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"Enhance the Power Quality of the Smart Grid Systemby Using Advance UPQC."

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Abstract: ***The UPQC is the grouping of a DVR and D- STATCOM which perform series, shunt compensating andphase shifting at the same time. This is capable to control the PQ with leading and lagging reactive and real power flow through a particular route with enhance the system stability. The salient options of UPQC device are its multiple management functions, like voltage management,transient stability improvement & damping oscillation. Voltage sag and swell compensation is important for secure system operation. This is a multivariable versatile AC transmission systems controller. In this work UPQC isexcited by PV array with DC link capacitor. In the SG using PMU and flow meter, measures the phase and relateddata, from this data of analysis centralized controller determine the harmonics amplitude and phase. At fault condition UPQC mitigate the fault with simultaneous or individual operation of series-shunt converters. At the presence of harmonics this two converter works simultaneously and optimized the harmonics injected by the UPQC, the centralized controller calculates the switching angle for same magnitude with opposite phase harmonics and inject into the system. These two components eliminate each other and make the grid approximately harmonics free with mitigate the active andreactive power problem.***

Keywords: UPQC, DSTATCOM, DVR, PV array, Power Quality

I. INTRODUCTION

To overcome the problem related power quality, voltage sag, voltage swell in grid we used FACT devices. Inthe last few years due to several reasons. One of the main reasons is that the massive use of power electronics devicesand growth of non-linear loads injects non-sinusoidal component into the grid, thus generates the PQ degradation.UPQC or Unified Power Quality Conditioner is one such FACTS device which can be used to compensate for most ofthe faults with minimal cost investment. UPQC has thepotential to eliminate both current and voltage relatedpower quality issues for the establishment of these lines enhancing the power quality.

The arrangement of both device D-STATCOM and DVRcan control the power quality of the source current and theload bus voltage. This paper proposes a configuration of UPQC which is a mix of both series and shunt converter. Theshunt converter takes out the current related unsettling influences while the series converter takes out the voltage related disturbances. To control the power factor by injecting the required reactive current. The control techniques are different. DVR is expected to respond fast thus employs PWM converters using IGBT devices. This project describes PI controller.

A PI controller is used to generate switching signal and a PWM generator is used for generating switching signal. Lower order harmonics are eliminated by proper selectionof switching angles and at the same time the higher order harmonics are suppressed by injecting same order harmonics with equal magnitude but opposite in phase from the other converter. The excitation of Modified UPQC converters are obtained from PV (Photo- Voltaic) panel.

A. UPQC (Unified Power Quality Conditioner)

A UPQC is a custom power device which can be considered as the combination of D-STATCOM and DVR. Here series converter is a DVR and shunt converter are a D-STATCOM.

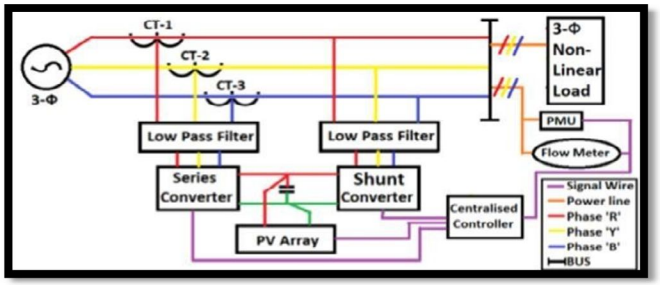


Figure 1: UPQC.

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B. D-Statcom

It is a custom power device which is employed to eliminate the harmonics from the source currents and also balance them in addition to providing reactive power Injection to regulate the load bus voltage or improve power factor.

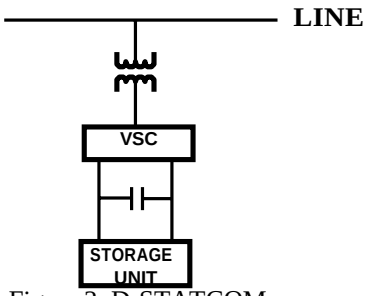


Figure 2: D-STATCOM

C. DVR (Dynamic Voltage Restorer)

A DVR is a device which can work as a harmonic isolator to stop the harmonics within the source voltage reaching the load in addition to balancing the voltages and providing voltage regulation.

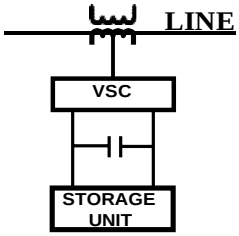


Figure 3: DVR

II. CONTROL ALGORITHM

The control algorithm is based on synchronously rotating reference frame transformation i.e. abc to dq0 transformation technique or Park's transformation. The expression of Vsa, Vsb, and Vsc in terms of V0, Vd, and Vq can be described as follows:

$$\begin{bmatrix} V_0 \\ V_d \\ V_q \end{bmatrix} = \frac{2}{3} \begin{bmatrix} \frac{1}{2} & 1 & \frac{1}{2} \\ \sin(wt) & \sin(wt-120) & \sin(wt-240) \\ \cos(wt) & \cos(wt-120) & \cos(wt-240) \end{bmatrix} \begin{bmatrix} V_{sa} \\ V_{sb} \\ V_{sc} \end{bmatrix} \quad (1)$$

Where Vsa, Vsb, Vsc are the supply voltage, V0, Vd, Vq are the zero axis, direct and quadrature axis voltages.

The supply voltage to the load is given in equation (2). When rated balanced voltage is applied and .The respective V0, Vd, and Vqare calculated in the following equations.

$$\left.\begin{aligned} v_{sa} &= V_{m1} \sin(wt \pm \alpha) \\ v_{sb} &= V_{m2} \sin(wt - 120 \pm \alpha) \\ v_{sc} &= V_{m3} \sin(wt - 240 \pm \alpha) \end{aligned}\right\} \quad (2)$$

$$v_0 = \frac{1}{3}(v_{sa} + v_{sb} + v_{sc})$$

$$= \frac{1}{3}[V_m \sin(wt) + V_m \sin(wt - 120) + V_m \sin(wt - 240)]$$

$$\therefore v_0 = 0 \quad (3)$$

$$v_d = \frac{2}{3}[v_{sa} * \sin(wt) + v_{sb} * \sin(wt - 120) + v_{sc} * \sin(wt - 240)]$$

$$= \frac{2}{3}[V_m \sin(wt) * \sin(wt) + V_m \sin(wt - 120) * \sin(wt - 120) + V_m \sin(wt - 240) * \sin(wt - 240)]$$

$$= \frac{2}{3}[V_m \sin^2(wt) + \sin^2(wt - 120) + \sin^2(wt - 240)]$$

$$= \frac{1}{3}V_m\left[\left(\frac{1 - \cos 2(wt)}{2}\right) + \left(\frac{1 - \cos 2(wt - 120)}{2}\right) + \left(\frac{1 - \cos 2(wt - 240)}{2}\right)\right]$$

$$= \frac{1}{3}V_m\left[(\cos(2wt)) + (\cos(2wt - 240)) + (\cos(2wt - 480))\right] \quad (4)$$

$$v_q = \frac{2}{3}[v_{sa} * \cos(wt) + v_{sb} * \cos(wt - 120) + v_{sc} * \cos(wt - 240)]$$

$$= \frac{2}{3}[V_m \sin(wt) * \cos(wt) + V_m \sin(wt - 120) * \cos(wt - 120) + V_m \sin(wt - 240) * \cos(wt - 240)]$$

$$= \frac{1}{3}V_m\left|(\sin(2wt)) + (\sin(2wt - 240)) + (\sin(2wt - 480))\right|$$

$$= \frac{1}{3}V_m(\sin(2wt) - \sin(2wt))$$

$$\therefore v_q = 0 \quad (5)$$

From equations (3),(4),(5)we can analyse that quadrature axis voltage and zero axis voltage are of zero value and direct axis voltage is a DC quantity of Vm.

At the point when uneven voltage is applied and by understanding the condition (2) the quadrature hub voltage and zero pivot voltage are not zero worth. The quadrature pivot voltage is air conditioning voltage with a recurrence of double the stockpile recurrence and zero hub voltage is air conditioning voltage with recurrence of supply recurrence.

The immediate hub voltage is a throbbing voltage with DC amount of normal estimation of, and air conditioning amount with a recurrence of double the stockpile recurrence.

Conditions above characterizes the change from three stage abc to dq0 reference outline. Right now, a-hub is adjusted to the d-pivot which is in quadrature with q-hub. Here ωt is the point between stage a-pivot and the d-hub.

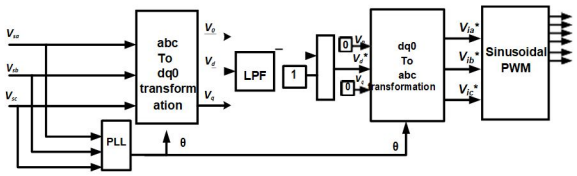


Figure 4: Reference Voltage Signal Generation Block Diagram.

Reference Voltage Signal Generation for Dynamic Voltage Regulator (DVR):

Right now every one of the voltages are taken in per unit framework in light of the fact that continuously reenactment the control technique is created in per unit framework. This control calculation screens the inventory voltage persistently. At whatever point there is any unsettling influences (hang/swell, unbalance) in the source voltage there will be a prompt deviation in the dq0 parts of the source voltage from those of the heap voltage of one for every unit. The reference infused voltages Via*, Vib*, Vic* are determined as clarified underneath.

The source voltages are changed to dq0-change by utilizing abc to dq0 change by utilizing the condition (1).The adjusted direct amount Vd is extricated by utilizing low pass channel under uneven voltages. By keeping quadrature voltage Vq and zero pivot voltage V0 to zero, the reference infused voltages are determined by changing V0, Vd, and Vq to abc change or reverse dq0 change given in condition (6). A PLL square is utilized to synchronize produced voltages of Voltage source inverter (VSI) with line voltages. Sinusoidal PWM method is utilized to create terminating heartbeats to voltage source inverter.

$$\begin{bmatrix} v_{a}^{*} \\ v_{b}^{*} \\ v_{c}^{*} \end{bmatrix} = \begin{bmatrix} 1 & \sin(wt) & \cos(wt) \\ 1 & \sin(wt-120) & \cos(wt-120) \\ 1 & \sin(wt-240) & \cos(wt-240) \end{bmatrix} \begin{bmatrix} 0 \\ v_{d}^{*} \\ 0 \end{bmatrix} \quad (6)$$

$$\left.\begin{aligned} v_{a}^{*} &= V_{d}^{*}\sin(wt) \\ v_{b}^{*} &= V_{d}^{*}\sin(wt-120) \\ v_{c}^{*} &= V_{d}^{*}\sin(wt-240) \end{aligned}\right\} \quad (7)$$

The reference injected voltages Via^{*}, Vib^{*}, Vic^{*} are calculated from equation (7), and the references injected voltages are used for the generation of pulses to inverter to fire IGBTs.

III. SIMULATION RESULT

The presentation examination of the Dynamic voltage Restorer (DVR) with various stockpile voltage conditions (voltage list, voltage swell, and voltage unbalance) to R-L load. The total model of the DVR is built in Simulink condition (MATLAB).

The model comprises of source, inverter, control square, EMI channel, Injection transformer, comparator, and load. The distinctive stock voltage unsettling influences are created by utilizing source. The inverter is utilized to change over DC supply to AC supply. The yield of the inverter contains essential voltage and the voltages of exchanging frequencies and products of exchanging frequencies. The voltages of exchanging frequencies and products of exchanging frequencies are wiped out by utilizing EMI channel. The beats are created by the comparator by contrasting sinusoidal sign and triangular sign. The AC voltage of the inverter is infused in each period of the line by utilizing infusion transformers. The reference signs to the PWM inverter are produced by utilizing control square.

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A. Case I: Balanced Supply Voltage

The voltage across the load is maintained constant for different supply voltage disturbances. When rated balancedvoltage is applied to the load, the injected voltage by the voltage source converter is zero ideally but supplies very small voltage to compensate drop in injection transformer.

The following equations represent the Balanced sourcevoltage.

$$v_{sa} = 338.846\sin(wt) \quad (8)$$

$$v_{sb} = 338.846\sin(wt - 120) \quad (9)$$

$$v_{sc} = 338.846\sin(wt - 240) \quad (10)$$

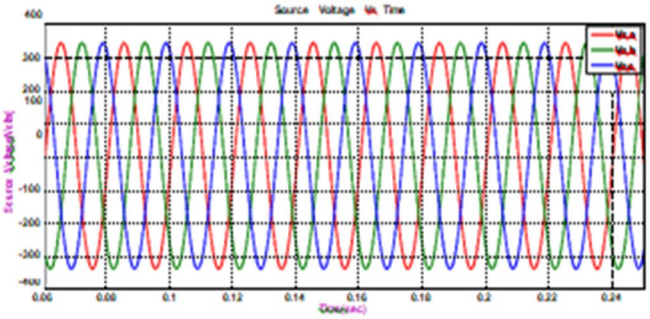


Figure 5: shows the waveform of Balanced SourceVoltage (simulation is done in Matlab Simulink).

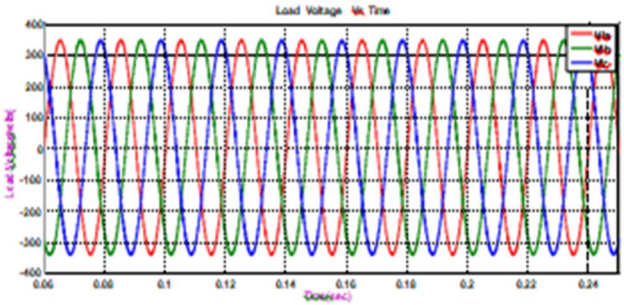


Figure 6: shows the waveform of Load Voltage (simulation is done in Matlab Simulink).

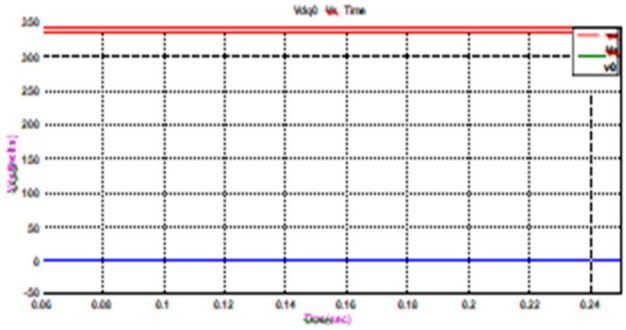


Figure 7: Direct, Quadrature and Zero axis voltages

Figure 7 shows the waveform of Direct, Quadrature and Zero axis voltages under balanced supply Voltage (simulation is done in Matlab Simulink).The Quadrature and zero axis voltages are of zero voltage after converting the source voltage to synchronously rotating reference frame (abc to dq0).

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B. Case II: Balanced supply voltage (sag)

The following equations represent the balanced sag voltagewith 20% of sag .The line to line voltage of 415V and the peak value of phase voltage is 338.846V.

$$v_{sa} = (338.846 * 0.8)\sin(wt) \quad (11)$$

$$v_{sb} = (338.846 * 0.8)\sin(wt - 120) \quad (12)$$

$$v_{sc} = (338.846 * 0.8)\sin(wt - 240) \quad (13)$$

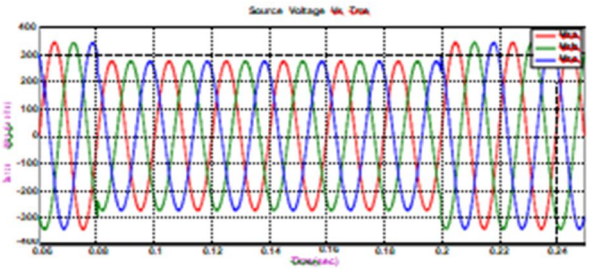


Figure 8: source voltage

Fig.8 shows the waveform of Balanced Sag Source Voltage (simulation is done in Matlab Simulink). The voltage sag is supplied from 0.08 to 0.2 seconds.

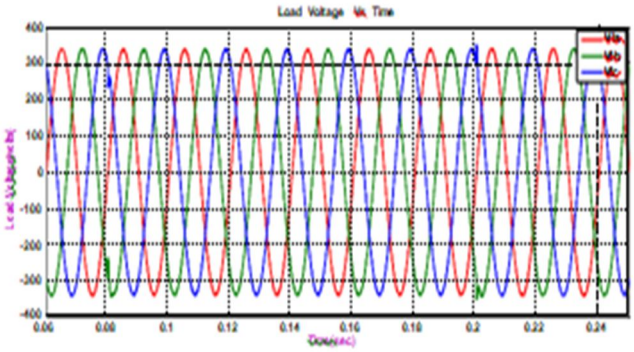


Figure 9: Load voltage

Figure 9 shows the waveform of Load Voltage (simulation is done in Matlab Simulink).The voltage is injected by DVR from 0.08 to 0.2seconds. From the waveform it can be observed that the voltage across load is maintained to rated voltage.

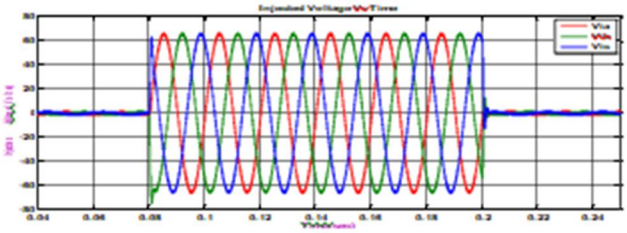


Figure 10: Injected Voltage

Figure 10 shows the waveform of Injected Voltage (simulation is done in Matlab Simulink). The voltage is injected by DVR from 0.08 to 0.2 seconds.

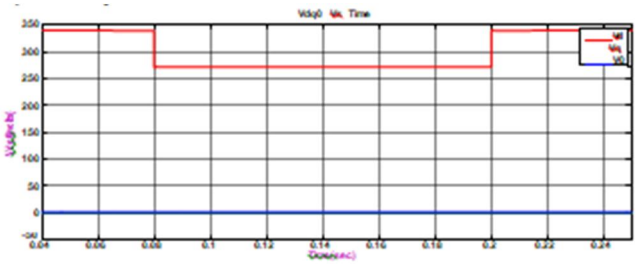


Figure 11: Direct, Quadrature and Zero axis voltage

Figure 11 shows the waveform of Direct, Quadrature and Zero hub voltages under Balanced Sag supply Voltage (reenactment is done in Matlab Simulink. By watching the waveform of 6-8 under Balanced Sag Supply voltage the immediate amount voltage is a DC voltage with abundancy of stage voltage. From the wave structure it very well may be seen that there is a plunge in Direct Quantity voltage from 0.08 to 0.2 seconds where the hang voltage is applied. The Quadrature and Zero hub voltages are of zero voltage in the wake of changing over the source voltage into synchronously turning reference outline (abc to dq0).

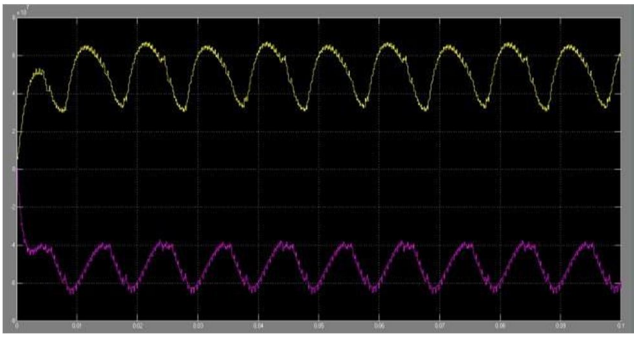


Figure 11: Matlab simulink Active and reactive powerwithout UPQC.

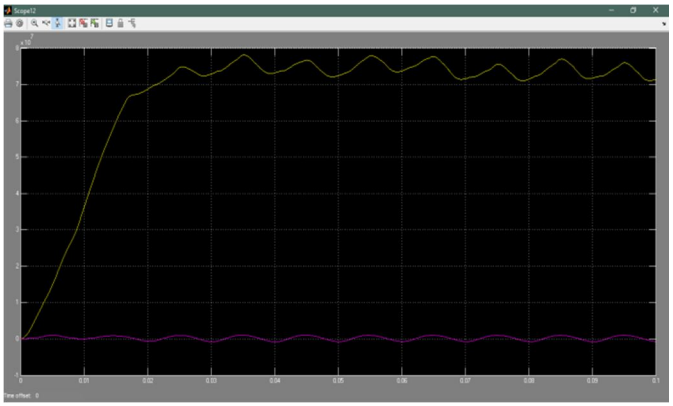


Figure 12: Matlab simulink Active and reactive powerwith UPQC

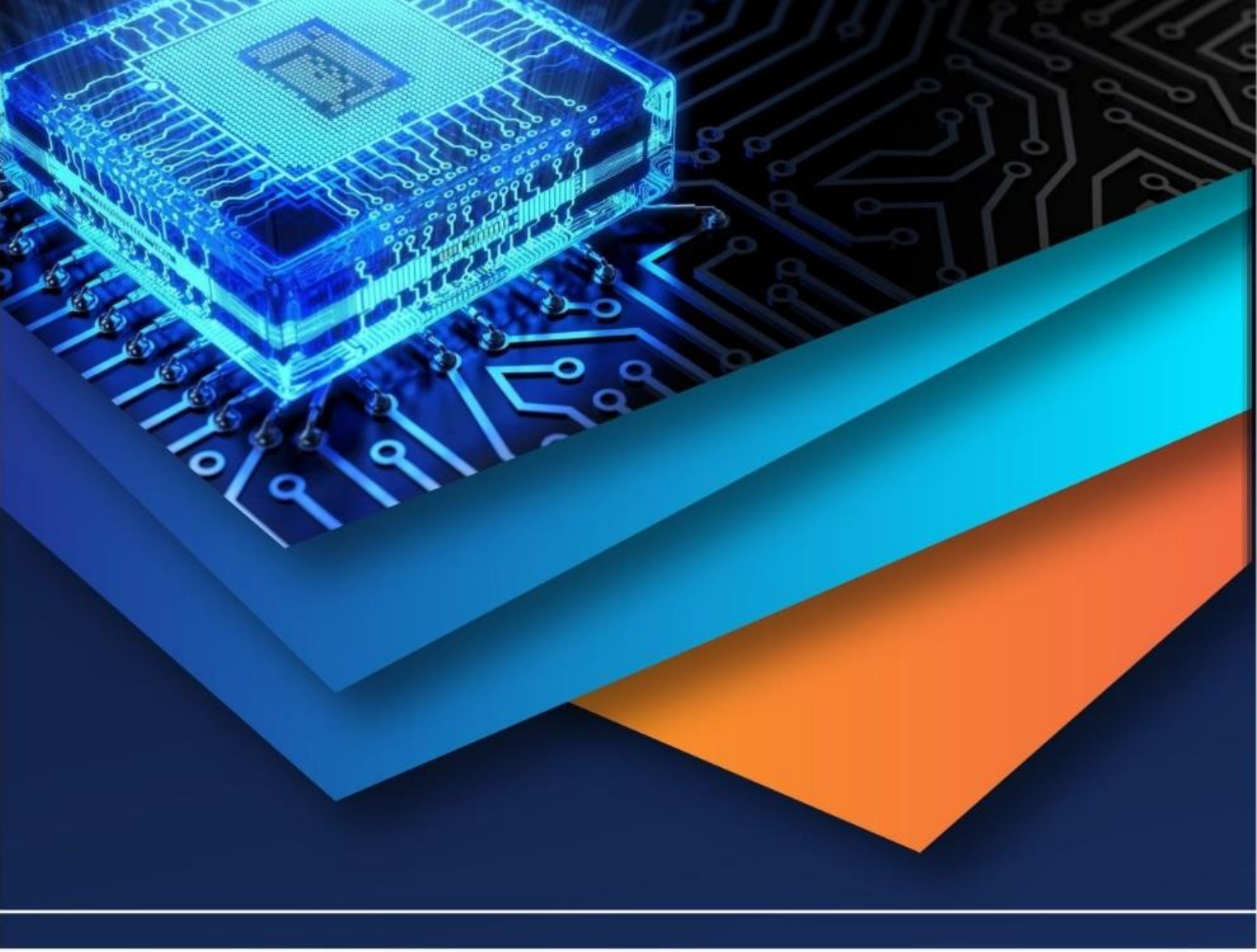
From fig. 11 and 12 we conclude that after using the UPQC the active and reactive power will increase.

IV. CONCLUSION

This paper analyses the performance of the DVR and D- STATCOM with different supply voltage conditions (voltage sag, voltage swell, and voltage unbalance) to R-L load. We analyzed the DVR with PI controller the load voltage during fault (or due to nonlinear load) is almost equal to the desired load voltage. DSTATCOM is proved to compensate voltage level under faulty condition. Using PI controller harmonics have been reduced considerably. Due to nonlinear load the power quality issues are increased. By using the UPQC the active and reactive power will also improve. Hence, it is conclude that, UPQC has a scope in improving power quality.

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