

Importance of Power Filter in Power System for Mitigation of Harmonics and Improvement of Power Quality

Jaydeepsingh R. Chauhan¹, Kaushal R. Chaudhari², Maulik V. Patel³

¹Electrical power system, DRP-ITR, KSV University, Gandhinagar, jaydeep230@yahoo.com

²Electrical power system, LDRP-ITR, KSV University, kaushal_chaudhari008@yahoo.com

³Electrical power system, LDRP-ITR KSV University, Gandhinagar, mvpatel.ee@gmail.com

Abstract—This paper includes Passive Power filters and Active Power Filters for Harmonics Reduction in the power system. Fundamental Concepts of Harmonics and its cause and effects.

Use of Power Filter with grid connected power system to improve Power Quality. Study of different techniques for Active Power Filter and Role of PWM Inverter for current compensation. Simulation of Three-Phase Three-Wire Passive Filter and Active Filter for Harmonics Reduction in the power system using MATLAB Environment.

Index Terms—Filter, Harmonics, Power Quality, Compensation, PWM Inverter

I. INTRODUCTION

THE nonlinear loads like UPS system, AC & DC Drive, Lighting ballasts, Arcing devices, Rotating machines, Phase controller, AC regulator generates harmonic current [9]. Passive Filter and Active Filter are used to eliminate load harmonic current [5]. Passive Power Filter is used in AC system for simplicity of operation and implement with low cost but the major drawback of passive filter are that its performance depend on the system parameters and it shows a resonance problem [10]. Therefore, the Active Power Filter has been used to compensate harmonic current and voltage related problems. The simulation analysis of Passive Filter and Active Filter is simulated in MATLAB Environment. It gives the performance result of THD at source side and load side.

II. HARMONICS TOTAL DISTORTION

Total Harmonics Distortion (THD) should be kept or maintain below 5% of the system [1]. Which is shown below in Table I and Table II by using Fast Fourier Transformation THD can be analysed.

Table I shows SCR = The Ratio I_{sc}/I_L is the ratio of the short circuit current at the Point of Common Coupling (PCC), TDD = Total Demand Distortion (Harmonic current Distortion in % of maximum Demand load current), PCC = Load is Connected at this Point, Measurements taken at this point

SCR= I_{sc}/I_L	<11	11<h<17	17<h<23	23<h<35	35<h	TDD
<20	4.0	2.0	1.5	0.5	0.3	5.0
20-50	7.0	3.5	2.5	1.0	0.5	8.0
50-100	10.0	4.5	4.0	1.5	0.7	12.0
100-1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Table I
 IEEE STD. 519 HARMONIC CURRENT LIMITS [1]

The standard equation for Find THD is given below,

$$\sqrt{\sum_{h=2}^{h=h_{max}} \frac{I_h^2}{I_1^2}} \quad (1)$$

Where, I_h = amplitude of harmonics current of h^{th} order, I_1 = Amplitude of Fundamental component of wave, h_{max} = Maximum number of harmonic included Power Filter Includes Passive Power Filter and Active Power Filter. Both are the advantageous for the power system to mitigate the harmonics.

Bus Voltage	Maximum Individual Harmonic Component (%)	Maximum THD (%)
69KV and Below	3.0 %	5.0 %
115KV to 161KV	1.5 %	2.5 %
Above 161KV	1.0 %	1.5 %

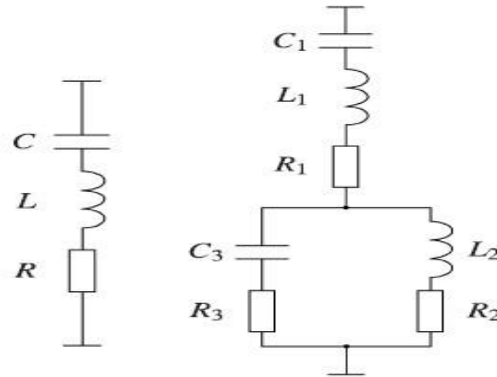
Table II
 IEEE STD. 519 HARMONIC VOLTAGE LIMITS [1]

III. POWER FILTER

A. Passive Power Filter

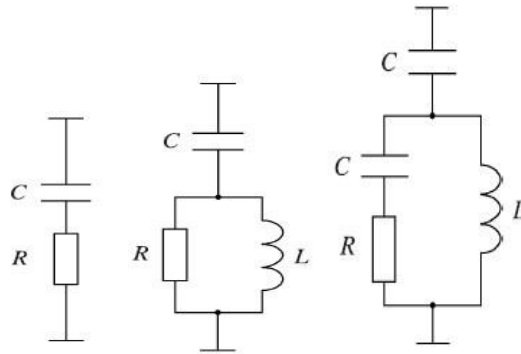
Passive Power Filters consisting of capacitors, inductors and resistors can be classified into tuned filters and high pass filters[5],[3]. They are connected with the nonlinear loads such as diode and thyristor rectifiers, AC electric arc furnace, AC and DC Drives , Induction motor. These are the major nonlinear current generated loads[5],[3][2].

Figures 1 and 2 show circuit configuration of the passive filters. Among them the combination of four single tuned filters to the 5th, 7th, 11th and 13th harmonic frequencies and second order high pass filter tuned around the 17th harmonic frequency has been used in a high power three phase thyristor rectifier[3],.



(a) Single Tuned (b) Double Tuned

Figure 1. Passive Tuned Filters: (a) Single Tuned, and (b) Double Tuned



(a) First Order (b) Second Order (c) Third Order

Figure 2. Passive High Pass Filters: (a) First Order, (b) Second Order, and (c) Third Order

Installation of such a passive filter in the vicinity of a nonlinear load is to provide low impedance paths for specific harmonic frequencies, thus resulting in absorbing the dominant harmonic current flowing out of the load.

The actual value of the low impedance path for each single tuned filter is affected by the Quality factor of the filter inductor Q , which determines the sharpness of the tuning. Similarly, second order high pass filter provides good filtering performance in a wide frequency range. Passive Power Filter have a positive point of achieving power factor correction of inductive loads, this is advantageous to Passive Power Filters but not all cases [3], [5], [4].

B. Active Power Filter

Active Power Filter is classified into Shunt Active Power Filter, and Series Active Power Filter. At present Shunt Active Power Filter is more preferable than Series Active Power Filter in terms of form and function and therefore series active filter are exclusively for harmonic filtering [3], [5], [2], [6], [7].

Figure 3 shows a system configuration of a single phase or three phase Shunt Active Power Filter for harmonic Current Filtering of a single or three phase diode rectifier with the capacitive DC load [5], [8]. This Active Filter is one of the most fundamental system configurations among various types of Active Filters. The DC load may be considered as an AC motor driven by a Voltage Source PWM Inverter in

many cases. This Shunt Active Power Filter can be controlled on a basis of the following criteria[5],[2],[3].

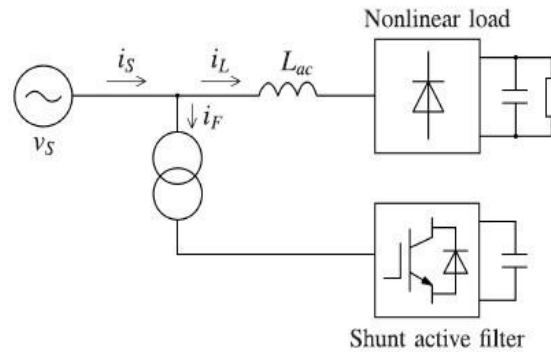


Figure 3. Single Phase or Three Phase Shunt Active Power Filter

- The controller Detects Instantaneous Load Current i_L .
- It extract Harmonic current i_{Lh} from the detected load current by means of Digital Signal Processing.
- The Active Power Filter draws the compensating current i_{af} from the utility supply v_s , so as cancel out the harmonic current i_{Lh} .

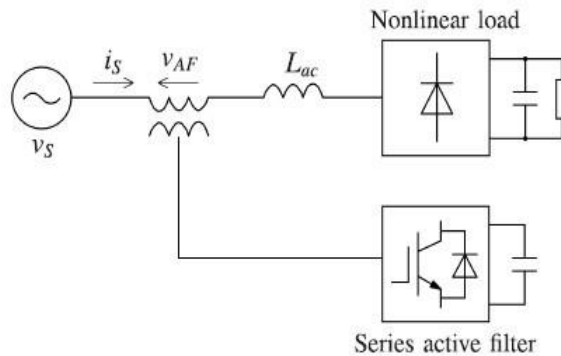


Figure 4. Single Phase or Three Phase Series Active Power Filter

Figure 4 shows a system configuration of a single phase or three phase series active filter for harmonic voltage filtering of a single phase or three phase diode rectifier with a capacitive dc load. The series active filter is connected in series with the utility supply voltage through a three phase transformer or three single phase transformers. This Shunt Active Power Filter can be controlled on a basis of the following criteria[5],[2],[3].

- The controller Detects Instantaneous Source Current i_s .
- It extracts the harmonic current i_{sh} from the detected supply current by means of digital signal processing,

- The active filter applies the compensating voltage v_{af} across the primary of the transformer. This results in significantly reducing the supply harmonic current i_{sh} when the feedback gain K is set to be enough high.

IV. SIMULATION MODEL OF THREE PHASE THREE WIRE SYSTEM

A. Passive Power Filter Based Three Phase Three Wire System

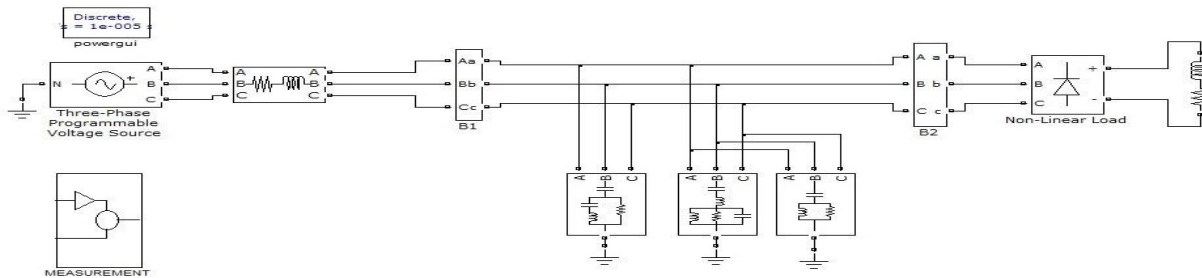


Figure 5. MATLAB Model of Passive Power Filter

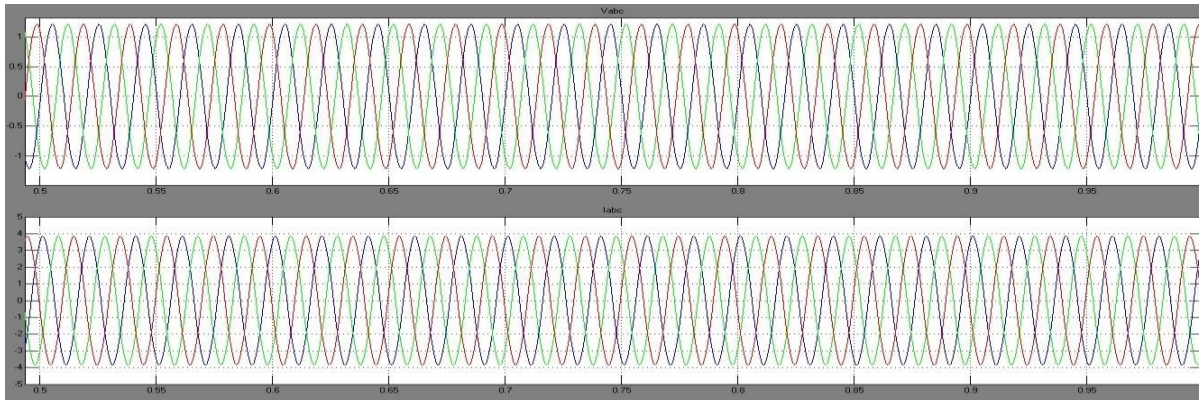


Figure 6. Voltage and Current of Source Side

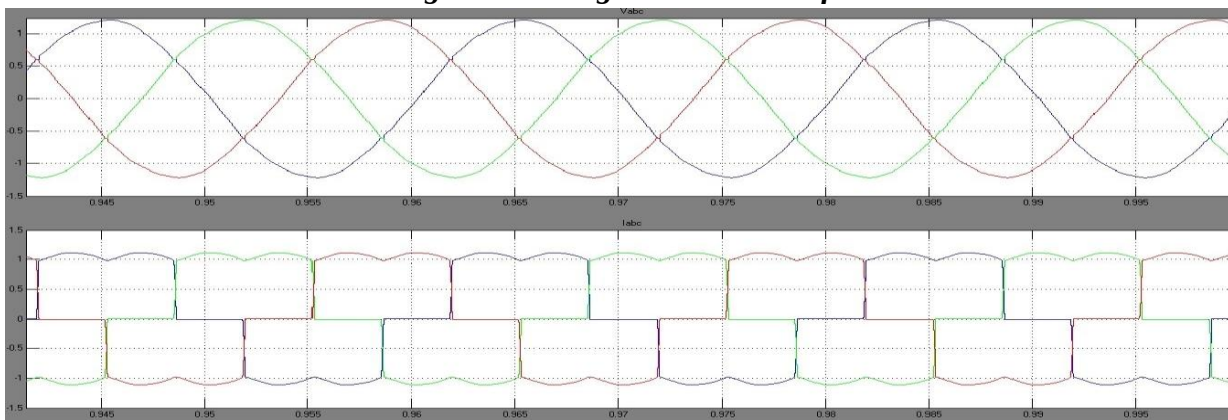


Figure 7. Voltage and Current of Load Side

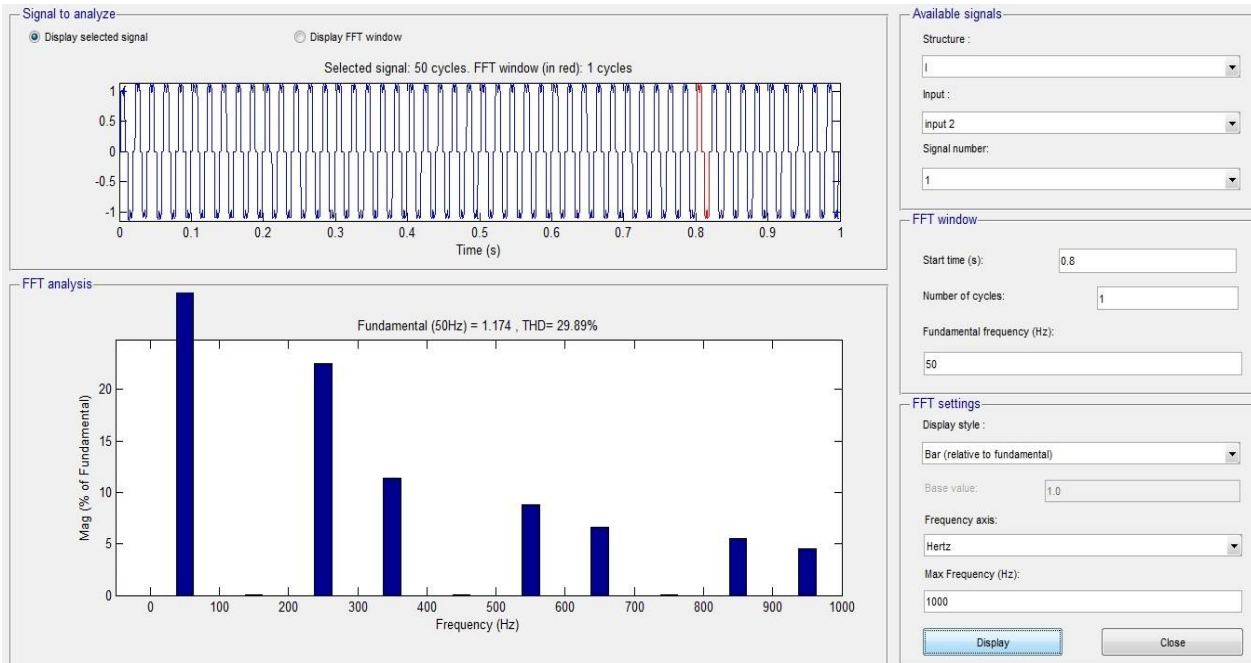


Figure 8. THD Load side

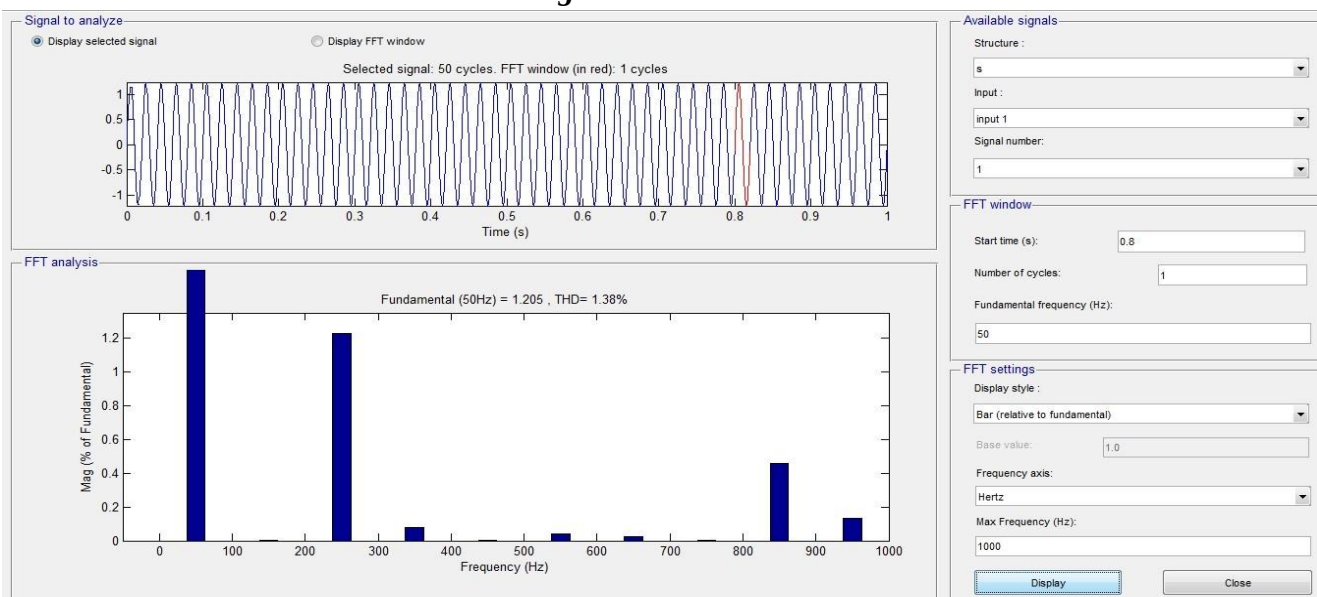


Figure 9. THD Source Side

B. Active Power Filter Based Three Phase Three Wire System

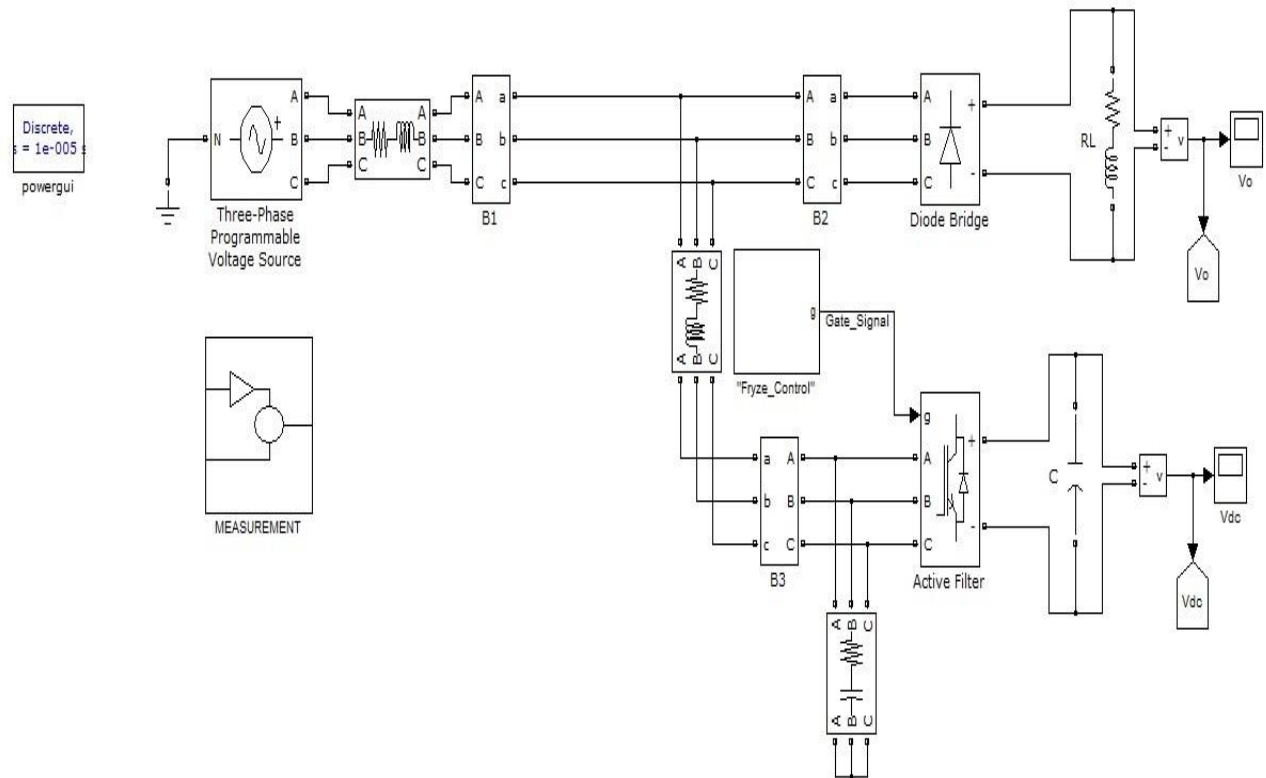


Figure 10. MATLAB model of Active Power Filter

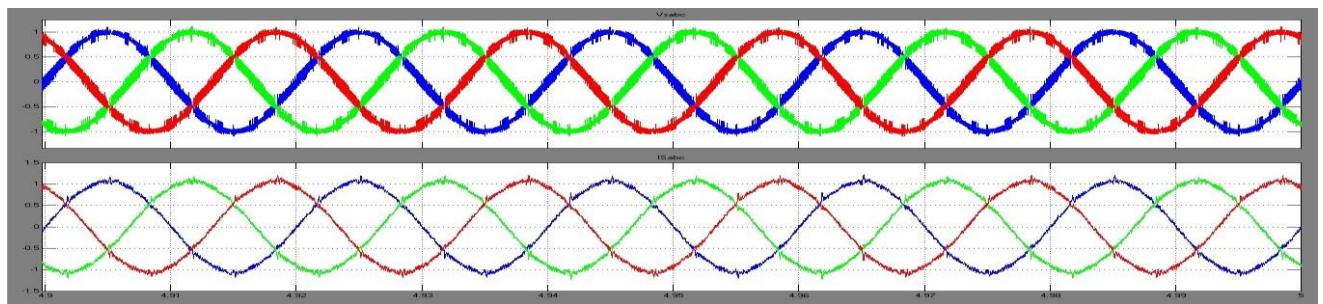


Figure 11 Source voltage and source current

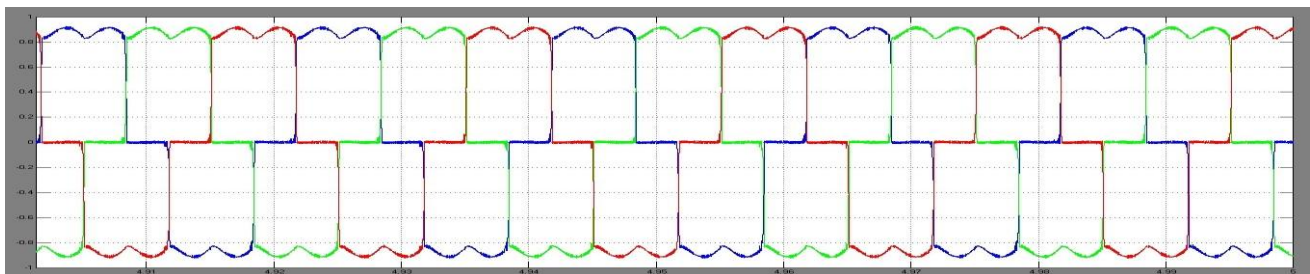


Figure 12 Load Current

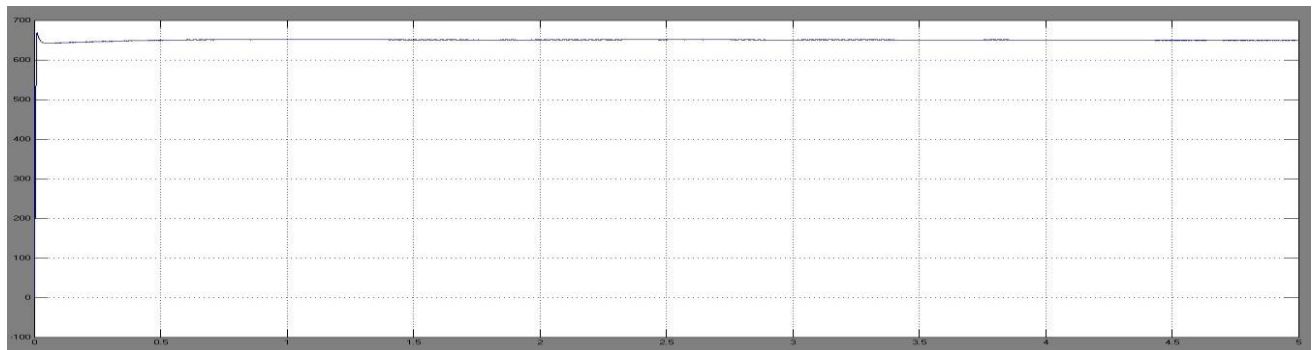


Figure 13 Vdc Build up

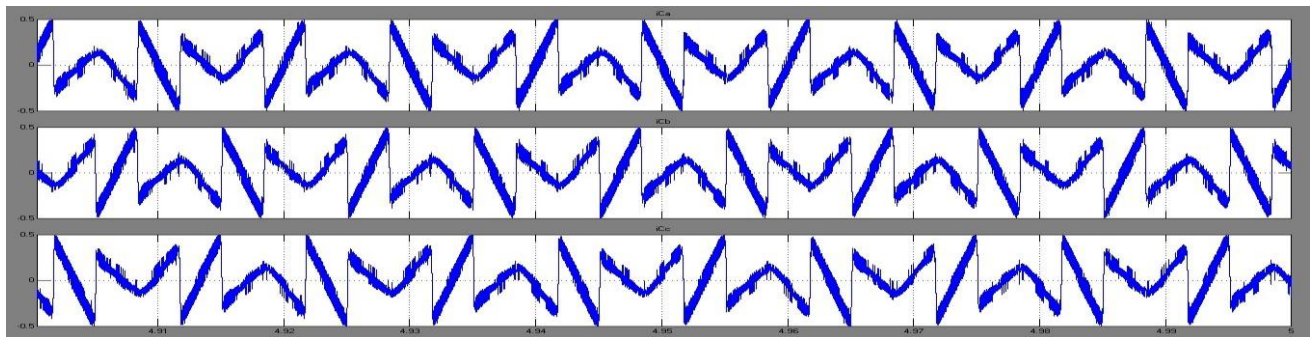


Figure 14. Compensating Current

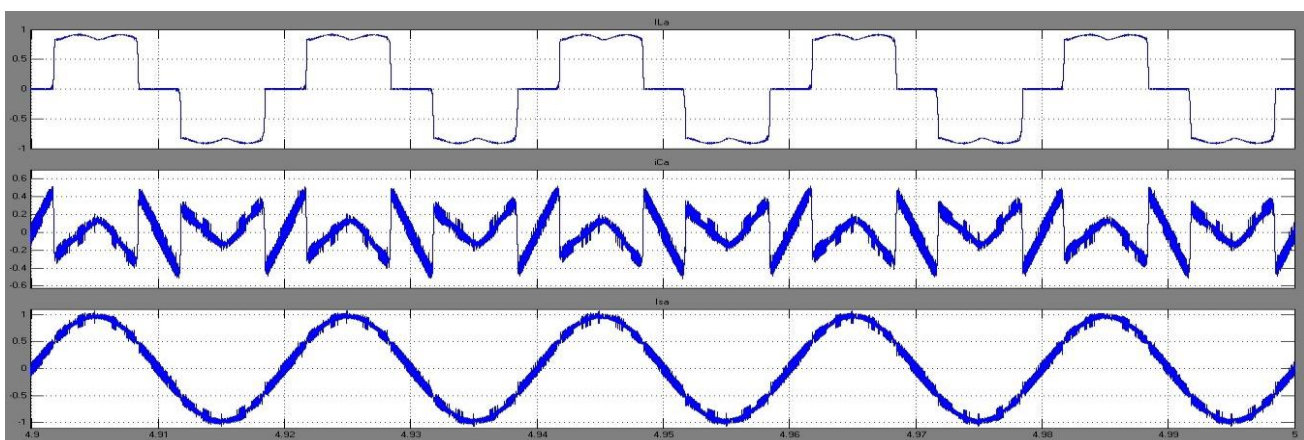


Figure 15 Comparison of Current i_L , i_C , i_S

Figure

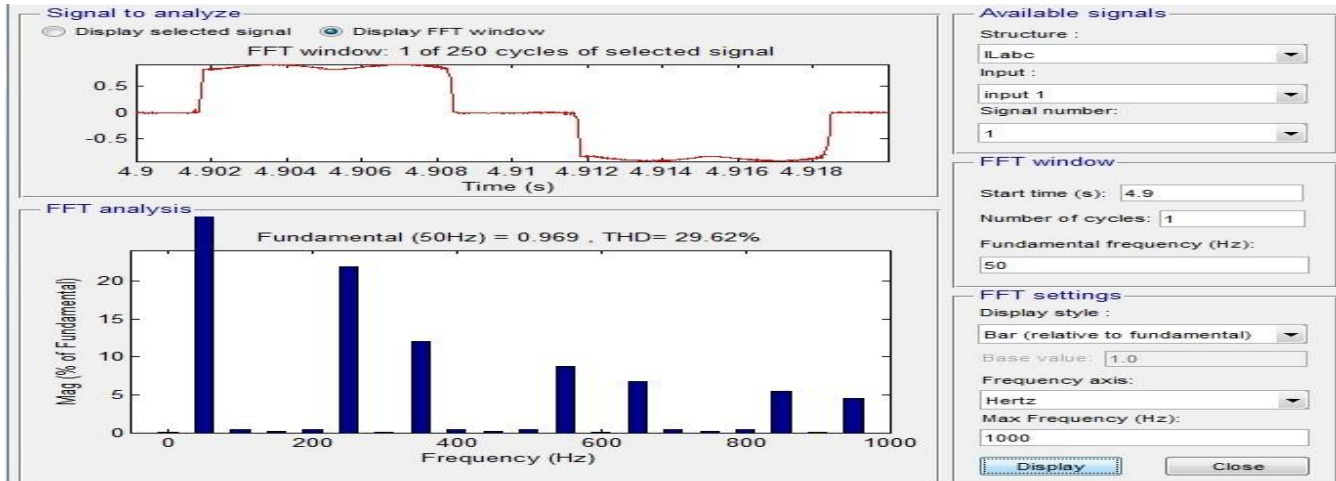
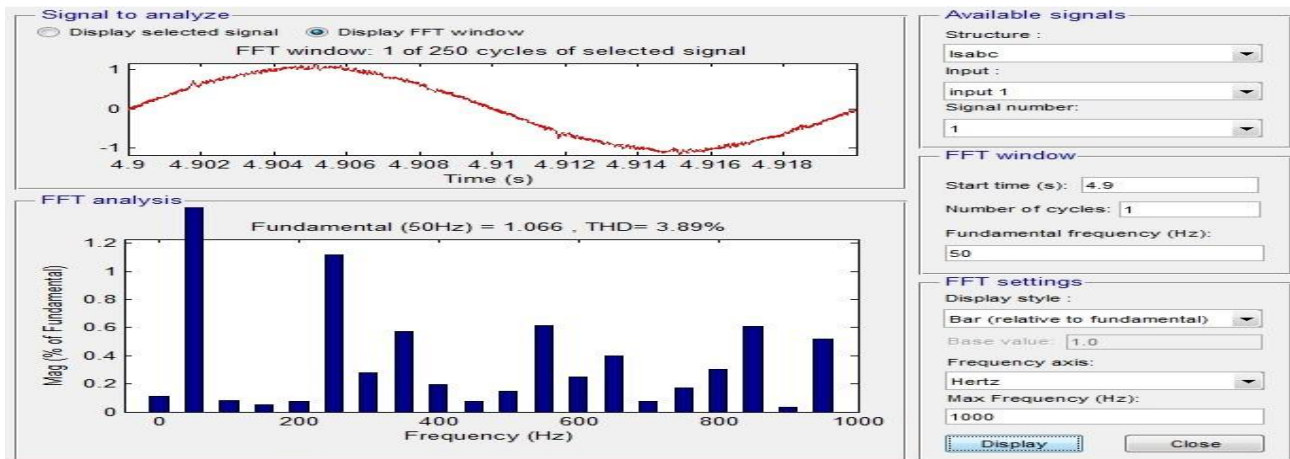


Figure 16(B) Load Side THD



Fig

ure 16(A)Source side THD

V Conclusion

Study of Passive Power Filter and Active Power Filter based on Simulation Analysis. Control Techniques and Control parameters are responsible to change the Results of Control Strategies. The THD shown in Table I and Table II are for the Current Harmonic limit and Voltage Harmonic limit respectively as per IEEE Std. 519 [1]. Due to Control Calculations of Parameters and Voltage Harmonics appear in the System is leads to increase THD in the system. This problem will be eliminate by controlling Voltage Harmonics.

Finally for Passive Power Filter THD at Load Side is 29.89% and at Source Side is 1.38%, for Active Power Filter THD at Load Side is 29.62% and at Source Side is 3.89%.which are acceptable results as per IEEE 519 std.

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