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Series Hybrid Filter for Harmonic Compensation in Three Phase System

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Abstract:
According to IEEE-519 standard the Total Harmonic Distortion (THD) in a power system must lie within 5%, but as the demand of power electronic devices is increasing exponentially, the harmonic generation is becoming a serious problem to the power system. Conventional passive filters may not have satisfactory performance but the auto tuned active filter is a mature technology to solve this serious problem of harmonic generation, but again if active filter is used alone, it's power rating and cost will be very high. Therefore a new approach of combined active and passive filter has been developed. The combination of active filter and passive filter is called Hybrid Filter. In this paper a hybrid system is used, in which the active filter is used in series and the passive filter is used in parallel with the line. The system is capable to remove current as well as voltage harmonics. The passive filter is tuned to eliminate the dominant current harmonics generated by nonlinear load as well as to supply the reactive power as required by the load, and the active filter improves the compensation characteristics of passive filter as well as eliminates the voltage harmonics generated due to non ideal source conditions. Synchronous Reference Frame (SRF) is used for the generation of reference compensating current, a PI controller is used for dc voltage regulation, and for the generation of gating signals for the IGBTs used in active filter, hysteresis band controller is used. The results and efficiency of the system are verified through MATLAB simulation. The results are found to be quite satisfactory as the proposed system maintains the THD, as per the limits of IEEE-519 standard.

Keywords: *Hybrid filter, Series active filter, Shunt passive filter, Hysteresis band controller, PI controller, Synchronous reference frame*

1. Introduction

Due to the nonlinear characteristics and switching action of power electronic devices, various power quality issues such as increased harmonics and reactive power components of current from ac mains, low system efficiency and a poor power factor are created in power system, which can disturb the other loads connected at the point of common coupling of the distribution network.

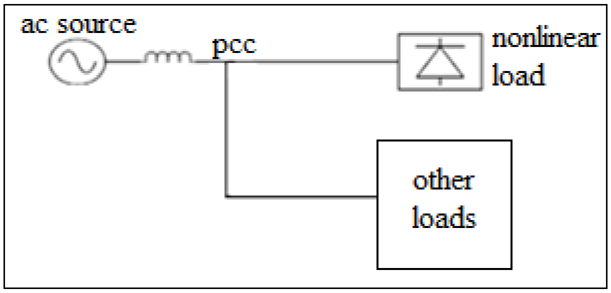

Figure 1: Power System

One solution to this problem is to use passive filter, which is tuned to eliminate a particular harmonic frequency. It may be single tuned or double tuned [3] as shown in figure 2.

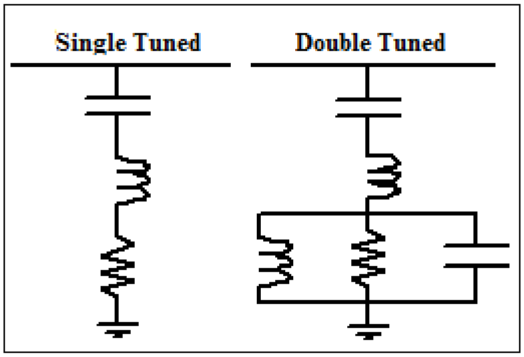

Figure 2: Single and Double Tuned Passive Filters

Though passive filters are economic and have simple structure, they have the disadvantages of fixed compensation, resonance and large size [2]. To overcome the shortcomings of passive filters, active filters were developed.
Following figure shows the basic compensation principal of series active filter [1, 9].

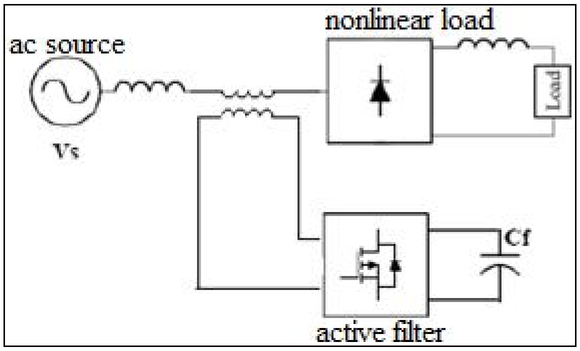

Figure 3: Basic Compensation Principal of Series Active Filter

The series active filter is connected at the source side with a coupling transformer. It acts as a harmonic isolator. It provides very high impedance at harmonic frequencies and forces the load harmonics to circulate through the passive filter. In this way it prevents the load harmonics from reaching towards source and thereby improves the source waveforms. Active filter can solve various power quality issues such as harmonic minimization, reactive power compensation, voltage imbalance, voltage flicker, and power factor improvement. Even though the active filters are an effective compensation system yet their cost is very high with the high power rating. This is the major drawback of active filters.
To reduce the power rating and hence the cost of active filters, the hybrid filters [2, 4, 5, 6, 7, 8, 9, 10, 11] have been developed, which are the combination of active filters and passive filters. Following figure shows the proposed topology of Hybrid Filter.

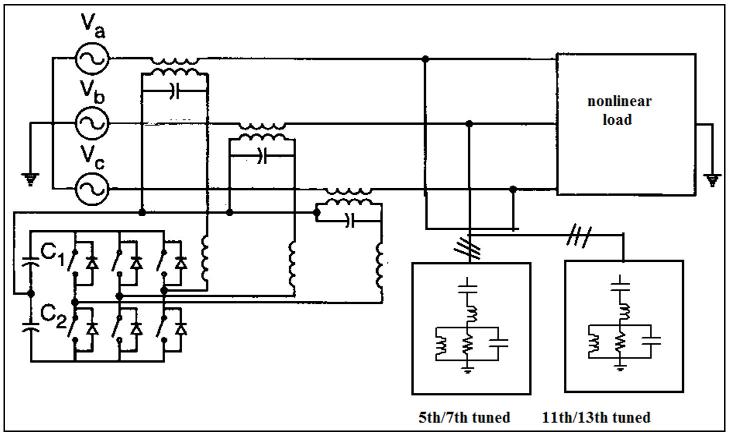

Figure 4: Proposed Topology

2. Control Strategy

For proper operation of active filter, an appropriate control strategy is necessary. The control strategy is designed to generate the gating signals for IGBTs used in active filter.

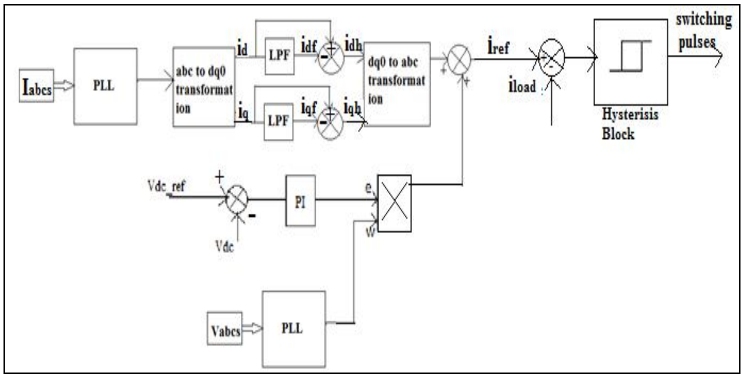

Figure 5: Block Diagram of Control Strategy

The control strategy is divided into three parts.

1) Generation of reference compensating current.
2) DC voltage regulation.
3) Generation of gating signals.

2.1. Generation of Reference Compensating Current

For the generation of reference compensating current, synchronous reference theory is used, which uses park transformation. It converts the three phase time domain signals from stationary abc coordinates to rotating dq0 coordinates. It reduces the three phase ac quantities (eg. Ua, Ub, and Uc) into two dc quantities (eg. Ud, Uq). For balanced system the 0 component is zero. The main purpose of this conversion is that the dc quantities are easier to filter and control.

The d-component of the signal consists of fundamental and harmonics active components, i.e., id = idf + idh. The q-component consists of fundamental and harmonics reactive components, i.e., iq = iqf + iqh. The fundamental active and reactive components (idf and iqf) are separated by low pass filters and subtracted from the complete d and q components respectively to get the harmonics active and reactive (idh and iqh) components. These harmonics components are then transformed back from dq coordinates to abc coordinates [6].

2.2. DC Voltage Regulation

The PI controller is used for the regulation of dc link capacitor voltage. The input to the PI controller is the difference of desired dc output voltage (Vdc_ref) and the actual dc output voltage. We can call this difference as an error between actual output and desired output. The PI controller processes this error and then the error is multiplied by the output of PLL, which is the frequency w, to get the error in the form of sinusoidal signal [5, 8].

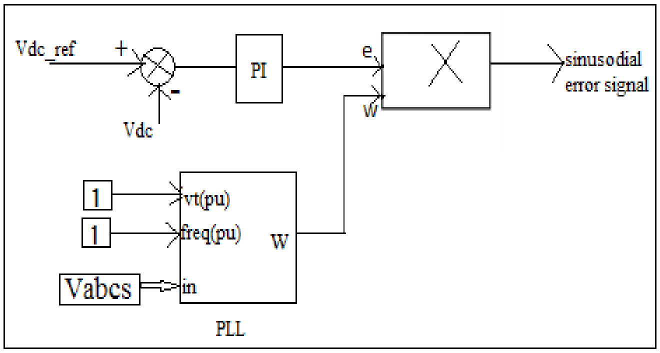

Figure 6: Generation of Error Signal Using PI Controller

This error is then added to the abc output of inverse park transform. The result is then the reference compensating current.

2.3. Generation of Gating Signals

A hysteresis band controller [9] is used for the generation of gating signals. It compares the actual load current wit the reference current. When the actual load current crosses the lower boundary of reference current, upper switch is turned on. When the actual load current crosses the upper boundary of reference current, lower switch is turned on. In this way gating signals are generated for the active filter switches.

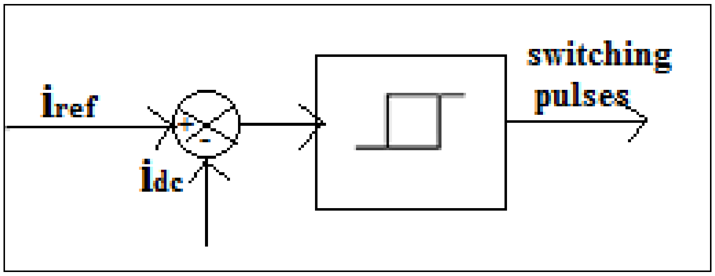

Figure 7: Hysrerisis Band Controller

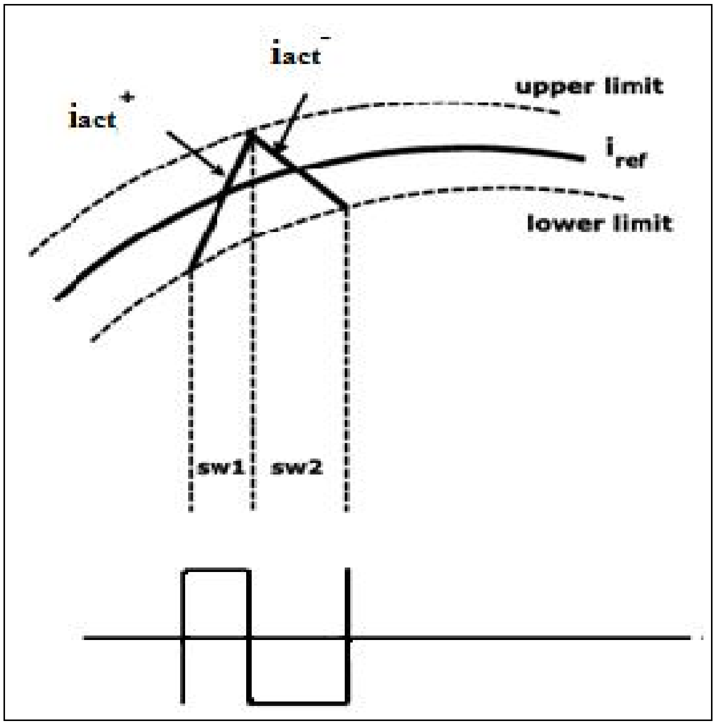

Figure 8: Generation of Gating Signals

3. Simulation Results

The overall simulation diagram is shown in following figure:

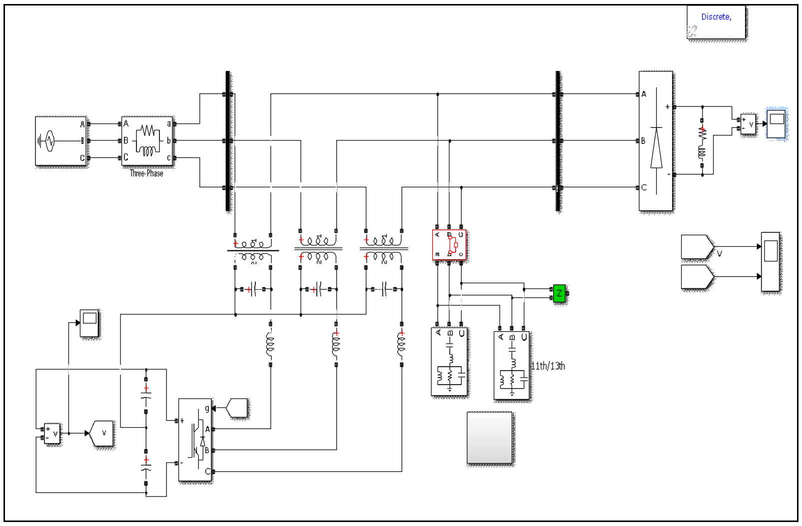

Figure 9: MATLAB Model for Proposed System

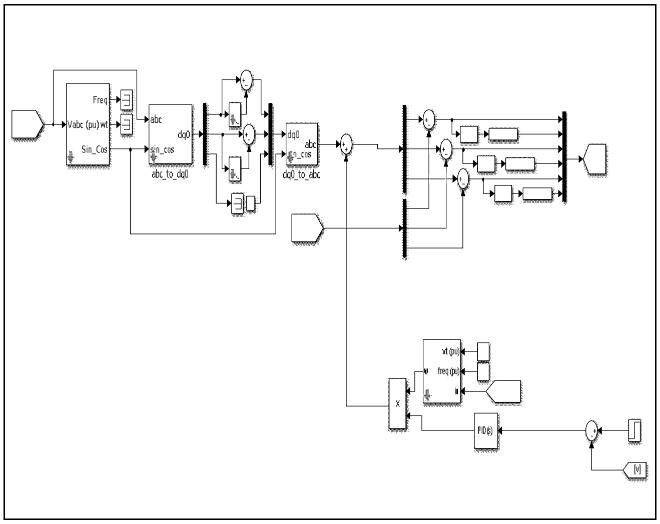

Figure 10: Subsystem Control Model

The harmonic compensation technique is implemented for a three phase power system, by using a hybrid filter. The source current waveform and its Total Harmonic Distortion (THD) spectrum, without filter are shown in figure 11(a), and figure 11(b) respectively. It indicates a THD of 12.20%, and the source voltage waveform and its Total Harmonic Distortion (THD) spectrum, without filter are shown in figure 11(c), and figure 11(d) respectively. It indicates a THD of 20.99%. The source current waveform and its Total Harmonic Distortion (THD) spectrum, with hybrid filter are shown in figure 12(a), and figure 12(b) respectively. It indicates a THD of 3.14%, and the source voltage waveform and its Total Harmonic Distortion (THD) spectrum, without filter are shown in figure 12(c), and figure 12(d) respectively. It indicates a THD of 3.51%. From these figures it is clear that the series hybrid filter reduces the harmonics to the limits as specified by IEEE-519 standard.

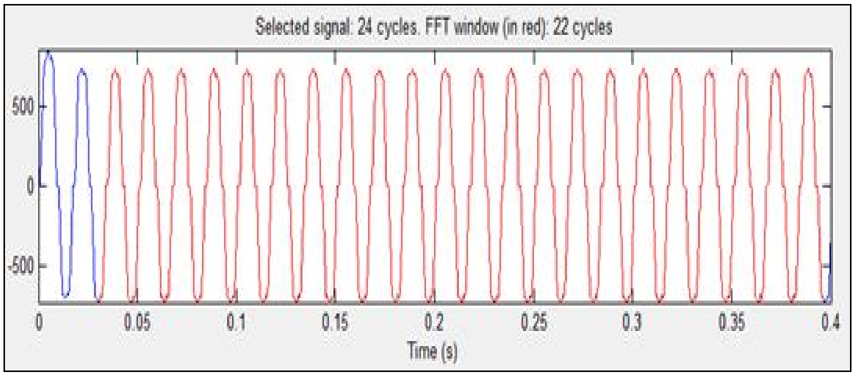

Figure 11(a): Source Current Waveform in Phase-a Without Filter

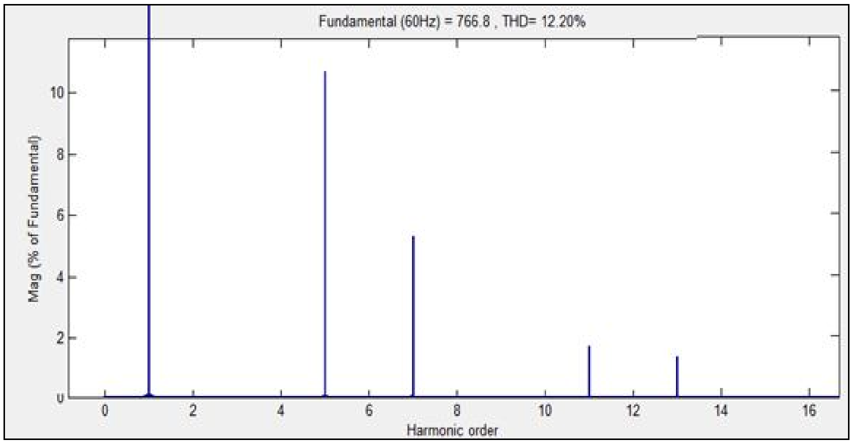

Figure 11(b): THD of Source Current Waveform in Phase-a Without Filter

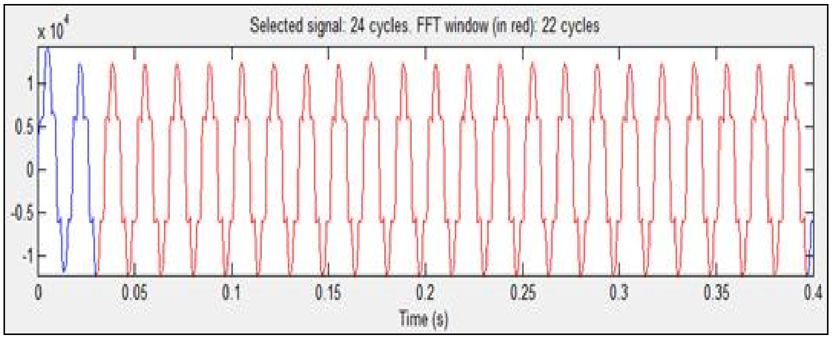

Figure 11(c): Source Voltage Waveform in Phase-a Without Filter

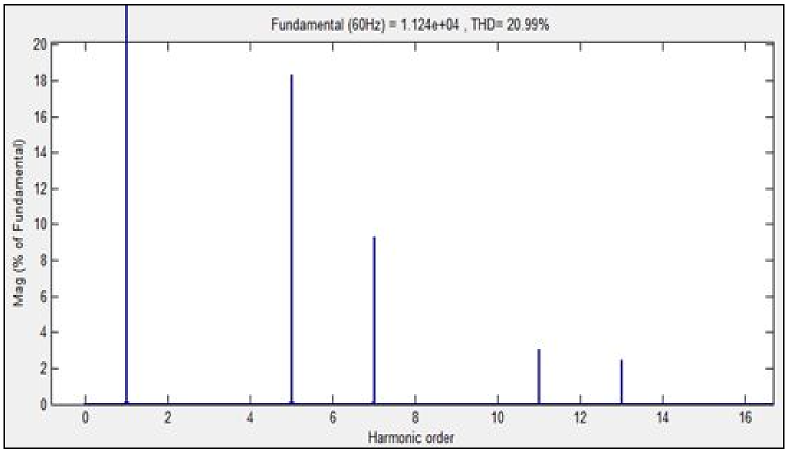

Figure 11(d): THD Spectrum of Source Voltage Waveform in Phase-a Without Filter

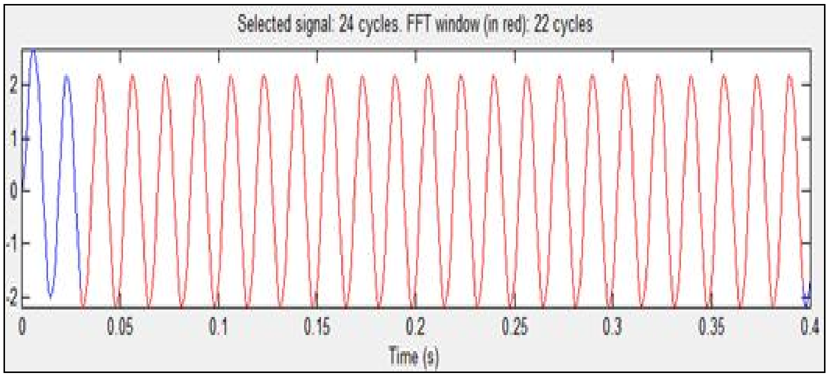

Figure 12(a): Source Current Waveform in Phase-a With Hybrid Filter

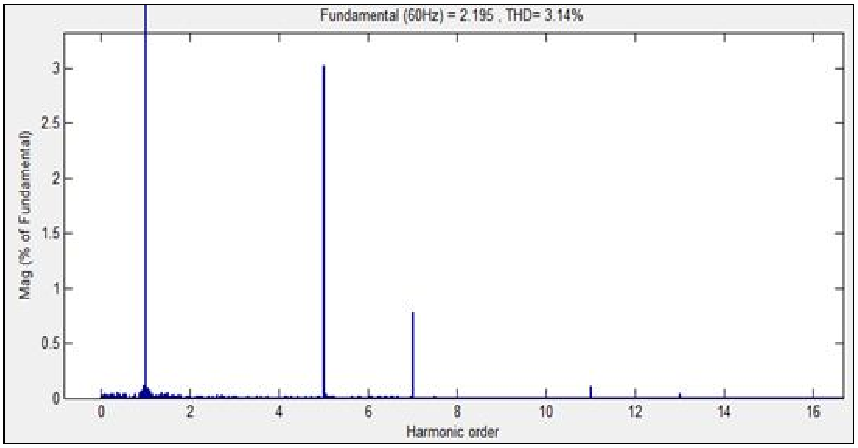

Figure 12(b): THD of Source Current Waveform in Phase-a Without Filter

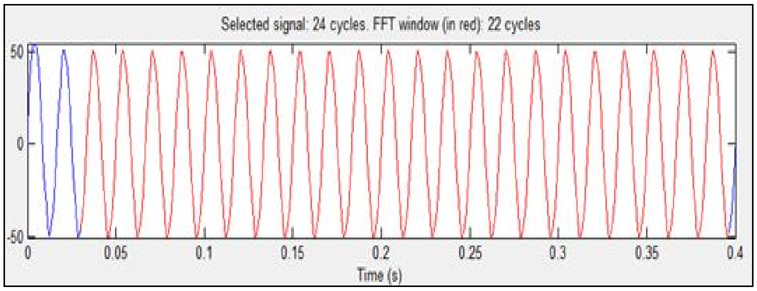

Figure 12(c): Source Voltage Waveform in Phase-a With Hybrid Filter

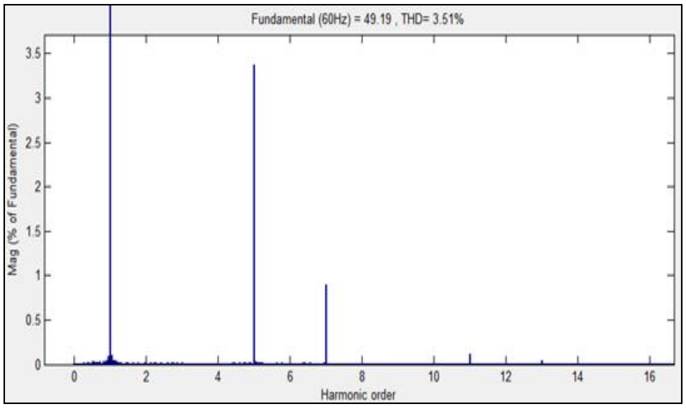

Figure 12(d): THD Spectrum of Source Voltage Waveform in Phase-a With Hybrid Filter

4. Conclusions

A three phase series hybrid filter involving a series active filter and a shunt passive filter has been proposed here for the compensation of voltage and current harmonics, which has been simulated by a MATLAB based model. The series hybrid filter has been found capable of operating satisfactorily. It has reduced the harmonics effectively below 5%, which meets the regulation of IEEE 519 standard

5. References

i. Bhim Singh, Kamal Al-Haddad, and Ambrish Chandra, “A Review of Active Filters for Power Quality Improvement”, IEEE Transactions on Industrial Electronics, VOL. 46, NO. 5, October 1999, pp. 960-971.

ii. Kannan Karthik, J.E.Quaicoe, “VOLTAGE COMPENSATION *AND* HARMONIC SUPPRESSION USING SERIES ACTIVE AND SHUNT PASSIVE FILTERS”, 0-7803-5957-7/00/$10.*0*00 2000 IEEE, pp. 582-586.

iii. J.C.Das, “Passive Filters—Potentialities and Limitations”, IEEE Transactions on Industry Applications, VOL. 40, NO. 1, January/February 2004, pp. 232-241.

iv. Y.S. Kim, J.S. Kim and S.H. Ko, “Three-phase three-wire series active power filter, which compensates for harmonics and reactive power” IEE Proc.-Electr. Power Appl., Vol. 151, No. 3, May 2004, pp. 276-282.

v. J. G. Pinto, R. Pregitzer, Luis. F. C. Monteiro, Carlos Couto,Joao L. Afonso, “A Combined Series Active Filter and Passive Filters for Harmonics, Unbalances and Flicker Compensation”, 1-4244-0895-4/07/$20.00 C 2007 IEEE, pp. 54-59.

vi. Khairul Nisak Md Hasan, Mohd Fakhizan Romlie, “Comparative Study on Combined Series Active and Shunt Passive Power Filter Using Two Different Control Methods”, 1-4244-1355-9/07/$25.00 @2007 IEEE, pp. 928-933.

vii. Ahad Kazami, Seyed Alireza Davari, “A Reference Detection Algorithm for Series Active Power Filters, Aimed at Current Harmonics and Reactive Power Compensation”, 1-4244-0737-0/07/$20.00_c 2007 IEEE, pp. 1761-1766.

viii. Mehdi Salehifar, Hossein Ali Mohammadpour, Amir Hassan Moghadasi, and Abbas Shoulaie, “Harmonic Elimination in Single Phase Systems by Means of a Hybrid Series Active Filter (HSAF), 978-1-4244-5971-1/10/$26.00 ©2010 IEEE, pp. 423-428.

ix. Vikash Anand, Dr.S.K.Srivastava, “Simulation And Performance Investigation of Series Active Power Filter Using Hysteresis Current Control Method”, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622, Vol. 2, Issue4, July-August 2012, pp. 1073-1080.

x. Kirti Mathuria, Arun Kumar Verma, Bhim Singh, and G. Bhuvaneswari, “Single-Phase Series Active Compensator Integrated with a Rectifier for Voltage Sags, Swells and
Harmonics Mitigation”, 978-1-4799-5912-9/14/$31.00 ©2014 IEEE, pp. 1-6.

xi. Mahmadasraf Abdulhamid Mulla, Chudamani Rajagopalan, Anandita Chowdhury, “Compensation of three-phase diode rectifier with capacitive filter working under unbalanced supply conditions using series hybrid active power filter”, IET Power Electron., 2014, Vol. 7, Iss. 6, pp. 1566-1577.