



Control of Power Quality Using Transformer less UPQC with SRF Control

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ABSTRACT: Power quality is the concept of powering linear and nonlinear loads in a manner suitable to the operation of the equipments. The most significant and critical power quality issues are voltage sag ,swell and current distortions. These problems may results in the tripping of critical equipments causes adverse effects in industrial plants can results in the stoppage of whole production with high loses associated. Custom power devices are found effective to all the power quality problems .In order to tackle both voltage and current related problems simultaneously UPQC is found effective. This paper investigates the effectiveness of transformer less UPQC based on the SRF theory. Transformer less UPQC avoids undesirable offset during energisation , increased loses and the cost. Same SRF control theory is using for both the shunt and the series converters which also helps in avoiding the complexity and the cost. The MATLAB / Simulink based simulations are provided to demonstrate this method.

KEYWORDS: Power Quality, Harmonic Compensation, Shunt converter, Hysteresis control, Series controller ,Synchronous reference frame theory

I. INTRODUCTION

With increase in nonlinear load power quality problems are inevitable. In addition loads are suffering from the poor power facto. The non linear loads draw harmonics of current from the supply .Harmonics produced by nonlinear load results in equipment overheating, low power factor and increased loses. Voltage sag and swell are generally associated with the system faults. These problems may occurs due to the changes in voltage for the short duration. Voltage sag and swell can negatively affects the performance of sensitive electronic equipments causing data errors, equipment damage and reduction in equipment life.DVR has the ability to compensate voltage related problems. DSTATCOM is effective in solving the current related problems .Conventionally filters found solution to the harmonics and distortions. But these filters are large in size and also have resonance problems. In order to solve voltage and current distortions effectively UPQC is found effective .In the conventional UPQC many control strategies have been proposed as wavelet transform, neural network and the fuzzy algorithm. These control algorithms are complex. In the proposed work, proper solution to the power quality issues can be obtained using the transformerless UPQC based on the SRF theory. This work analyses the performance of Unified Power Quality Conditioner (UPQC) using Park transformation theory. Unified Power Quality Conditioner consists of voltage source converter and current source converter with a common DC link. One converter is connected in series between the source and nonlinear load and operates as voltage source converter. The other converter is connected as shunt and operates as current source converter. Power handled by converters should be exchanged simultaneously through DC link. This will also avoid shorting during the switching of both converters. The supply voltage has to be distorted by connecting the nonlinear load. The output of series converter is allowed to pass through the low pass filter and is used for attenuating high frequency components generated by high frequency switching at the output of series converter. Transformer injects the compensating voltage and current. High pass filter absorbs the current switching ripples .Reference current is generated by the action of the shunt controller .Similarly reference voltage has to be generated by the action of the series controller. The reference signals has to be generated by the Synchronous Reference Theory (SRF).Park transformation is employing here. The hysteresis control technique for the system is also provided in this paper. Simulation results in the final part shows the advantages of SRF method applying to the transformer less UPQC. Control developed for both the converters and the simulation works are also included in the paper.



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II . LITERATURE SURVEY

An effective solution for power Quality has been searching from decades. Through this journey Filters have been found as one of the solution of power quality issues. To avoid the ill effects of harmonics on the operation of sensitive equipments, it is necessary to keep harmonic contents below safe limit by installing filter at load end. The simplest way of eliminating harmonics of different orders is to install filters at the location generated by different loads . Series connected filters are connected in series with power system network and offer high impedance at tuning frequencies high impedance offered by filters allow very little harmonics are passed. Shunt connected filters is most commonly used filters in A.C. power system network and offers very low impedance path to harmonics. Shunt type of filters are cheaper than series type because the shunt connected filters are designed for graded insulation levels which makes the components cheaper than the series filter components. Passive filters are LC resonating or parallel resonating circuits which offer very high or low impedance at tuning frequency. These filters are resistive at tuned frequency, capacitive at below tuned frequencies and inductive beyond tuned frequency. . The drawback of series filters are high cost, because the rating of filter component required is rated full load current. In order to absorb the source current harmonics filter impedance have to be less than the source impedance. The TCR is act like a variable susceptance. Variation of firing angle changes the susceptance and consequently the fundamental-current component which leads to a variation of reactive power absorbed by the reactor because the applied ac voltage is constant. DVR, Dynamic Voltage Restorer is found as effective in solving the voltage related problems. But current related problems cannot be solved with this technique. DSTATCOM is found as the solution to current related problems and the current distortions. Voltage related problems cannot be solved here. Hence it cannot be considered as the effective solution for the power quality issues. In order to solve both the voltage and current related problems at the same time UPQC is found effective. Different control theories are using for both the shunt and series converters in UPQC. This involves the complexity and the cost. In this work effective solution to power quality can be obtained with the UPQC with same control theory using for both the converters. UPQC with transformer results in undesirable offset during energisation , increases the lost and also the cost. Without using transformer an effective solution to power Quality is essential. Hence in the proposed work UPQC without transformer is implementing.

III. SRF THEORY

SRF theory implements a transformation from three phase to two phase with the same angular velocity as sinusoidal quantity. Park transformation is mostly employing here. According to the SRF theory a balanced ,distortion free and constant magnitude has d and q component only o component will be zero .As per SRF for generating the reference voltage abc to dqo transformation is employing.

Proper controlling of converters can be obtained using SRF theory. The desired load current is applied to the park transformation and transformed to d,q,0 coordinates. The generated components are allowed to pass through the filter for cancelling out the harmonics and feeding for inverse park transformation. Phase Locked Loop is used to generate two quadrature unit vectors($\sin\omega t$, $\cos\omega t$). PLL also helps in synchronization with the supply voltage..The reference signals along with sensed load current are feeding to the hysteresis controller . The output from the controller is the set of switching signals for the shunt controller .Hence the shunt controller can be able to control the current related problems.The control of both shunt and series converters can be obtained through the Synchronous Reference Frame Theory.

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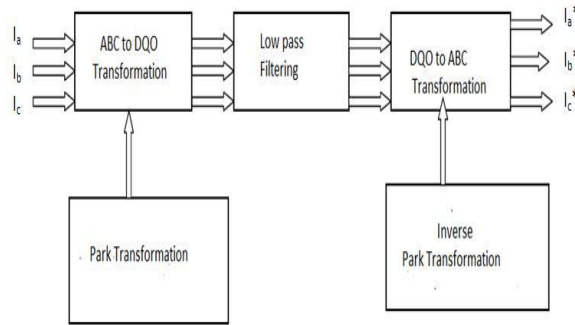


Figure1: Reference signal generation of shunt controller

$$\begin{bmatrix} i_d \\ i_q \\ i_0 \end{bmatrix} = \sqrt{2/3} \begin{bmatrix} \cos(\omega t) & \cos(\omega t - \frac{2\pi}{3}) & \cos(\omega t + \frac{2\pi}{3}) \\ -\sin(\omega t) & -\sin(\omega t - \frac{2\pi}{3}) & -\sin(\omega t + \frac{2\pi}{3}) \\ 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad (4)$$

$$[Id] = \sqrt{2/3} \left[I_a (\cos\omega t) + I_b \cos\left(\omega t - \frac{2\pi}{3}\right) + I_c \cos\left(\omega t + \frac{2\pi}{3}\right) \right] \quad (5)$$

$$[Iq] = \sqrt{2/3} \left[I_a (\sin\omega t) + I_b \sin\left(\omega t - \frac{2\pi}{3}\right) + I_c \sin\left(\omega t + \frac{2\pi}{3}\right) \right] \quad (6)$$

Proper control of voltage can be obtained using SRF theory. The desired voltage is applied to the park transformation and transformed to d,q,0 coordinates. The signals coming after the dq0 transformation is allowed to pass through a low pass filter. The generated components are allowed for inverse park transformation. The reference values are given to the hysteresis controller. Hysteresis controller decides the required gating signals when exceeds the upper or the lower limits. The computed reference signal have to be within the limits (H/2 or -H/2). No switching action is taken when the error is within the hysteresis band. When the error hits the hysteresis band proper switching action is occurring.

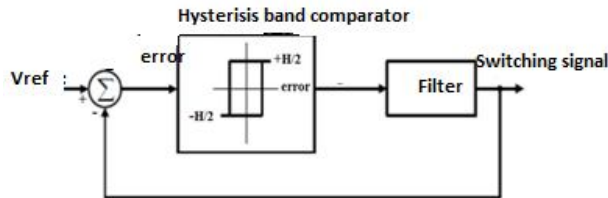


Figure 2: Hysteresis band comparator

Proper control of switching signals are obtained by the action of hysteresis controller and fed to the converter. The output voltage which is at the load terminal becomes sinusoidal with proper amplitude irrespective of distortions and harmonics present in the supply voltage. The difference between the reference current and the sensed current are allowed to pass through the hysteresis controller and the control signals obtained are finally feeding to the shunt controller. The hysteresis band current control is characterized by the very fast response, stability, and also the accuracy. Proper generation of switching signals are carried out by the hysteresis controller. Depending up on the variation of the current the switching frequency of the hysteresis band current control method will vary. The current varies from the upper limit to the lower limit of the hysteresis band and also vice versa.

IV. RESULT AND DISCUSSION

The performance of UPQC with SRF theory based control were tested by simulating a three phase system with non linear load in MATLAB systems environment. The nonlinear load in the three phase system is a three phase diode bridge rectifier with Resistance load. Test system is created and the disturbances are analysed. Distortions in the voltage and current are analysed and effective control for the shunt and series converters have developed.

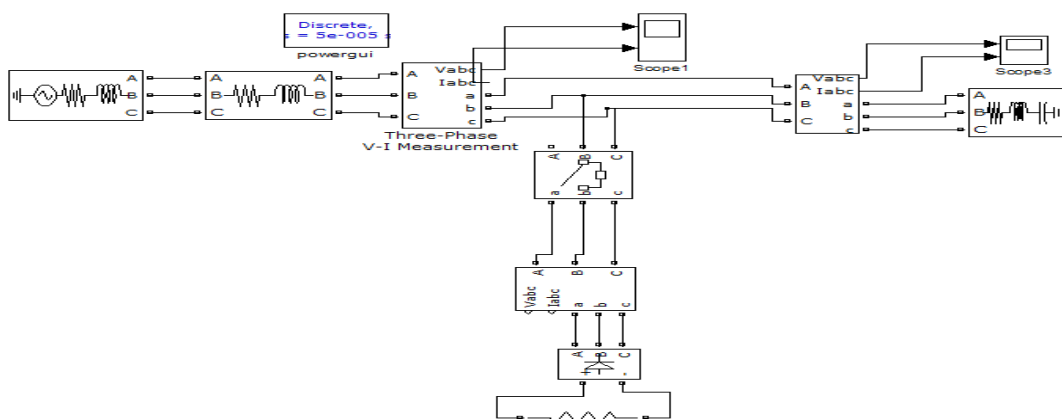


Fig 3: Testing system with nonlinear load

Figure 3 shows the test system with linear and non linear load. The supply voltage is 415V. The frequency is fifty Hertz. The supply voltage and supply current also the load voltage and load current is distorted.

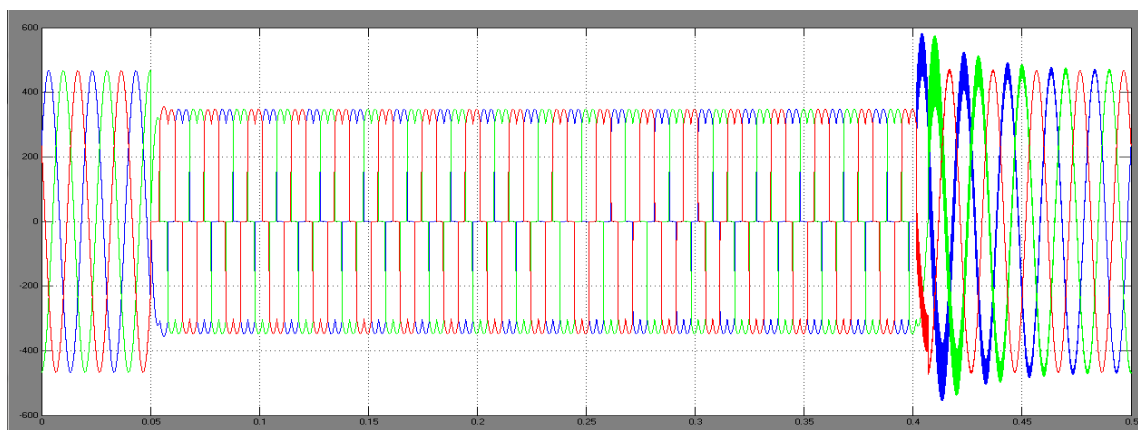


Fig 4, it shows the graph of time Vs Voltage of test system(Non linear load is applying from .05 to 0.4)

Figure 4 shows the distorted voltage . By applying proper control technique the distortions in the voltage have to be controlled.

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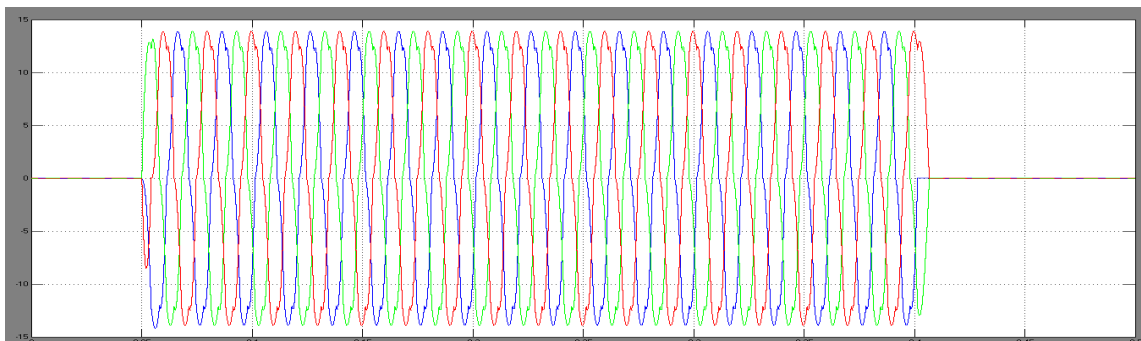


Fig 5, it shows the graph of time Vs current of test system (Non linear load is applying from .05 to 0.4)
Figure 5 shows the distorted current. By applying proper control technique the distortions in the current have to be controlled.

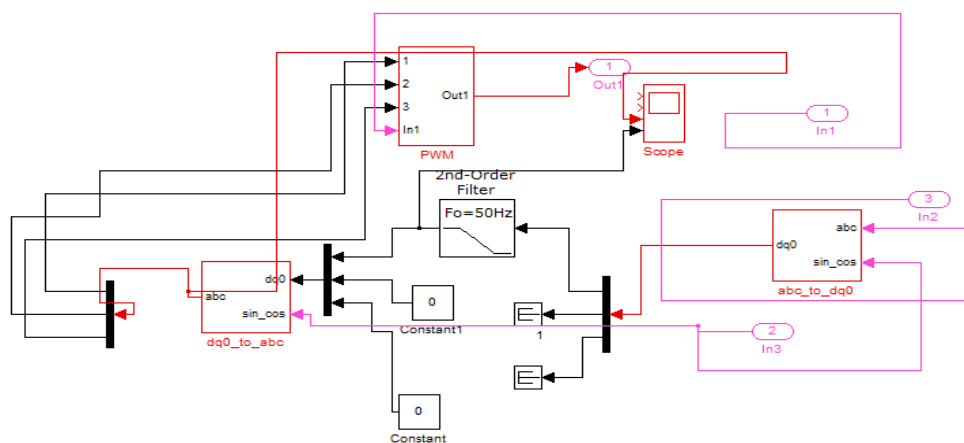


Fig 6 , Control developed for the converters

Figure 6 shows the control technique developed for the shunt converter. Park transformation is done for the abc to dq0 transformation. Low pass filter is used to filtered out unwanted frequency signals. Inverse park transformation is done for the generation of reference signals. Same control technique is using for both the converters ,the shunt and the series which helps in avoiding the undesirable cost and the complexity.

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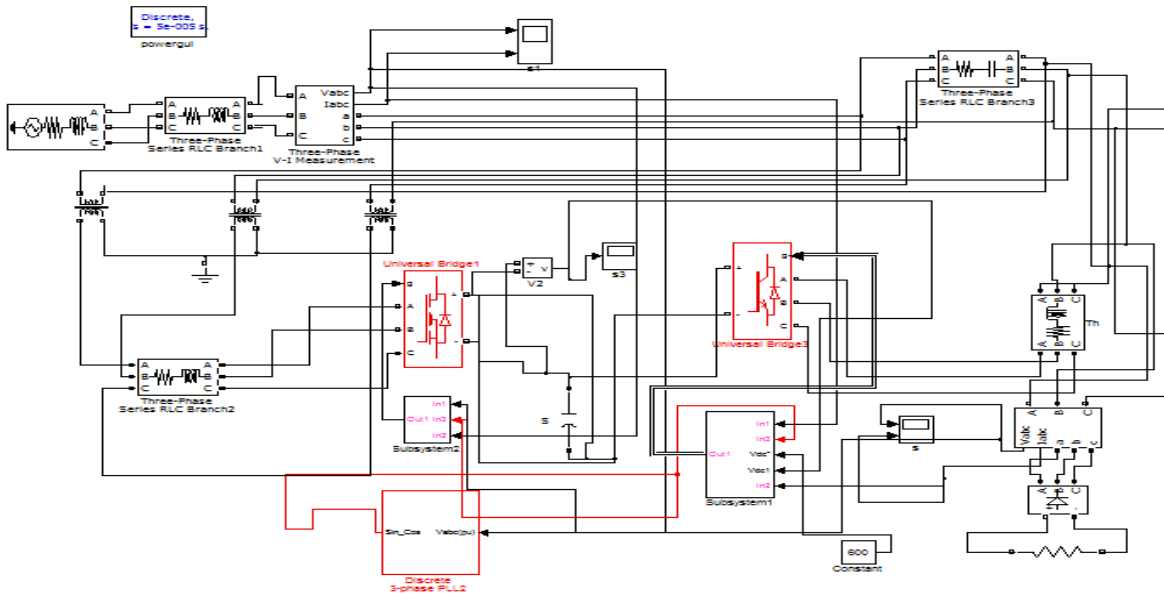


Fig 7, Conventional method ,UPQC with transformer

Figure 7 shows the UPQC with transformer developed as the conventional method. Here the proper compensation of source voltage and current is obtained. But UPQC with transformer leads to undesirable offset during energisation , increased losses and the cost. In order to avoid this proper control of UPQC without transformer is essential.

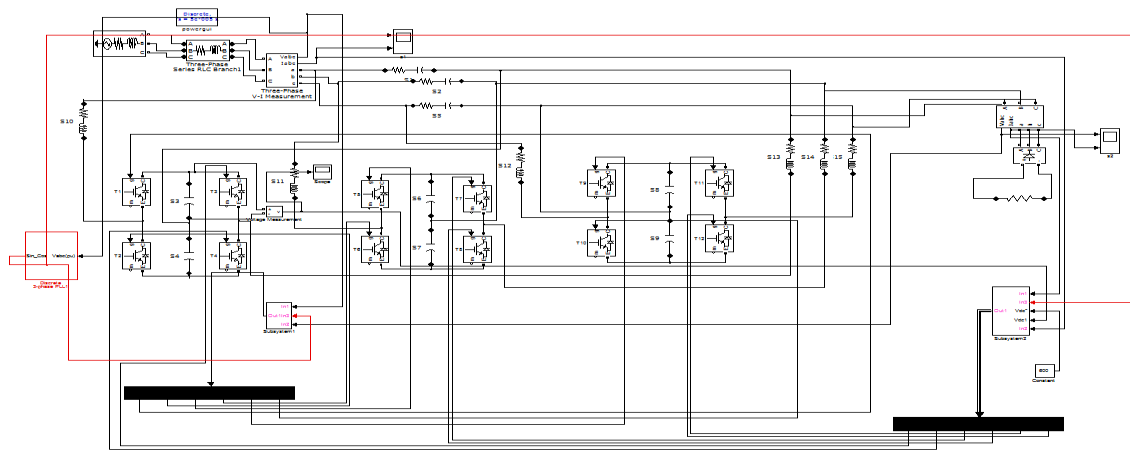


Fig 8 Transformer less UPQC

Figure 8 shows the transformer less UPQC based on the SRF control. In the place of transformer capacitors are placed .Proper control can be obtained with the capacitors. Shunt and the series converter has developed. Series converter is developed and is connected through the capacitor .Non linear load is connected. This helps to avoid undesirable offset during energisation, and increased losses



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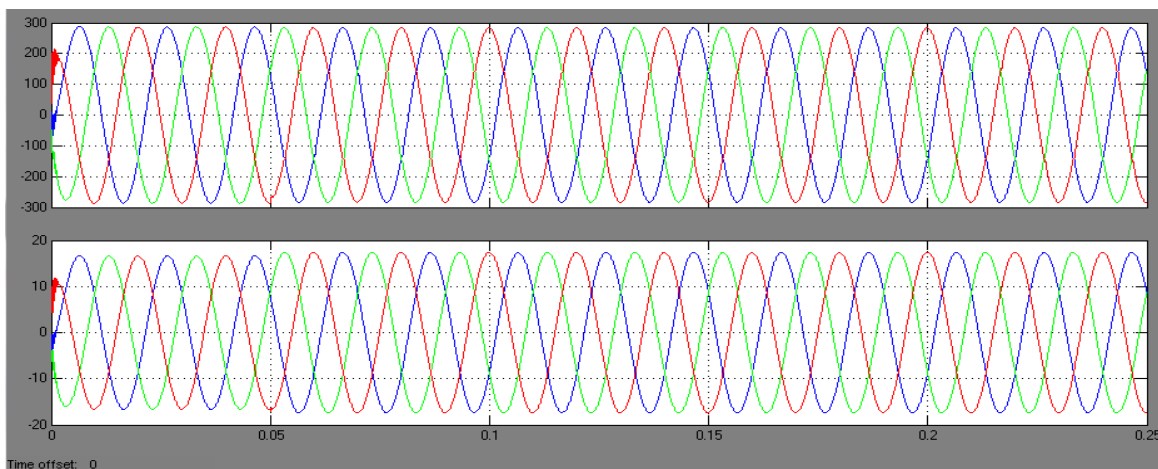


Fig 9 , it shows the graph of time Vs current of compensated voltage and current

Figure 9 shows the compensated voltage and the current. The disturbances in the voltage and the current in the supply are compensated with the transformer less UPQC. Transformer less UPQC also helps to avoid undesirable offset during energisation and makes the output perfectly sinusoidal.

VI.CONCLUSION

Upqc control using srf theory has proved as effective solution to the major power quality problems. The control circuit of shunt and series converter developed using synchronous reference frame theory, was investigated in this paper. A detailed description of shunt and series controller and the srf theory has been provided here. Simulations are carried out and the results conclude that the synchronous reference frame method applied to the transformer less upqc provides better power quality improvement and also helps to avoid undesirable harmonics, distortions ,increased loses and cost .Compared to the UPQC with transformer based on SRF control this method of transformer less UPQC is effective and avoids undesirable offset and harmonics.

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