Moderation of Power Quality By Unified Power Quality Conditioner (UPQC) Using PQ Theory

K.S.Sri Kanth *, ** Indranil Saaki *** Musthak Ahmed Shaik
*Professor, Department Of EEE, KL University, Guntur Dis, AP, INDIA.
**Assistant Professor, Department Of R&D, Global e-Smart Technologies, Visakhapatnam, AP, INDIA.
***Assistant Professor, Department Of EEE, KL University, Vijayawada, AP, INDIA.

Abstract— *Majority of the distributed generations from renewable energy sources are connected to the grid through power electronic interface, which introduce additional harmonics in the distribution systems. Research is being carried out to integrate active filtering that is the combination of series APF and shunt APF connected back to back on the dc side and share a common dc-link capacitor with specific interface such that a common power quality (PQ) platform could be achieved. For generalized solution, a unified power quality conditioner (UPQC) could be the most comprehensive PQ protecting device for sensitive non-linear loads and Unbalanced, which require quality input supply. Also, load current harmonic isolation needs to be ensured for maintaining the quality of the supply current.*

The present paper describes a review for UPQC, for enhancing PQ of sensitive non-linear loads. Based on voltage compensation strategy, the control scheme has been designed, which are termed as UPQC with. A s the power circuit configuration of UPQC remains same for the model, with modification of control scheme only, the utility of UPQC can be optimized depending upon the application requirement.

This paper presents a review on the UPQC to improve the electric power quality at distribution levels. Therefore, power can be transferred from one feeder to adjacent feeders to compensate for sag/swell and interruption. The performance of the UPQC as well as the adopted control algorithm is illustrated by simulation. The present work study the compensation principle and different control strategies used here are based on PI Controller of the UPQC in detail. The results obtained in MATLAB on feeder system show the effectiveness of the proposed configuration.

Index Terms— **Active power filter (APF), harmonic compensation, power quality, reactive power compensation, unified power quality conditioner (UPQC), Proportional Integrator (PI) ,voltage sag and swell compensation.**

I. INTRODUCTION

Distributed generation (DG) systems have both advantages and disadvantages in relation to grid power quality (PQ). They can increase the efficiency of systems by local power generation. More reliable and uninterrupted power can be provided to customers, with energy cost savings. Worldwide DG penetration in the grid is on the rising. Deregulation of electricity market may contribute to rising penetration level of DG from renewable energy sources (wind, solar, biomass, etc.) in the near future [4]. From the perspective of environmental protection, DG from renewable energy sources is of great importance, as they minimize harmful emissions. As most of the DG systems are interfaced to the grid through power electronic interface, hence injection of additional higher frequency harmonics in the system is obvious. Therefore, additional grid integration problems are equally worrying from electrical pollution point of view if not attended properly. Furthermore, variable wind speed, variation in solar and tidal power, etc., are uncontrollable parameters which are bound to affect the generated power quality. Research is being carried out to integrate active filtering i.e., series and shunt active filters options into the integrating power electronic converters themselves [2,5], but they need to be case specific. From the perspective of sensitive non-linear loads in the distribution system, a common platform of PQ needs to be ensured; as PQ varies due to various types of sources of generation. Hence, suitable power conditioning interfaces are recommended for sensitive non-linear loads. These type of loads primarily include production industries (like automotive plants, paper mills, chemical and pharmaceutical industries, semiconductor manufacturing plants, etc.), and critical service providers like medical centres, airports, broadcasting centres, etc. Typical grid integration problems associate with voltage and frequency compatibility and requirement of active and reactive power. A power conditioning equipment can act as an interface between the grid and sensitive loads, so that the load can remain insensitive to the variation of power quality from the utility. Unified power quality conditioner (UPQC) happens to be the most comprehensive power conditioning equipment that can mitigate both voltage and current quality problems [6,7]. Functionally UPQC is a combination of series and shunt active filter, for maintaining desired quality of both the incoming voltage and current. But its coordinated control gives it unique feature in terms of shared responsibility and reduced VA rating as compared to individual dynamic voltage restorer (DVR) [8,11] or active power filter (APF) [6,9,11]. The control schemes described in this paper have current control strategy, based on hysteresis current control. The series Voltage compensation can be performed in a number of ways, which are non-unique. The insight gained could be useful for design of control strategy of UPQC for various applications.

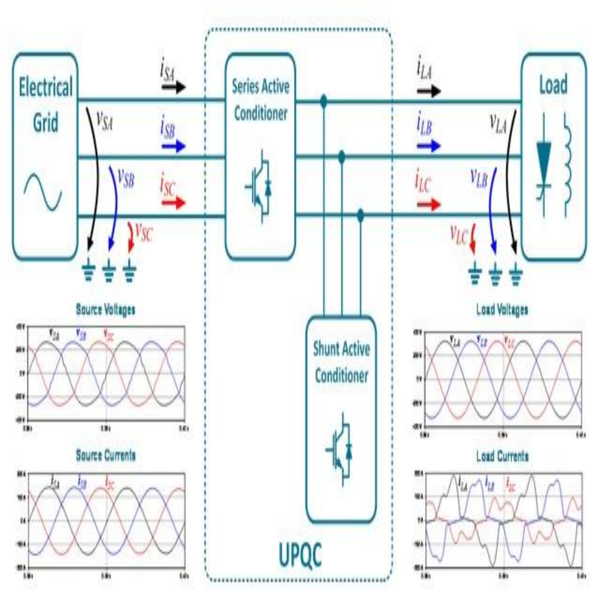

Fig 1: UPQC General block diagram representation.

II. UPQC TOPOLOGY AND POWER FLOW STRATEGY

A UPQC consists of voltage source inverters connected in cascade as shown in Fig. 1. Inverter 1 (Series Inverter SE) is connected in series with the incoming utility supply through a low pass filter and a voltage injecting transformer. Inverter 2 (Shunt Inverter SH) is connected in parallel with the sensitive load, whose power quality needs to be strictly maintained. The main purpose of SH is to provide required VAR support to the load, and to suppress the load current harmonics from flowing towards the utility and it is operated in current controlled mode. SE is responsible for compensating the deficiency in voltage quality of the incoming supply, such that the load end voltage remains insensitive to the variation of utility supply. The UPQC discussed in this paper have same power circuit configuration. But as the control strategies are different in SE, the individual loading of SH and SE varies and the overall rating of the UPQC differs, which is the thrust of this paper and is explained in the subsequent sections. The UPQC also has a few other important components that are essential for interfacing of the same. (Series Inverter SEI) is connected in series with the incoming utility supply through a low pass filter and a voltage injecting transformer. Inverter 2 (Shunt Inverter SH) is connected in parallel with the sensitive load, whose power quality needs to be strictly maintained. The main purpose of SH is to provide required VAR support to the load, and to suppress the load current harmonics from flowing towards the utility and it is operated in current controlled mode. SE is responsible for compensating the deficiency in voltage quality of the incoming supply, such that the load end voltage remains insensitive to the variation of utility supply. The SE needs to be connected to the supply side through a series injection transformer and a low pass filter (LPF), to eliminate the high switching frequency ripple of the inverter. The filter may inject some phase shift, which could be load dependent, but suitable feedback control is to be designed to dynamically adjust the shift, which is described in the control section. The active power flow through the UPQC originates from the utility, as it is the only source of active power. But the reactive power and load harmonic currents are shared between the SH and loads primarily. Therefore, SH provides harmonic isolation to the utility. SE may also share some VAR depending upon the control, described further in the subsequent section.

III. POWER QUALITY PROBLEMS

Power quality is very important term that embraces all aspects associated with amplitude, phase and frequency of the voltage and current waveform existing in a power circuit. Any problem manifested in voltage, current or frequency deviation that results in failure of the customer equipment is known as power quality problem. The increasing number of power electronics based equipment has produced a significant impact on the quality of electric power supply. Low quality power affects electricity consumers in many ways. The lack of quality power can cause loss of production, damage of equipment or appliances, increased power losses, interference with communication lines and so forth. Therefore, it is obvious to maintain high standards of power quality [3]. The major types of power quality problems are: Interruption, Voltage-sag, Voltage-swell, Distortion, and Harmonics.

A. Interruption

An interruption is defined (Fig 2) as complete loss of supply voltage or load current. Interruptions can be the result of power system faults, equipment failures, and control malfunction. There are three types of interruptions which are characterized by their duration:

1. The momentary interruption is defined as the complete loss of supply voltage or load current having duration between 0.5 cycles & 3 sec.
2. The temporary interruption is the complete loss lasting between 3 seconds and 1 minute,
3. The long term interruption is an interruption which has duration of more than 1 minute.

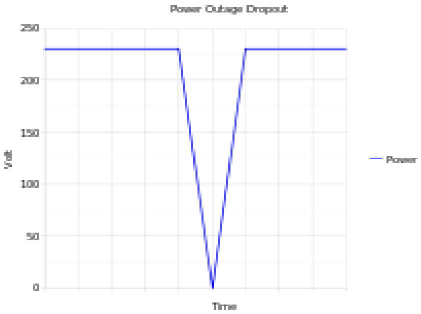

Fig 2 : Power Interruption

B. Voltage Sags

Voltage sags (dips) are short-duration reductions in rms voltage caused by short-duration increases of the current. The most common causes of the over currents leading to voltage sags are motor starting, transformer energizing and faults. A sag is decrease in voltage at the power frequency for duration from 0.5 cycle to 1min. Voltage sags are usually associated with system faults but can also caused by energisation of heavy loads at starting of large motors (Fig 3).

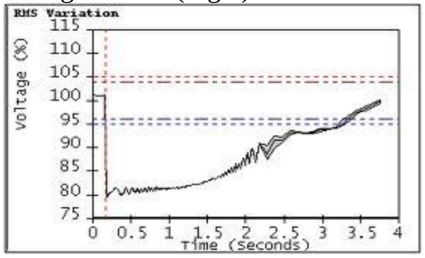

Fig 3 : Voltage Sag

C. Voltage Swells

Voltage swell is an rms increase in the ac voltage, at the power frequency, for duration from a half cycle to a few seconds. As shown in Fig 4.,Voltage can rise above normal level for several cycles to seconds. Voltage swells will normally cause damage to lighting, motor and electronic loads and will also cause shutdown to equipment. The severity of voltage swell during a fault condition is a function of fault location, system impedance and grounding.

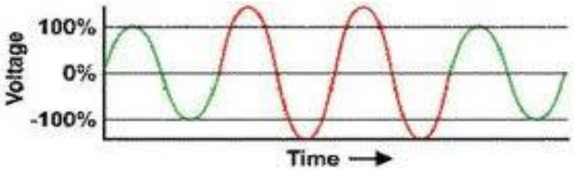

Fig 4 : Voltage Swells

D. Waveform Distortion

Voltage or current waveforms assume non sinusoidal shape called distorted wave as shown in Fig 5. When a waveform is identical from one cycle to the next, it can be represented as a sum of pure sine waves in which the frequency of each sinusoid is an integer multiple of the fundamental frequency of the distorted wave.

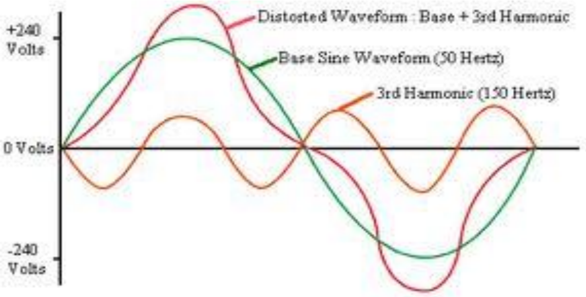

Fig 5 : Waveform Distortion

E. Harmonics

Harmonics are sinusoidal voltages or current having frequency that are integer multiples of the Fundamental frequency. Here, 3rd harmonics is seen in the figure 6.

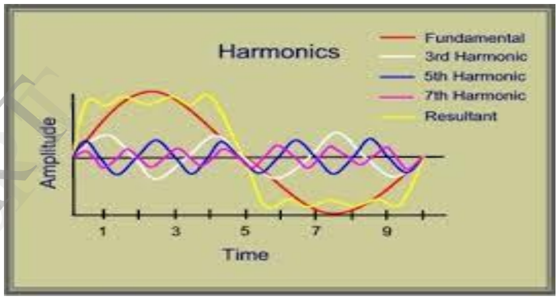

Fig 6: Harmonics

IV. CONTROL STRATEGY OF UPQC

Control strategy play very important role in system's performance. The control strategy of UPQC may be implemented in three stages:

i. Voltage and current signals are sensed
ii. Compensating commands in terms of voltage and current levels are derived
iii.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 power transformer or voltage sensor and current signals are sensed using current transformer or current sensor [7]. In second stage derivation of compensating commands are mainly based on two types of domain
Methods: (1) Frequency domain methods
(2) Time domain method.

Frequency domain methods: This 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 controls 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 [8]. In third stage the gating signals for semiconductor switches of UPQC based on derive compensating commands in terms of voltage or current. Then, these compensating commands are given to PWM, hysteresis or fuzzy logic based control techniques.

A. APF SERIES COMPENSATOR

The system side voltage may contain negative-zero-sequence as well as harmonics components which need to be eliminated by the series compensator [15-16]. The control of the series compensator is shown in Figure.7. The system voltages are detected then transformed into synchronous dq-0 reference frame using equation (1). *Series-APF:* Functions of the series APFs in each feeder are:

i. To mitigate voltage sag and swell;
ii. To compensate for voltage distortion, such as harmonics;
iii. To compensate for interruption (in Feeder only).

The control block diagram of each series APF is shown in Fig. 7. The bus voltage (u_{t_abc}) is detected and then transformed into the synchronous *dq0* reference and then transformed into the synchronous *dq0* reference frame using

$$u_{t\_dq0}=T_{abc}^{dq0}\,u_{t\_abc}=u_{t1p}+u_{t1n}+u_{t10}+u_{th}\ \text{……}(1)$$

Where
$$\begin{cases} u_{t1p}=[u_{t1p_d}\ u_{t1p_q}\ 0]^T \\ u_{t1n}=[u_{t1n\_d}\ u_{t1n\_q}\ 0]^T \\ u_{t10}=[0\ 0\ u_{00}]^T \\ u_{th}=u_{th\_d}\ u_{th\_q}\ u_{th\_0}]^T \end{cases}\quad\text{……..}$$
(2)

u_{t1p} , u_{t1n} and u_{t10} are fundamental frequency positive-, negative-, and zero-sequence components, respectively, and u_{th} is the harmonic component of the bus voltage.

According to control objectives of the UPQC, the load voltage should be kept sinusoidal with constant amplitude even if the bus voltage is disturbed. Therefore, the expected load voltage in the synchronous *dq0* reference frame ($u_{l\_dq0}^{exp}$) only has one value

$$u_{l\_dq0}^{exp}=T_{abc}^{dq0}\,u_{l\_abc}^{exp}=\begin{bmatrix}u_m\\0\\0\end{bmatrix}\quad\text{………….. (3)}$$

Where the load voltage in the *abc* reference frame ($u_{l\_abc}^{exp}$) is

$$u_{l\_abc}^{exp}=\begin{bmatrix}u_m\cos(wt)\\u_m\cos(wt-120^0)\\u_m\cos(wt+120^0)\end{bmatrix}\quad\text{………… (4)}$$

The compensating reference voltage in the synchronous *dq*0 reference frame ($u_{sf\_dq0}^{ref}$) is defined as

$$u_{sf\_dq0}^{ref}=u_{t\_dq0}-u_{l\_dq0}^{exp}\quad\text{………… (5)}$$

This means u_{t1p_d} in (2) should be maintained at U_m while all other unwanted components must be eliminated. The compensating reference voltages in (5) are then transformed back into the *abc* reference frame. By using an improved SPWM voltage control technique (since PWM control with minor loop feedback) [8], the output compensation voltage of the series APF can be obtained.

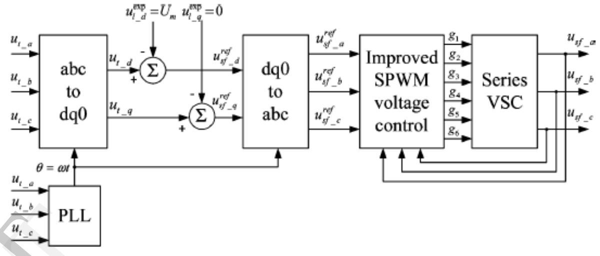

Fig.7.Control block diagram of the series APF of the UPQC

B.PROPOSED SHUNT CONTROLLER METHOD USING PQ-THEORY

The control algorithm for series active power filter (APF) is based on unit vector template generation scheme, whereas the control strategy for shunt APF is discussed in this section. Based on the load on the 3P4W system, the current drawn from the utility can be unbalanced. In this paper a new control strategy is proposed to compensate the current unbalance present in the load currents by expanding the concept of single phase p—q theory (8), (9). According to this theory, a signal phase system can be defined as a pseudo two-phase system giving π/2 lead or π/2 lag, that is each phase voltage and current of the original three-phase system can be considered as three independent two phase systems. These resultant two phase systems can be represented in α—β coordinates, and thus, the p—q theory applied for balanced three phase system can also be used for each phase of unbalanced system independently. The actual load voltages and load currents are considered as α—axis quantities whereas the π/2 lead load or π/2 lag voltages and π/2 lead or π/2 lag load currents are considered as β—axis quantities. In this paper π/2 lead is considered to achieve a two phase system for each phase. The major advantage of p-q theory is that it gives poor results under distorted and/or unbalanced input/utility voltages. In order to eliminate these limitations, the reference load voltage signals extracted for series APF are used instead of actual load voltages.

For phase a, the load voltage and current in α—β coordinates can be represented by π/2 lead as

$$\begin{bmatrix} v_{La\_\alpha} \\ v_{La\_\beta} \end{bmatrix} = \begin{bmatrix} v_{La}^{*}(\omega t) \\ v_{La}^{*}(\omega t + \frac{\pi}{2}) \end{bmatrix} = \begin{bmatrix} v_{Lm}\sin(\omega t) \\ v_{Lm}\cos(\omega t) \end{bmatrix}$$

…………(6)

$$\begin{bmatrix} i_{La\_\alpha} \\ i_{La\_\beta} \end{bmatrix} = \begin{bmatrix} i_{La}(\omega t + \varphi L) \\ i_{La}[(\omega t + \varphi L) + \frac{\pi}{2}] \end{bmatrix}$$ ………….(7)

Where $v_{La}^{*}(\omega t)$ represents the reference load voltage and v_{Lm} represents the desired load voltage magnitude. Similarly for phase b, the load voltage and current in α—β coordinates can be represented by π/2 lead as,

$$\begin{bmatrix} v_{Lb\_\alpha} \\ v_{Lb\_\beta} \end{bmatrix} = \begin{bmatrix} v_{Lb}^{*}(\omega t) \\ v_{Lb}^{*}(\omega t + \frac{\pi}{2}) \end{bmatrix} = \begin{bmatrix} v_{Lm}\sin(\omega t - 120°) \\ v_{Lm}\cos(\omega t - 120°) \end{bmatrix}$$

………….(8)

$$\begin{bmatrix} i_{Lb\_\alpha} \\ i_{Lb\_\beta} \end{bmatrix} = \begin{bmatrix} i_{Lb}(\omega t + \varphi L) \\ i_{Lb}[(\omega t + \varphi L) + \frac{\pi}{2}] \end{bmatrix}$$

………….(9)

In addition for phase c, the load voltage and current in α—β coordinates can be represented by π/2 lead as

$$\begin{bmatrix} v_{Lc\_\alpha} \\ v_{Lc\_\beta} \end{bmatrix} = \begin{bmatrix} v_{Lc}^{*}(\omega t) \\ v_{Lc}^{*}(\omega t + \frac{\pi}{2}) \end{bmatrix} = \begin{bmatrix} v_{Lm}\sin(\omega t + 120°) \\ v_{Lm}\cos(\omega t + 120°) \end{bmatrix}$$ ………….(10)

$$\begin{bmatrix} i_{Lc\_\alpha} \\ i_{Lc\_\beta} \end{bmatrix} = \begin{bmatrix} i_{Lc}(\omega t + \varphi L) \\ i_{Lc}[(\omega t + \varphi L) + \frac{\pi}{2}] \end{bmatrix}$$

………….(11)

By using the definition of three phase p—q theory, for balanced three-phase system (3), the instantaneous power components can be represented as

Instantaneous active power

$$p_{L,abc} = v_{L,abc\_\alpha} \cdot i_{L,abc\_\alpha} + v_{L,abc\_\beta} \cdot i_{L,abc\_\beta} \,.$$

………….(12)

Instantaneous reactive power

$$q_{L,abc} = v_{L,abc\_\alpha} \cdot i_{L,abc\_\beta} - v_{L,abc\_\beta} \cdot i_{L,abc\_\alpha} \,.$$

………….(13)

Considering the phase a, the phase-a instantaneous load active and instantaneous load reactive powers can be represented by

$$\begin{bmatrix} p_{La} \\ q_{La} \end{bmatrix} = \begin{bmatrix} v_{La\_\alpha} & v_{Lb\_\beta} \\ -v_{Lb\_\beta} & v_{La\_\alpha} \end{bmatrix}$$

………….(14)

Where

$$p_{La} = \bar{p}_{La} + \tilde{p}_{La}$$

………….(15)

$$q_{La} = \bar{q}_{La} + \tilde{q}_{La}$$

………….(16)

In (14) and (15), $\bar{p}_{La}$ and $\bar{q}_{La}$ represent the DC components that are responsible for fundamental load active and reactive powers, whereas $\tilde{p}_{La}$ and $\tilde{q}_{La}$ represent the ac components that are responsible for harmonic powers. The phase-a fundamental instantaneous load active and reactive power components can be extracted from p_{La} and q_{La}, respectively by using a low pass filter.

Therefore, the instantaneous fundamental load active power for phase-a is given by

$$p_{La,1} = \bar{p}_{La}$$

………….(17)

And Instantaneous fundamental load reactive power for phase-a is given by

$$q_{La,1} = \bar{q}_{La}$$ ………….(18)

Similarly the fundamental instantaneous load active and the fundamental instantaneous load reactive powers for phases-b and c can be calculated as

Instantaneous fundamental load active power for phase b

$$p_{Lb,1} = \bar{p}_{Lb}$$ ………….(19)

Instantaneous fundamental load reactive power for phase b

$$q_{Lb,1} = \bar{q}_{Lb}$$

………….(20)

Instantaneous fundamental load active power for phase c

$$p_{Lc,1} = \bar{p}_{Lc}$$ ………….(21)

Instantaneous fundamental load reactive power for phase c

$$q_{Lc,1} = \bar{q}_{Lc}$$ ………….(22)

Since the load current drawn by each phase may be different due to different loads that may be present inside plant, therefore the instantaneous fundamental load active power and the instantaneous fundamental load reactive power demand for each phase may not be the same. In order to make this load unbalanced power demand, seen from the utility side, as a perfectly balanced fundamental three phase active power, the unbalanced load power should be properly redistributed between utility, UPQC and load such that the total load seen by the utility would be linear and balanced load. The unbalanced or balanced reactive power demanded by the load should be handled by a shunt APF. The aforementioned task can be achieved by summing instantaneous load active power demands of all the three phases and redistributing it again on each utility phase that is from equations (17), (19) and (21).

$$p_{L,Total} = p_{La,1} + p_{Lb,1} + p_{Lc,1} \quad \ldots\ldots\ldots\ldots(23)$$

$$p^*_{S/ph} = (p_{L,Total})/3 \quad \ldots\ldots\ldots\ldots(24)$$

Equation (24) gives the distributed per phase fundamental active power demand that each phase of utility should supply in order to achieve perfectly balanced source currents. From (24) it is evident that under all the conditions the total fundamental active power demand by the loads would be equal to the total power drawn from the utility but with perfectly balanced way even though the load currents are unbalanced. Thus the reference compensating currents representing a perfectly balanced three-phase system can be extracted by taking the inverse of (25).

$$\begin{bmatrix} i^*_{Sa\_\alpha} \\ i^*_{Sa\_\beta} \end{bmatrix} = \begin{bmatrix} v_{La\_\alpha} & v_{La\_\beta} \\ -v_{La\_\beta} & v_{La\_\alpha} \end{bmatrix}^{-1} . \begin{bmatrix} p^*_{S/ph} + p_{dc/ph} \\ 0 \end{bmatrix} \quad \ldots\ldots\ldots\ldots(25)$$

In (24), $p_{dc/ph}$ is the precise amount of per-phase active power that should be taken from the source in order to maintain the dc-link voltage at a constant level and to overcome the losses associated with UPQC, The oscillating instantaneous active power $\tilde{p}_{La}$ should be exchanged between the load ad shunt APF. The reactive power term q_{La} in (25) is considered as zero since the utility should not supply load reactive power demand. In the above matrix, the α-axis reference compensating current represents the current that is at $\frac{\pi}{2}$lead with respect to the original system.

Therefore, $i^*_{Sa}(t) =$

$$\{v_{La\_\alpha}(t)/(v^2_{La\_\alpha} + v^2_{La\_\beta})\}.\{p^*_{\frac{S}{ph}}(t) + p^*_{dc/ph}(t)\} \quad \ldots\ldots\ldots\ldots(26)$$

Similarly the reference source currents for phases b and can be estimated as

$$i^*_{Sb}(t) = \{v_{Lb\_\alpha}(t)/(v^2_{Lb\_\alpha} + v^2_{Lb\_\beta})\}.\{p^*_{\frac{S}{ph}}(t) + p^*_{dc/ph}(t)\} \quad \ldots\ldots\ldots\ldots(27)$$

$$i^*_{Sc}(t) = \{v_{Lc\_\alpha}(t)/(v^2_{Lc\_\alpha} + v^2_{Lc\_\beta})\}.\{p^*_{\frac{S}{ph}}(t) + p^*_{dc/ph}(t)\} \quad \ldots\ldots\ldots\ldots(28)$$

The reference neutral current signal can be extracted by simply adding all the sensed load currents without actual neutral current sensing as

$$i_{L\_n}(t) = i_{La}(t) + i_{Lb}(t) + i_{Lc}(t) \quad \ldots\ldots\ldots\ldots(29)$$

$$i^*_{Sh\_n}(t) = -i_{L\_n}(t). \quad \ldots\ldots\ldots\ldots(30)$$

The proposed balanced per-phase fundamental active power estimation, dc link voltage control based on PI regulator, the reference neutral current generation are shown in figures A:(a) and (d) respectively.

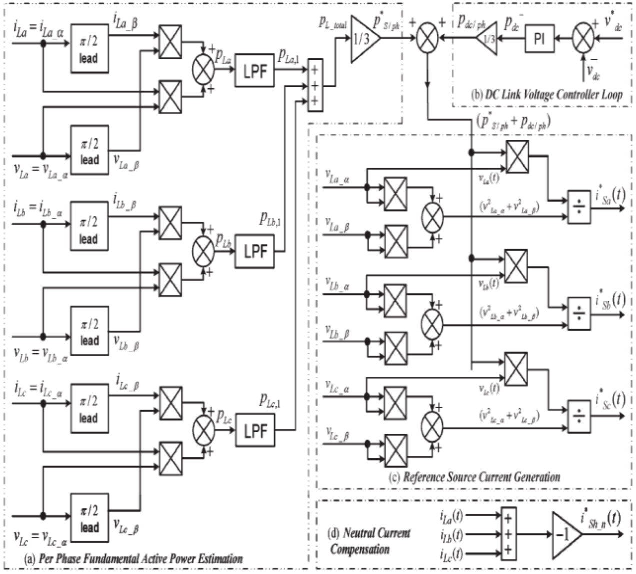

Figure.8. Shunt active filter control block diagram. (a) Proposed balanced per-phase fundamental active power estimation. (b) DC-link voltage control loop. (c) Reference source current generation. (d) Neutral current compensation.

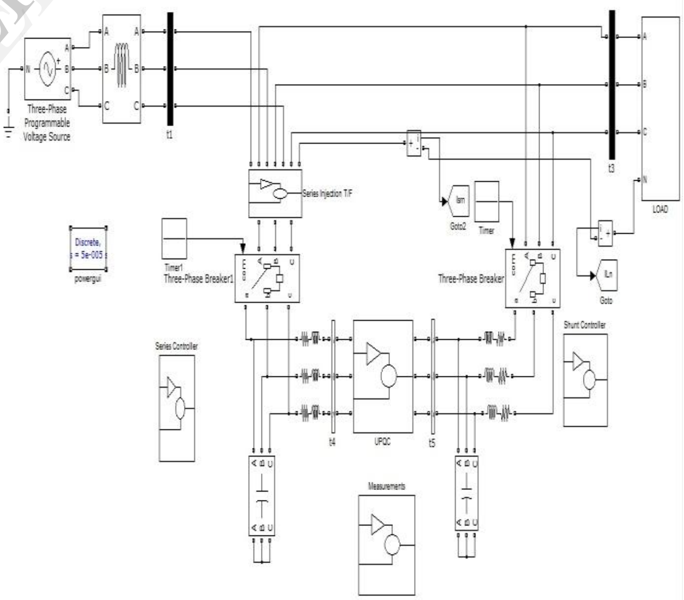

Fig.9.Simulation Block Diagram For UPQC with PQ theory

V. SIMULATION RESULTS

The harmonic content of input and output of the Bridge converter are shown in Figure 9. (Three phase voltages) and Figure 9. (Three phase currents). due to non-linear loads, such as large thyristor power converters, rectifiers, voltage and current flickering due to arc in arc furnaces, sag and swell due to the switching of the loads etc. One of the many solutions is the use of a combined system of shunt and active series filters like unified power quality conditioner (UPQC).

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. The control strategies used here are based on PI controller of the UPQC in detail. The control strategies are modeled using MATLAB/SIMULINK. The simulation results are listed in comparison of different control strategies are shown in figures.

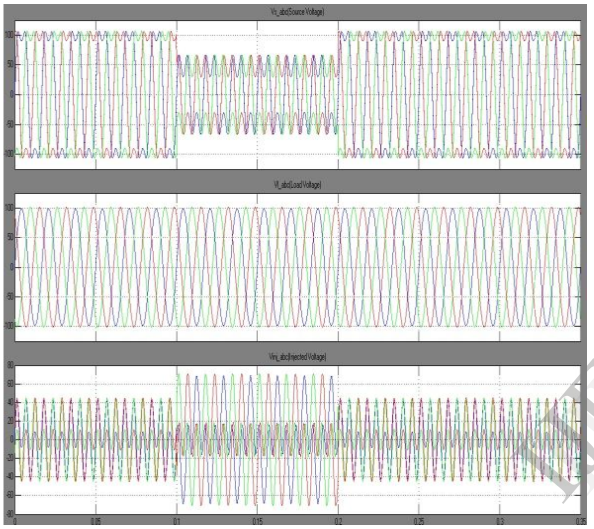

Fig.10.input Voltage, Load Voltage and Injected Voltage with sag condition

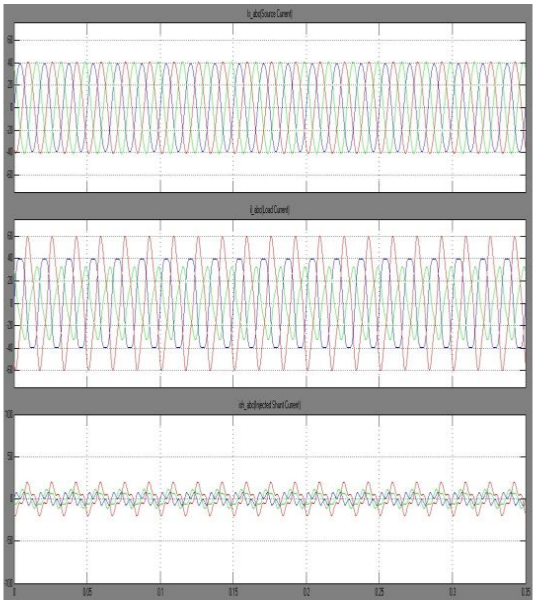

Fig.11.input current, unbalanced Load current and Injected current with sag condition using unbalanced load

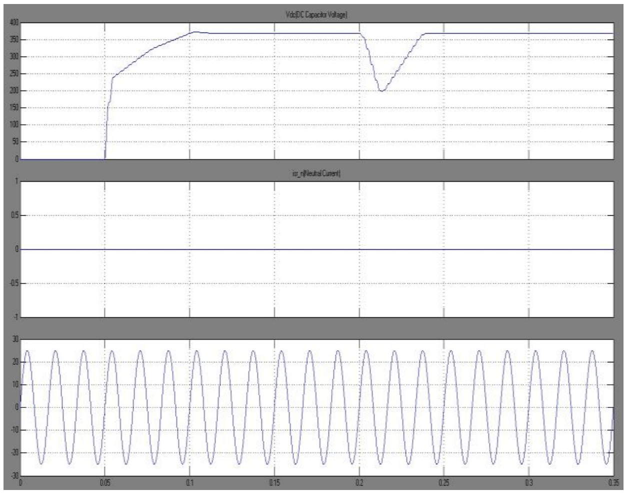

Fig.12.Dc Voltage, Neutral compensation current and without compensation

To verify the operating performance of the proposed UPQC, a 3-Φ electrical system, a PLL extraction circuit with SPWM controlled UPQC with PQ theory is simulated using MATLAB software.

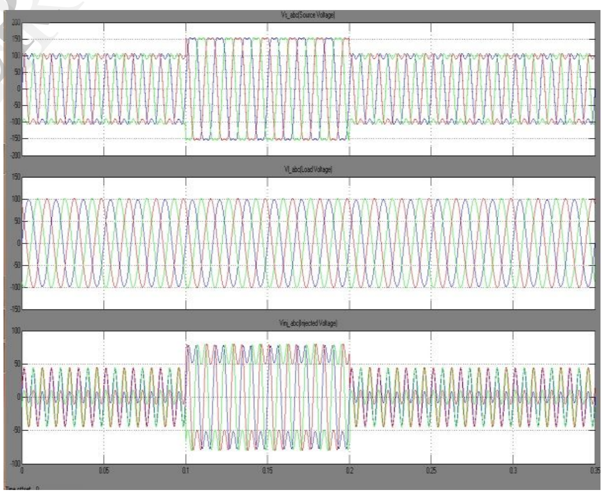

Fig.13. input distorted and swell Voltage, Compensated Load Voltage and Injected Voltage with Swell condition

The shunt APF is put into the operation at instant '0.2 sec'. Within the very short time period the shunt APF maintained the dc link voltage at constant level as shown in Figure.10, 13. In addition to this the Series APF also helps in compensating the voltage harmonics/sag and Swell generated by the nonlinear load. It is evident that before time '0.1 sec', as load voltage is distorted, As soon as the series APF put in to operation at '0.1 sec' the load current profile is also improved. Before time '0.2 sec', the source current is equal to load current. But after time '0.2 sec', when shunt APF starts maintaining The DC link Voltage and Neutral Current Compensation Simulation Results shown in Fig.12 it injects the compensating current in such a way that the source current becomes sinusoidal .Current injected by the shunt APF is shown in Figure.11. Model of the UPQC has been developed with different shunt controllers and simulated results.

VI. CONCLUSION

The power quality problems in distribution systems are not new but customer awareness of these problems increased recently. It is very difficult to maintain electric power quality at acceptable limits. One modern and very promising solution that deals with both load current and supply voltage imperfections is the Unified Power Quality Conditioner (UPQC).Proposed model for the UPQC is to compensate input voltage harmonics and current harmonics caused by non-linear load. This paper presented review on the UPQC to enhance the electric power quality at distribution level. 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, reactive current and neutral current. In this paper several UPQC configurations have been discussed. Among all these configurations, UPQC - DG could be the most interesting topology for a renewable energy based power system.

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