage waveforms are constant, this is verified by taking 20% voltage sag & swell. The instantaneous reactive power theory is used for shunt APF control algorithm by measuring mains voltage and currents. The conventional methods require measurements of the load, source and filter voltages and currents. In the simulation results it shows that, when unbalanced and nonlinear load current or unbalanced and distorted mains voltage conditions occur the above control algorithms eliminate the impact of distortion and unbalance of load current on the power line, making the power factor unity.

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