International Journal of Advanced Technology in Engineering and Science www.ijates.com
Volume No 03, Special Issue No. 01, March 2015 ISSN (online): 2348 – 7550

POWER QUALITY IMPROVEMENT USING HYBRID FILTER

ChamandeepKaur

Assistant Professor, Department of Electrical Engineering

Bhutta Group of Institutions, (India)

ABSTRACT

The electricity supply would, ideally, show a perfect sinusoidal voltage at every point of the power network. In reality, it is almost impossible to accomplish such desirable conditions. Voltage and current waveforms deviate massively from a sinusoidal. These waveform deviations are described by the use of waveform distortion and usually called harmonic distortion.Even if harmonic distortion is a quite old phenomenon it today presents one of the mainconcerns for public utilities, distribution system operators as well as their end customers.Already in the first years of operation of power distribution networks, there were first disturbances.. The major concern at this time was the effect that harmonic distortion had for the electric machines itself. Another well-known issue was interference in the telephone lines. But in general it can be said that harmonic distortion in former times did not have the same dangerous potential like it has today. This paper presents the design and formulation of hybrid filter to lower the harmonics and improve the power quality..

Keywords: Shunt Passive Filter, Series Active Filter, Hybrid Filter

I LITERATURE BACKGROUND

Enjeti et al., 1992), entitled "Analysis and design of an active power filter to cancel harmonic currents in low voltage electric power distribution systems", presents active power filter design considerations used for improving current quality in low voltage electric power distribution systems. Among various types of filters, shunt active filter is used for current harmonics removal and improves the power quality in electric power distribution system.

(**Hirofumi Akagi et al.,1998),** entitled "The unified power quality conditioners: the integration of series-active and shunt-active filters", In this paper the main purpose of a UPQC is to compensate for voltage flicker/imbalance, reactive power, negative sequence current, and harmonics. In other words, the UPQC has the capability of improving power quality at the point of installation on power distribution systems or industrial power systems. This paper discusses the control strategy of the UPQC, with a focus on the flow of instantaneous active and reactive powers inside the UPQC.

Singh, Bhim Al-Haddad et al., 1998), entitled "Harmonic elimination, reactive power compensation and load balancing in three-phase, four-wire electric distribution systems supplying non-linear loads" In this paper, a new control scheme of a three-phase active power filter (APF) is proposed to eliminate harmonics, to compensate reactive power and neutral currents and to remedy system unbalance, in a three-phase four-wire electric power distribution system, with unbalanced non-linear loads. The APF is realized using three single phase IGBT based PWM-VSI bridges with a common dc bus capacitor.

(Bhimsingh et al., 1999), entitled " A review of active filters for power quality improvements", presents in this paper presents a comprehensive review of active filter (AF) 21configurations, control strategies, selection of components, other related economic and technical considerations, and their selection for specific applications. It is aimed at providing a broad perspective on the status of AF technology to researchers and application engineers dealing with power quality issues.

(**Fujita et al., 2000),**entitled "A hybrid active filter for damping of harmonic resonance in industrial power system", explains the feature of passive filter and active filter in a combined way called hybrid filter for the elimination of harmonic resonance in industries. In a hybrid filter, active filter works for the elimination of voltage harmonics and passive filter is used for the elimination of current harmonics.

(AdilM.and Al-Zamil et al.,2001), entitled "A Passive Series, Active Shunt Filter for HighPower Applications" This paper presents a hybrid series passive/shunt active power filtersystem for high power nonlinear loads. This system is comprised of a three-phase shunt active filter and series ac line smoothing reactance installed in front of the target load. The proposed system significantly reduces the required shunt active filter bandwidth. The space-vector pulse width modulation (PWM) controller is based on a dead-beat control model. It is implemented digitally using a single 16-bit microcontroller. This controller requires only the supply current to be monitored, an approach different from conventional methods.

II. INTRODUCTION TO HYBRID FILTER

The hybrid filter, which is a combination ofan active series filter and passive shunt filter . It is quitepopular because the solid-state devices used in the active seriespart can be of reduced size and cost (about 5% of the load size)and a major part of the hybrid filter is made of the passiveshunt *L–C* filter used to eliminate lower order harmonics. Ithas the capability of reducing voltage and current harmonics ata reasonable cost.

Series active filter and parallel passive filter topology shown in fig. 1, An active power filter is implemented with a three-phase pulse width modulation (PWM) voltage-source inverter operating at fixed switching frequency. When this equipment is connected in series to the ac source impedance it is possible to improve the compensation characteristics of the passive filters in parallel connection. In order to allow current harmonic compensation, parallel LC filter must be connected between the nonlinear loads and the series transformers.It is well known that series active power filters compensate current system distortion caused by non-linear loads by imposing a highimpedance path to the current harmonics which forces the high frequency currents to flow through the LC passive filter connected in parallel to the load. The high impedance imposed by the series active power filter is created by generating a voltage of the same frequency that the current harmonic component that needs to be eliminated. Current harmonic and voltage unbalance compensation are achieved by generating the appropriate voltage waveforms with the three phases PWM-source inverter.

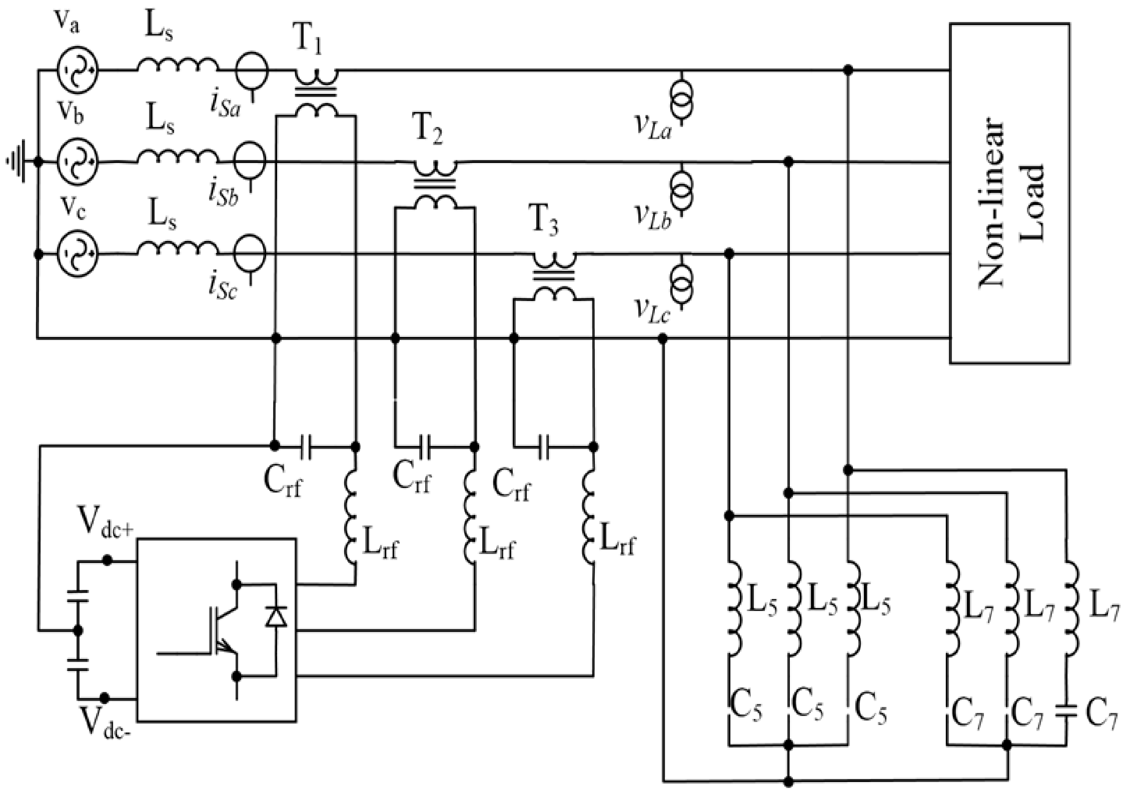

Figure 1.Series active filter and shunt passive filter topology

III CONTROL STATERGIES

3.1 The Dual Instantaneous Reactive Power Theory

3.1.1 SRF Controller

The synchronous reference frame theory or d-q theory is based on time-domain reference signal estimation techniques. It implements the operation in steady-state or transient state as well as for generic voltage and current waveforms. It allows controlling the active power filters in real time system. Another important characteristic of this theory is the simplicity of the calculations, which involves onlyalgebraic calculation. The basic structure of SRF controller consists of direct (d-q) and inverse (d-q)- park transformations as shown in fig 2. These can valuable for the calculation of a specific harmonic component of the input signals.

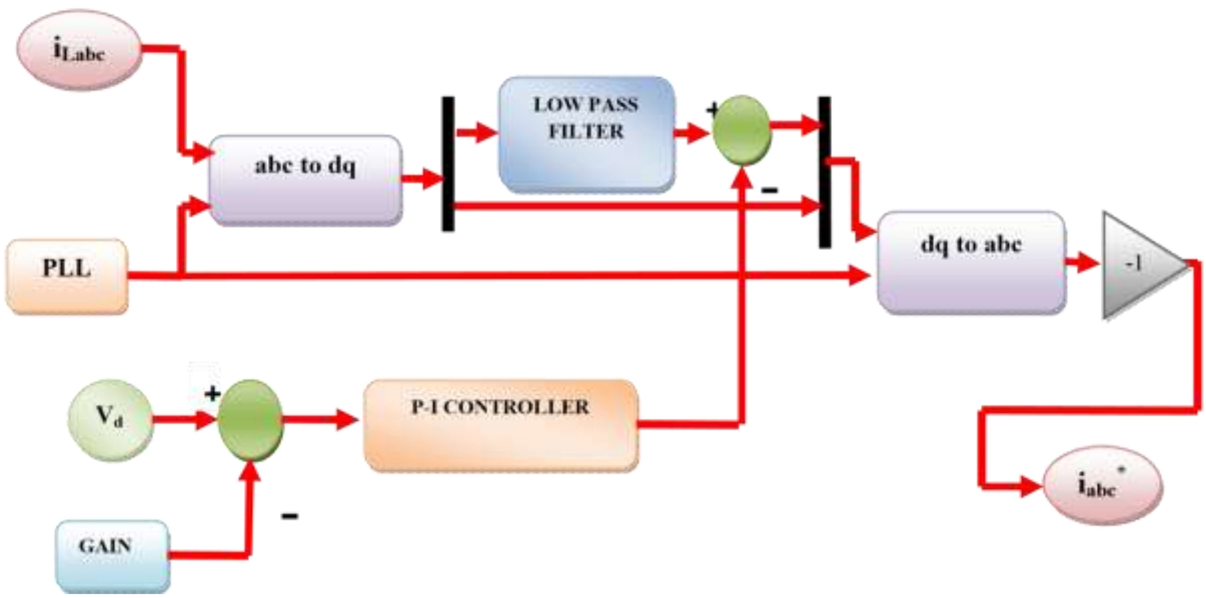

Figure 2.Synchronous d-q reference frame based compensation algorithm

These three phase space vectors stationary coordinates are simplychanged into two axis dq rotating reference frame transformation. This algorithm simplifies creating id-iq(rotating current coordinate) from three phase stationary coordinate load current ia .ibic, as shown in equation.

$$I_{dqo} = T I_{abc} = \sqrt{\frac{2}{3}} \begin{bmatrix} \cos(\theta) & \cos(\theta - \frac{2\pi}{3}) & \cos(\theta + \frac{2\pi}{3}) \\ -\sin(\theta) & -\sin(\theta - \frac{2\pi}{3}) & -\sin(\theta + \frac{2\pi}{3}) \\ \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} & \frac{\sqrt{2}}{2} \end{bmatrix} \begin{bmatrix} I_a \\ I_b \\ I_c \end{bmatrix}$$

The d-q transformation output signals depend on the load current (fundamental and harmonic components) and the performance of the Phase Locked Loop (PLL). The PLL circuit offers the rotation speed (rad/sec) of the rotating reference frame, where ωt is set as fundamental frequency component. The PLL circuit provides sinɵ and cosɵ. The id-iq current are sent over low pass filter (LPF) for filtering the harmonic components of the load current, which permits only the fundamental frequency components.

3.2 PQ Theory

The instantaneous reactive power theory is the most widely used as a control strategy for the APF. It is mainly applied to compensation equipment in parallel connection. This theory is based on a Clarke coordinate transformation from the phase coordinates (see figure 3). In a three-phase system voltage and current vectors can be defined by

$v=[\ v_a v_b v_c]^T$ $i =[\ i_a i_b i_c]$ - (1)

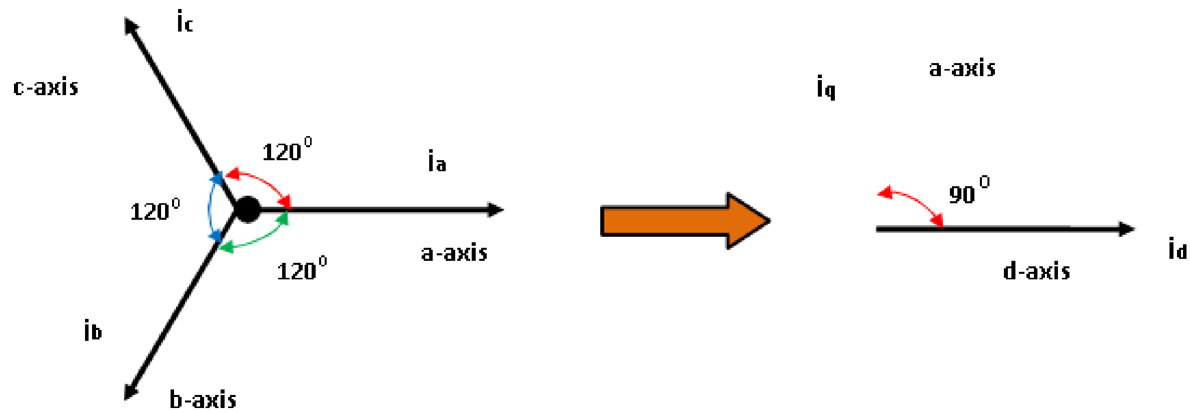

Figure 3.Transformation from the phase reference system (abc) to the (0αβ) system.

Instantaneous reactive power theory (IRPT) uses the park transform, to generate two orthogonal rotating Vectors (α and β) from the three phase vectors (a, b and c). This transform is applied to the voltage and current and is given by eqn 2,3

$$\begin{bmatrix} v_0 \\ v_\alpha \\ v_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} v_a \\ v_b \\ v_c \end{bmatrix} \quad - (2)$$

$$\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} = \sqrt{\frac{2}{3}} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_a \\ i_b \\ i_c \end{bmatrix} \quad - \quad (3)$$

By looking at instantaneous powers, the harmonic content can be visualized as a ripple upon a DC offset representing the fundamental power. By removing the DC offset and performing the inverse park transform the harmonic current can be determined The supply voltage and load current are transformed into αβ quantities. The instantaneous active and reactive powers p and q are calculated from the transformed voltage and current .

IV THREE PHASE SYSTEM WITH HYBRID FILTER

The system is shown in figure 4 has been simulated in the Matlab Simulink platform to verify the proposed control.Each power device has been modelledusing the SimPowerSystem toolbox library. Figure 4 shows the Simulink diagram of hybrid filter .It is constituted by a series active filter and shunt passive filter connected in parallel with the load. The power circuit is a three phase system supplied by a sinusoidal balanced three phase 415v source, 50hz frequency with a source inductance of 5.8mH and a source resistance 3.6Ω.An active power filter consists of a three phase pulse width modulation PWM voltage source inverter .When this equipment is connected in series to the ac source impedance it is possible to improve the compensation characteristics of the passive filters in parallel connection.The inverter consists of an Insulated Gate Bipolar Transistor (IGBT) bridge. An LC filter has been included to eliminate the high frequency components at the output of the inverter. This set is connected to the power system by means of three single-phase transformers having rated power 1000VA and frequency 50 Hz with a turn ratio of 1:1. Also passive LC filter are connected in parallel with nonlinear load to eliminate the 5th & 7th order harmonics. The parameters of passive elements are $L_{5=}$13.5mH C_5=30µF L_7=6.75mH C_7=50µF. The passive filter is designed only to compensate source current harmonics, the reactive power was not considered. The nonlinear load is a three phase diode rectifier having snubber resistance 500Ω and snubber capacitance 250µF .The APF series control based on the instantaneous reactive theory is used. In fact, the instantaneous reactive power here is defined from a dot product; this results in a remarkable simplification in the implementation of the reference generation method. The final development allows any compensating strategy to be obtained among them, unity power factor. The strategy is applied to a three phase system with balanced loads. The simulation results used to verify the theoretical behavior are presented

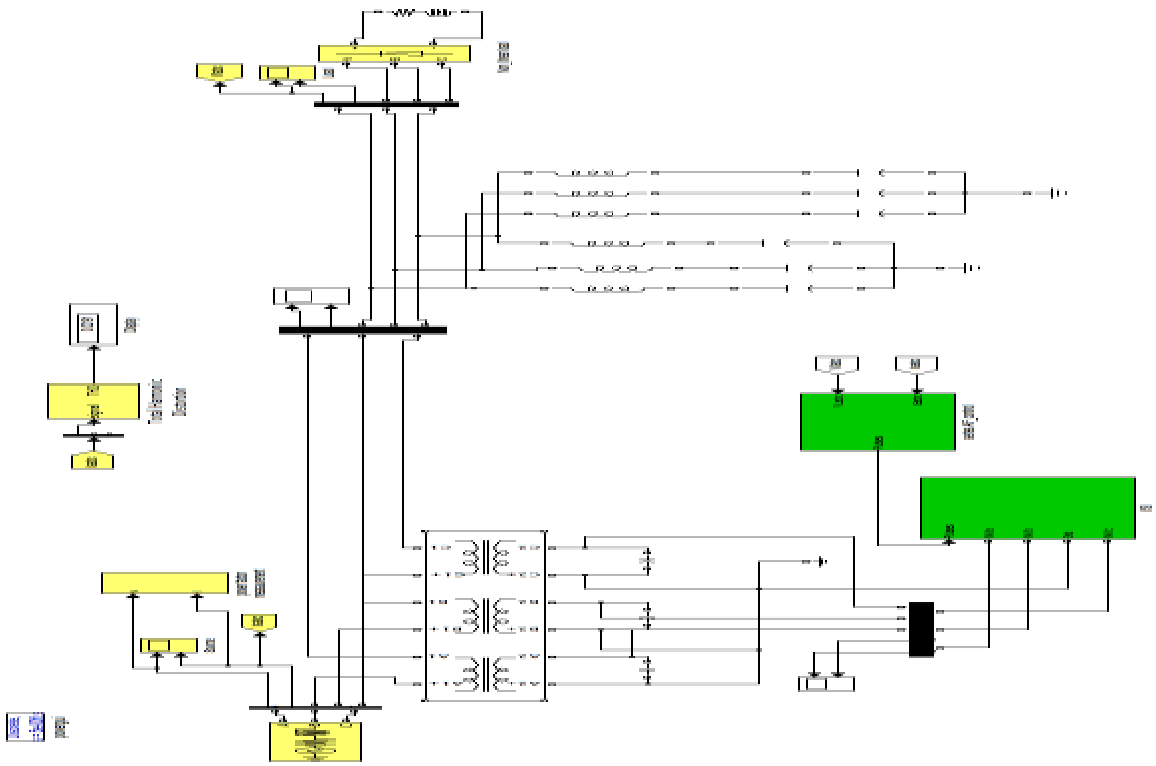

FIGURE 4 Simulink Diagram of Three Phase System Using Hybrid Filter

V SIMULATION RESPONSE

The system parameters considered for the study of Hybrid Filter is given below in Table 1.

COMPONENTS	SPECIFICATIONS
AC Source	V_s=415v , f=50HZ , R_s=3.6Ω ,L_S=5.8Mh
Non Linear Load	R_L=40Ω , L_L=50mH
Passive Filter	L_5=13.5mH C_5=30F , L_7=6.75mH C_5 =50F

5.1 Simulation Response without Filter

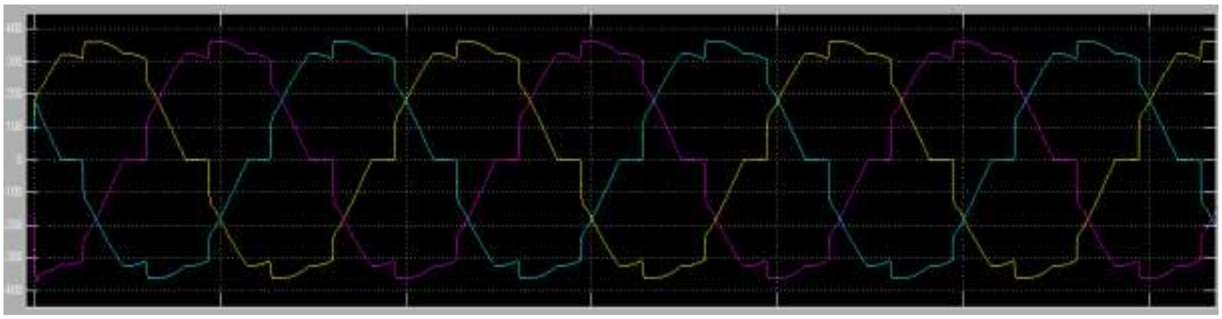

Figure-5Waveforms of source voltage without filters

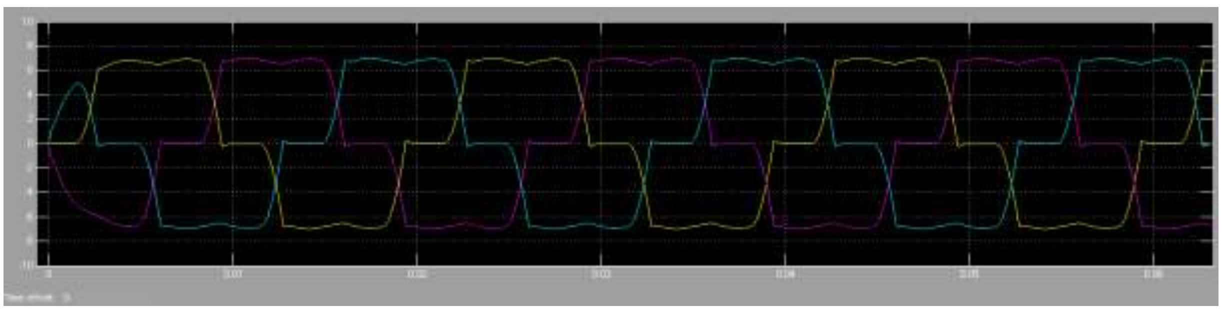

Figure-6 Waveforms of source current without filters

5.2 Simulation Response with Hybrid Filter

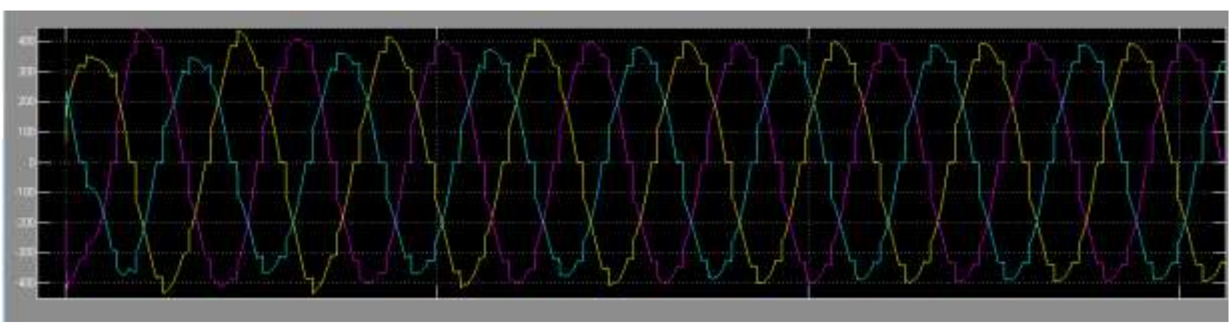

Figure-7 Waveforms of load voltage with hybrid filter

Figure 8 Waveforms of load current with hybrid filter

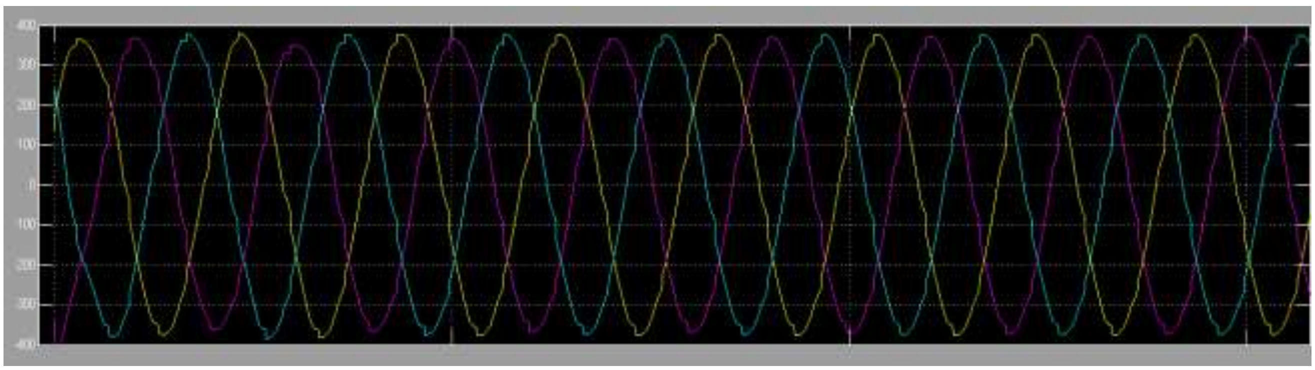

Figure 9 Waveforms of source voltage with hybrid filter

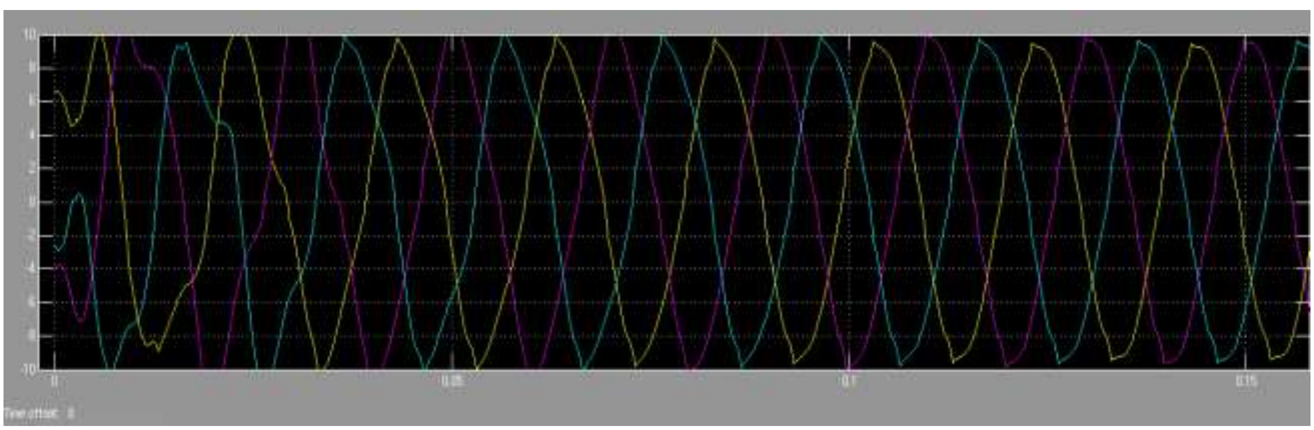

Figure 10 Waveforms of source current with hybrid filter

When the series active filter is connected, the THD of the source current falls to 2.1%. The waveform is shown in Fig. 10. Now, the power factor rises to 0.998. This allowsus to verify the proposed control improvement in thecompensation characteristic of the passive filter and itpractically achieves unity power factor. Figure 7 and 8 shows the waveforms of load voltage and current.

VI CONCLUSION

This paper proposed hybrid filter design to enhance the power quality in transmission and distribution system.

REFERENCES

- Third EditionBhim Singh, Kamal Al-Haddad, Senior Member, IEEE, and Ambrish Chandra, Member, IEEE(1999) "A Review of Active Filters for Power Quality Improvement "IEEE Transactions Industrial Electronics , VOL. 46, NO. 5, OCTOBER 1999.
- Adil M. Al, -Zamil, Member, IEEE, and David A. Torrey, Member, IEEE(2001), "A Passive Series, Active Shunt Filter for High Power Applications", Transactions of Power Electronics, Vol. 16 NO. 1, 2001.
- C. NaliniKiran, SubhransuSekhar Dash, S.PremaLatha (2011)"A Few Aspects of Power Quality Improvement Using Shunt Active Power Filter" International Journal of Scientific & Engineering Research Volume 2, Issue 5, May-2011 .
- Jinn-Chang , Hurng-Liahng , Kuen-Der , Hsin-Hsing Hsiao (2012), "Three-phase four- wire hybrid power filter using a smaller power converter" Electric Power Systems Research 87 (2012)
- Mark F,Roger C.[2012] "Electrical Power System Quality" Tata McGraw-Hill

BIOGRAPHY

Name - Chamandeepkaur

Designation-Assistant Professor in Bhutta College of Institutions, India

Department of Electrical

Qualification-Btech (Electrical Engg) from Guru Nanak Dev Engineering College

Mtech(power Engg) from Guru Nanak Dev Engineering College

Phone no-8968334007