# UVTG CONTROL STRATEGY FOR THREE PHASE FOUR WIRE UPQC TO IMPROVE POWER QUALITY

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***Abstract*** **– This paper presents a control strategy of a three-phase, four-wire Unified Power Quality Conditioner (UPQC) to improve power quality. The UPQC is realized by the integration of series and shunt Active Power Filters (APF) sharing a common DC bus capacitor. For the control of series APF, and shunt APF a simple scheme based on the Unit Vector Template Generation (UVTG) is applied. The performance of the applied control algorithm is evaluated in terms of mitigation of voltage and current harmonics in a three-phase, four-wire distribution system. The reference signals and sensed signals are used in a hysteresis controller to generate switching signals for shunt and series APFs. In this proposed UPQC control scheme, the current/voltage control is applied to the fundamental supply currents/voltages instead of fast-changing APF currents/voltages, thus reducing the computational delay. The current project will be done by using MATLAB/ Simulink to achieve performance of UPQC.**

***Index Terms-*** **Active Power Filter (APF) , Power Quality(PQ),Unit Vector template Generation (UVTG), Unified Power Quality conditioner (UPQC), three phase four wire(3P4W) system.**

## I. INTRODUCTION

The main objective of electric utility companies is to supply their customers with uninterrupted sinusoidal voltage of constant magnitude. However this is becoming increasingly difficult to do, because the size and number of non-linear and poor power factor loads such as adjustable speed drives, computer power supplies, furnaces and traction drives are increasing rapidly. Due to their nonlinear nature, these solid state converters cause excessive neutral currents in three phase four wire systems. Moreover, in the case of the distribution system, the overall load on the system is seldom found to be balanced. In the past, the solutions to mitigate these identified power quality problems were through using conventional passive filters. But their limitations such as, fixed compensation, resonance with source impedance and the difficulty in tuning time dependence of filter parameters have ignited the need for active and hybrid filters. The rating of active filters is reduced through augmenting them with passive filters to form hybrid filters, which reduce overall cost. Also they can provide better compensation than either passive or active filters. If one can afford the cost, then a hybrid of two active filters provides the best solution and thus it is known as a unified power quality conditioner (UPQC) or universal active filter. Therefore, the development of hybrid filter technology has been from a hybrid of passive filters to a hybrid of active filters to provide a cost-effective solution and optimal compensation.

The function of unified power quality conditioner is to compensate supply voltage flicker/imbalance, reactive power, negative-sequence current, and harmonics. In other words, the UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. Therefore, the UPQC is expected to be one of the most powerful solutions to large capacity loads sensitive to supply voltage flicker/ imbalance. The UPQC consisting of the combination of a series active power filter (APF) and shunt APF can also compensate the voltage interruption if it has some energy storage or battery in the dc link. In this paper a new control algorithm for the UPQC system is optimized without measuring transformer voltage, load and filter current, so that system performance is improved. The proposed control technique has been evaluated and tested under unbalanced load conditions using MATLAB/Simulink software.

## II. UNIFIED POWER-QUALITY CONDITIONER (UPQC)

The UPQC consists of two voltage source inverters connected back to back with each other sharing a common dc link. One inverter is controlled as a variable voltage source in the series APF, and the other as a variable current source in the shunt APF. Fig. 1 shows a basic system configuration of a general UPQC consisting of the combination of a series APF and shunt APF. The main aim of the series APF is harmonic isolation between load and supply; it has the capability of voltage flicker/ imbalance compensation as well as voltage regulation and harmonic compensation at the utility-consumer PCC. The shunt APF is used to absorb current harmonics, compensate for reactive power and negative-sequence current, and regulate the dc link voltage between both APFs.

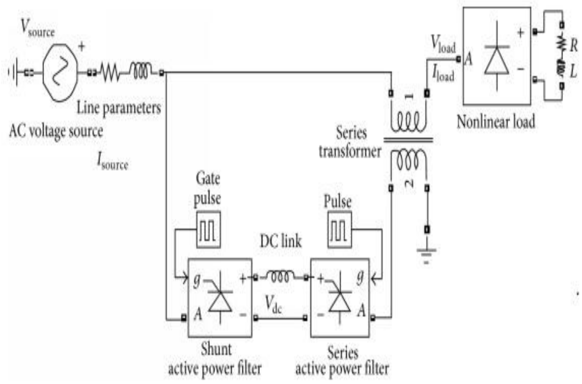


Fig.1 Basic system configuration of UPQC

In this paper unified power quality conditioner (UPQC) is being used as a universal active power conditioning device to mitigate both current as well as voltage harmonics at a distribution end of power system network. The control algorithm of UPQC in MATLAB/ Simulink simulation software is shown in Fig.2.

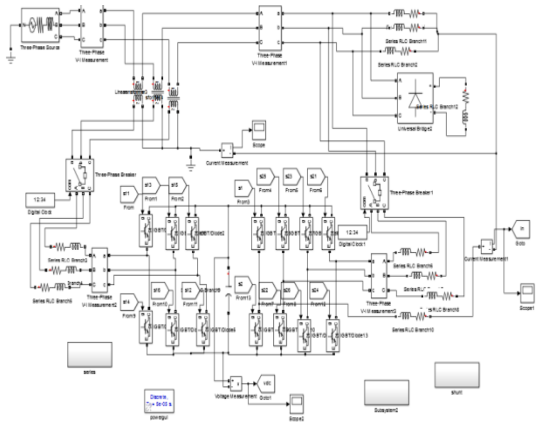

Fig. 2 Simulation Circuit of UPQC

## III. UPQC CONTROL STRATEGY

### 3.1. Series Control Strategy:

A simple control algorithm based on UVTG[2] is used to control the series APF of proposed topology. The series is controlled in such a way that it injects voltages ($v_{fa}$, $v_{fb}$ and $v_{fc}$), which cancel outs the distortions present in the supply voltages ($v_{sa}$, $v_{sb}$ and $v_{sc}$), thus making the voltages at PCC ($v_{la}$, $v_{lb}$ and $v_{lc}$) perfectly sinusoidal with the desired amplitude. In other words, the sum of supply voltage and the injected series filter voltage makes the desired voltage at the load terminals. The control strategy for the series APF is shown in Fig. 3.

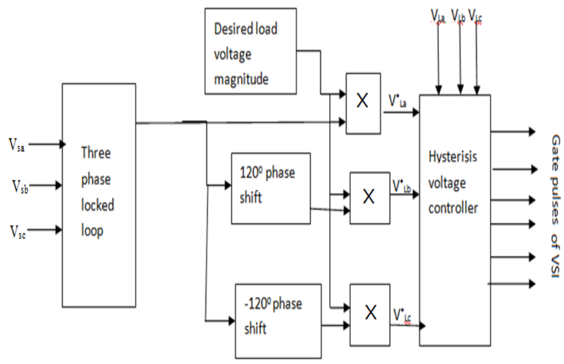


Fig.3 Control Scheme of Series APF

Three-phase distorted supply voltages are sensed and given to PLL which generates two quadrature unit vectors (sin*wt*, coswt). The in-phase sine and cosine outputs from the PLL are used to compute the supply in phase, $120^0$ displaced three unit vectors (ua, ub and uc) using eqn.(1) as

$$\begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \frac{-1}{2} & -\frac{\sqrt{3}}{2} \\ \frac{-1}{2} & \frac{\sqrt{3}}{2} \end{bmatrix} \begin{bmatrix} \sin\theta \\ \cos\theta \end{bmatrix} \quad \text{.................... (1)}$$

The computed three in-phase unit vectors then multiplied with the desired peak value of the PCC phase voltage ($V^*_{lm}$), which becomes the three-phase reference PCC voltages as:

$$\begin{bmatrix} v^*_{la} \\ v^*_{lb} \\ v^*_{lc} \end{bmatrix} = V^*_{lm} \begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix} \quad \text{........... (2)}$$

The computed voltages from reference voltages from eqn. (2) are then given to the hysteresis voltage controller along with the sensed three phase PCC voltages ($v_{la}$, $v_{lb}$ and $v_{lc}$). The output of the hysteresis controller is switching signals to the six switches of the VSI of series APF. The hysteresis controller generates the switching signals such that the voltage at PCC becomes the desired sinusoidal reference voltage.

**3.2. Shunt Control Strategy:**

The control algorithm for shunt APF [2] consists of the generation of three-phase reference supply currents ($i^*_{sa}$, $i^*_{sb}$ and $i^*_{sc}$) and it is depicted in Fig.4.

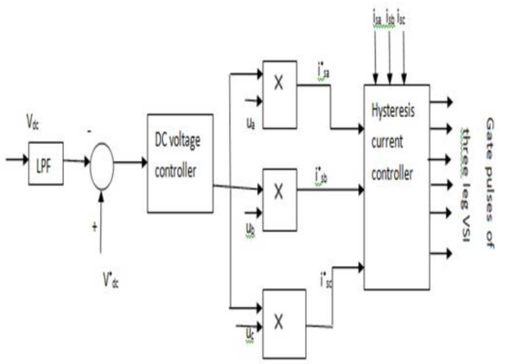


Fig.4 Control Scheme of Shunt APF

This algorithm uses supply in-phase; $120^0$ displaced three unit vectors computed in eqn. (1).The amplitude of the reference supply current ($I^*_{sp}$) is computed from the comparison of average and the reference value of the dc bus voltage of the back to back connected VSIs results in voltage error, which is fed to a proportional integral (PI) controller. The output of the PI controller is taken as the reference amplitude ($I^*_{sp}$) of the supply currents. The three in-phase reference supply currents are computed by multiplying their amplitude ($I^*_{sp}$) and in-phase unit current vectors as:

$$\begin{bmatrix} i^*_{sa} \\ i^*_{sb} \\ i^*_{sc} \end{bmatrix} = I^*_{sp} \begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix} \quad \text{....... (3)}$$

The computed three-phase supply reference currents are compared with the sensed supply currents and are given to a hysteresis current controller to generate the switching signals to the switches of the shunt APF which makes the supply currents follow its reference values. In this control scheme, the current control is applied over the fundamental supply currents instead of the fast changing APF currents, thereby reducing the computational delay and number of required sensor. In addition to this, no extra control is required for the mitigation of source neutral current.

## IV. SIMULATOIN RESULTS

In this study, the control algorithm for the UPQC is evaluated by using MATLAB/Simulink software under combination of linear and nonlinear load conditions. The simulated UPQC system parameters are given in appendix. The simulation results for the proposed 3P4W system realized from a 3P3W system utilizing UPQC are shown in below. Utility voltages are assumed to be distorted with voltage THD of 27.62%.The distorted voltage profile is shown in fig.5.The UPQC should maintain the voltage at load bus at a desired value and free from distortion. The plant load is assumed to be the combination of a balanced three-phase diode bridge rectifier followed by an R–L load, which acts as a harmonic generating load, and three different single-phase loads. The shunt and series active filters are turned on at t=0.1sec. The series APF injects the required compensating voltages through series transformer, making the load voltage free from distortion (THD = 13.34%) are shown in fig. 6.the series APF injected profile is shown in fig. 7. Simultaneously, the shunt APF injects the compensating currents to achieve the balanced source current, free from distortion, as discussed in the previous section. The compensated source currents shown in Fig. 8 are perfectly balanced with the THD of 0.49%. The currents injected by the shunt APF are shown in fig. 9.

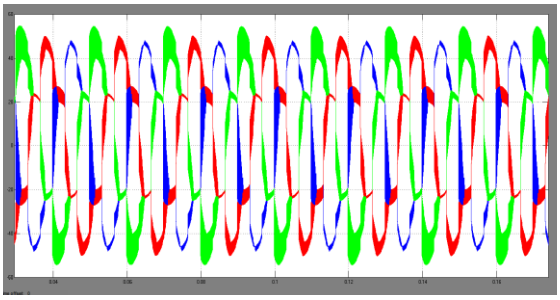

Fig. 5. Utility voltage

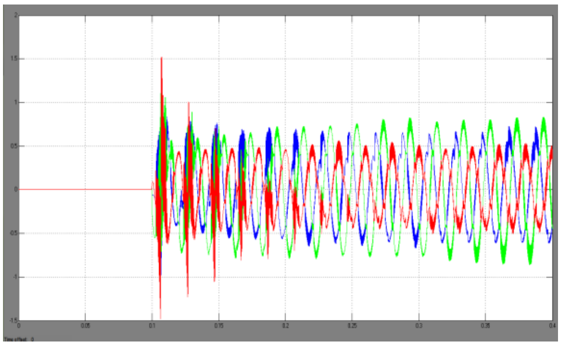

Fig. 6. Load voltage

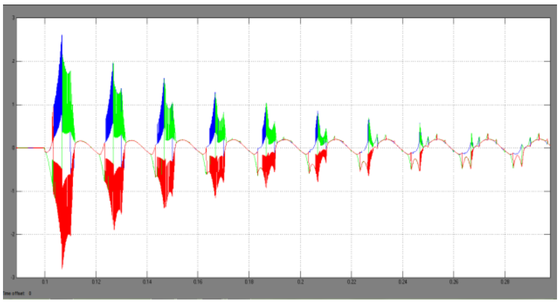

Fig. 7. Injected voltage

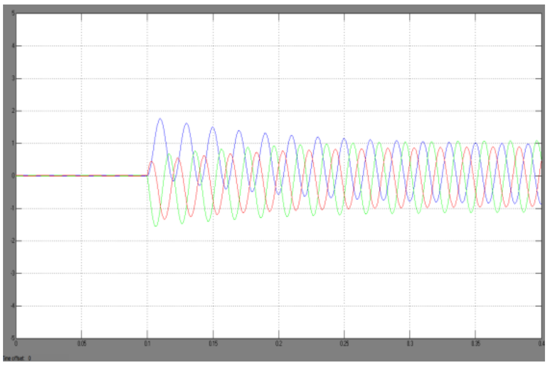

Fig. 8.source current

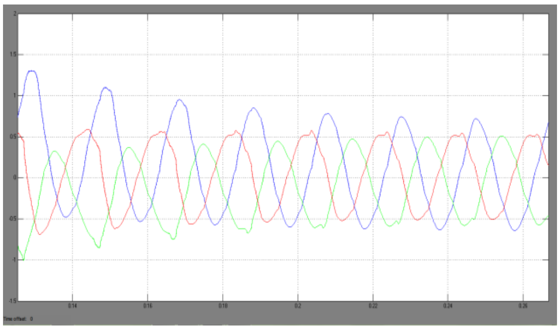

Fig. 9. Shunt compensating current

The FFT analysis of source current and load voltages are shown in fig. 10 and fig. 11.

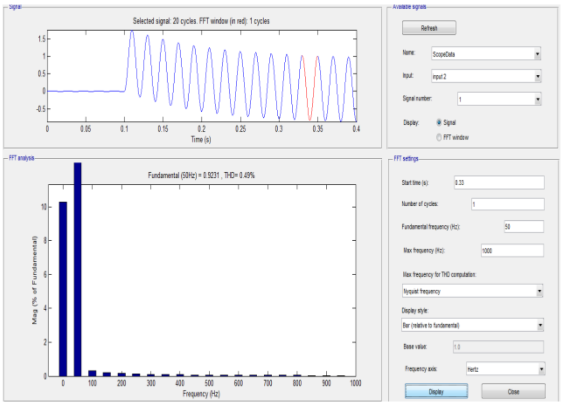

Fig 10.FFT analysis of source current

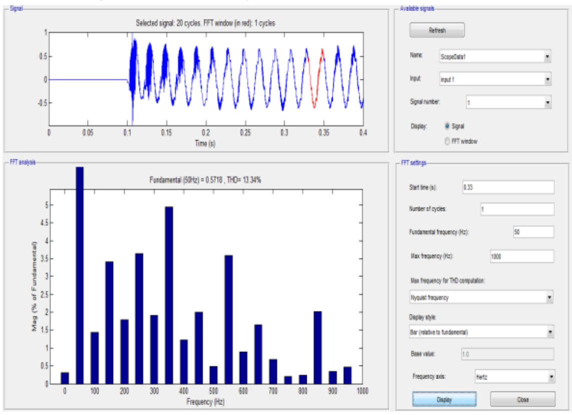

Fig 11.FFT analysis of load voltage

## V. CONCLUSION

UVTG control for a 3P4W distribution system utilizing UPQC has been proposed in this paper. This proposed topology would be very useful to expand the existing 3P3W system to 3P4W system where UPQC is installed to compensate the different power quality problems. The MATLAB/Simulink-based simulation results show that the utility side source currents are perfectly balanced and are free from distortion. Here the power quality problems like voltage and current unbalanced and finding the total harmonic distortion (THD) of 3P4W system with UPQC are presented.

## APPENDIX

The system parameters are given as follows: Vs = 400 V (rms voltage), f = 50 Hz, $L_{Sh}$ = 1mH, $R_{Sh}$ = 1 Ω, $L_{Sr}$ = 1mH, $R_{Sr}$ = 0.1 Ω, and $C_{dc}$ = 2200 μF.
Plant loads:
1) Three-phase diode bridge rectifier followed by R–L load with R = 10 Ω and L = 4mH.
2) Three single-phase loads of R=0.01Ωand L=3.3mH.

## REFERENCES


1. V. khadkikar and A. Chandra, "A novel structure for three-phase four wire distribution system utilizing unified power quality conditioner (UPQC)",IEEE Transaction on industryapplication,Vol.45,no.5,pp.1897-1902,Sep/oct.2009.

2. Yash Pal, A. Swarup, B. Singh "A New Topology of Three-Phase Four-Wire UPQC with a Simplified Control Algorithm" **,** Majlesi Journal of Electrical Engineering Vol. 6, No. 1, March 2012.

3. Bhim Singh and Venkateswarlu .P, "A Simplified Control Algorithm for Three-Phase, Four-Wire Unified Power Quality Conditioner", Journal of Power Electronics, Vol. 10, No. 1, January 2010.
4. Paduchuri. Chandra Babu and Subhransu.Sekhar.Dash, "Design of Unified Power Quality Conditioner (UPQC) Connected To Three Phase Four Wire System", International Journal of Computer and Electrical Engineering, Vol.4, No.1, February 2012.
5. Metin Kesler, Engin Ozdemir "A Novel Control Method for Unified Power Quality Conditioner (UPQC) Under Non-Ideal Mains Voltage and Unbalanced Load Conditions" 2010 IEEE