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A Survey Report on Power Quality Improvement by using UPQC in a system

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Abstract — **The electronics equipments have been proved their numerous value of the power system but in the system have also one disadvantage of affecting the power quality by injecting harmonics into the system or by drawing excessive amount of reactive power. It has been always difficult to maintain the quality of electric power so as to keep it within the acceptable limits. The shunt active filter is mainly advantageous in removing the current related problems and the improvement of power factor and regulation of DC link voltage. So that the Unified power quality Conditioner (UPQC) has emerged as one of the best solutions in order to mitigate the power quality problem. UPQC is a combination of back to back connected series and shunt APFs through a common DC link voltage, the two APFs function differently. Whereas in the report have been the series APF helps in correction of voltage related problems such as voltage sag or swell by acting as a controlled voltage source. The voltage that is injected in series with the load by series Active Power filter is made to follow a control method which results in a sinusoidal load voltage that is the sum of the voltage injected by the series inverter and the input voltage of the power system.**

Index Terms - **conditioner (UPQC, Active power filter (APF), p-q theory, harmonics, power quality (PQ), unified power quality).**

I. INTRODUCTION

Power quality problems have received a great attention now a day because of their bad economical impacts on both utilities and customers. Low power quality affects electricity consumer in many ways. The lack of power quality can cause loss of production, damage of equipment or appliances. From the customer perspective, a power quality problem is defined as any power problem manifested in voltage, current, or frequency deviations that result in power failure or disoperation of customer of equipment.

One modern and very promising solution that deals with both load current and supply voltage imperfections is the Unified Power Quality Conditioner (UPQC) [1]. The UPQC is able to compensate supply voltage power quality issues such as, sags, swells, unbalance, flicker, harmonics, and for load current power quality problems such as, harmonics, unbalance and reactive current. The quality of the Electrical power is affected by many factors like harmonic contamination, due to non-linear loads, such as large thruster power converters, rectifiers, voltage and current flickering due to arc in arc furnaces, sag and swell due to the switching of the loads etc. This device combines a shunt active filter together with a series active filter in a back to back configuration, to simultaneously compensate the supply voltage and the load current or to mitigate any type of voltage and current fluctuations and power factor correction in a power distribution network [2]. In other words, the UPQC has the capability of dealing with electrical pollutant at the point of common coupling in power distribution system. Controlling methods has the most significant role in any power electronics based system. It is the control strategy which decides the efficiency of a particular system. The efficiency of a good UPQC system solely depends upon its various used controlling method.

In this paper, the proposed control method for the UPQC is optimized so that system performance is improved. This paper presents, a simplified instantaneous reactive power or p-q theory based control techniques applied to compensate power quality (PQ) problems by using UPQC. The proposed control technique has been evaluated & tested using MATLAB/SIMULINK software with and without UPQC.

II. GENERALIZED UPQC SYSTEM

At distribution level UPQC is the most attractive solution to compensating many power Quality problems. The UPQC is one of the APF family members where shunt and series APF functionalities are integrated together to achieve superior control over several power quality problems simultaneously. The term active power filter (APF) is a widely used in the area of electric power quality improvement. APF have the ability to mitigate some of the major power quality problems effectively.

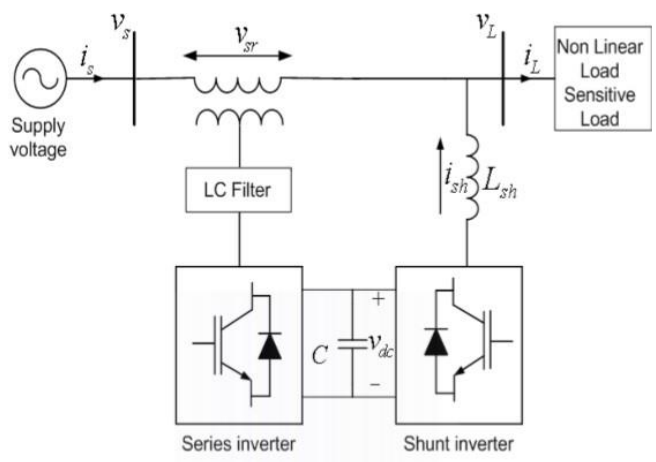

Fig.1 Generalized block diagram of UPQC system

The Series active filter and shunt active filter compensate the power quality problems of the source voltages and load currents, respectively and UPQC system shown in fig.1 is a combination of a series active power filters and shunt active power filter in cascade via a common DC link capacitor.

The series component of the UPQC is responsible for mitigation of supply side disturbances such as voltage sag/swells, flicker, voltage unbalance and harmonics. The shunt component is responsible for mitigating the current quality problem such as poor power factor, harmonics in the load current and load unbalance. No power supply is connected at the DC link. It contains only a relatively small DC capacitor as a small energy storage element [3]. 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, whereas, the shunt APF is most suitable to compensate for load reactive power demand and unbalance, to eliminate the harmonics from supply current, and to regulate the common DC link voltage. The series converter of the UPQC behaves as a controlled voltage source, that is, it behaves as a series APF, whereas the shunt converter behaves as a controlled current source, as a shunt APF.

The integrated controller of the series and shunt APF of the UPQC to provide the compensating voltage reference v_{sr} and compensating current reference i_{sh} to be synthesized by converters. The current i_L represents all nonlinear loads that should be compensated. The shunt active power filter of UPQC can compensate all undesirable current components including harmonics imbalances due to negative and zero sequence components at the fundamental frequency and the load reactive power as well. The same kind of compensation can be performed by series active power filter for the supply voltage as well. Additionally, the shunt active power filter has to provide the dc link voltage regulation absorbing or injecting energy from or into the power distribution system to cover losses in both the converters [4].

III. CONTROL STRATEGIES OFUPQC

Reference and Control signal generation plays important role in UPQC system as strategy is decided on that behalf. The implementation of control strategy of UPQC involves the derivation of compensating commands in terms of voltage and current levels and the gating signals for semiconductor switches of UPQC are generated using PWM, hysteresis or fuzzy logic based control techniques. In the first stage voltage signals are sensed using voltage sensor and current signals are sensed using current sensor. In second stage derivation of compensating commands involves Frequency domain methods and Time domain methods. Frequency domain methods, which, is based on the Fast Fourier Transform (FFT) of distorted voltage or current signals to extract compensating commands. This FFT are not popular because of large computation, time and delay.

Control methods of UPQC in time-domain are based on instantaneous derivation of compensating commands in form of either voltage or current signals. There are mainly two widely used time domain control techniques of UPQC are the instantaneous active and reactive power or p-q theory and Synchronous reference frame method or d-q theory. In p-q theory instantaneous active and reactive powers are computed, while, the d-q theory deals with the current independent of the supply voltage. Both methods transforms voltages and currents from abc frame to stationary reference frame (p-q theory) or synchronously rotating frame (d-q theory) to separate the fundamental and harmonic quantities. In third stage the gating signals for the Voltage Source Converters of UPQC derived based on compensating commands in terms of voltage or current. Then, these compensating commands are given to PWM, hysteresis or fuzzy logic based control techniques. In this paper, the focus is on implementing the p-q theory, as it is simpler to implement. PI controller along with Pulse Width Modulation techniques is used to generate the switching signals with hysteresis controller to limit the amount of current excursion [5].

IV. THE PROPOSED UPQC CONTROLALGORITHM

The *p-q Theory* is based on the ab0 transformation, also known as the *Clarke Transformation*, which consists in a real matrix to transform three-phase voltages and currents into the ab0 stationary reference frame, given by:

$$\begin{bmatrix} V_0 \\ V_\alpha \\ V_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} \quad (1)$$

The inverse transformation is given by:

$$\begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \frac{1}{\sqrt{2}} & 1 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & \frac{\sqrt{3}}{2} \\ \frac{1}{\sqrt{2}} & -\frac{1}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} V_0 \\ V_\alpha \\ V_\beta \end{bmatrix} \quad (2)$$

Similarly, generic instantaneous three-phase line currents (i_a, i_b, i_c) can be transformed into ab0axis.

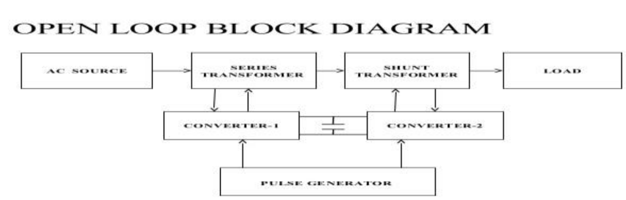

Fig.- 2 : block representation of UPQC on inverters.

One advantage ofapplying the ab0 transformation is the separation of zero- sequence components into the zero-sequence axis. Naturally, the a- and b-axis do not have any contribution from zero- sequence components. If the three-phase system has three wires (no neutral conductor), no zero-sequence current components are present and i_0 can be eliminated in the above equations, simplifying them. The present analysis will be focused on three-wire systems. Therefore, zero-sequence voltage or current is not present [13] [14]. In this situation the real and imaginary powers are given by:

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix}. \quad (3)$$

where, p is the real power and represents the total energy flow per time unity in the three-wire three-phase system in terms of abc components; q is the imaginary power and has a non-traditional physical meaning and gives the measure of the quantity of current or power that flows in each phase without transporting energy at any instant. The simulation diagram of p-q implementation is as shown in Fig.2

Proportional- Integral (PI) Control is important to increase the speed of the response and also to eliminate the steady state error. The PID controller block is reduced to P and I blocks only as shown in figure.

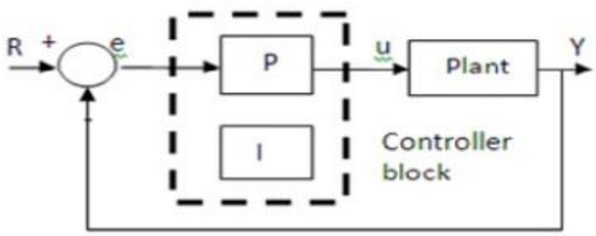

Fig.3 Block diagram of PI Controller

Proportional Integral (PI) Controller block diagram the proportional and integral terms is given by: $K_p$and $K_I$are adjusted to obtain the desired output. Hysteresis control is used to limit the amount of current excursion [6] [7]. With the hysteresis control, limit bands are set on either side of a signal representing the desired output waveform .The inverter switches are operated as the generated signals within limits. The control circuit generates the sine reference signal wave of desired magnitude and frequency, and it is compared with the actual signal. The actual signal wave is thus forced to track the sine reference wave within the hysteresis band limits [8] [9].

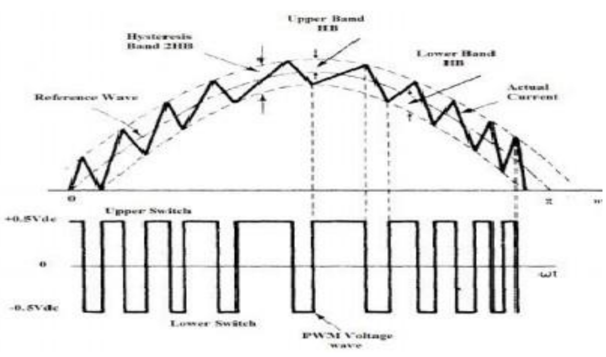

Fig.4 Basic hysteresis Control

V. SIMULATION DIAGRAM ANDRESULTS

In this paper, the simplified control algorithm for UPQC is evaluated by using simulation results given in MATLAB/Simulink software. In simulation studies, the result are specified before and after UPQC system is operated. The proposed control algorithm has considerably good simulation results as compared the conventional control algorithms. The simulation results shows an improvement in various voltages as well as currents on load and source side.

VI CONCLUSION

In this paper, a Unified Power Quality Conditioner (UPQC) has been investigated for power quality enhancement. UPQC is installed to compensate the different power quality problem which may play important role in future UPQC-based distribution system. The modelling of series APF, shunt APF and UPQC has been carried out. The proposed control method synchronous reference frame (SRF) theory has been used to model series APF and instantaneous reactive power (p-q) theory has been used to model shunt APF. The performance of the proposed control method for UPQC system was verified through simulations with MATLAB/Simulink software.
Results wave:-

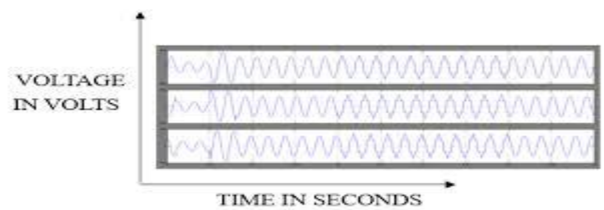

Fig:5 - UPQC for power quality improvements

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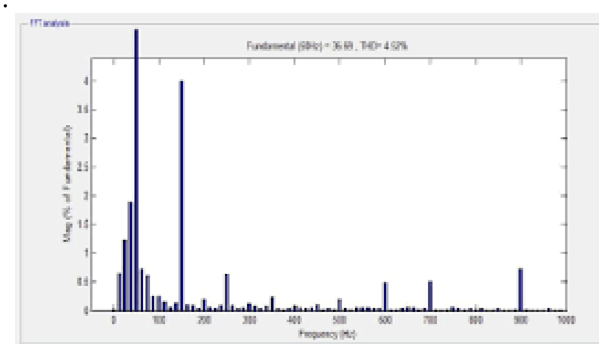

Fig:6 - UPQC based on modular multilevel inverter.

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