

AN IMPROVED IUPQC CONTROLLER TO IMPROVE POWER QUALITY

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Abstract : This paper present improved unified power quality conditioner (iUPQC) of dual topology to increases its applicability in power quality compensation and in micro grid application. An iUPQC provides reactive power support to regulate the load bus voltage as well as the voltage at grid side bus. The iUPQC is combination of two active filters, series active filter and shunt active filter used to reduce harmonics and unbalances. The new feature increase use of iUPQC to provide solution in future of smart grid, microgrid and distributed generation. Contempt the addition power quality compensation feature, the grid voltage regulation reduces inner loop circulating power inside the iUPQC which would allow lower power rating of series converter. The experimental results verify aim of improved iUPQC the grid voltage regulation and reduce harmonic distortion was achieved with different load conditions.

Key word – iUPQC, Power quality, microgrid.

1. INTRODUCTION

As per today's concern reliability of supply and power quality are most important aspects of any power delivery system. Nowadays power electronics devices are widely used in power system due to technological improvement. However, wide use of power electronic driven load in industry has increases power quality problems. The power electronic devices are more sensitive it requires ideal supply voltage in order to functioning properly otherwise they are big reason for abnormal harmonic currents in distribution system. In this case, devices can eliminate this problem have been developed in past. Some of the solution carries a flexible compensator as unified power quality conditioner (upqc) and the static synchronous compensator (STATCOM).

The power circuit of UPQC consists of shunt active filter and series active filter connected in cascade manner. Combination of series and shunt active filter allows simultaneous compensation of load current and supply voltage therefore compensated supply voltage delivered to the load and current drawn from grid are kept balanced and sinusoidal. In [2]-[4] dual topology of iUPQC is presented, in which shunt active filter behaves as an ac voltage source and series active filter act as an AC current source, both at fundamental frequency.

The UPQC consist of two voltage source inverter connected in parallel through a common DC link capacitor. The DVR & STATCOM are series and parallel connected voltage source inverter respectively. The series inverter DVR operates in voltage controlled mode. When voltage sag occurs the DVR injects a voltage in quadrature to the supply voltage such that the voltage at the point of common coupling (PCC) is always maintained at desired magnitude. The STATCOM has been widely used in transmission network to regulate the voltage by means of reactive power compensation. The STATCOM is generally used for voltage regulation and UPQC & iUPQC is used for more applications. By combining STATCOM & iUPQC device a wider scenario of application can be achieved particularly in case of distributed generation in smart grid, and as coupling device to grid tie micro grids[1].

2. IMPROVED UNIFIED POWER QUALITY CONDITIONER

The main difference between conventional UPQC & iUPQC is the sort of source imitate by series and shunt power converters. In upqc series converter is controlled as nonsinusoidal voltage source and shunt converter a nonsinusoidal current source. Hence in real time the upqc controller has to determine and synthesize correctly the harmonic voltage and current to be compensated[16]. In case of iUPQC the series converter acts as a controlled sinusoidal current source & the shunt converter act as a controlled sinusoidal voltage source. There is no need to determine the harmonic voltage & current to be compensated, since the harmonic voltages appear naturally across the series current source and the harmonic current flow naturally into the shunt voltage source.

The conventional upqc has disadvantages as follows :

1. the leakage inductance of the series connected transformer impacting the voltage compensation generated by series filter,
2. requiring a high bandwidth to harmonic content of voltage and current references,
3. complex calculations of harmonic extraction of grid voltage.

The above drawbacks can overcome by iUPQC as shown in fig.2. The series active filter work as high impedance for current harmonics and indirectly compensates the harmonics, unbalances, & disturbances of grid voltage sine the connected transformer voltage equal to the difference between grid voltage and load voltage. In the same manner, shunt active filter indirectly compensates the unbalances, displacement and harmonics of grid current providing a low impedance path for the harmonic load current[2].

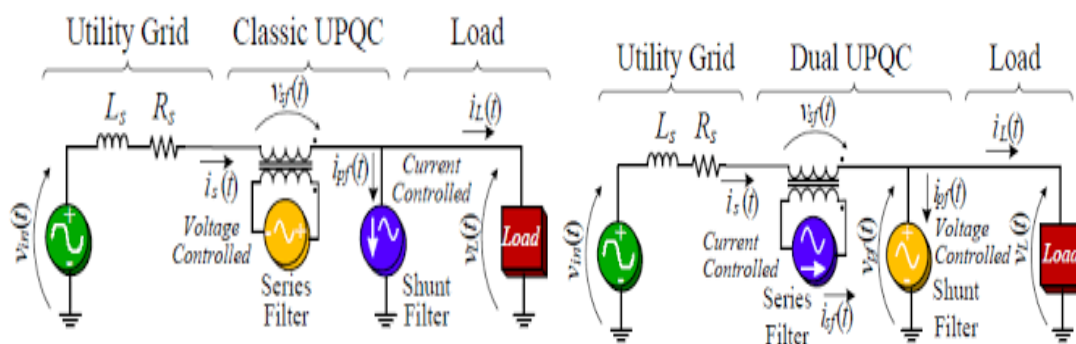


Fig.1. conventional upqc fig. 2 dual topology of upqc (iUPQC)

In this paper an improved controller which extends the iUPQC functionalities. In this controller involves all functionalities of conventional ones, including the voltage regulation at load side bus and here also providing voltage regulation at the grid side bus, like STATCOM to the grid

3. PROPOSED SYSTEM

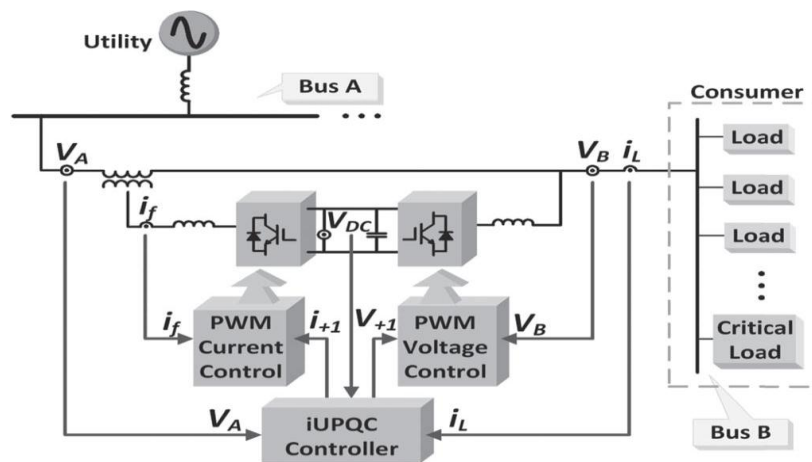


Fig.3. modified iUPQC configuration.

Fig .3 shows hardware of three phase, three wire system used in controller. In which we consider two buses bus A and bus B to see the performance of iUPQC. Bus A is connected to utility and bus B is connected to load. Fig.4 shows a

proposed controller. The inputs of controller are voltage voltages at bus A, current flows from bus B (i_L) and the voltage of common dc link capacitor (vdc).

The outputs of controller are shunt voltage reference and the series current reference to the pulse width modulation (PWM) controllers.

In this Clark's transformation is used to simplify measured variables. The grid voltage in α - β reference frame can be calculated by

$$\begin{bmatrix} V_{A_alpha} \\ V_{A_beta} \end{bmatrix} = \begin{bmatrix} 1 & 1/2 \\ 0 & \sqrt{3}/2 \end{bmatrix} \begin{bmatrix} V_{A_ab} \\ V_{A_bc} \end{bmatrix} \dots\dots\dots(1)$$

The shunt controller imposes the voltage at bus B. thus, it is necessary to synthesize sinusoidal voltages with amplitude and frequency. These signals send to PWM controller are outputs of PLL(phase locked loop). The use of VA+1 is useful to decrease the circulating power through series & shunt converter under normal condition.

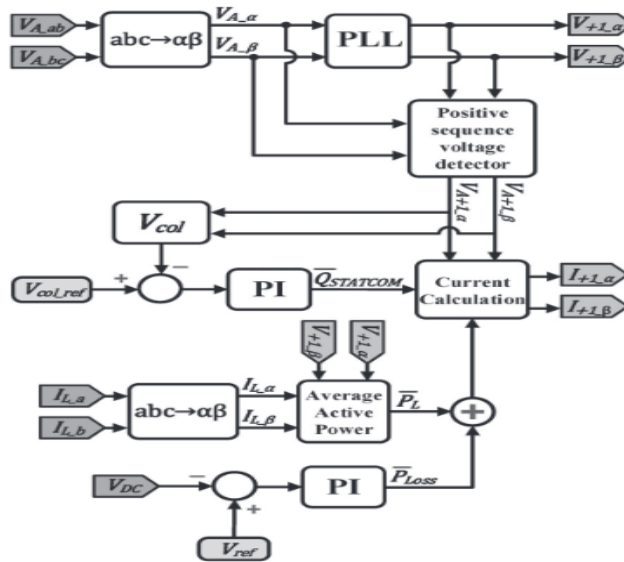


Fig.4.Main iUPQC ontrroller

The load active power can be determined by

$$P_L = V_{+1_alpha} i_{L_alpha} + V_{+1_beta} i_{L_beta} \dots\dots\dots(2)$$

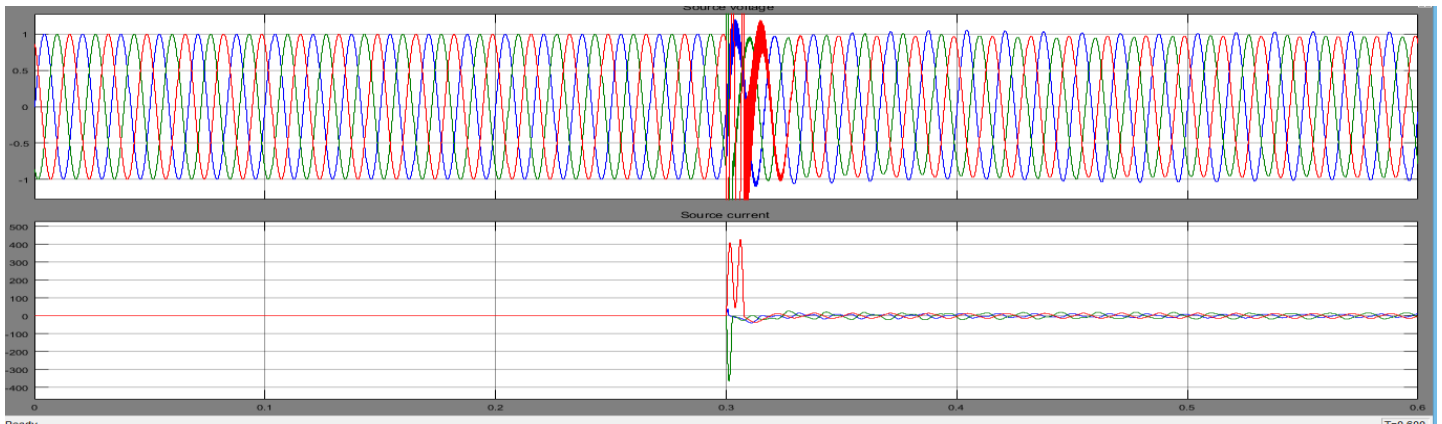
Where, i_{L_alpha} , i_{L_beta} are load currents and V_{+1_alpha} , V_{+1_beta} are reference voltages for shunt converter. To provide voltage regulation like STATCOM at grid bus control loop is used control voltage at grid side is represented by QSTATCOM in fig.4.

$$V_{col} = \sqrt{V_{A+1_alpha}^2 + V_{A+1_beta}^2} \dots\dots\dots(3)$$

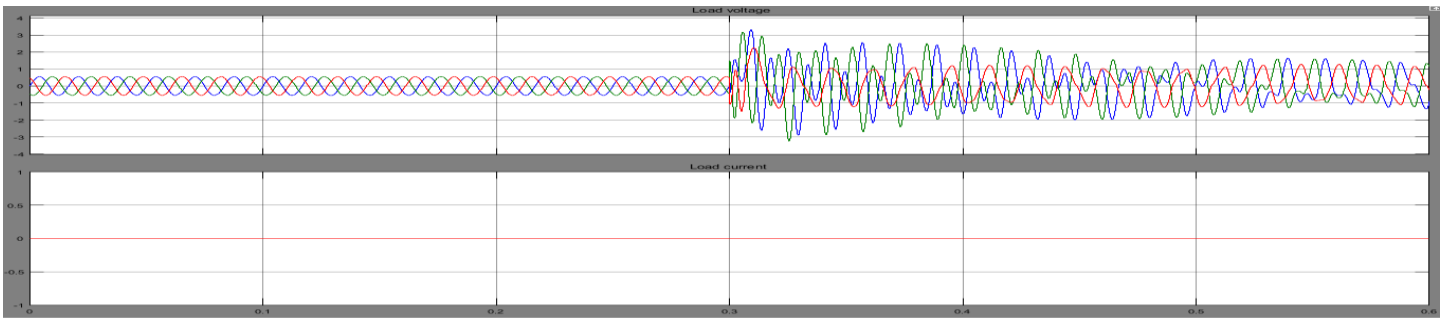
The current reference i_{+1_alpha} & i_{+1_beta} of series converter are determined by

$$\begin{bmatrix} i_{+1_alpha} \\ i_{+1_beta} \end{bmatrix} = \frac{1}{V_{A+1_alpha}^2 + V_{A+1_beta}^2} \begin{bmatrix} V_{A+1_alpha}^2 & V_{A+1_beta}^2 \\ V_{A+1_beta}^2 & -V_{A+1_alpha}^2 \end{bmatrix} \begin{bmatrix} P_L + P_{Loss} \\ Q_{STATCOM} \end{bmatrix} \dots\dots\dots(4)$$

4. Experimental results

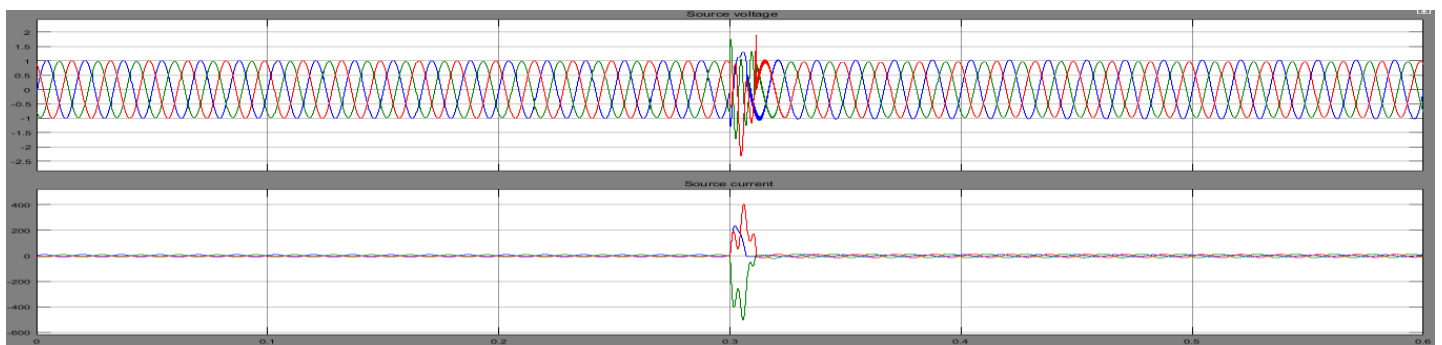


(a)

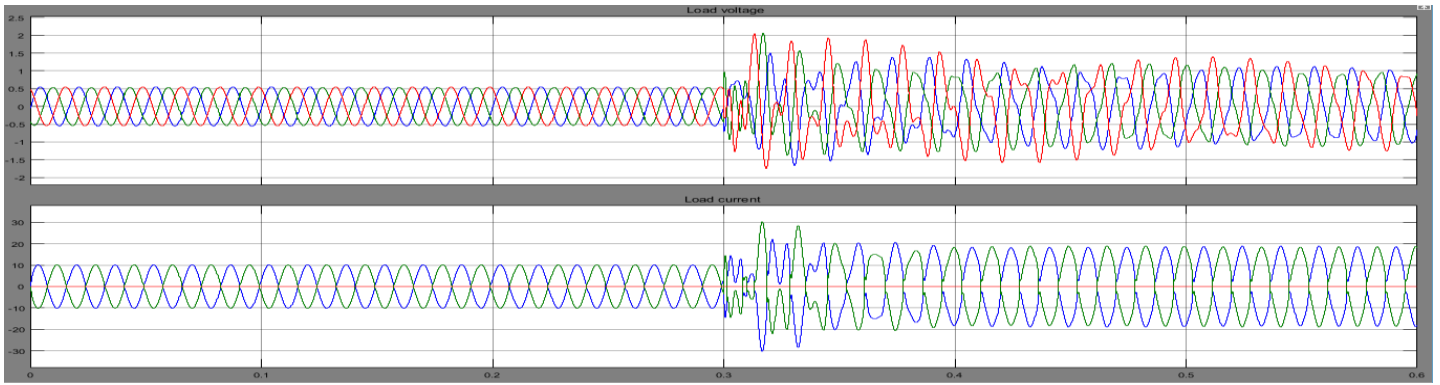


(b)

Fig.5. iUPQC response at no load condition (a) source voltage & current, (b) grid voltage & current.



(a)



(b)

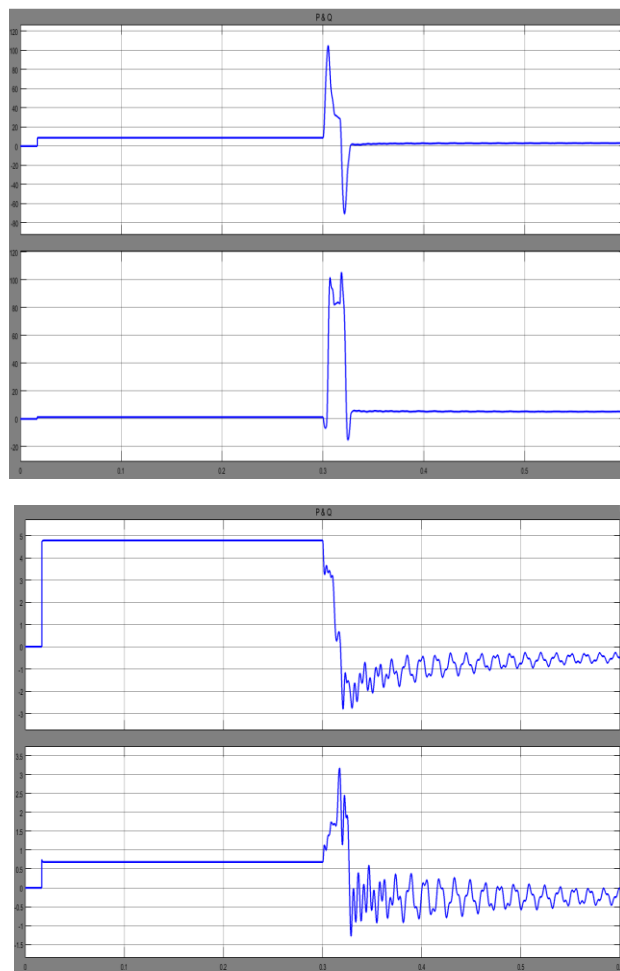
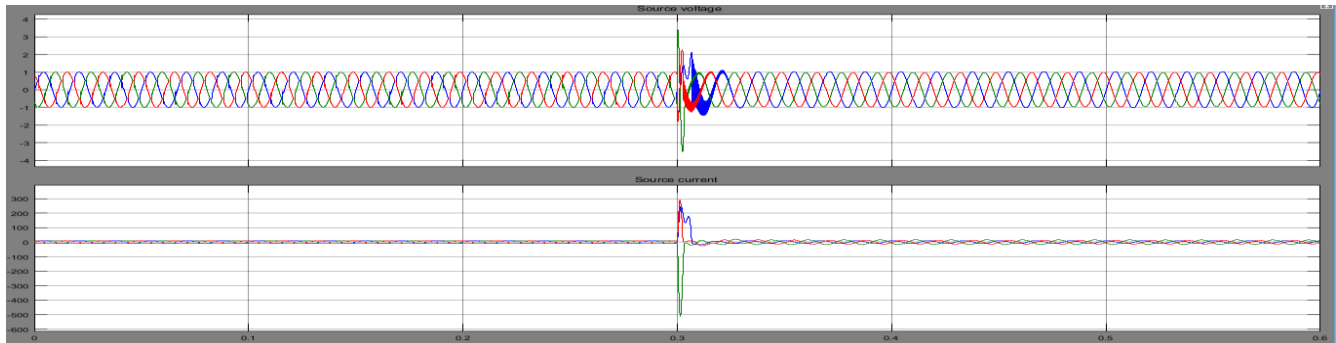
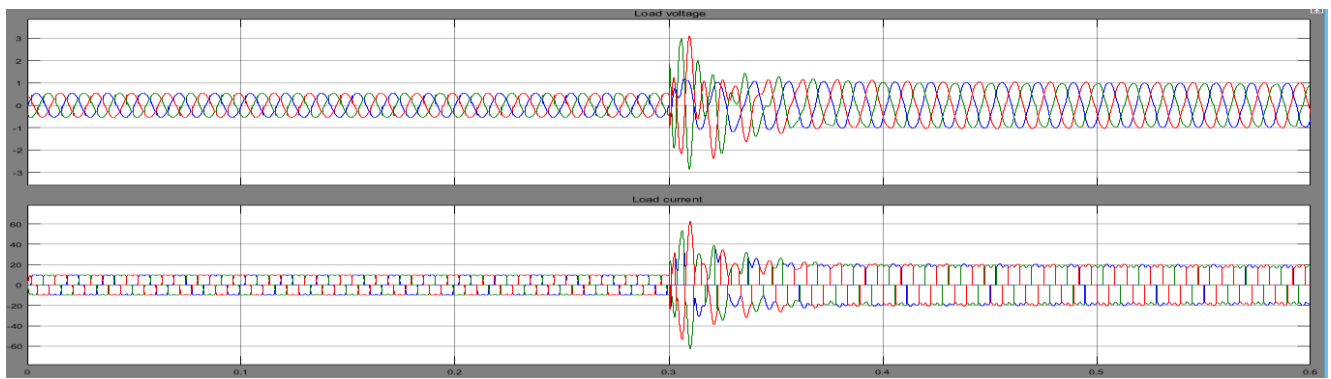


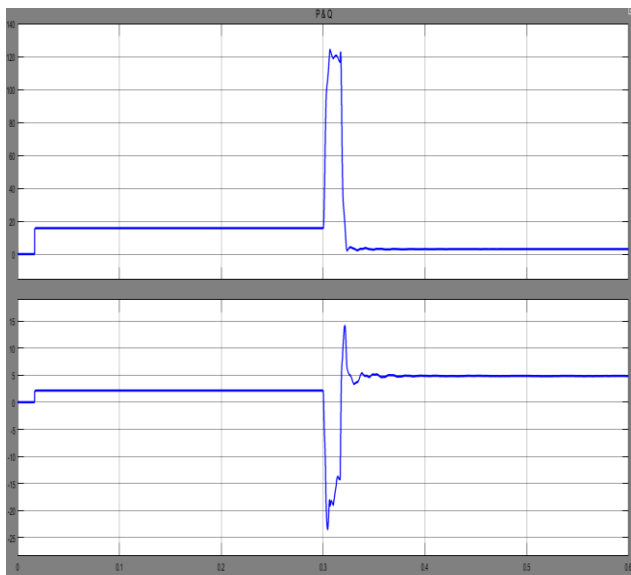
Fig.6. iUPQC response during connection of two phase diode rectifier (a) source voltage & current, (b) load voltage & current, (c) active & reactive power at bus A, (d) active and reactive power at bus B.



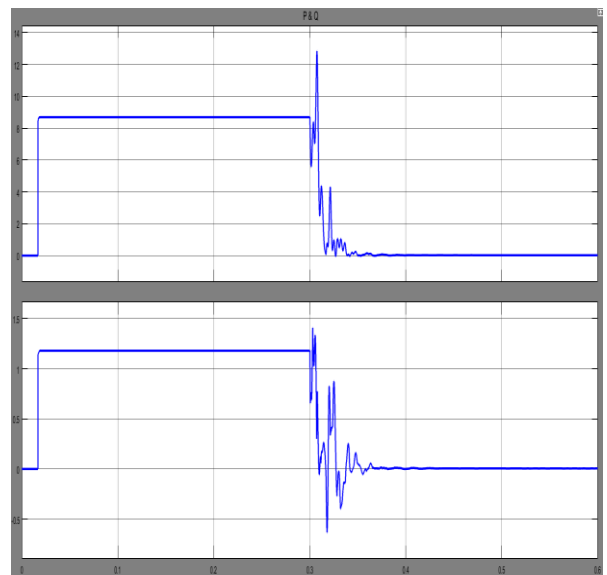
(a)



(b)



(c)



(d)

Fig.7. iUPQC response during the connection of three phase diode rectifier (a) source voltage & current, (b) load voltage & load current, (c) active & reactive power at busA ,(d) active & reactive power at bus B.

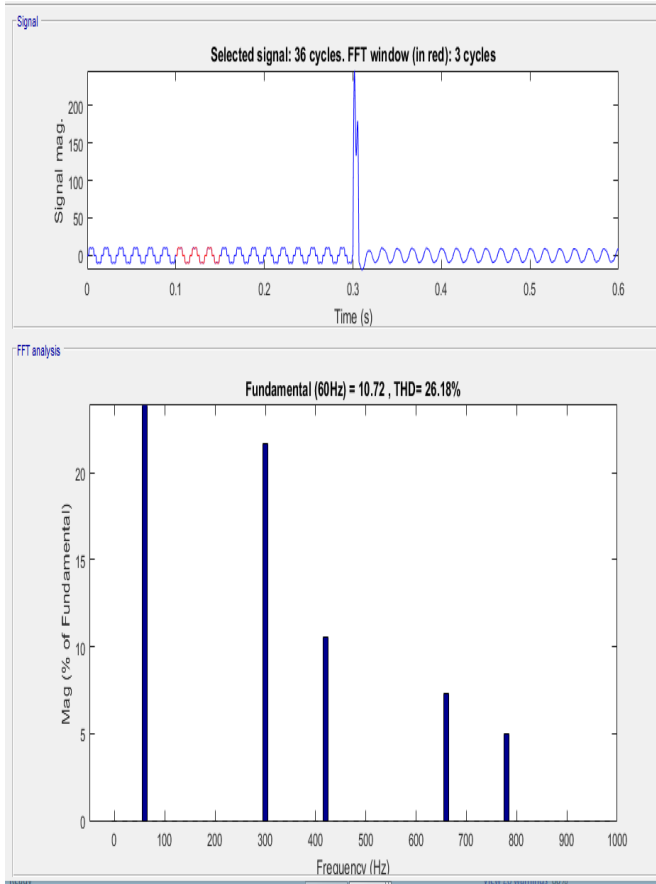


Fig.8. THD without using iUPQC

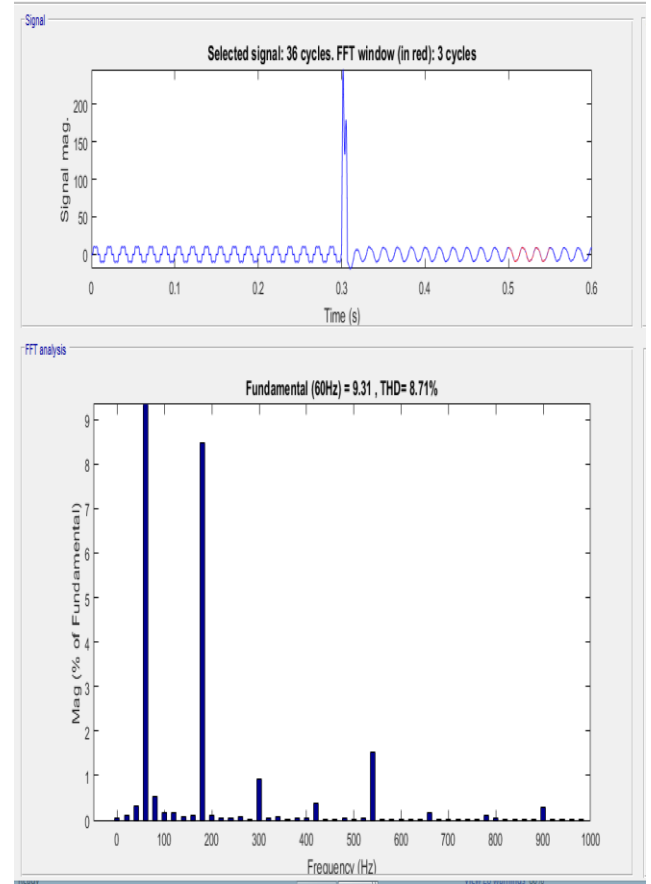


Fig.9. THD with iUPQC

To verify all the power quality related issues describe in this paper is verified using different cases is shown in fig.5, fig.6 and in fig.7 as shown above. Hence, iUPQC can perform all the power quality compensations, as mention in this paper including grid voltage regulation, harmonic distortion reduction.

5. CONCLUSION

The main objective of this controller is to improve power quality of electrical system. This controller mitigates all the power quality issues like voltage sag, voltage swell & unbalances. In addition to all power quality compensation feature iUPQC is act as STATCOM at grid bus to regulate the voltage at grid side. This additional feature enhances applicability of iUPQC and provides new solution for future. The experimental results shows iUPQC achieves the voltage regulation with different load condition like no load condition and load condition with nonlinear loads as well as it reduces harmonics distortion. Harmonics distortion without iUPQC is 26.18% and when we use iUPQC configuration it becomes 8.17%. The iUPQC gives better solution for power quality improvement.

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