International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume-3, Issue-12, December 2015

Generalized UPQC system with an improve Voltage and Current under Distorted and Unbalanced Load Conditions

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***Abstract*— Poor quality of power is the major issue on the distribution side because the nonlinear load is affected to the load as well as source voltage and current. Now days the power quality is very essential so to improve the voltage and current of the distribution line. This paper deals with to improve the load and source voltage and current using a Unified Power Quality Conditioner (UPQC). A synchronous reference base theory is used for series APF as a d-q-o theory is used and to control shunt APF Clark transformation are applied. The dc voltage control using the PI controller. To use a mitigate the unbalance load voltage, source current, harmonics with reactive power compassion. The simulation results based on MATLAB/Simulink program are presented to show the effectiveness of the proposed UPQC on distribution system.**

***Index Terms*— Series Active power filter (SAPF), Shunt Active power filter (SAPF), unified power quality conditioner (UPQC).**

I. INTRODUCTION

In recent years active methods for power quality control have become more attractive compared with passive ones due to their fast response, smaller size, and higher performance. Active Power Filters (APF) have the ability of current harmonics suppression and power factor correction some active circuits were developed to compensate unbalanced currents as well as limit the neutral current. In general, parallel-connected converters have the ability to improve the current quality while the series-connected regulators inserted between the load and the supply, improve the voltage quality. For voltage and current quality control, both series and shunt converters are necessary, which is known as Unified Power Quality Conditioner (UPQC) with connect a common dc link.

In this paper proposed control for the UPQC system is optimized source voltage, load voltage, source voltage, and source current are measured, evaluated, and tested under unbalanced and distorted load conditions using Mat lab/Simulink software [2].

II. GENERAL UPQC

UPQC consist of series and shunt APFs for simultaneous compensation of voltage and current. It is used for mitigate a sag, swell, flickers, eliminates voltage and current harmonics, reactive power compensation etc, [2],[9]. The series active filter has capability of voltage compensation as well as voltage regulation. The main function of the shunt active filter is to absorb current harmonics, reactive power compensation. The series and shunt active filter are connected with a common dc link.

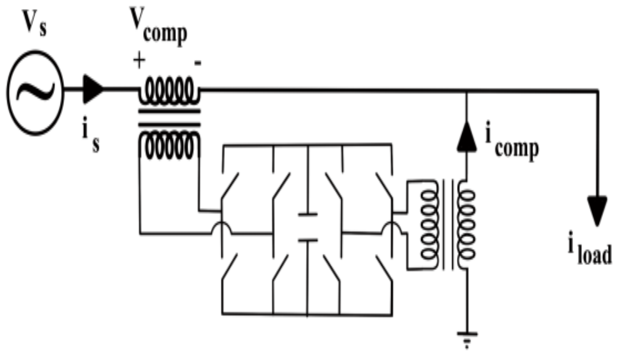

Fig. 1 General UPQC

III. SERIES ACTIVE FILTER CONTROL STRATEGY

A simple control method is developed to control the series active filter [2]. The proposed series APF reference voltage signal generation algorithm is shown in Fig.(2). In equation (2) supply voltages V_{abc} are transformed to d-q-0 coordinates. The theta (θ) is defined by the angle between phase A to the d-axis .

$$\begin{bmatrix} v_d \\ v_q \\ v_0 \end{bmatrix} = [T] \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \qquad (1)$$

$$\begin{bmatrix} v_d \\ v_q \\ v_0 \end{bmatrix} = \begin{bmatrix} \cos(\theta) & \cos(\theta - \frac{2\pi}{3}) & 1 \\ \sin(\theta) & \sin(\theta - \frac{2\pi}{3}) & 1 \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \qquad (2)$$

Where,

T is the transformation metrics, v_a, v_b, v_c are instantaneous source voltage of phase A, B and C respectively and v_d, v_q, v_0 are d-axis ,q-axis, 0-axis component of reference frame respectively.

The load side reference voltages are V^*_{Labc} are calculated as given equation(4). The switching signal are assessed by comparing reference voltages and the load voltages V_{Labc} and via PWM controller. PLL conversion is used for reference voltage calculation. The load reference voltage V_{labc} are calculated by using

$$\begin{bmatrix} v_{La} \\ v_{Lb} \\ v_{Lc} \end{bmatrix} = T^t \begin{bmatrix} 0 \\ v_{sd} \\ 0 \end{bmatrix} \qquad (3)$$

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$$\begin{bmatrix} v^*_{La} \\ v^*_{Lb} \\ v^*_{Lc} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \sin(\theta) & \cos(\theta) & 1 \\ \sin(\theta - \frac{2\pi}{3}) & \cos(\theta - \frac{2\pi}{3}) & 1 \\ \sin(\theta + \frac{2\pi}{3}) & \cos(\theta + \frac{2\pi}{3}) & \frac{1}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad (4)$$

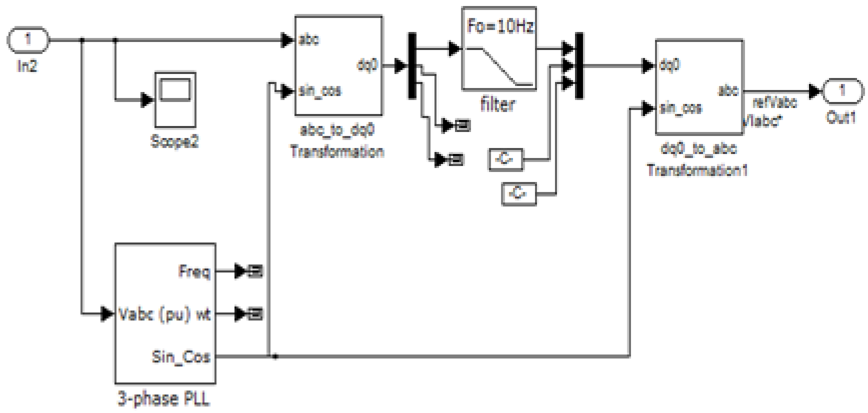

Fig. 2 dq0 method for series APF.

IV. Control of Shunt APF

The shunt APF described in this paper used to compensate the current harmonics and reactive power generated by the non linear load. The reference current signal generation block diagram is done by using Clark transformation. The shunt APF is work on the generalized theory of instantaneous reactive power theory in three phase circuit also known as instantaneous power theory of p-q theory. The p-q active(p) and reactive (q) theory consist of an algebraic transformation of the three phase voltage and current in abc coordinated to α-β-0 coordinates. In instantaneous power theory the instantaneous three phase voltage and current are calculated as give following equations (5),(6).

$$\begin{bmatrix} v_0 \\ v_\alpha \\ v_\beta \end{bmatrix} = \frac{\sqrt{2}}{3} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad (5)$$

$$\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} = \frac{\sqrt{2}}{3} \begin{bmatrix} \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad (6)$$

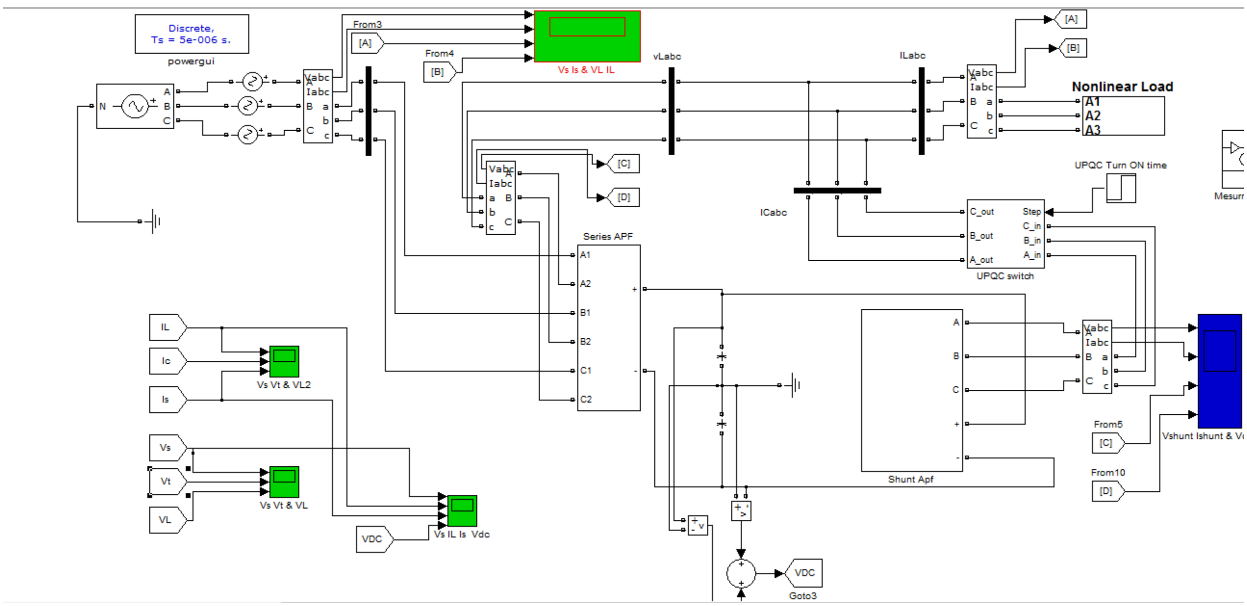

Fig. 3. UPQC system

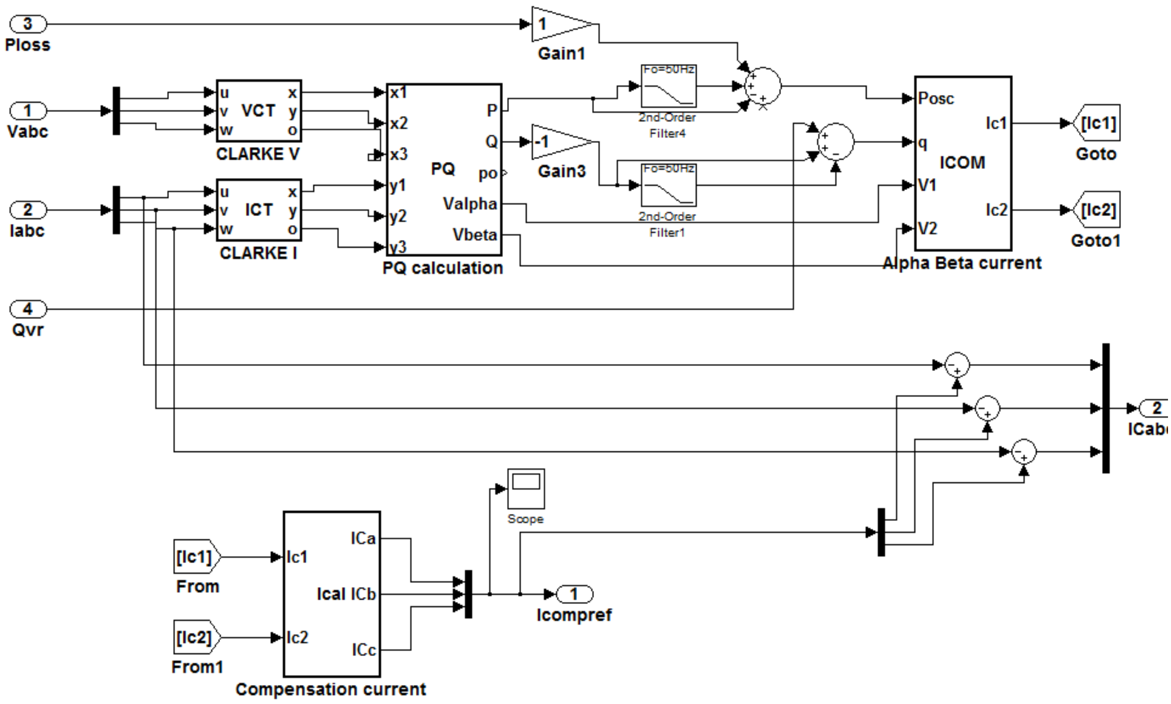

Fig.4 Shunt APF control block diagram

The instantaneous active and reactive power in α-β-0 coordinates are calculated with the following expression.

$p_0=V_0I_0$ (7)

$p= V_\alpha I_\alpha + V_\beta I_\beta$ (8)

$q= V_\alpha I_\alpha - V_\beta I_\beta$ (9)

the power components p and q are related to the same α-β voltage and current.

$$\begin{bmatrix} p \\ q \end{bmatrix} = \begin{bmatrix} v_\alpha & v_\beta \\ -v_\beta & v_\alpha \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix} \quad (10)$$

$V_\alpha I_\alpha$ and $V_\beta I_\beta$ are instantaneous real and imaginary powers respectively. The objective to the proposed theory is to make the source to deliver the constant active power demand by the load.

The shunt APF compensate the current harmonics, the reactive power and regulate dc link capacitor voltage.

$$\begin{bmatrix} i_{c\alpha^*} \\ i_{c\beta^*} \end{bmatrix} = \frac{1}{U} \begin{bmatrix} v_{s\alpha} & v_{s\beta} \\ v_{s\beta} & -v_{s\alpha} \end{bmatrix} \begin{bmatrix} -p + P_{loss} \\ -q \end{bmatrix} \quad (11)$$

Where $U = V_{s\alpha}^2 + V_{s\beta}^2$

The above equation is Shunt control calculated reference value of compensating current for harmonics current and load reactive power.

V. PI CONTROLLER

The control scheme consist of PI controller the peak value of reference current is estimated by regulating dc link voltage. The actual voltage across the capacitor is compare with the set reference value. The output of the PI controller is considered as peak value of supply current (Im). Which is compare with actual active power component of the load current and loss component of APF to maintain the average capacitor value to the constant value. The maximum current value is multiplied by the unit sine vector in phase with the respective source voltage to obtain the reference compensating current. These estimated reference current séances actual currents are compared at a hysteresis band.

VI. RESULT AND CONCLUSION

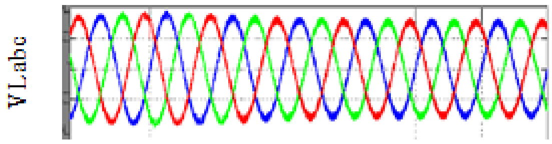

Fig 5 Load voltage

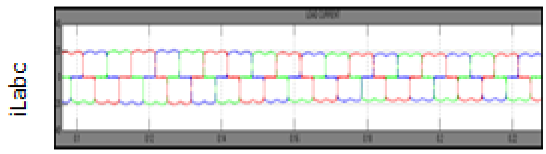

Fig. 6 Load Current

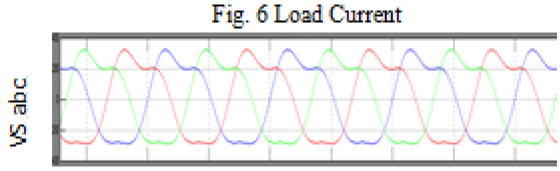

Fig.7 Unbalanced and distorted mains voltage

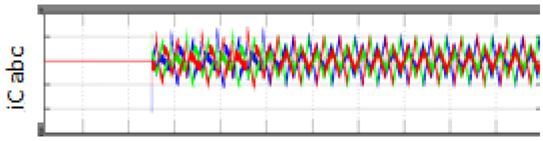

Fig.8 injected Compensator current

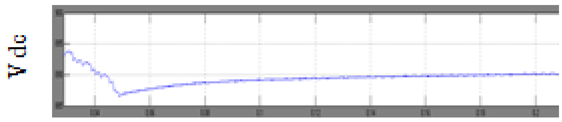

Fig. 9 dc link Voltage

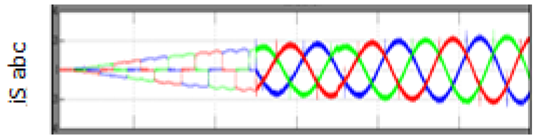

Fig.10 Source current

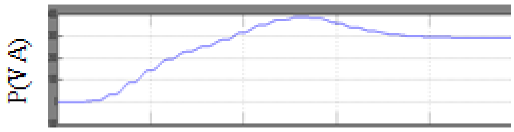

Fig.11 Instantaneous active power

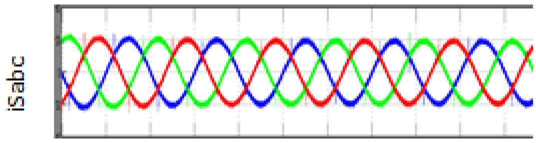

Fig.12 Source current

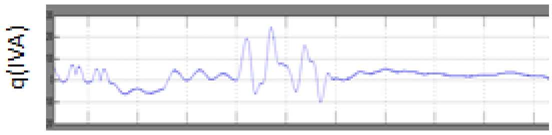

Fig.13 Instantaneous reactive power

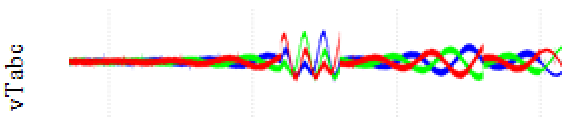

Fig 14 injected Transformer voltage

This paper describe a new control strategy use in UPQC system, which mainly compensate under non ideal mains voltage and unbalanced load current conditions. The proposed control strategy use only loads and mains voltage Measurement for series APF based as synchronous reference frame based theory .the p-q-0 theory is used for shunt APF control algorithm by measuring mains voltage and currents. This method is required to measurement of the sources ,load and filter voltages and currents.

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