REVIEW OF UPQC CONTROL TECHNIQUES FOR POWER QUALITY IMPROVEMENT

Kolipaka Srivani, Aiswarya rajalaxmi
Department of electrical engineering
Lovely professional university, Punjab.

ABSTRACT
This paper deals with the UPQC with different control techniques for solving the power quality problems such as harmonics, sag, swell, voltage regulation, load balancing and power factor improvement in the 3-phase distribution system. UPQC is the combination of both shunt and series active filters connected to the dc common link. Voltage based distortions are solved by series active filters and current based problems solved by shunt active filter. MATLAB/SIMULINK is used for modeling of UPQC.

KEY WORDS: UPQC, POWER QUALITY.

I. INTRODUCTION
Power electronics devices playing an important role in transmission and distribution systems. Power electronic devices due to non-linear loads draw harmonics and reactive power from the supply side. These injected harmonics, excessive reactive burden and excessive neutral currents cause low efficiency and poor power factor. In the previous days passive filters are used to solve the power quality problems but these passive filters have specified limitations. A new custom power device is adopted for solving the power quality problems. The custom power device is applicable only to the distribution system.

UPQC one of the custom power device designed with the one series APF and shunt APF connected to the common link. Series active filter acts as DVR and shunt APF acts as D-STATCOM. Generally DVR is used to solve the voltage based distortions and DSTATCOM solve the current based distortions.

II. SYSTEM DISCRIPTION
The structure of UPQC consists of series active filter and shunt active filter connected to the common link. Loads such as diode or thyristor bridge rectifiers draws a highly inductive nature loads at the point of common coupling (PCC). These can compensate by shunt APF connected with the load and loads such as diode bridge rectifier with high dc capacitive filters draws a high power supplies in terms of AC to DC form for AC drives. These types of loads are managed by connecting series active filter with load and solve the voltage based problems and follows a control law injected voltages and input should be sinusoidal, thus utility voltages are unbalanced or not a sinusoidal due the different clients are connected on the same grid so proper selection magnitude and phase for injected voltages will makes voltages balanced at the load end side.

III. REVIEW OF UPQC CONTROL TECHNIQUES
Sundeep kumar.R, Ganesan.p(2006) are published a paper in which a 250kva UPQC is developed for field trial results. The 250kva upqc solves power quality issues like voltage swell, sag, reactive currents and harmonics. This UPQC is developed at center of development of advanced computing (CDAC), which is located at trivandrum, India. UPQC is combination of series and shunt filter connected to a dc common link. The control strategy used for shunt active filter is d-q reference frame theory. This control law is used to maintain the dc bus to the reference value and compensation of reactive power and harmonics are taken from the load. The reference voltages using d-q axis is expressed as

\[ V_d = i_d R + L \frac{di}{dt} + Li_q + V_g \]
In the second section of the paper, Mishra and others injected controllable power and used the proposed method in which PI, ANN, FUSSY controllers were employed. In the paper, a new method was proposed for UPQC for power quality improvement. UPQC is combination of series and shunt active filter connected to a common dc link. An instant adjustment of the series and shunt filters such that the power quality related problems like voltage sags, swells, flickers, harmonics and voltage imbalances are solved. U_a, U_b, and U_c are three phase voltages and calculated voltage. The proposed method of this paper involves series and shunt active filter connected to a common dc link.

This 250 kva UPQC improves power quality problems [1].

A.Jayalaxmi, G.Tulasiram and K.Uma Rani (2006) are published a paper in which PI, ANN, FUSSY controllers used for shunt filter for generating reference current signals. PI controller is closed loop system. In this controller the V_dc is sensed at the regular intervals and compared with the V_ref. The error signal is proceeds to PI controller and the output of controller is denoted by I_{sp(c)}. FUSSY controller is adaptive nature and robust performance in cases of parameters variation controller is present. In FUSSY the PI controller is combined with the intelligent and adaptive of fuzzy based controller. In ANN controller the units are trained to perform particular function by adjusting values of elements and uses LMVB (Levenberg Marquardt Back Propagation) algorithm. For series control direct and in direct methods are used for generating reference signals[2].

Siva Kumar G. Kalyan Kumar B. Mahesh and K. Mishra (2008) are published a paper in which a new methodology is used for UPQC unbalance voltage sag with minimum real power injection. This real power injection is compared with the UPQC-Q minimum real power injection. Particle swarm optimization (PSO) is tool for voltage angle injection with constraints on injected voltage. The proposed method of UPQC with minimum real power injection during the mitigation of voltage sag with phase jumps having constraints, those are 1. Angle of injection of SEAPF with respect to V1/2 should be -90 ≤ θj ≤ 90, 2. Total magnitude of SEAPF injected voltage, abs (V_{inj,j}) < 0.5 pu and 3. Phase jump elimination, θ_a+δ_a = θ_b+δ_b = θ_c+δ_c. In the second constraints voltage rating of SEAPF and proposed method has more adequate SEAPF voltages. The advantage of this method is the real power injection is less compared to other methods. PSO is one of the popular method used for solve the optimization problems. This method is more economical and more compact devices so the stored amount is reduced [3].

A. Kazemi, R. Rezaeipour (2008) published a paper in their paper a new method is proposed for UPQC for power quality improvement. UPQC is combination of series and shunt active filter connected to a common dc link. An instant adjustment of the series and shunt filters such that the power quality related problems like voltage sags, swells, flickers, harmonics and voltage imbalances are solved. U_a, U_b, and U_c are three phase voltages and calculated voltage. The proposed method of this paper involves series and shunt active filter connected to a common dc link.

The reference voltage can be calculated as

\[
U = \left( \sqrt{abs \left( \frac{1}{2} \right)} \right)^T \left( \begin{array}{c} u^a_T \\ u^b_T \\ u^c_T \end{array} \right)
\]

Parallel active filter control should be in such a way that the reactive power of load be completely supplied by UPQC in order to maintain the load power factor be 100% in the network point of view. So, this principle was used in parallel control signal preparation and the reference current is calculated after computing the instantaneous active power of load [4].

H. Toodeji, S. H. Faith and G. B. Gharehpetian (2009) published a paper, in which possibility of active power controller is added to shunt and series active filters of UPQC so that active power can be deliver to each part be managed. The main use of series filter is elimination harmonics and voltage imbalances. In control system of series filter, the load voltage transferred to dqo coordinates and difference between real and reference values are transferred to PI controller. The output of PI controller is reference of d-axis voltage. Similarly the difference of reference and real values generates q-axis voltage. In Shunt filter controller, load current is transferred to dqo coordinates. Where d axis current is used to active power control and q axis for reactive power control. Reference power is obtained from power generated by wind turbine and injection of actual power by series filter. In this after finding current references, the abc coordinate currents are obtained by reverse transformation. These currents are compared with the output currents of inverter and the errors are passed through a PI controller and these are applied to the PWM generator. Using this proposed method, each part of UPQC injected controllable power and we could deliver the power to load centers and network side. In this VSC as a rectifier with the variable speed wind turbine and its proper controlled to extract maximum power from wind [5].
Yash pal and A.Swarup (2010) published a paper in their the performance of UPQC is done with a new control technique that unit vector template technique(UTT) and PI controller. UTT technique is used to get reference voltage signals for series filter and UTT generation is done with the help of Phase locked loop. Vector templates are multiplied with the peak amplitudes (V_{imm}). The reference load voltages are obtained with the equations as,

\[ V_{1ar} = V_{imm} * u_a \]
\[ V_{1br} = V_{imm} * u_b \]
\[ V_{1cr} = V_{imm} * u_c \]

Reference current signals are generated by shunt active filter and it uses two closed loop PI controllers. One controller is used to get the reference currents in phase with voltage at point of common coupling (pcc). Another PI controller is used for amplitude of quadrature components of reference supply currents. A UPQC using UTT technique improves the power quality like voltage and current harmonics mitigation, power factor correction, load balancing and mitigation of voltage sag and swell[6].

A.Swarup and Bhim singh (2010) published a paper in their paper in which 3-phase 4-wire UPQC is proposed for power quality improvement. in 3phase 4W distribution system two different topologies are proposed. A comparative analysis of these topology along with four leg voltage based inverter of UPQC with four wire is proposed in this paper. The synchronous reference frame (SRF) theory is used as control technique for shunt and series active filter. The control strategy for series filter is used to calculate 3 phase reference voltages at load terminals (v1_a, v1_b and v1_c). The series filter injects the voltages which cancels the distortions in the supply voltages. A PLL is used for synchronization with supply voltages. A distorted three phase supply voltages are given to PLL which generates two quadrature unit vectors. The sensed supply voltage is multiplied with a suitable value of gain before applied as an input to PLL. The inverse peak transform is done for desired peak value of voltages at point of common coupling. That can be expressed as

\[
\begin{bmatrix}
  v_{1a} \\
  v_{1b} \\
  v_{1c}
\end{bmatrix} =
\begin{bmatrix}
  \cos \theta & -\sin \theta & 0 \\
  \cos \left(\theta - \frac{2\pi}{3}\right) & -\sin \left(\theta - \frac{2\pi}{3}\right) & 1 \\
  \cos \left(\theta + \frac{2\pi}{3}\right) & -\sin \left(\theta + \frac{2\pi}{3}\right) & 1
\end{bmatrix}
\begin{bmatrix}
  v_a \\
  v_b \\
  v_c
\end{bmatrix}
\]

The computed reference voltages from and the sensed three phase actual load voltages(v1_a, v1_b and v1_c)are given to the hysteresis controller. 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 sinusoidal reference voltage with desired magnitude. Therefore, the injected voltage across the series transformer through the ripple filter cancels out the distortions present in the supply voltage. The control scheme of shunt active filter consist of three phase reference supply currents received from PL and load currents transferred to dquo components using the park’s transformation.

\[
\begin{bmatrix}
  i_a \\
  i_b \\
  i_c
\end{bmatrix} =
\begin{bmatrix}
  \cos \theta & -\sin \theta & 0 \\
  \cos \left(\theta - \frac{2\pi}{3}\right) & -\sin \left(\theta - \frac{2\pi}{3}\right) & 1 \\
  \cos \left(\theta + \frac{2\pi}{3}\right) & -\sin \left(\theta + \frac{2\pi}{3}\right) & 1
\end{bmatrix}
\begin{bmatrix}
  V_{1a} \\
  V_{1b} \\
  V_{1c}
\end{bmatrix}
\]

In this reference currents compared in the hysteresis control and generate the switching signals to the series active filters. These proposed three phase four wire UPQC solve power quality problems and gives satisfactory results. Using both configurations of UPQC the load voltages harmonic and supply currents are below the IEEE-519 standards [7].

Nikith hari, k.vijayakumar(2011) published a paper in their paper the performance of UPQC done with the versatile control strategy. These proposed control schemes gives better response under dynamic and steady state. The control schemes for shunt active filters uses hysteresis control for shunt filter applications. These hysteresis control is easy to model and increase the speed and response of system. The control scheme for series active filter uses Two UPQC terms are defined in depending on the angle of the injected voltage. Those are UPQC-P and UPQC-Q. In UPQC-Q the injected voltage is maintained 90 degrees with respect to the supply current. This is the reason that the series compensator consumes no active power in steady state. In UPQC-P the injected voltage is in phase with both the supply current and voltage so that the series compensator consumes only the active power, which is delivered by the shunt compensator through the dc link. The UPQC-P algorithm is easy to implement and with this algorithm the voltage rating of series filter is reduced. UPQC-Q is not work in case of load is purely resistive nature. The enhanced steady state and dynamic performance of UPQC is due to this versatile control strategy using average dc voltage.
regulation, hysteresis controller based current tracking for shunt active filter and PWM controlled series active filter. The performance of the UPQC is compared with DVR and DSTATCOM [8].

B.S.Mohamed and K.S.Rama rao (2011) published a paper in their a new configuration of UPQC is designed for two feeder distribution system for power quality improvement. In this paper the instantaneous reactive power theory (p-q) is used for shunt active filter for reference signal generation. In this three phase current signals for feeder1 are generated by using (a,b,c) coordinates to α,β,0 transformation. It can be expressed as

\[
\begin{bmatrix}
{i_{refa}} \\
{i_{refb}} \\
{i_{reff}}
\end{bmatrix} = \sqrt{3} \begin{bmatrix}
\frac{1}{2} \\
\frac{1}{2} \\
\frac{1}{2}
\end{bmatrix} \begin{bmatrix}
\sin(\theta) \\
\cos(\theta) \\
\sin(\theta - 120^\circ)
\end{bmatrix} \begin{bmatrix}
1 \\
0 \\
1
\end{bmatrix}
\]

For series filter uses synchronous reference frame theory. To ensure that the load2 receive only sinusoidal voltage, the maximum load voltage of feeder2 is transformed from d,q,0 to a, b, c using inverse Park transformation that generates three-phase sinusoidal voltages.

\[
\begin{bmatrix}
V_{refa} \\
V_{refb} \\
V_{reff}
\end{bmatrix} = \begin{bmatrix}
\sin(\theta - 120^\circ) \\
\cos(\theta) \\
\sin(\theta + 120^\circ)
\end{bmatrix} \begin{bmatrix}
1 \\
0 \\
1
\end{bmatrix}
\]

The proposed UPQC with the series controller has the capability of improving the power quality at the point of common coupling in distribution systems [9].

Yash pal and A.Swarup (2011) published a paper, in which three phase four wire UPQC is designed for power quality improvement. Unit vector template technique is used for series active filter for reference voltage signal generation and Icos(φ) theory for shunt active filter for reference voltage signal generation. Three in phase unit vectors are represented as

\[
\begin{bmatrix}
u_a \\
u_b \\
u_c
\end{bmatrix} = \begin{bmatrix}
1 \\
\frac{1}{2} \\
\frac{1}{2}
\end{bmatrix} \begin{bmatrix}
\sin(\theta) \\
\cos(\theta) \\
\sin(\theta - 120^\circ)
\end{bmatrix}
\]

These three in phase voltages are multiplied with desired peak amplitude voltages.

\[
\begin{bmatrix}
v_{1a} \\
v_{1b} \\
v_{1c}
\end{bmatrix} = v_{im} \begin{bmatrix}
u_a \\
u_b \\
u_c
\end{bmatrix}
\]

The control algorithm for series filter senses the (i_{sa}, i_{sb} and i_{sc}) reference source currents (i_{sa}, i_{sb}, i_{sc}) are compared in a hysteresis current controller to generate the switching signals to the switches of the shunt APF which makes the supply currents sinusoidal, balanced in-phase with the voltage at PCC. Using the Icos(φ) theory of three phase four wire UPQC reduces number of current sensors and carries fast computation. The UPQC is satisfactory under transient’s conditions [10].

IV. CONCLUSION

After this survey we realized that, there are different control techniques are used for reference current and voltage signal generation for series active filter and shunt active power filter. UPQC is one of custom power device in the distribution system solve the different power quality problems as voltage sag and swell, current harmonics, power factor correction etc.

REFERENCES