© 2015 IJSRSET | Volume 1 | Issue 6 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Simulation & Analysis of Unified Power Quality Conditioner (UPQC) for Power Quality Improvement

Keyur V. Patel, Priyank R Bhavsar
Electrical Engineering, Shakalchand Patel College of Engineering, Visnagar, Mehsana, Gujarat, India

ABSTRACT

This paper presents an analysis on the unified Power quality conditioner (UPQC) to improve the electric power quality at distribution levels. Conventional power quality mitigation equipment is a providing to be poor for an increasing number of applications. Different approaches in compensation and recent developments in fields. Single modern and very promising solution that deal with both load current and supply voltage inadequacy is the Unified Power Quality Conditioner (UPQC). This is intended to present a broad overview on the different possible UPQC system configurations for single-phase (two-wire) and three-phase (three-wire and four-wire) networks.

Keywords: Active power filter (APF), Power quality, Unified Power Quality Conditioner (UPQC).

I. INTRODUCTION

E-commerce has become one of the vital parts of the modern life. Online payment is the supportive application for the payment of money for the products we buy. For the past years online security breach created a major problem and lots of money had been stolen. The proposed document deals by securing the payment through iris recognition [1]. This method also adds the method of using visual cryptography for securing the user credentials. This visual cryptography method was formerly invented by Moni Naor and Adi Shamir in 1994[6].

II. METHODS AND MATERIAL

A. Classification of UPQC

The Unified Power Quality Conditioner are classified on various bases like topology, supply type and compensation method converter used, The UPQC is classified in two main groups which is based on, 1) Physical structure and 2) Voltage sag compensation [4].

1. Physical structure:

The key parameters that aspect to these classifications are: Number of phases, Type of energy storage device used, and Physical location of shunt and series inverter.

(1a) Converter based classification
- voltage source inverter (VSI)
- current source inverter (CSI)

(1b) Supply system based classification
  a) Single-Phase
    a1) Two H-bridge (total 8 switches)
    a2) 3-Leg topology (total 6 switches)
    a3) Half Bridge (total 4 switches
  b) Three-Phase
    b1) Three-Wire
    b2) Four-Wire
      b2.1) Four-Leg
      b2.2) Split Capacitor
      b2.3) Three-H Bridge

(1c) UPQC Configuration based classification
  a) Right Shunt (UPQC-R)
  b) Left Shunt (UPQC-L)
  c) Interline (UPQC-I)
  d) Multi-Converter (UPQC-MC)
  e) Modular (UPQC-MD)
  f) Multilevel (UPQC-ML)
  g) Distributed (UPQC-D)

h) Distributed Generator integrated (UPQC-DG)

2. Voltage Sag Compensation:

The voltage sag on a system is considered as one of the important power quality problems. There are mainly four methods to compensate the voltage sag in UPQC-based applications.

(2a) UPQC-P (Active Power Control)
(2b) UPQC-Q (Reactive Power Control)
(2c) UPQC-VAmin (Minimum VA Loading)
(2d) UPQC-S (Active-Reactive Power Control)

B. Basic Structure of UPQC

UPQC consist of combined series and shunt APFs for simultaneous compensation of voltage and current. The series APF is inserts a voltage, which is added at a point of common coupling (PCC) such that the load end the voltage remains unaffected by any voltage disturbance, whereas the shunt APF is most suitable to compensate for load reactive power demand and unbalance, to reduce the harmonics from regulate common DC link voltage and to supply current. [1, 2].

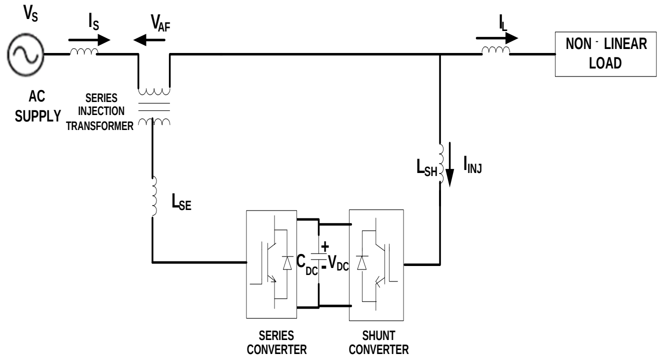


Figure 1 : Line diagram of unified power quality conditioner

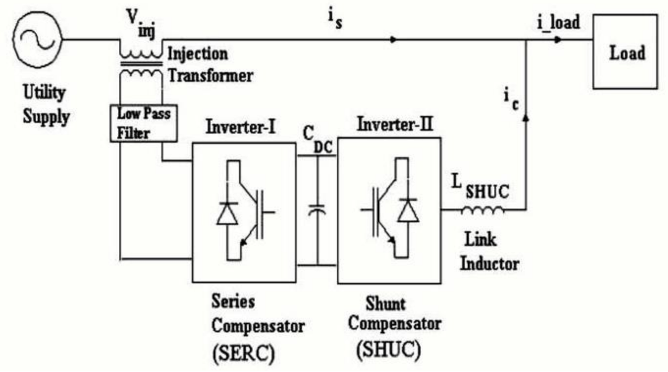


Figure 2 : Right Shunt UPQC Structure

The series PWM converter of the UPQC behaves as a controlled voltage source, that it is behaves as a series APF, whereas a shunt PWM converter behaves like 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 smallEnergy storage element.

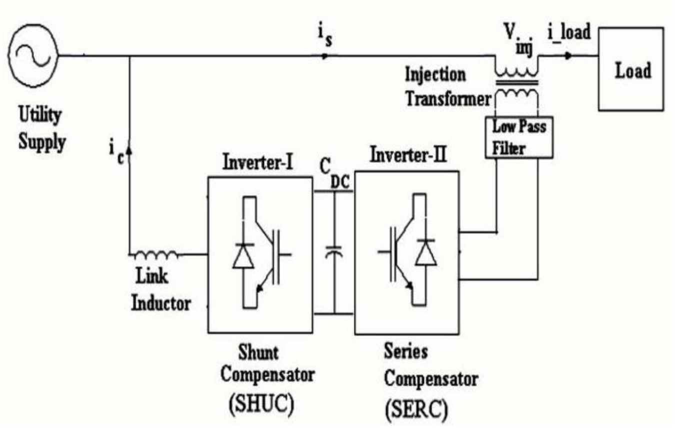


Figure 3 : Left Shunt UPQC Structure

The left shunt configuration can be get by changing the place of the Shunt compensator and the series compensator in Fig 3. The majority of the work reported on UPQC is on application of right shunt UPQC, as its characteristics are more favorable than those of the left shunt UPQC in applications when the shunt compensator has tocompensate for load reactive power and harmonics and the series compensator has to compensate for voltage disturbances from the source side When the application of UPQC is considered for a distribution network as in where UPQC has two different loads, one of them is voltage sensitive and the other generates harmonics, the left shunt configuration is preferred[9,1]

The UPQC has the capability of improving power quality at the point of installation on power distribution systems. Unified power quality conditioner is a combination of series active filter and shunt active filter connected in cascade via a common dc link capacitor. The deteriorating quality of electric power is mainly because of current and voltage harmonics due to wide spread application of static power electronics converters, zero and negative sequence components originated by the use of single phase and unbalanced loads, reactive power, voltage sag, voltage swell, flicker, voltage interruption etc. The series active filters are 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 and the shunt active filters are 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 [4] [10].

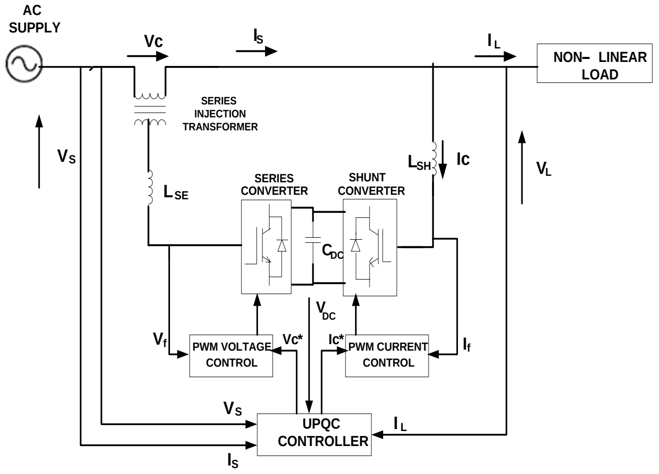


Figure 4 : Basic configuration of UPQC

Figure 4. shows the schematic diagram of unified power quality conditioner. The UPQC consists of power circuit formed by series and shunt PWM converters, dc link capacitor and UPQC controller. The series converter of the UPQC work as a controlled voltage source and the shunt converter is work as a controlled current source. One important feature of the UPQC is no power supply is connected at the common dc link which may be either capacitor or inductor which is depending on converter based topology. In voltage source inverter based topology the small dc capacitor is required as a small energy storage element [4] [10].

Figure 4. Shows the basic configuration fa UPQC. The UPQC has two distinct parts:
1. PowercircuitformedbyseriesandshuntPWMconverters;
2. UPQCcontroller.

The UPQC controller is provide the compensating voltage reference V_C^* and compensating current reference I_C^* to series and shunt converter respectively which is synthesized by using PWM voltage and current control technique. The shunt active filter can eliminate all undesirable current components, including harmonics, imbalances due to negative and zero sequence components at the fundamental frequency.

In order to cancel the harmonics produced by a nonlinear load, the shunt converter should inject a current as given by following equation:

$$I_C(\omega t) = I_S(\omega t) - I_L(\omega t) \qquad (1)$$

Where, $I_C(\omega t)$, $I_S(\omega t)$ and $I_L(\omega t)$ represents the shunt inverter compensating current, source current, and load current, respectively.

The series active filter can eliminate the supply voltage related problems by injecting voltage in series with line to achieve distortion free voltage at the load terminal. The series converter should inject a voltage as given by following equation:

$$V_C(\omega t) = V_L(\omega t) - V_S(\omega t) \qquad (2)$$

Where, $V_C(\omega t)$, $V_L(\omega t)$ and $V_S(\omega t)$ represents the series inverter injected voltage, load voltage, and actual source voltage, respectively.

The series APF of the UPQC can compensate the supply voltage related problems by injecting voltage in series with line to achieve distortion free voltage at the loadterminal. These rise inverter of UPQC can be represented by following equation:

$$V_C(\omega t)=V_L(\omega t)–V_S(\omega t) \qquad (3)$$

Where, $V_C(\omega t)$, $V_L(\omega t)$ and $V_S(\omega t)$ represents these rise inverter injected voltage, load voltage, and actual source voltage, respectively.

C. Control Procedure of UPQC

Control Procedure play very important role in system’s performance. The control procedure of UPQC may be implemented in three stages:
1) First sensed Voltage and current signals
2) The Compensating commands regarding voltage and current levels are obtain
3) The gating signals for semiconductor switches of UPQC are generated using fuzzy logic, PWM, or hysteresis based control techniques

In the first stage voltage signals are sensed using power transformer (PT) or current signals and voltage sensor are sensed using current sensor or current transformer [7].

In second stage deduction of compensating commands are mainly based on two types of domain methods:

(1) Frequency domain methods, and
(2) Time domain method.

Frequency domain methods, which, are based on the current signals to extract compensating commands or Fast Fourier Transform (FFT) of distorted voltage. 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 current signals or voltage. Mainly two widely used time domain control techniques of UPQC are:

1. p-q theory or the instantaneous active and reactive power and
2. d-q theory or Synchronous reference frame method.

In p-q method instantaneous active and reactive powers are calculate, while, the d-q method deals with the current independent of the supply voltage. Both methods modify voltages and currents from abc frame to stationary reference frame (p-q theory) or synchronously rotating frame (d-q theory) to unconnected the fundamental and harmonic quantities [8]. In third and final stage stage of the gating signals for semiconductor switches of UPQC based on derive compensating commands in terms of voltage or current. Then, these recompense commands are given to PWM, hysteresis or fuzzy logic based control techniques.

D. UPQC Based On Synchronous Reference Frame (SRF) Theory

1) The conventional synchronous reference frame (SRF) based method can be used to eliminate harmonics presents in supply voltage or current. The SRF method is based on a-b-c to d-q-0 transformation which also known as park transformation. Figure 5. shows the a-b-c to d-q-0 transformation. The reference frame transformation is formulated from a three-phase a–b–c stationary system to the direct axis (d) and quadratic axis (q) rotating coordinate system so it is also known as d-q method [12] [13],[14].

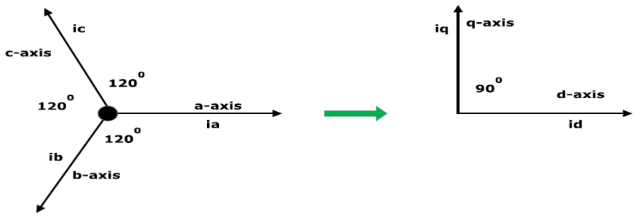


Figure 5 : a-b-c to d-q-0 transformation (park transformation)

In the SRF method the transformation angle (ωt) presents the angular position of the reference frame which is rotating at constant speed in synchronism with the three phase ac voltage. In the SRF method d-q-0 axes are rotate synchronously with supply voltages.

1. Control technique of series active filter

The proposed control strategy is aimed to compute mainly the three phase reference voltage at the load terminal. The series active filter based on SRF method can be used to solve the voltage related power quality problems such as, voltage sag, voltage swell and voltage harmonics. The SRF method is used in series active filter for generating reference voltage signal. The supplyvoltages V_{Sabc} are transforming into d-q-0 which is given in equation below.

$$\begin{bmatrix} V_d \\ V_q \\ V_0 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \sin(\omega t) & \sin\left(\omega t - \frac{2\pi}{3}\right) & \sin\left(\omega t + \frac{2\pi}{3}\right) \\ \cos(\omega t) & \cos\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t + \frac{2\pi}{3}\right) \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} V_{Sa} \\ V_{Sb} \\ V_{Sc} \end{bmatrix}$$

Where ωt is the transformation angle and V denotes voltages.

In the SRF ωt is a time varying angle that represents the angular position of the reference frame which is rotating at constant speed in synchronism with the three phase ac voltage. Synchronous Reference Frame method (SRF) is one of the most common and probably it is the best method.

To implement the SRF method and for reference voltage calculation the phase locked loop (PLL) is used to generate the transformation angle (ωt) which presents the angular position of the reference frame. This transformation presents is known as park transformation [6]. Figure 6.Shows the Control block diagram of d-q theory for generating voltage reference signal in SAF. The low pass filter is used to obtain the reference source voltage in d-q coordinates.

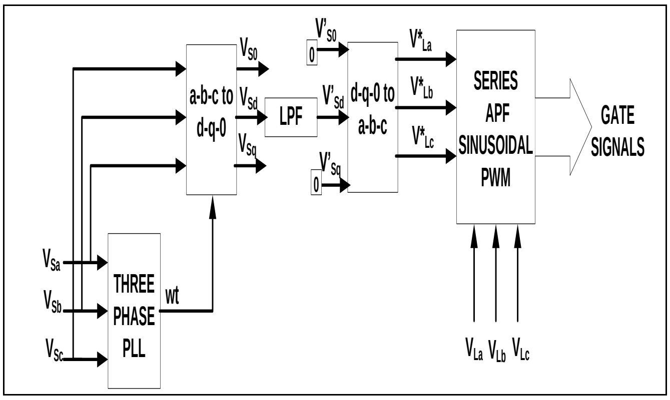


Figure 6 : Control block diagram of d-q theory of Series APF

The inverse park transformation is used for generating reference voltage signal which is given in equation below is convert the reference load voltage (V'_{Labc}) are transform d-q-0 into a-b-c.

$$\begin{bmatrix} V'_{La} \\ V'_{Lb} \\ V'_{Lc} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \sin(\omega t) & \cos(\omega t) & \frac{1}{\sqrt{2}} \\ \sin\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t - \frac{2\pi}{3}\right) & \frac{1}{\sqrt{2}} \\ \sin\left(\omega t + \frac{2\pi}{3}\right) & \cos\left(\omega t + \frac{2\pi}{3}\right) & \frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} V_d \\ V_q \\ V_0 \end{bmatrix}$$

After generating reference load voltage (V^*_{Labc}) are compared with sensed load voltage (V_{Labc}) in sinusoidal pulse width modulation technique. This comparison between reference load voltage and sensed load voltage in sinusoidal PWM technique generate gating signals for series voltage source converter. In series voltage source converter as a switching device use insulated gate bipolar transistor (IGBT) which can compensate all voltage related problems, such as voltage sag, voltage swell and voltage harmonics.

2. Control technique of shunt active filter

The shunt active filter based on SRF method can be used to solve the current related power quality problems which are mainly generated by nonlinear load. The SRF method is used in shunt active filter for generating reference current signal [8]. The source currents (I_{Sabc}) are transform into d-q-0 which is given in below equation.

$$\begin{bmatrix} I_d \\ I_q \\ I_0 \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \sin(\omega t) & \sin\left(\omega t - \frac{2\pi}{3}\right) & \sin\left(\omega t + \frac{2\pi}{3}\right) \\ \cos(\omega t) & \cos\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t + \frac{2\pi}{3}\right) \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} I_{Sa} \\ I_{Sb} \\ I_{Sc} \end{bmatrix}$$

Figure 7.Shows the control block diagram of shunt active filter based on d-q theory. For reference current calculation the SRF based method uses source voltages, source currents and dc link voltages as shown in figure 7. The phase locked loop (PLL) is used to generate the transformation angle (ωt) which presents the angular position of the reference frame. Figure 3.shows the Simulink diagram of d-q theory for generating current reference signal in shunt active filter. [8]

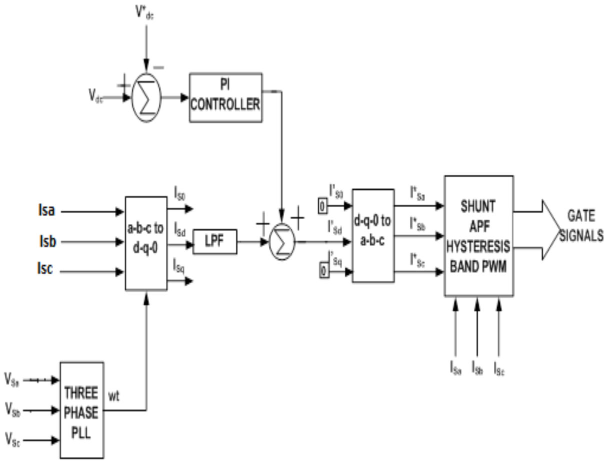


Figure 7: Control block diagram of d-q theory in shunt active filter

The inverse park transformation is used for generating reference current signal which is given in below equation is convert the reference source current (I_{Sabc}) are transform d-q-0 into a-b-c which is given in below equation.

$$\begin{bmatrix} I'_{La} \\ I'_{Lb} \\ I'_{Lc} \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} \sin(\omega t) & \cos(\omega t) & \frac{1}{\sqrt{2}} \\ \sin\left(\omega t - \frac{2\pi}{3}\right) & \cos\left(\omega t - \frac{2\pi}{3}\right) & \frac{1}{\sqrt{2}} \\ \sin\left(\omega t + \frac{2\pi}{3}\right) & \cos\left(\omega t + \frac{2\pi}{3}\right) & \frac{1}{\sqrt{2}} \end{bmatrix} \begin{bmatrix} I_d \\ I_q \\ I_0 \end{bmatrix}$$

E. Hysteresis Technique for Active Filter

1. Hysteresis technique for series active filter

There are various types voltage-controlled pulse width modulation (PWM) techniques available among all of them hysteresis controllers offer inherent simplicity in implementation and excellent dynamic performance.

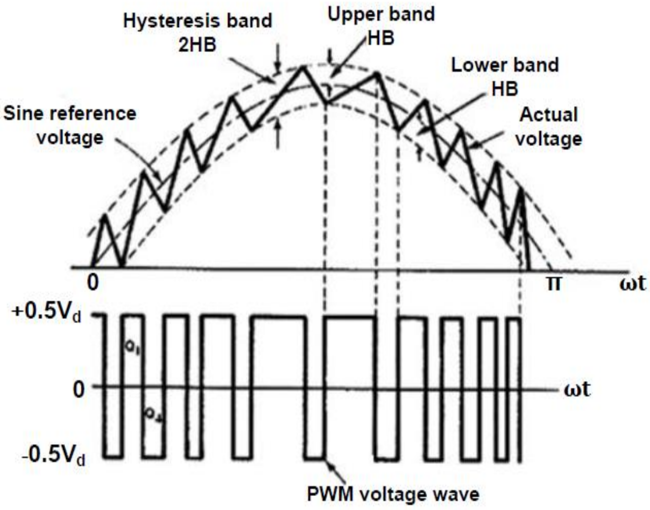


Figure 8 : Hysteresis voltage control technique

Hysteresis-band PWM is basically an instantaneous feedback voltage control technique of PWM where the actual voltage continually tracks the command voltage within a hysteresis band. Figure 8 explains the operation principle of hysteresis band PWM for a half bridge inverter. The control circuit generates the sine reference voltage wave of desired magnitude and frequency, and it is compared with actual voltage wave. As the voltage exceeds an upper hysteresis band, the upper switch in half bridge is turned off and lower switch is turned on. As a result, the output voltage transition from $+0.5V_d$, and $-0.5V_d$, and the voltage starts to decay. In same way as voltage crosses the lower band limit, the lower switch is turned off and the upper switch is turned on. In comparison with other control technique hysteresis voltage control has a very fast response and simple operation but the disadvantage of this method is variable switching frequency [2].

The hysteresis band voltage control for series active power filter is used to generate the switching pattern of the inverter. There is various voltage control methods proposed for active power filter configurations; but the hysteresis voltage control method is proven to be the best among other voltage control methods, because ofquick voltage controllability, easy implementation and unconditioned stability. The hysteresis band voltagecontrol is robust, provides excellent dynamics and fastest control with minimum hardware [5][11].

Figure 9 shows the comparison between the reference load voltage (V_L^*) and sensed load voltage (V_L) and the generating error is given to hysteresis band which generates switching instants of series voltage source converter. Figure 10 shows the Simulink diagram of hysteresis voltage controller.

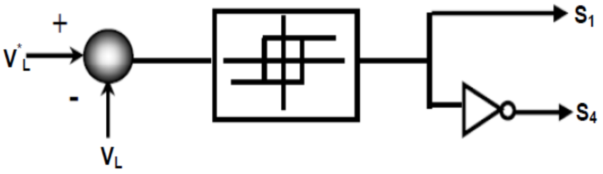


Figure 9 : Control block of hysteresis band voltage control technique

The reference voltage to be injected by the series active filter is referred asV_L^* and the actual voltage of the series active filter is referred asV_L. The control scheme decides the switching pattern of series active filter in such a way to maintain the actual load voltage of the filter to remain within a fixed hysteresis band (HB) as indicated.

The switching logic is formulated as follows:

$$V_L=V_L^*-HB \tag{4}$$

$$V_L=V_L^*-HB \tag{5}$$

Where,

V_L= actual load voltage

V_L^*= reference load voltage

HB = hysteresis band and S1, S2, S3, S4 are switches of voltage source inverter.

From above discussion note that the switching frequency of the hysteresis voltage control method described above depends on how fast the voltage changes from upper limit to lower limit of the hysteresis band. Therefore, the switching frequency does not remain constant throughout the switching operation, but varies along with the voltage waveform.

2. Hysteresis technique for shunt active filter

There are various types current controlled pulse width modulation (PWM) techniques available among all of them hysteresis controllers offer inherent simplicity in implementation and excellent dynamic performance. Hysteresis-band PWM is basically an instantaneous feedback current control technique of PWM where the actual current continually tracks the command current within a fixed hysteresis band. Figure 10.explains the operation principle of hysteresis band PWM for a half bridge inverter. The control circuit generates the sine reference current wave of desired magnitude and frequency, and it is compared with actual current wave.

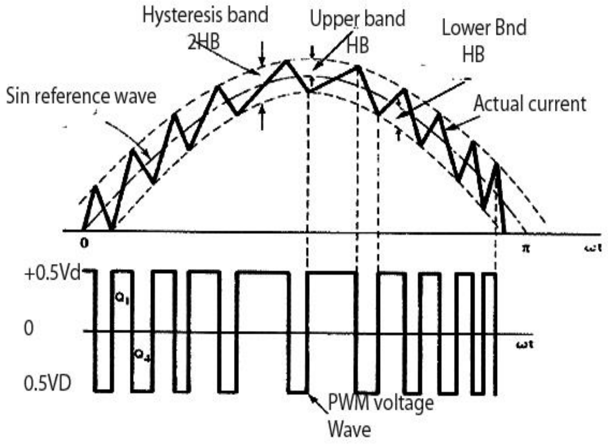


Figure 10. Hysteresis current control technique

As the current exceeds an upper hysteresis band, the upper switch in half bridge is turned off and lower switch is turned on. As a result, the output voltage transition from +0.5 Vd, and -0.5Vd, and the current starts to decay. In same way as current crosses the lower band limit, the lower switch is turned off and the upper switch is turned on. The main disadvantage of this method is variable switching frequency. To solve the problem of variable switching frequency so, adaptive hysteresis current control technique is applied [2]. The switching frequency is not fixed in hysteresis current control technique, so, it was introduced the concept of the average switching frequency. The hysteresis band current control for active power filter is used to generate the switching pattern of the inverter. There are various current control methods proposed for active power filter configurations; but the hysteresis current control method is proven to be the best among other current control methods, because of quick current controllability, easy implementation and unconditioned stability. The hysteresis band current control is robust, provides excellent dynamics and fastest control with minimum hardware [2] [11].

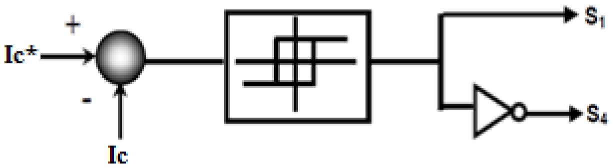


Figure 11: Hysteresis current control technique

Figure 11.Shows the comparison between the reference source current (I_S^*) and sensed source current (I_S) and the generating error is given to hysteresis band which generates switching instants of shunt current source converter. Figure 12. Shows the Simulink diagram of hysteresis current controller.

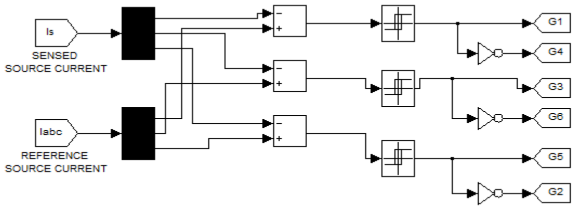


Figure 12. Simulink diagram of hysteresis current controller

The reference current to be injected by the shunt active filter is referred as I_S^* and the actual current of the shunt active filter is referred as Is. The control scheme decides the switching pattern of shunt active filter in such a way to maintain the actual source current of the filter to remain within a fixed hysteresis band (HB) as indicated in figure 6.

The switching logic is formulated as follows:

$$I_S = I_S^{*} – HB \tag{6}$$

$$I_S = I^{*}s + HB \tag{7}$$

Where, I_S= actual source current
I_S^* = reference source current

HB = Hysteresis band and S1, S2, S3, S4 are switches of voltage source inverter. During condition of equation (6) switches S1, S2 ON & S3, S4 OFF and during condition of equation (7) switches S1, S2 OFF & S3, S4 ON

From above discussion note that the switching frequency of the hysteresis current control technique described above depends on how fast the current changes from upper limit to lower limit of the hysteresis band.

Therefore, the switching frequency does not remain constant throughout the switching operation, but varies along with the current waveform.

F. Simulink Model of UPQC

The UPQC has the capability of improving power quality at the point of installation on power distribution systems. The UPQC is a combination of series active filter and shunt active filter connected in cascade via a common dc link capacitor[4][10].

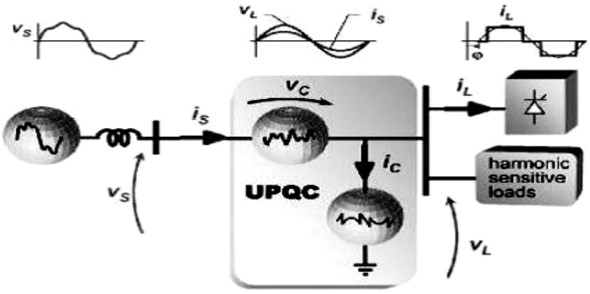


Figure 13. Basic block diagram of unified power quality conditioner

Figure13.showsthatthe UPQC is combines both princ ip les of shunt current compensation andseries voltage compensation. The compensation principle of series active filter is achieve dby injecting voltage (VC) inseries with supply voltages othatloadvoltage

G. Role of DC SIDE Capacitor

The DC side capacitor serves two main purposes: (i) it maintains a DC voltage with small ripple in steady state, and (ii) serves as an energy storage element to supply real power difference between load and source during the transient period. In the steady state, the real power supplied by the source should be equal to the real power demand of the load plus a small power to compensate the losses in the active filter. Thus, the DC capacitor voltage can be maintained at a reference value.

However, when the load condition changes the real power balance between the mains and the load will be disturbed. This real power difference is to be compensated by the DC capacitor. This changes the DC capacitor voltage away from the reference voltage. In order to keep satisfactory operation or the active filter, the peak value of the reference current must be adjusted to proportionally change the real power drawn from the source. This real power charged/discharged by the capacitor compensates the real power consumed by the load. If the DC capacitor voltage is recovered and attains the reference voltage, the real power supplied by the source is supposed to be equal to that consumed by the load again.

Thus, in this fashion the peak value or the reference source current can be obtained by regulating the average voltage of the DC capacitor. A smaller DC capacitor voltage than the reference voltage means that the real power supplied by the source is not enough to supply the load demand. Therefore, the source current (i.e. the real power drawn from the source) needs to be increased, while a larger DC capacitor voltage than the reference voltage tries to decrease the reference source current. This change in capacitor voltage has been verified from the simulation results.

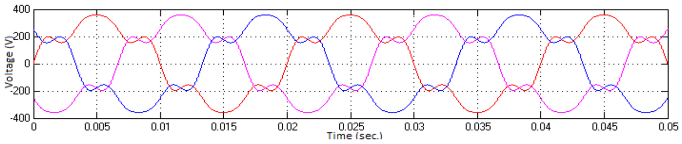
The real/reactive power injection may result in the ripple voltage of the DC capacitor. A low pass filter is generally used to filter these ripples, which introduce a finite delay. To avoid the use of this low pass filter the capacitor voltage is sampled at the zero crossing of the source voltage. A continuously changing reference current makes the compensation non-instantaneous during transient. Hence, this voltage is sampled at the zero crossing of one of the phase voltage, which makes the compensation instantaneous. Sampling only twice in cycle as compared to six times in a cycle leads to a slightly higher DC capacitor voltage rise/dip during transients, but settling time is less.
The design of the power circuit includes three main parameters:

- Selection of filter inductor, Lc.
- Selection of DC side capacitor, Cdc.
- Selection of reference value of DC side capacitor voltage, Vdcref.

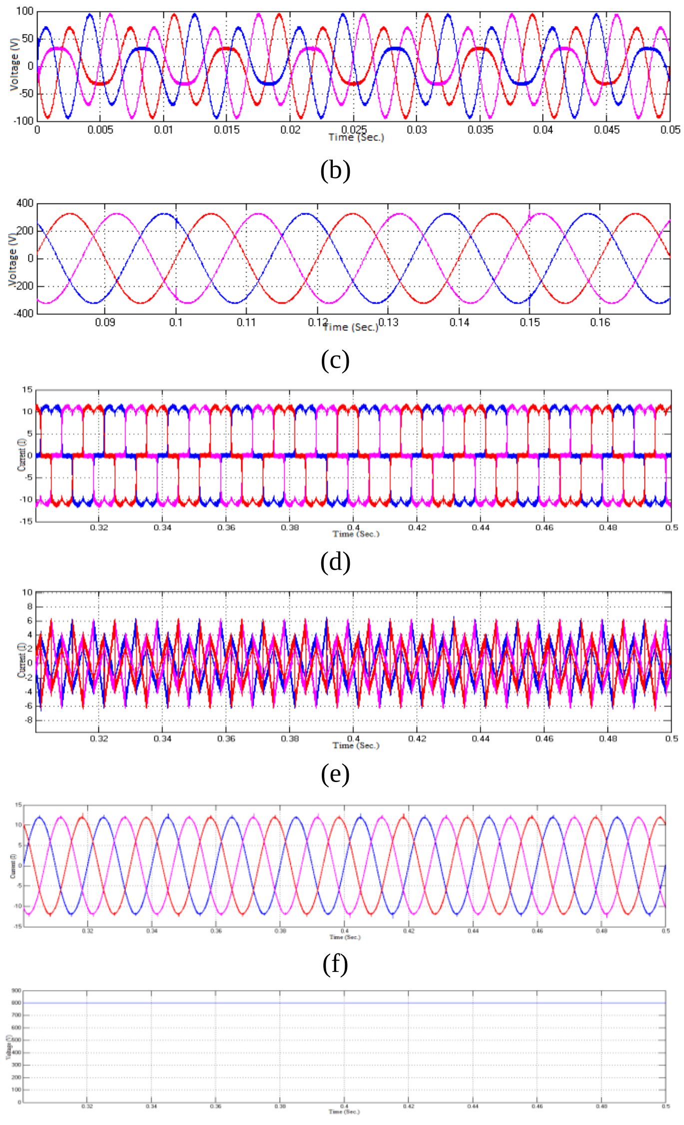
III. RESULTS AND DISCUSSION

Simulation Results

In this section, the simulation result of series APF is shown.The developed model of series APF



(a)



(b)

(c)

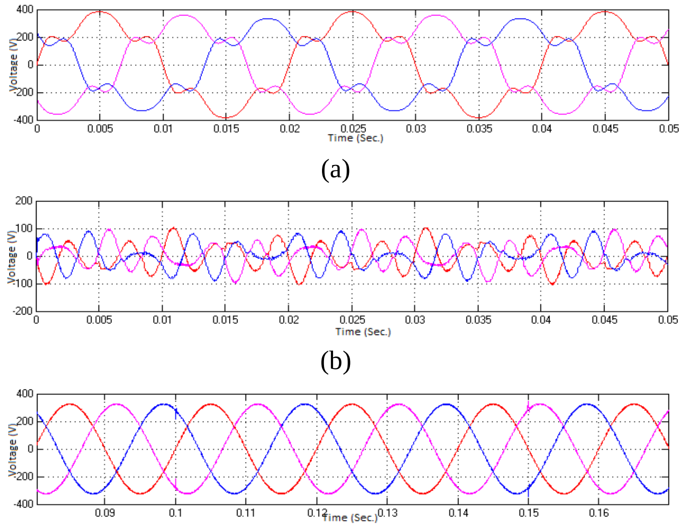
(d)

(e)

(f)

(g)

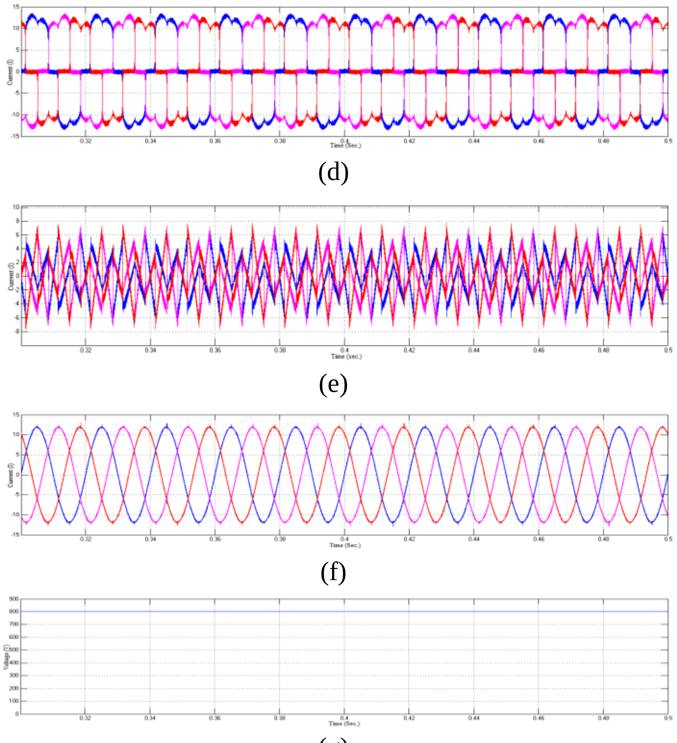
Figure 15. Balanced Voltage Condition (a) Source Voltage (b) Transformer Injected Voltage (c) Load Voltage (d) Load Current (e) Shunt APF Injected Current (f) Source Current (g) DC Source Voltage



(a)

(b)

(c)



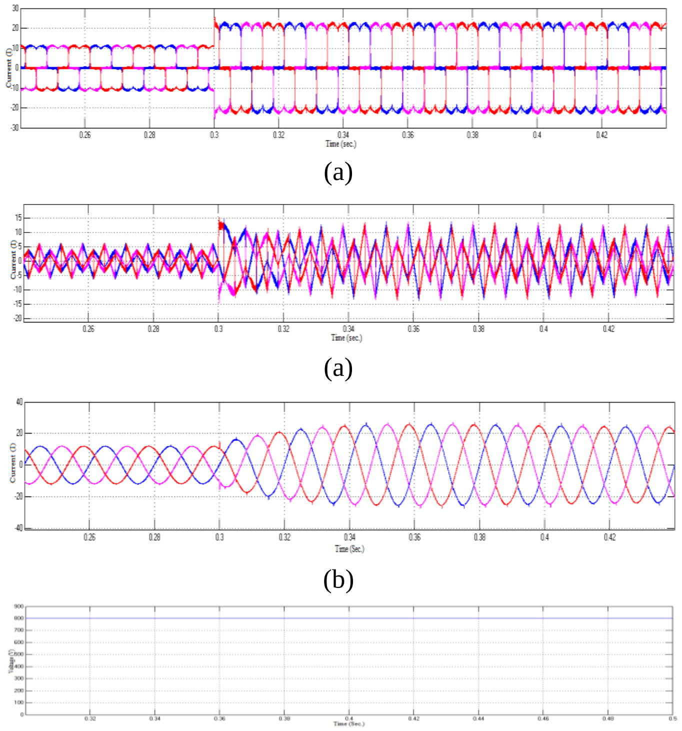
(d)

(e)

(f)

(g)

Figure 16. Unbalanced Voltage Condition (a) Source Voltage (b) Transformer Injected Voltage (c) Load Voltage (d) Load Current (e) Shunt APF Injected Current (f) Source Current (g) DC Source Voltage



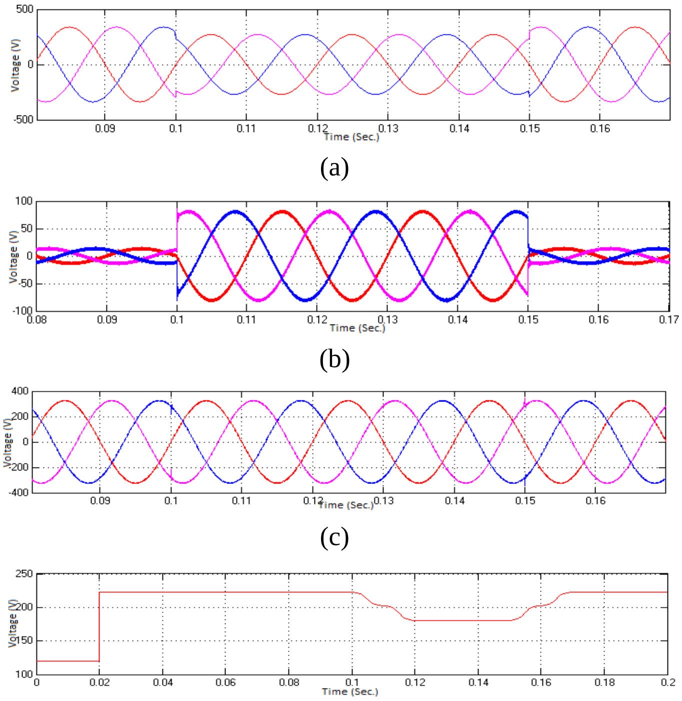
(a)

(a)

(b)

(c)

Figure-17. Transient Current Condition (a) Load Current (b) Shunt APF Injected Current (c) Source Current (d) DC Source Voltage



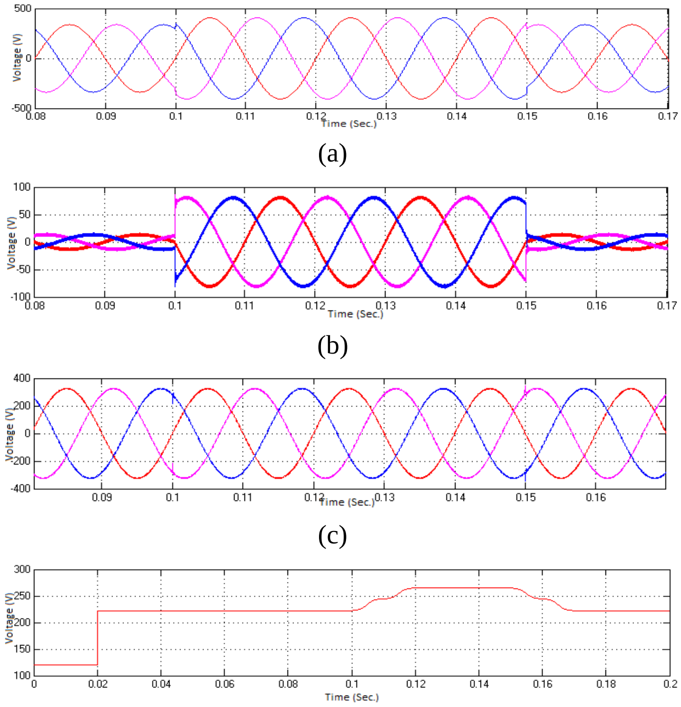
(a)

(b)

(c)

(d)

Figure 18. Voltage Sag Condition (a) Source Voltage (b) Transformer Injected Voltage (c) Load Voltage (d) RMS Value



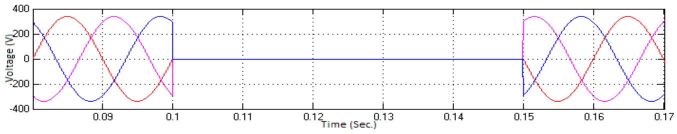
(a)

(b)

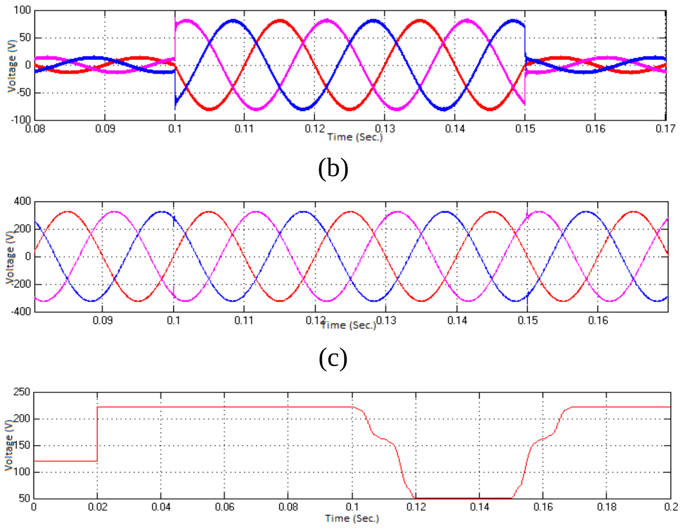
(c)

(d)

Figure 19. Voltage Swell Condition (a) Source Voltage (b) Transformer Injected Voltage (c) Load Voltage (d) RMS Value



(a)

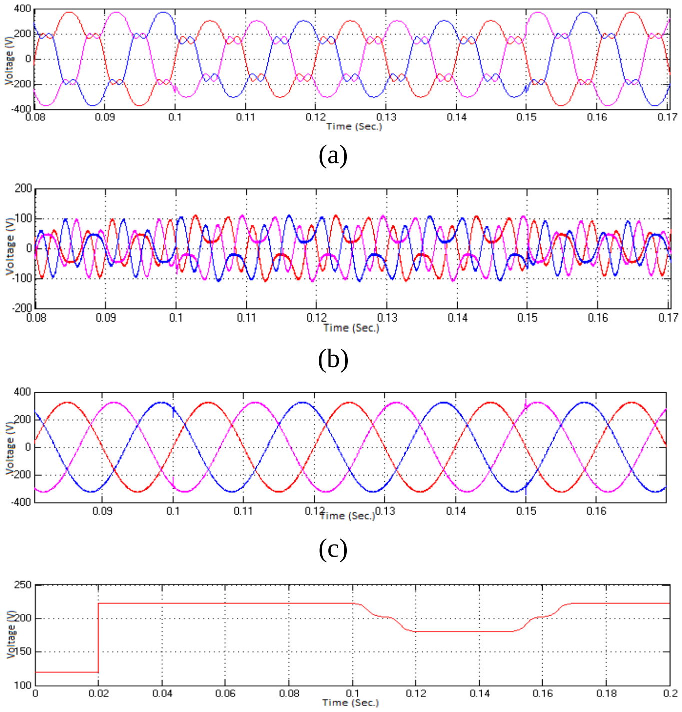


(b)

(c)

(d)

Figure 20. Voltage Interruption Condition (a) Source Voltage (b) Transformer Injected Voltage (c) Load Voltage (d) RMS Value



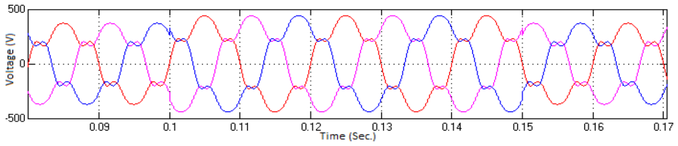
(a)

(b)

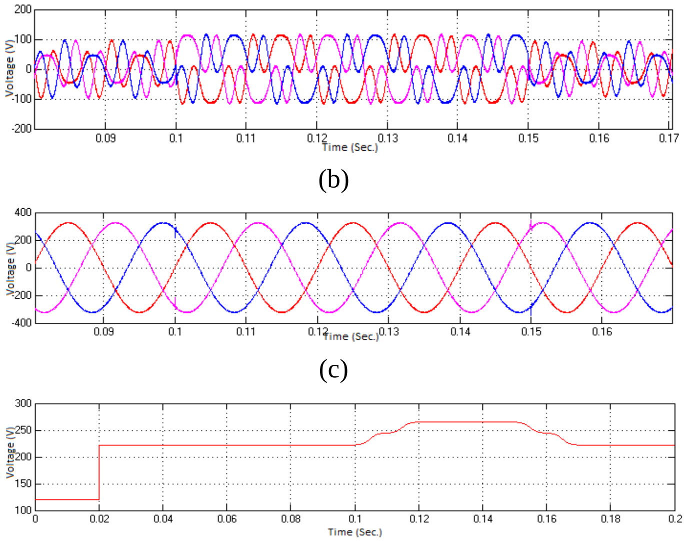
(c)

(d)

Figure 21. Voltage Sag with Harmonics Distortion Condition (a) Source Voltage (b) Transformer Injected Voltage (c) Load Voltage (d) RMS Value



(a)



(b)

(c)

(d)

Figure 22. Voltage Swell with Harmonics Distortion Condition (a) Source Voltage (b) Transformer Injected Voltage (c) Load Voltage (d) RMS Value

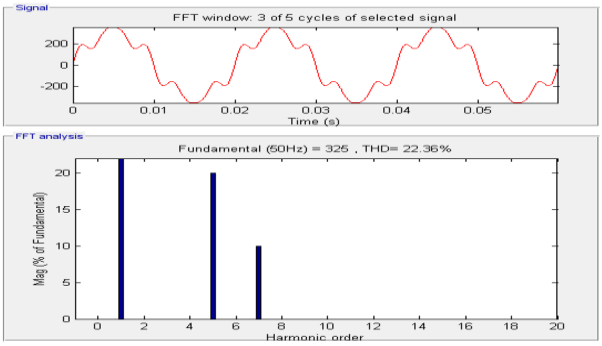


Figure 23. THD=22.36% of Source voltage

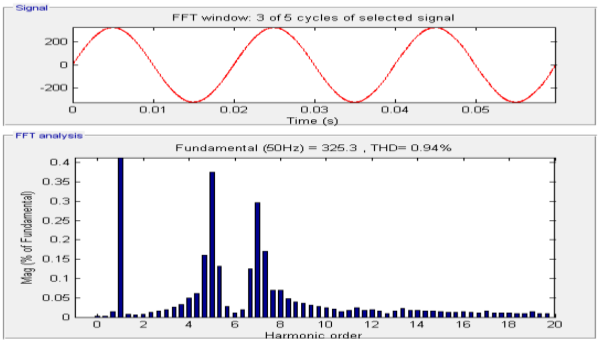


Figure 24. THD=0.94% of Source voltage

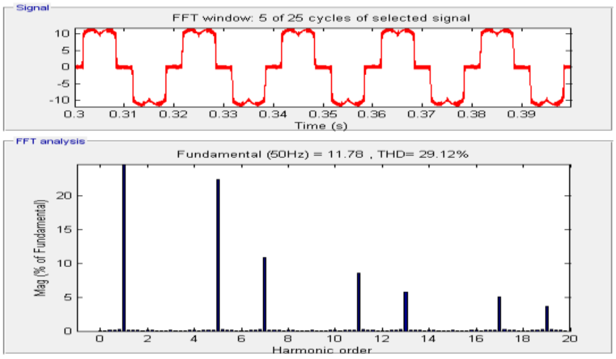


Figure 25.THD=29.12 % of Load Current

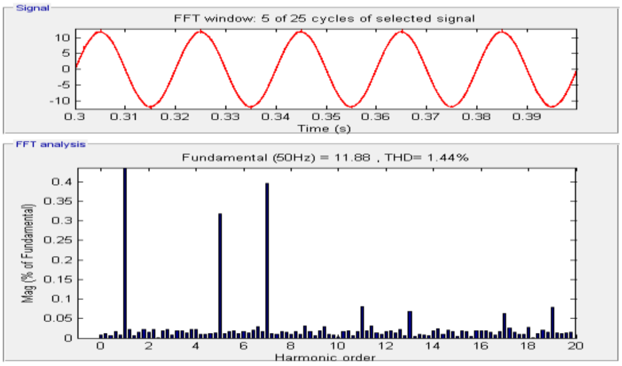


Figure 26. THD=1.44 % of Source Current

Table-1. Simulation results and THD level of Voltage waveforms at the PCC

System Voltage Condition	Phase	Before Compensation		After Compensation	
		Voltage THD (%)	RMS	Voltage THD (%)	RMS
Balanced Voltage (V)	A	22.36	235.5	0.94	230
	B	22.36	235.5	1.09	230
	C	22.36	235.5	1.07	230
Unbalanced Voltage (V)	A	20.76	252.8	4.19	237.5
	B	22.36	235.5	4.91	230
	C	24.22	218.3	4.97	212
Voltage Sag with Harmonics Distortion	A	21.45	235.5	1.40	229.6
	B	21.45	235.5	1.46	229.6
	C	21.45	235.5	1.41	229.6
Voltage Swell with Harmonics Distortion	A	21.45	235.5	1.40	229.4
	B	21.45	235.5	1.46	229.4
	C	21.45	235.5	1.41	229.4

Table-2. Simulation results and THD level of Current waveforms at the PCC

System Condition	Phase		Before Compensation		After Compensation	
			Current THD (%)	RMS	Current THD (%)	RMS
Balanced Voltage (V)	A		29.12	8.67	1.44	8.40
	B		29.05	8.69	1.41	8.40
	C		28.98	8.68	1.40	8.40
Unbalanced Voltage (V)	A		25.73	8.57	1.60	7.92
	B		29.13	8.10	1.53	7.74
	C		33.80	7.41	1.51	7.82
Transient Current Condition	Low Load Condition	A	29.23	8.67	2.79	8.40
		B	29.06	8.69	3.36	8.40
		C	29.08	8.68	3.29	8.40
	High Load Condition	A	29.34	17.3	2.73	16.7
		B	29.47	17.3	2.73	16.7
		C	29.79	17.3	2.71	16.7

IV. CONCLUSION

Problems in The power quality at distribution systems are old but customer recognition of these problems increased recently. AMain evaluation of UPQC for improvement in Power Standard at distribution level has been reported in this paper. It’s very tough to maintain electric power quality at acceptable limits. One modern and very favorable solution that deals with both load current and supply voltage imperfection is the Unified Power Quality Conditioner (UPQC). This paper presented evaluation on the UPQC to improve the electric power quality at distribution level. The UPQC is able to compensate supply voltage power quality problems such as harmonics, voltage sags, voltage swells,voltage unbalance, and voltageflicker and for load current power quality problems such as, unbalance, harmonics, reactive current and neutral current. In this paper some UPQC layouts have been discussed. Among all these arrangement, UPQC-DG could be the most interesting topology for a renewable energy based power system.

V. REFERENCES

Books

[1]. C. Sankaran., “Power Quality” CRC Press -2002.

[2]. EwaldF.. Fuchs. and Mohammad A.S. Masoum, “Power Quality in Power System and Electrical Machines.” 2008.

Papers

[1] H. Akagi., Edson HirokazuWantanbe .and Mauricio Aredes, “Instantaneous Power Theory and Applications to Power Conditioning” IEEE Press 2007.

[2] VinodKhadkikar., “Enhancing Electric Power Quality Using UPQC: A Comprehensive Overview”, IEEE TRANSACTIONS ON POWER ELECTRONICS, Vol. 27, No. 5, MAY-2012.

[3] S. Srinath, M. P. Selvan and K. Vinothkumar,“Comparative Evaluation of Performance of DifferentControl Strategies on UPQC Connected DistributionSystem”, 5th International Conference on Industrialand Information Systems (ICIIS), JULY 29-AUG. 01,2010.

[4] NassarMendalek, Kamal AI-Haddad, “Modeling andNonlinear Control of Shunt Active Power Filter in theSynchronous Reference Frame”, IEEE, 2001.

[5] Bhim Singh, Kamal Al-Haddad and Ambrish Chandra, “A Review of Active. Filters for Power Quality Improvement”, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, Vol. 46, No. 5, October-1999.

[6] MetinKesler and EnginOzdemir, “Synchronous-Reference Frame-Based Control Method for UPQC Under Unbalanced and Distorted Load Conditions”, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL-58, NO. 9, SEPTEMBER 2011.

[7] M. Basu, N. G. Jayanti, M. F. Conlon, K. Gaughan, “Application of a Unified Power Quality Conditioner (UPQC) to Enhancement of the Fault Ride-Through Capability of Wind Generation”, Proceedings of the 40th International Universities Power Engineering Conference(UPEC), Cork, Ireland, Sept-2005

[8] Vinod Khadkikar, A. Chandra, A. O. Barry and T. D. Nguyen, “Steady State PowerFlow Analysis Of Unified Power Quality Conditioner (UPQC)” IEEE CCECE/CCGEL, Ottawa, May 2006

[9] M. Basu, S. P. Das, and G. K. Dubey, “Experimentalinvestigation of performance of a single phase UPQC forvoltage sensitive and non-linear loads.” in Proc. PowerElectro. Drive System, Oct. 22-25, 2001

[10] K.N.Barot, R.N. Rathod, “Three Phase Shunt Active Power Filter Based on PQ Theory For Harmonic Mitigation and Power Quality Improvement”,International Conference on Electrical Engineering and Computer Sciences (ICEECS) April 2012

[11] J. C. Das, “Passive Filters-Potentialities and Limitations” Senior Member, IEEE, 00939994/04$20.00 © 2004 IEEE, IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS, VOL. 40, NO. 1, JANUARY/FEBRUARY 2004

[12] H.Ezoji, A.Seikholeslami, M.Tabasi and M.M.Saeednia, “Simulation of DynamicVoltage Restorer Using Hysteresis Voltage Control”, European Journal of Scientific Research, 2004