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REDUCTION OF HARMONICS IN POWER DISTRIBUTION SYSTEMS USING HYBRID ACTIVE FILTER

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ABSTRACT:- *The best solution for the elimination of harmonics and hence improving the power quality in distribution systems is by the usage of filters. The resonance among the line inductance and correction capacitors leads to harmonic propagation in the power distribution systems. Installing the shunt hybrid filter at the end bus of a distribution feeder is one of the possible solutions to mitigate the harmonic propagation. This paper presents the design and simulation hybrid active filter based on voltage detection consisting of seventh-tuned LC passive power filter and a 3ϕ active power filter connected in series to mitigate the harmonic propagation under the worst-case situation that is under no load. The filter is connected in parallel to the system. Simulation is carried out for a 415V, 50Hz system in MATLAB. The THD is reduced from 19% without filter to 1.5% with the addition of hybrid filter.*

***Keywords*:** *harmonic propagation, power distribution systems, tuned filters, hybrid active filters*

I. INTRODUCTION

The improvement in technologies over the recent years has led to the increase of power electronic loads in distribution feeders. Thus, leading to increased usage of capacitors for correcting the power factor in distribution systems. This causes harmonic propagation because of resonance amongst line inductances and capacitors used for correcting power factor. This situation is worst during no-load conditions. In real power distribution systems, this situation occurs at night times. To mitigate these harmonics active filters had been proposed and tested [1]-[2]. These active filters act like damping resistor to harmonic frequencies. It's not economically feasible to install filters at the neighbourhood of each harmonic producing load, to achieve harmonic mitigation throughout the feeder filters must be installed at the end terminal of the distribution feeder [3]. The cost of installing active filters should be taken care by the electricity supply company. Practically size of the active filters is too large for installation on the electric poles. Problems of cost and size can be overcome with the help of a new alternative of shunt hybrid active filter is proposed [4]. The shunt hybrid active power filter is the combination of a tuned passive power filter and an active power filter connected in series with each other. The voltage detection based hybrid power filter acts like damping resistor to the frequencies of the harmonics. Simulation results is obtained for a hybrid active power filter connected to a 415V, 50Hz feeder simulator. The complete control of the filter is digital.

System design

Figure.1 shows a basic block diagram of the complete system which mainly consists of a source, the distribution feeder and the hybrid filter and the load which is non-linear in nature. The harmonics are generated because of the resonance caused amongst the line inductances and power factor correction capacitances. Since simulations are carried out the harmonics are indicated by a harmonic generator and this paper mainly concentrates on the worst-case condition of harmonic propagation which is under no-load/light load conditions, hence the load is not considered while doing simulations.

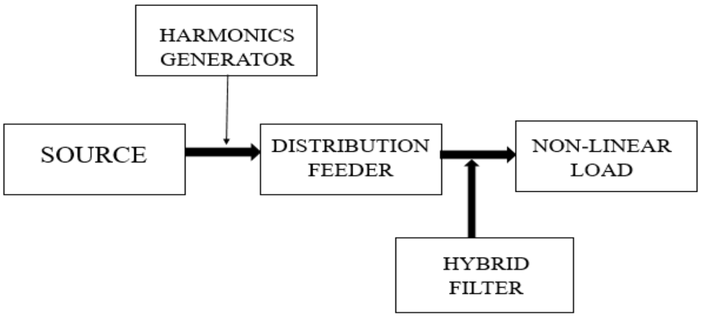

Figure.1 Block diagram of proposed system

The hybrid active power filter is a combination of tuned LC passive power filter and an active power filter. Both the filters are connected in series to each other and they are in turn shunted to the distribution system as illustrated in figure.2. This connection topology of the hybrid filters helps in eliminating the requirement of a step-down transformer as the capacitor of the passive power filter levies a high impedance for fundamental frequencies, thus making sure that the fundamental voltage appears across it. This in turn reduces the rating of the active filter as the tuned LC filter decouples fundamental voltage from the power distribution system. Therefore, this filter can be connected directly to the feeder without the need for stepping-down the voltage.

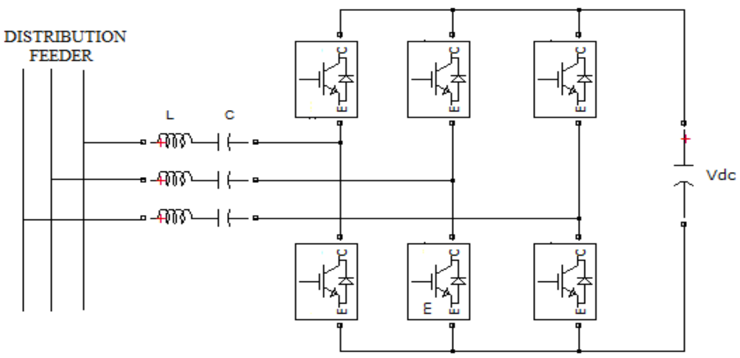

Figure.2 Topology of hybrid filter

II. CONTROL TECHNIQUE

The best method to detect harmonic components from the 3ϕ current and voltage waveforms is the p-q theory which is time domain based. The 3ϕ voltage and currents detected are transformed to d-q system of coordinates. Then to extract the dc components which are corresponding to the fundamental frequency in d-q system two high pass filters of cut-off frequency of 50Hz is used i.e. the high pass filters removes the fundamental voltage and currents from the 3ϕ system.

To control the current the reference current value is obtained from the multiplication of the harmonic voltage detected and the voltage control gain K_V. Then the detected current and reference current are compared and the resultant signal is increased by a current control gain K_C. From this the converter reference voltage(V^*_{ch}) is obtained.

Now the obtained harmonic voltages and currents are transformed back to three phase from synchronous frame. Coming to the dc-bus voltage control, it is necessary since the active power filter has the tendency to absorb excess of active power which may result in the damage of the active filter. Active power control technique is used for the controlling of dc-bus voltage. As per p-q theory dc component of synchronous frame is active power. And there is no flow of direct axis current through the passive filter hence by controlling the quadrature axis component the active power is controlled. The detected dc bus voltage and the reference value are compared and the error signal is enlarged. Then the control signal which is obtained is converted back to 3ϕ reference frame(V^*_b) from the d-q reference frame and then added to the converter reference voltage. The signals obtained from the addition of V^*_{ch} and V^*_b is the compared with the pwm signals generated by the PWM generator and the pulses are obtained for the switches of the active filter.

Design considerations

In thehybridactive power filter the current is controlled by detecting the voltage. The compensating current I_C in the filters comprises of both fundamental as well as the harmonic components. The passive LC filter impedance determines the fundamental components and the active filter controls the harmonic components. At the bus where the filter is installed the 3-phase currents and voltages are detected. From each phase of the detected 3ϕ voltages harmonic voltage V_h is extracted and this voltage is magnified by a voltage control gain K_V. Hence the harmonic current reference $I^*_{ch}$is computed by using the equation

$I^*_{ch}= K_v * V_h$……… (1)

TABLE I: SIMULATION PARAMETERS

PARAMETER	VALUE	PARAMETER	VALUE
Line inductor L	0.25mH	Filter Capacitor C_f	100µF
Resistor R	0.3Ω	Dc busvoltage V_{dc}	146V
Correction Capacitor C	1250µF	Dc bus capacitor C_{dc}	1500µF
Filter inductor L_f	2mH		

Passive filter

The passive filter is designed for 7th harmonic frequency i.e. 350hz as harmonic propagation occurs around 7th harmonic frequency and comparing 7th tuned and 5th tuned filters, 7th tuned is less bulky. Its performance in reducing the harmonic impedances of the 11th and 13th harmonic frequencies is much better than fifth-tuned filters. The L_f and C_f values are computed using the relation

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Active filter

The actual harmonic currents I_{ch} are obtained from the compensating currents (I_C) which is detected. For harmonic frequencies, the active power filter acts like a damping resistor of 1/ K_V (V/A) [5]. The voltage control gainKvis the inverse of characteristic impedance(Z_0)of distribution feeder.

$Z_0 = \sqrt{\frac{L}{C}}$………. (2)

Control gain $K_V = 1/ Z_0$ ……(3)

Compensating current I_c is calculated using the formula

$I_C = \sqrt{\left\{\left(\frac{V_f}{Z_f}\right)^2 + (K_v v_h)^2\right\}}$ ……… (4)

Where V_f = phase voltage(rms value) at installation bus and V_h is harmonic voltage (assumed to be 3% of supply voltage).

The capacity of the filter is calculated using the formula

$\sqrt{\frac{3}{2}} * V_{dc} * I_C$ ……. (5)

III. SIMULATION AND RESULTS

A. SIMULATION

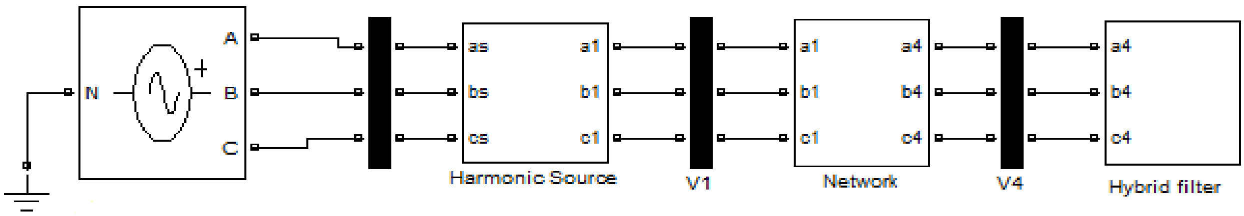

Figure.3 Simulation model of shunt hybrid filter

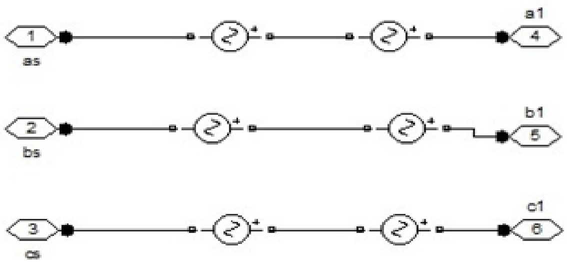

Figure.4 Harmonic source (voltage sources with 5th and 7th harmonic frequencies)

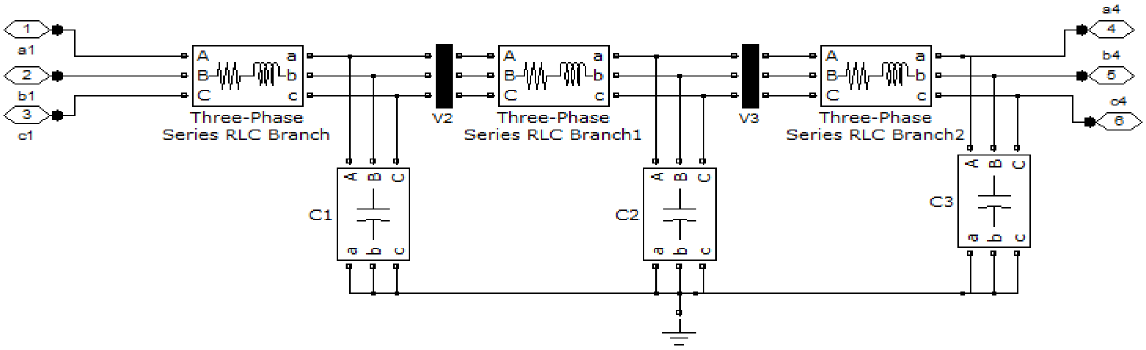

Figure.5 Network representing distribution system

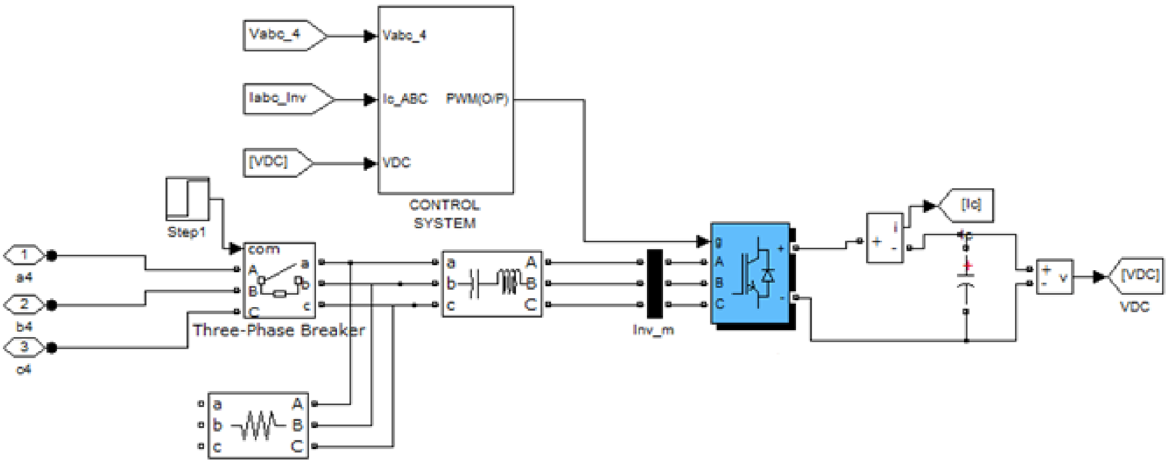

Figure.6 Hybrid filter

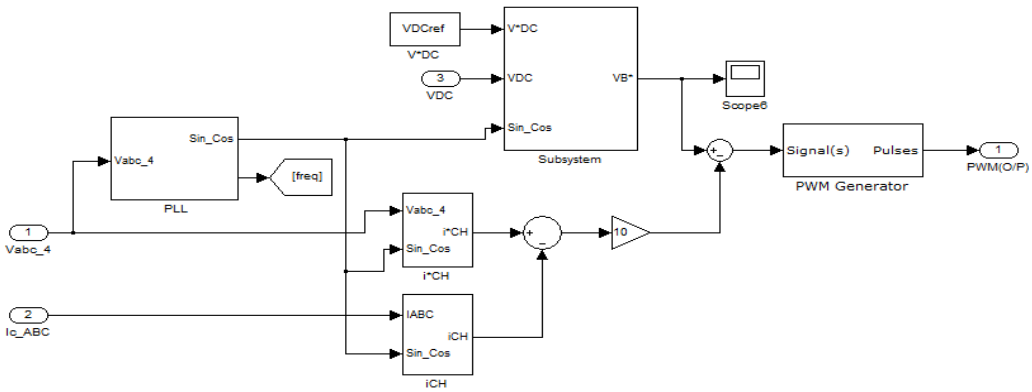

Figure.7 Control system

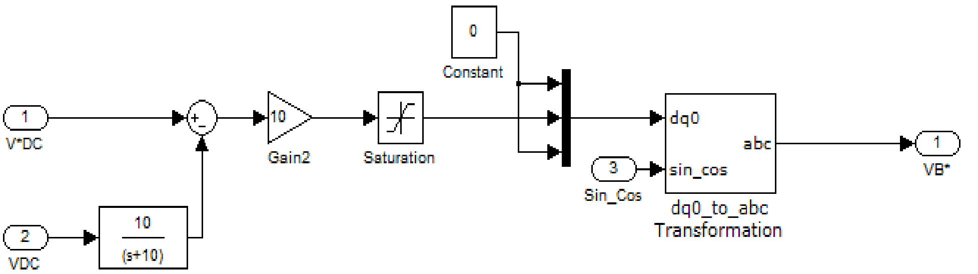

Figure.8 DC bus voltage control

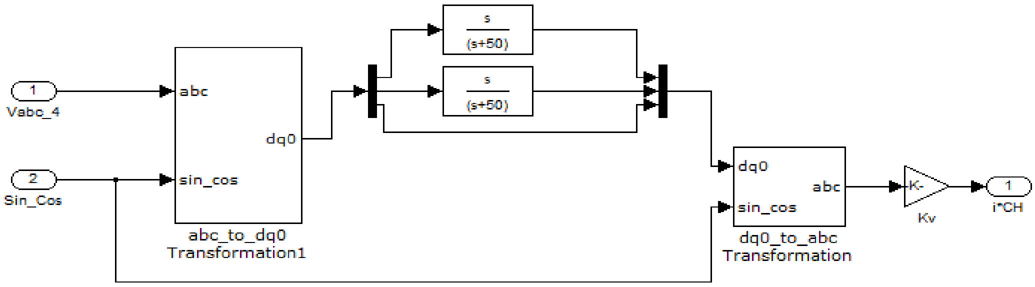

Figure.9 Generation of reference current

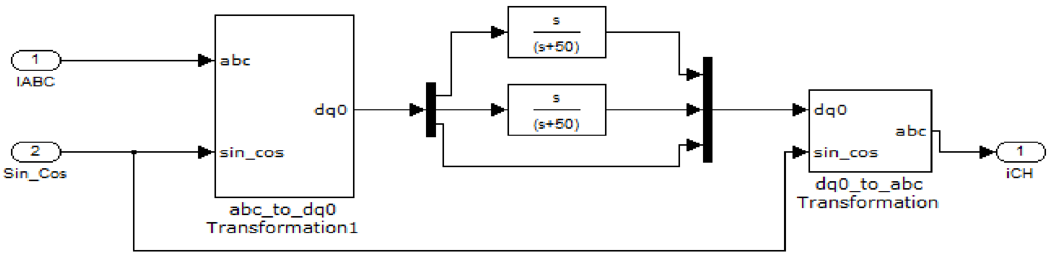

Figure.10 Harmonic current detection

B. RESULTS

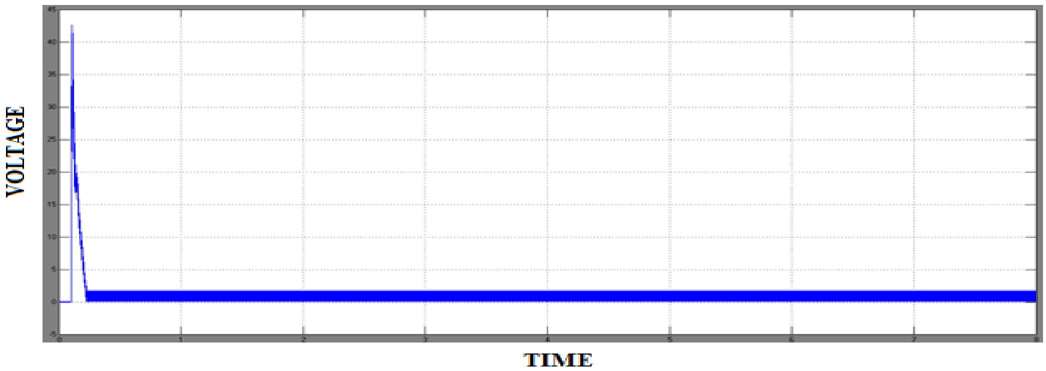

Figure.11 DC voltage Vdc(2V)

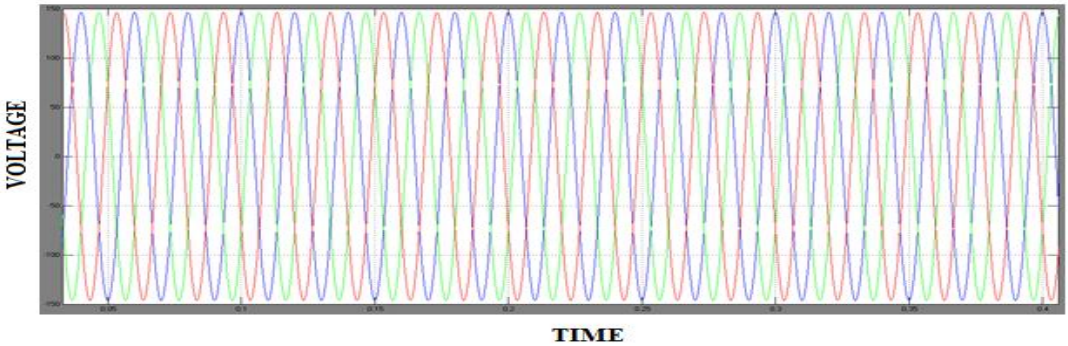

Figure.12 Voltage V^{*}_{B}(146V)

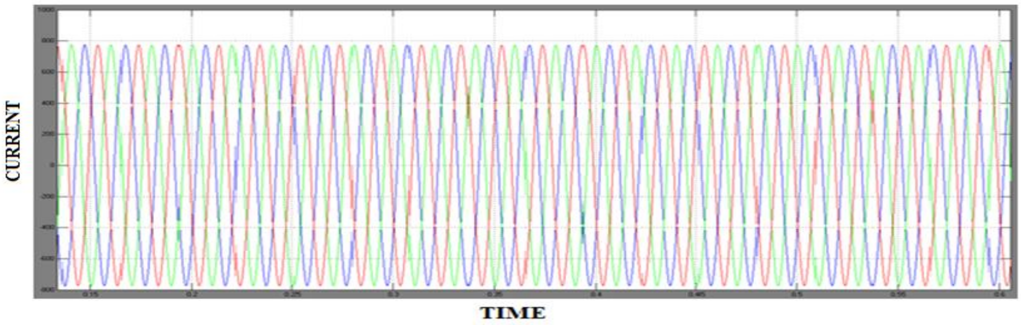

Figure.13 Reference current I^{*}_{ch}(750A)

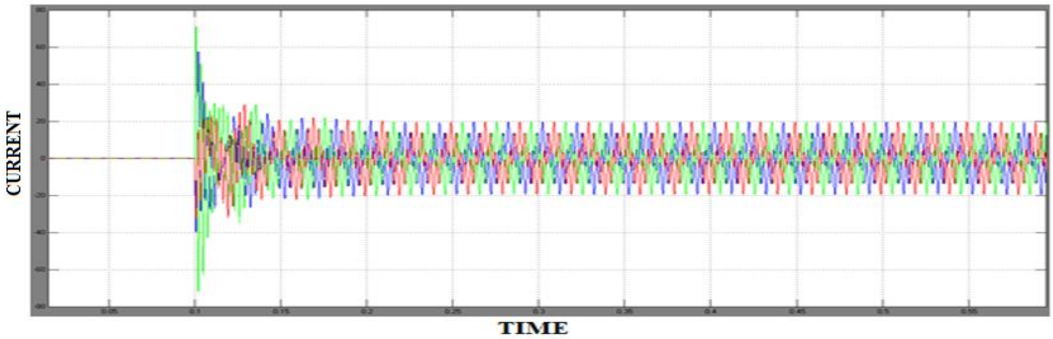

Figure.14 Harmonic current I_{ch}(20A)

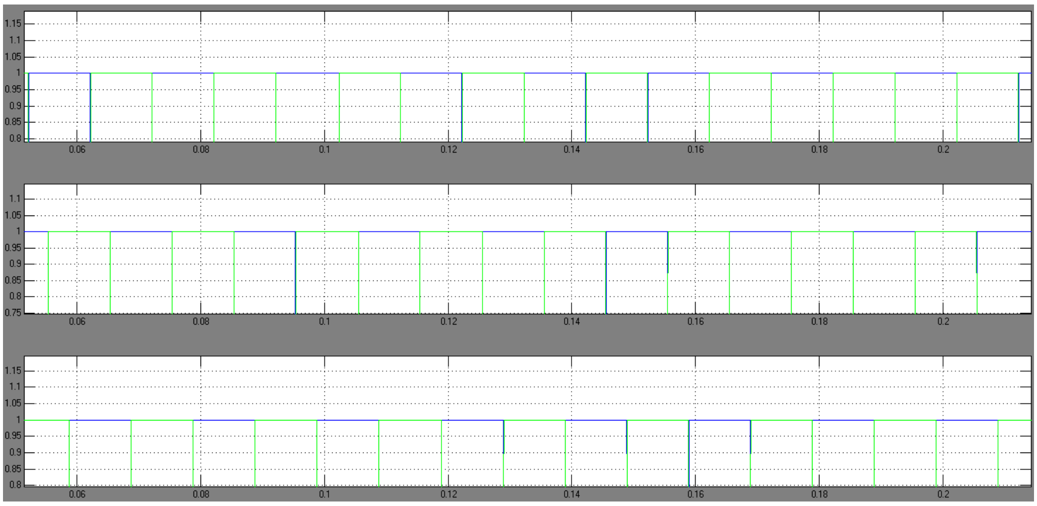

Figure.15 PWM signals for the IGBT switches

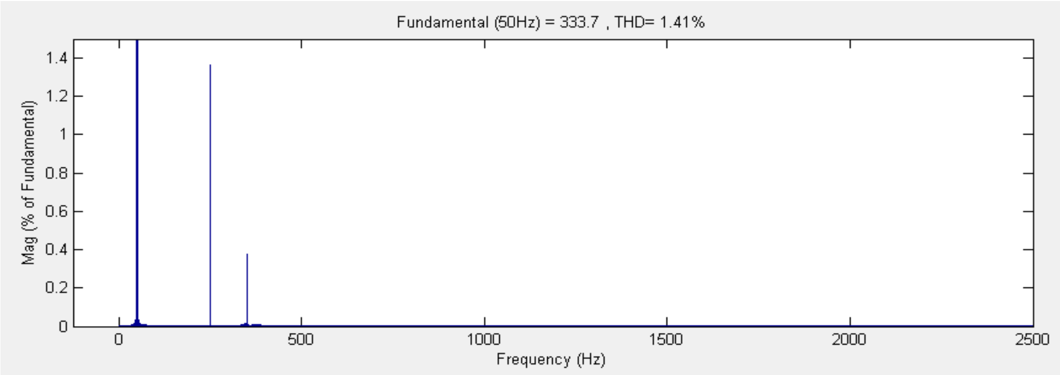

Figure.16 Total harmonic distortion at V_4

TABLE II: THD VALUES

	WITHOUT FILTER			WITH PASSIVE FILTER			WITH HYBRID FILTER		
	5^{TH}	7^{TH}	THD	5^{TH}	7^{TH}	THD	5^{TH}	7^{TH}	THD
V_1	3%	3%	4.24%	3%	3%	4.24%	3%	3%	4.24%
V_2	1.75%	5.56%	7.01%	5.50%	2.08%	5.88%	2.23%	2.07%	3.04%
V_3	0.52%	9.9%	9.92%	7.65%	0.94%	7.71%	0.98%	1.76%	2.01%
V_4	2.21%	18.61%	18.74%	9.33%	0.31%	9.33%	1.36%	0.38%	1.41%

IV. CONCLUSION

The paper discusses the installation, design aspects and the simulation of shunt hybrid active power filter. It should be installed at the end terminal of power distribution feeder such that it eliminates the harmonic propagation throughout the feeder. This filter eliminates the harmonics of the distribution system for the worst-case situation i.e. under no load. The filter topology used in this paper also reduces the rating of the filter hence reducing the size. The total harmonic distortion reduced from 18.74% without the filter to 9.33% with addition of just the passive filter but the THD value reduces to 1.41% with the addition of the hybrid filter which is within the limit of 5% prescribed by the IEEE standards.

V. REFERENCES

1. “A new approach to harmonic compensation in power systems—a combined system of shunt passive and series active filters,” by F. Z. Peng, H. Akagi, and A. Nabae
2. “A shunt active filter based on voltage detection for harmonic termination of a radial power distribution line,” by H.Akagi,H.Fujita,.
3. “Control and performance of a fully-digital-controlled shunt active filter for installation on a power distribution systemP. Jintakosonwit, H. Akagi,,H. Fujita
4. “Control strategy and site selection of a shunt active filter for damping of harmonic propagation in power distribution systems,” by H. Akagi,.
5. “A 6.6-kV Transformerless Shunt Hybrid Active Filter for Installation on a Power Distribution System,” by Rub´enInzunza, Student Member, IEEE, and Hirofumi Akagi.
6. “Implementation and performance of automatic gain adjustment in a shunt active filter for harmonic damping throughout a power distribution system,” by Jintakosonwit, S. Ogasawara

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