Power Quality Improvement using Shunt Active Power Filter

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Abstract: A power quality issue is due to the any deviation on fundamental voltage, current and frequency. Due to power quality issues more electrical equipments are damage.non linear load with power electronic switches and higher frequency switching devices more affect to power quality. For improvement of power quality use a n shunt active power filter. In this paper introduced two different control techniques for shunt active power filter. One is the instantaneous active reactive power theory and second is synchronous reference frame theory. There are comparative analysis between two control techniques. The simulation results are presented by MATLAB/SIMULINK software.

***Index Terms* - Active power filter, Hysteresis control, THD, power quality**

I. INTRODUCTION

Power quality has become a very important issue in present. Power quality means no any distortion on fundamental voltage, current and frequency. The use of non linear load generate current and voltage harmonics which are affected a power quality. Due to nonlinear load source drawn a non sinusoidal current and then there are a more reactive power drawn by source so there a low efficiency of generation system. For harmonic and reactive power compensation must be require and then the shunt active power filter use. The shunt active power filter control the reactive power and mitigates the harmonics. In this paper we described instantaneous active reactive power theory[5] and synchronous reference frame theory for shunt active power filter[4]. when the supply voltage are balanced, both control strategies have good compensation characteristics but when the supply voltages unbalanced then than instantaneous active reactive power theory is unable to good result.

II. ACTIVE POWER FILTER

Active power filter measure source voltage and load current to find the harmonics which are injected from the load side. Active power filter generate a harmonic current which are difference between load current and source current. Active power filter classified based upon its connection, topology wise and also phase wise.

Based upon its connections manner, classify shunt active power filter and series active power filter. It is classified phase wise like single phase and three phase and based on topology three phase three wire and three phase four wire. Active power filter is not only for harmonic mitigation but also use for power factor correction, sag and swell compensation etc.

III.SHUNT ACTIVE POWER FILTER

The active power filter shunt connected nearer to the load for compensation of harmonics. The principle of shunt active power filter injecting harmonic current into the system, of the same magnitude and anti phase to that of the load harmonics. Thus the source current made sinusoidal[2].

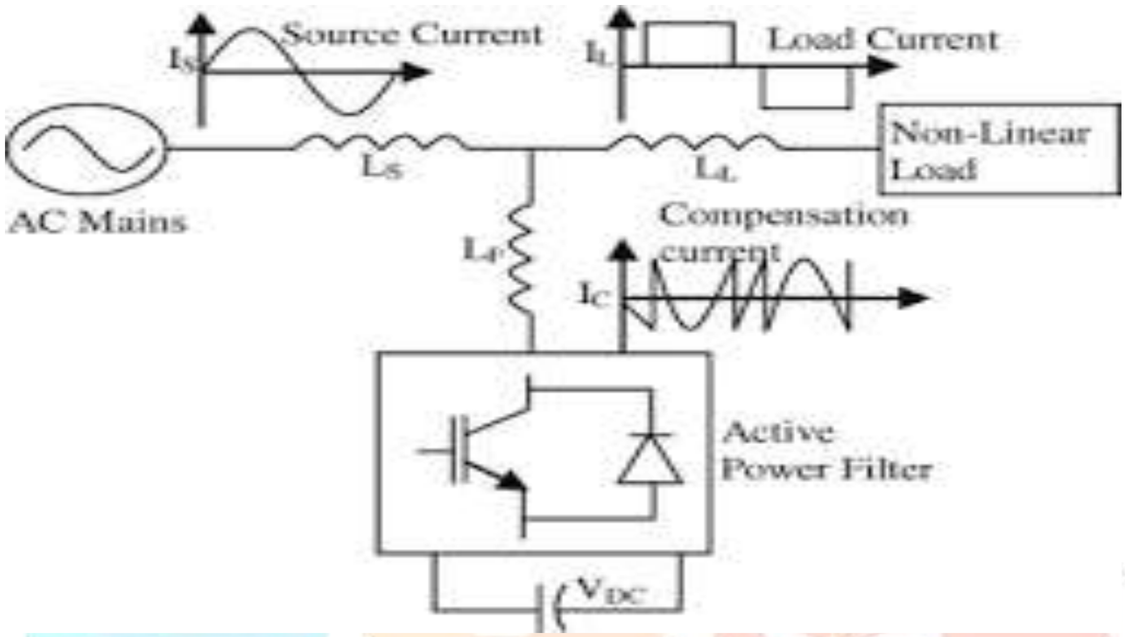

Fig. 1 Block diagram of shunt active power filter

Fig shows the basic block diagram of shunt active power filter shunt active power filter are good for filtering performance. the active power filer is connected parallel with non linear load. Is is the source current, Il is load current and Ic is compensating current.

IV. Instantaneous active reactive power theory

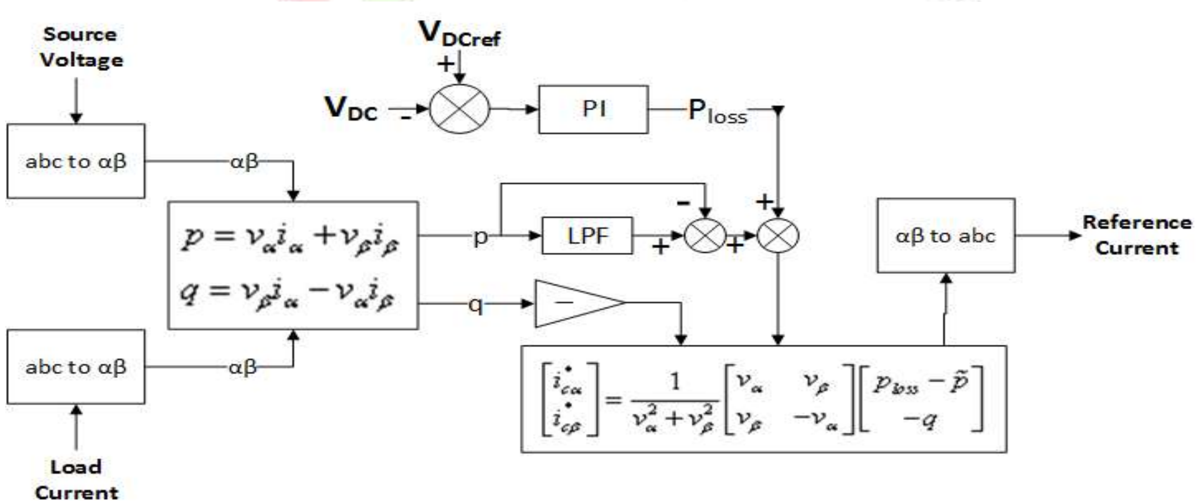

Fig. 2 Block diagram of instantaneous active reactive power theory

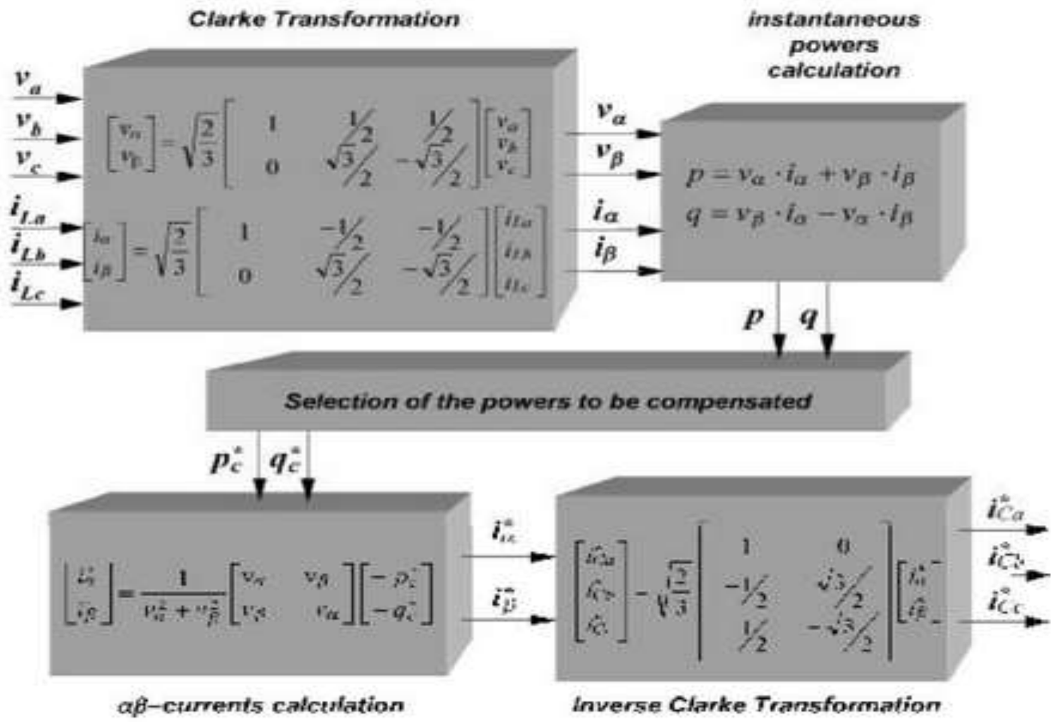

Fig. 3 Calculation block diagram for control theory

This theory first introduced by H. Akagi. this theory use for three phase as well as single phase network[2]. In this theory first the three phases voltage and currents transformation from a b c to alpha beta coordinates. The three phases a b c are shifter 120 degree each other and fixed on same plane. alpha and beta placed 90 degree to each other. The transformation done by Clarke transformation.

Fig shows the control method based on p q theory for shunt active power filter. after Clarke transformation ,there are instantaneous power calculated. there are active and reactive power calculate. both power has two parts one is average power and second oscillating power the oscillating active power and all reactive power compensated so only average active power drawn by source. the reference current generate by following equation

$$\begin{bmatrix} i^*_{c\alpha} \\ i^*_{c\beta} \end{bmatrix} = \frac{1}{v_\alpha^2 + v_\beta^2} \begin{bmatrix} v_\alpha & v_\beta \\ v_\beta & -v_\alpha \end{bmatrix} \begin{bmatrix} p_{loss} - \tilde{p} \\ -q \end{bmatrix}$$

And then alpha beta coordinates transformed to a b a b c by inverse Clarke transformation.

V. Synchronous reference frame theory

This theory based on transformation from a-b-c to d q 0 frame[3]. Abc is in a stationary frame and the d q o rotating reference frame. the fig shows the block diagram for this theory.

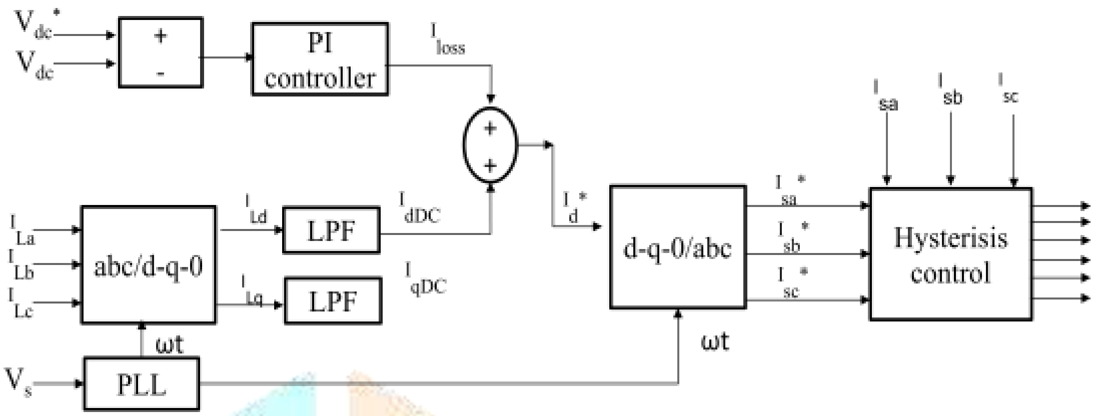

Fig. 3 Block diagram of synchronous reference frame theory

In this system load current sensed and then transformed to d q 0 frame using following equation

$$\begin{pmatrix} I_{Ld} \\ I_{Lq} \\ I_{L0} \end{pmatrix} = \frac{2}{3}\begin{pmatrix} \cos\theta & \cos\left(\theta - 2\frac{\pi}{3}\right) & \cos\left(\theta + 2\frac{\pi}{3}\right) \\ \sin\theta & \sin\left(\theta - 2\frac{\pi}{3}\right) & \sin\left(\theta + 2\frac{\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{pmatrix}\begin{pmatrix} I_{La} \\ I_{Lb} \\ I_{Lc} \end{pmatrix}$$

There are the direct axis and quadrature axis components which has harmonics and fundamental parts. Using low pass filter harmonics part removed direct axis and quadrature axis reference current given by following equation.

$$I_{Ld}^{*} = I_{Ld} + I_{loss}$$

$$I_{Lq}^{*} = I_{Lq} + I_{qr}$$

Using inverse park transformation the reference source current obtained.

$$\begin{pmatrix} I_{sa}^{*} \\ I_{sb}^{*} \\ I_{sc}^{*} \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta & 1 \\ \cos\left(\theta - 2\frac{\pi}{3}\right) & \sin\left(\theta - 2\frac{\pi}{3}\right) & 1 \\ \cos\left(\theta + 2\frac{\pi}{3}\right) & \sin\left(\theta + 2\frac{\pi}{3}\right) & 1 \end{pmatrix}\begin{pmatrix} I_{Ld}^{*} \\ I_{Lq}^{*} \\ I_{0}^{*} \end{pmatrix}$$

After getting the source reference current, it is compared to actual source current and then generate the gating pulse for voltage source inverter.

VI. Simulation and result

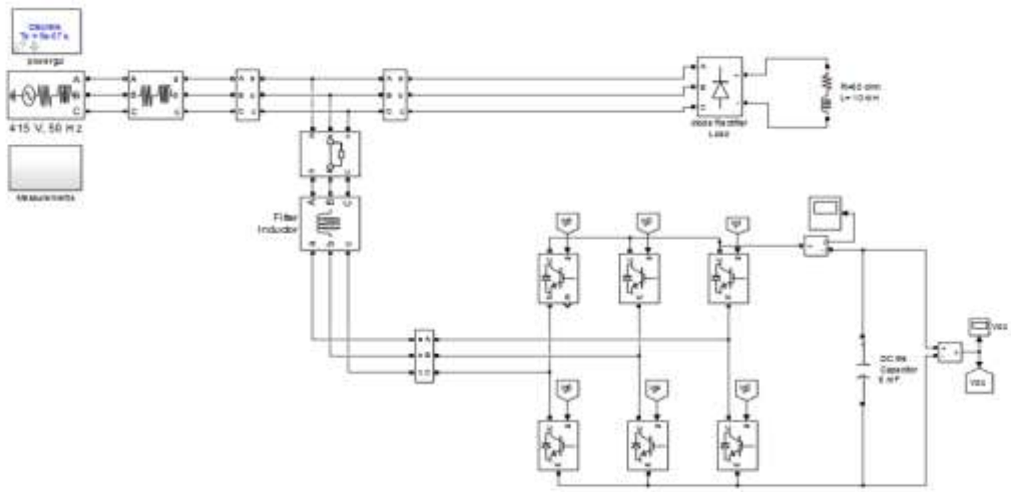

Fig. 4 Simulink model of shunt active power filter

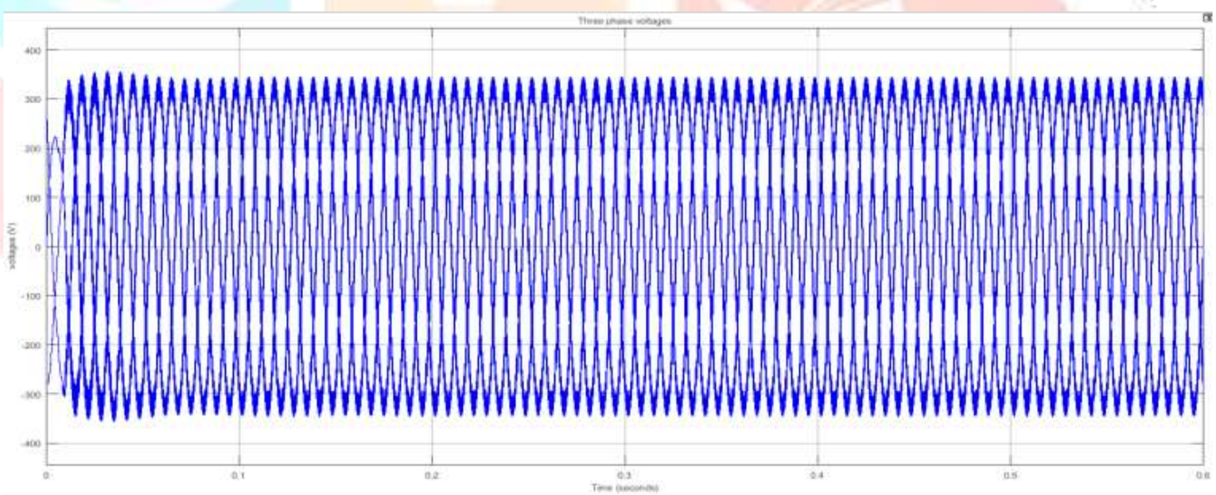

Fig. 4 Three phase balanced voltages

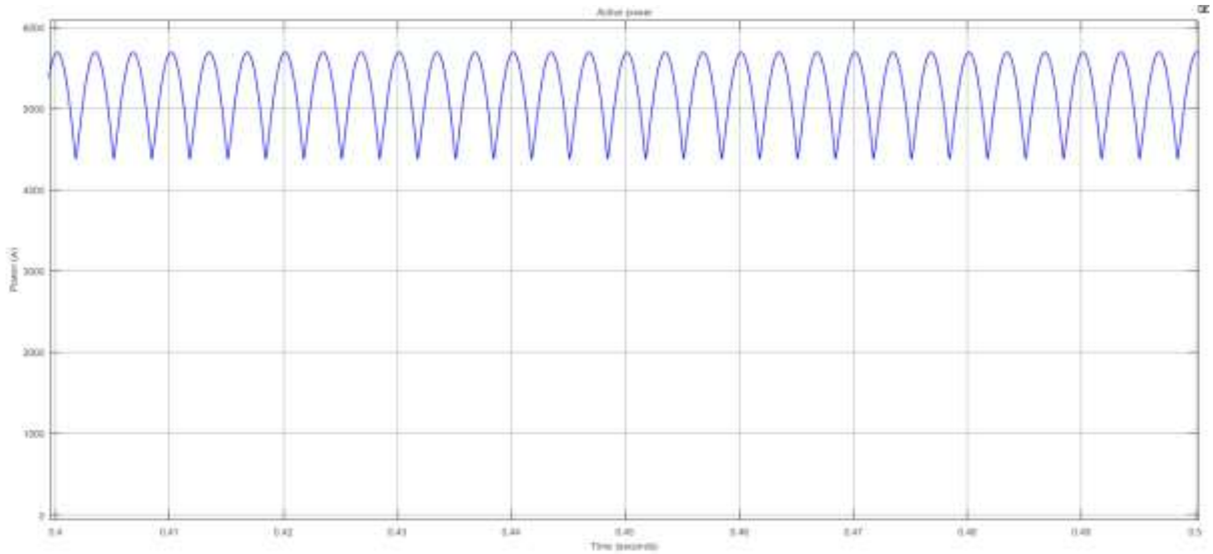

Fig 5 Active power drawn from source

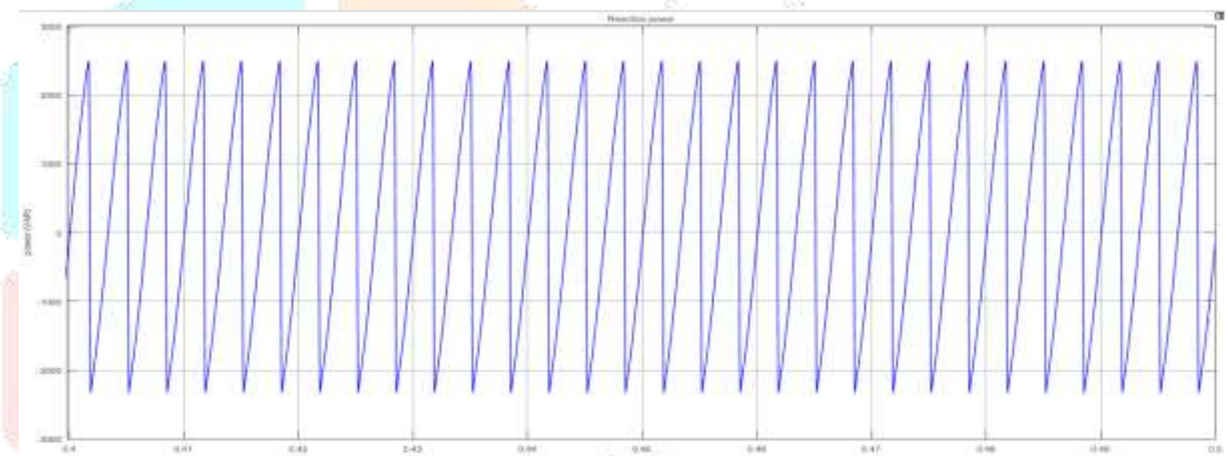

Fig. 6 Reactive power drawn from source by load

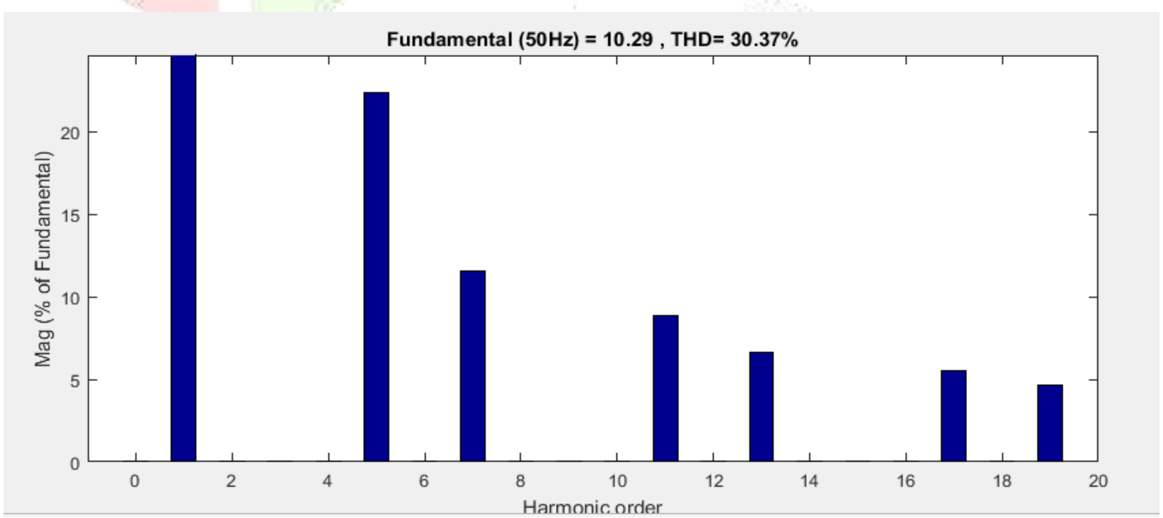

Fig. 7 FFT analysis of load current

➢ Instantaneous active reactive power theory

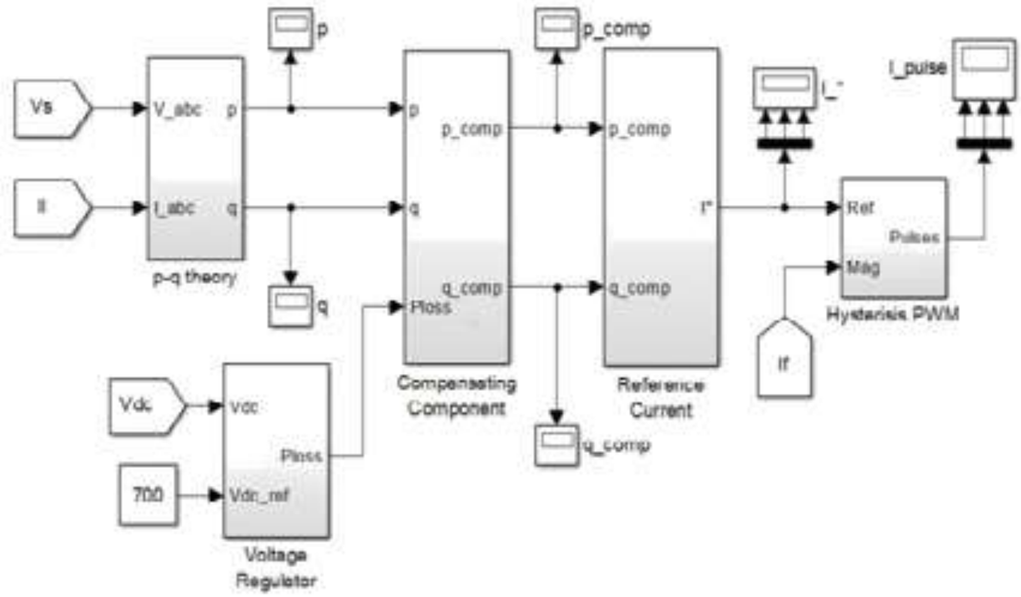

Fig. 8 Instantaneous active reactive power theory

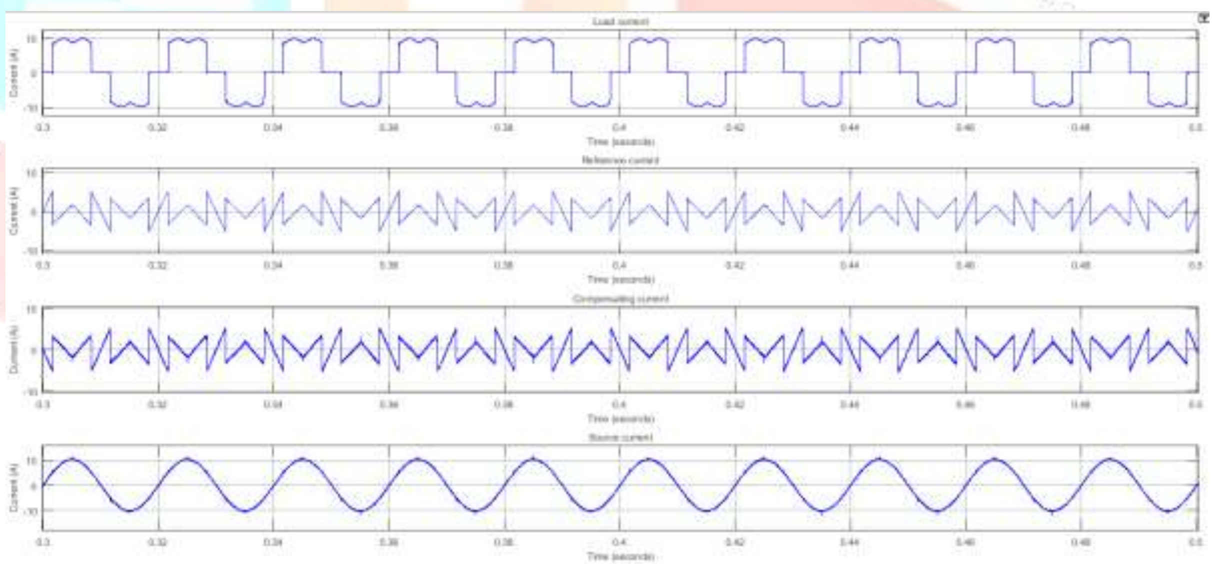

Fig 9 Current waveforms for instataneous active reactive power theory

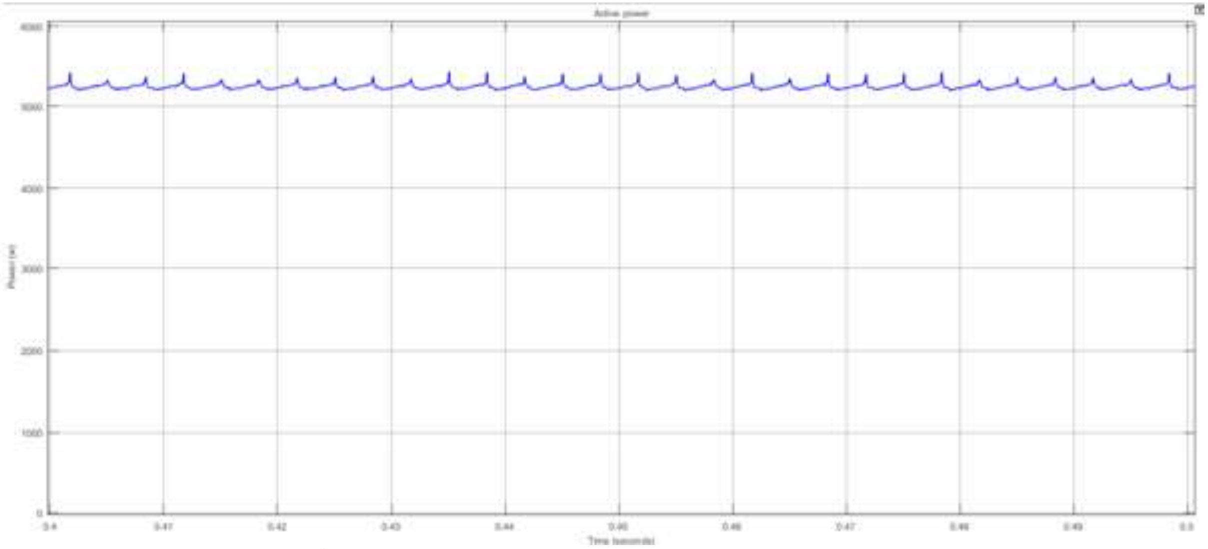

Fig. 10 Active power after filtering

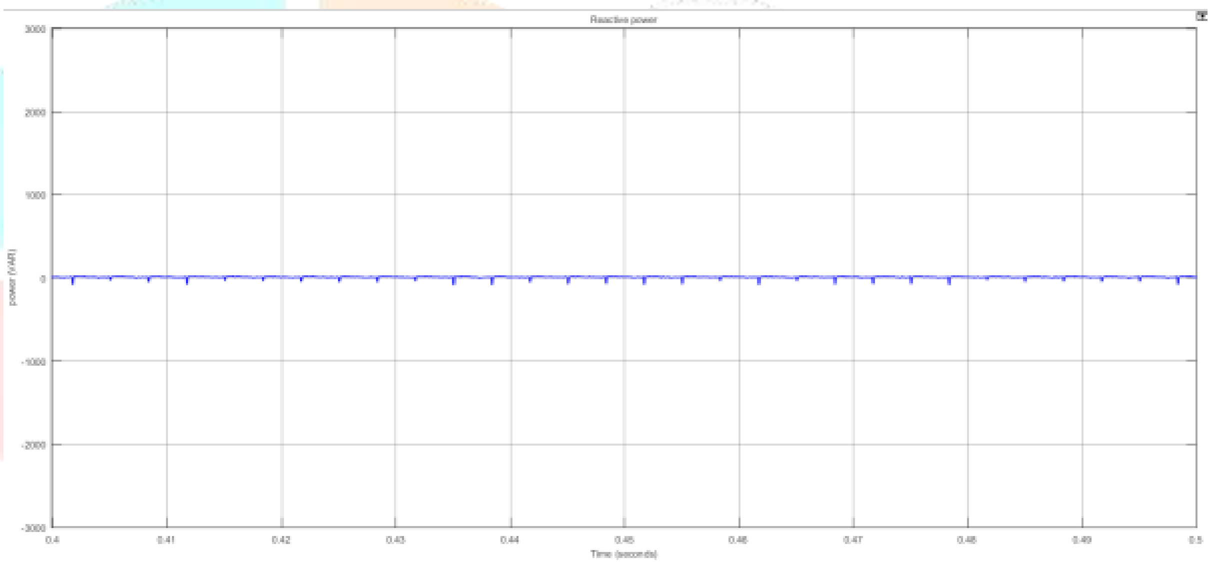

Fig. 11 Reactive power after filtering

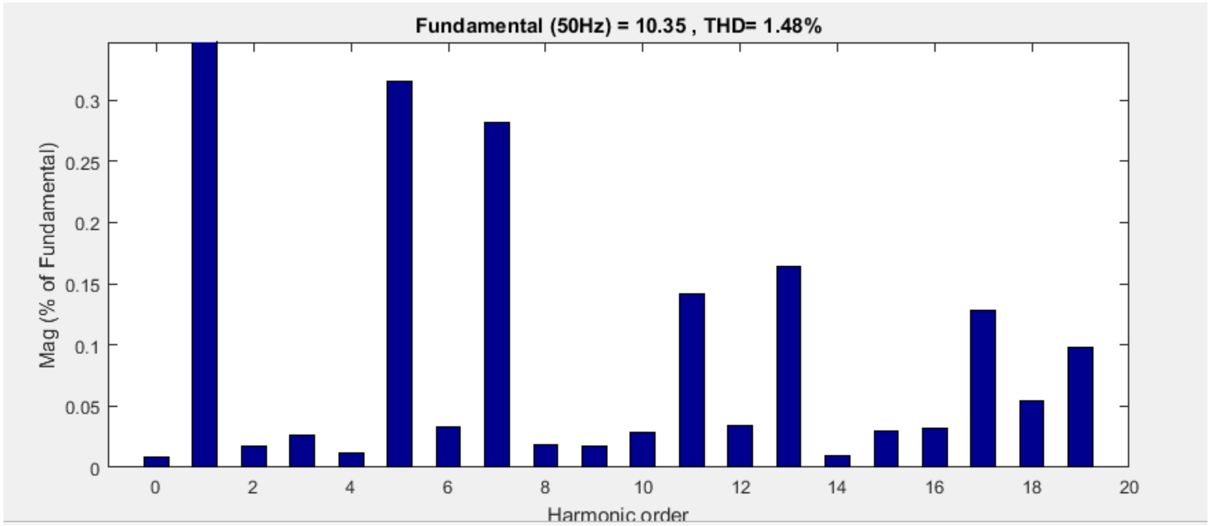

Fig 12 FFT analysis of source current

- Synchronous reference frame theory

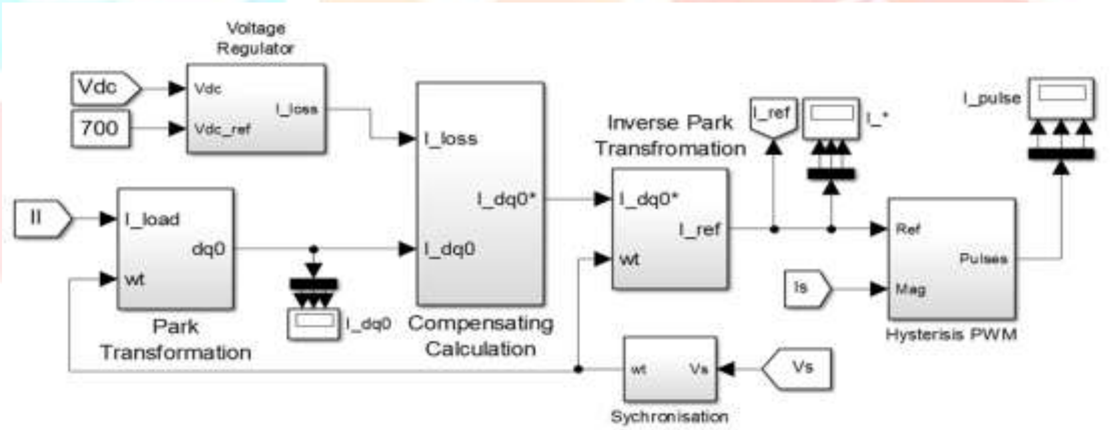

Fig. 13 synchronous reference frame theory

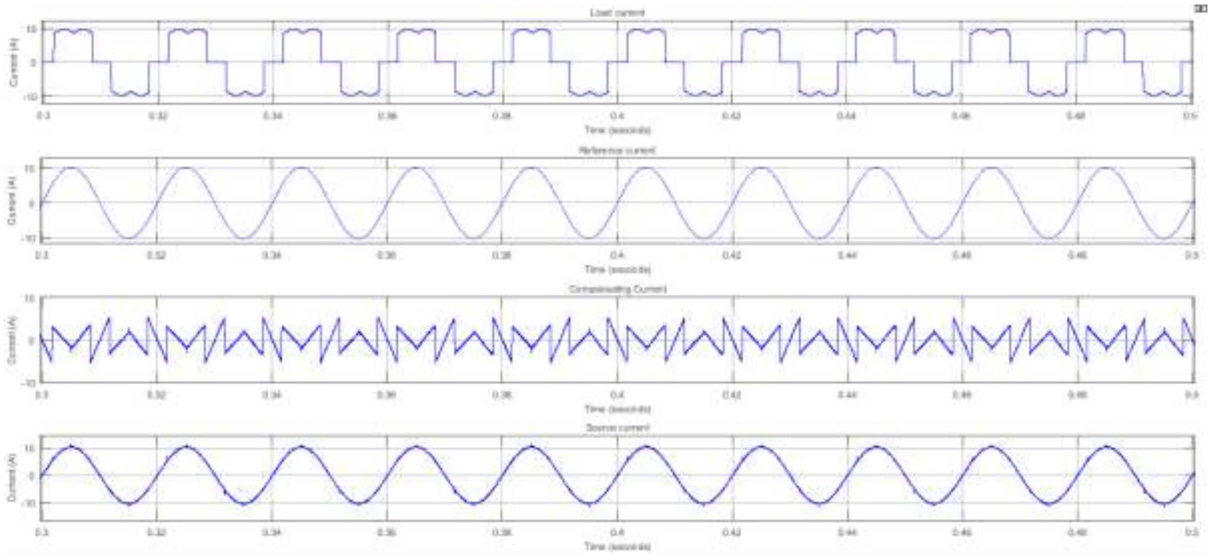

Fig. 14 current waveforms for synchronous reference frame theory

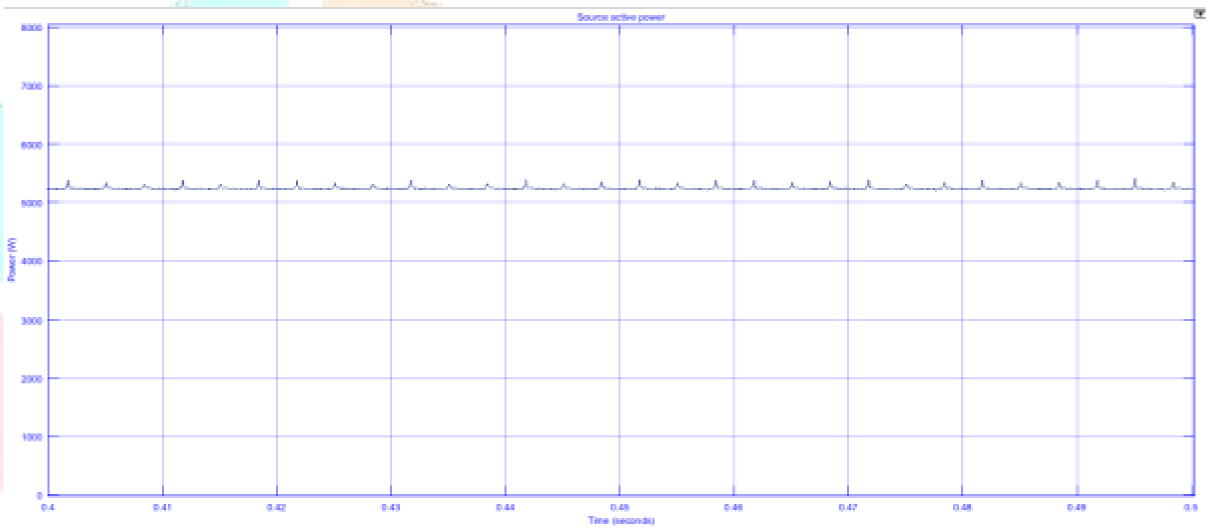

Fig. 15 Active power after filtering

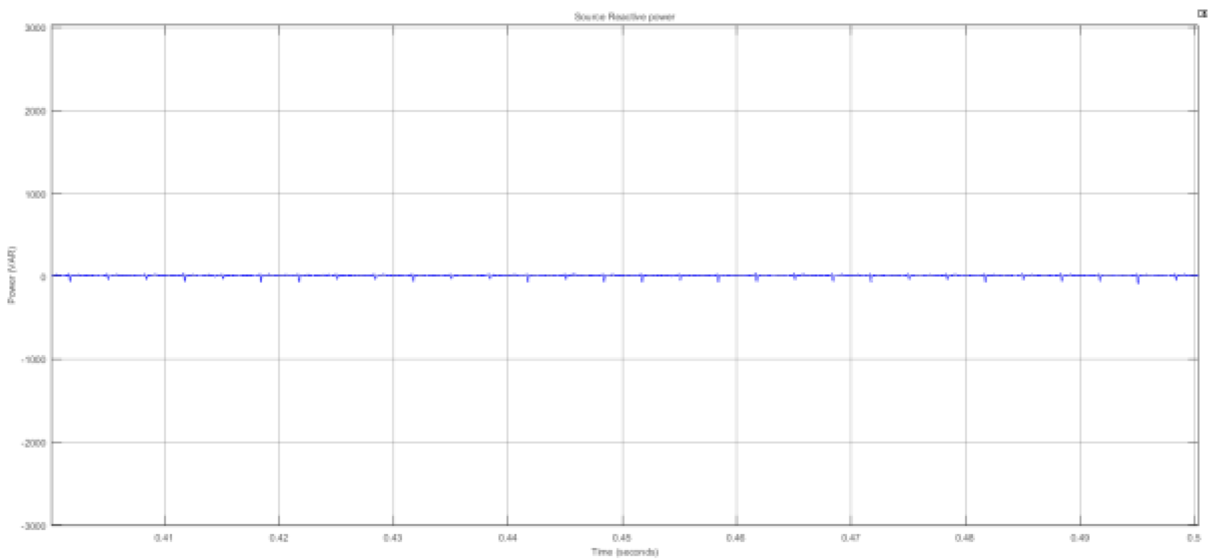

Fig. 16 Reactive power after filtering

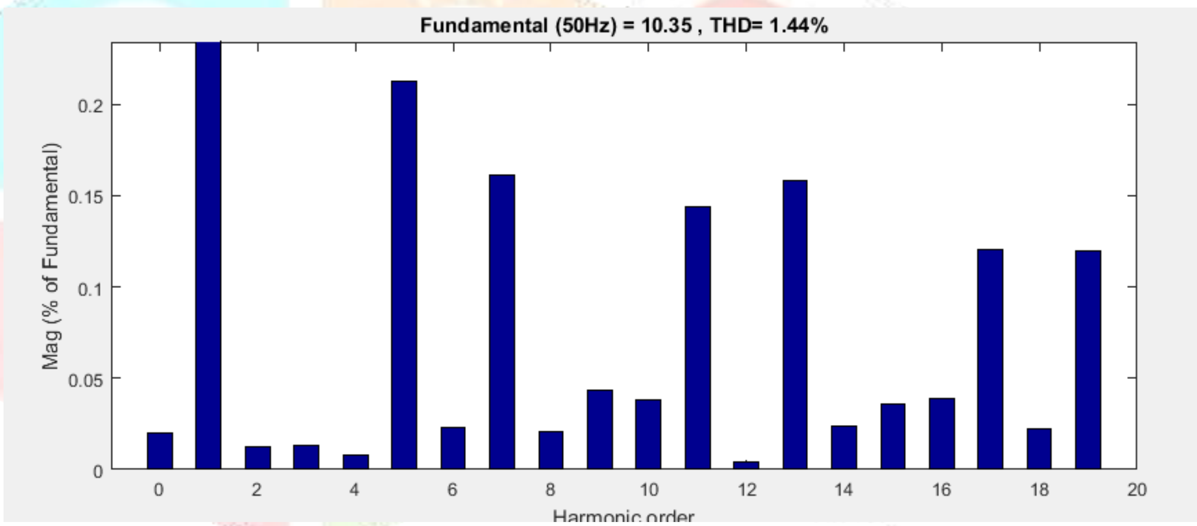

Fig. 17 FFT analysis of source current

VII. Conclusion

After study these two control strategy based on simulation analysis, the result of FFT analysis nearly equal to similar. To compare both techniques Synchronous reference frame theory is superior. The following table shows the results of THD analysis.

Load current THD (%)	Source current THD (%)	
	Instantaneous active reactive power theory	Synchronous reference frame theory
30.37	1.48	1.44

Table shows the THD analysis and there are source current good results so power quality improve by shunt active power filter.

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