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Simulation and design of PFC boost converter with constant output voltage and EMI filter

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Abstract: *This paper perform simulation and design of PFC boost converter with EMI Filter which provides approximate unity power factor with constant output voltage .EMI filter is design for the purpose of products must fulfill with international electromagnetic compatibility(EMC) standards which have been developed to control conducted and radiated emissions from electrical and electronics systems. Power factor stage is require to make the input current waveform in phase to the voltage and in view of power supply like a simple resistor. The MATLAB Simulink model for proposed system is implemented and the experimental results are achieved. These experimental results are match up with the simulation results.*

Keywords: Power Factor Correction, Electromagnetic Interference, Diode Rectifier, Boost Converter

1.INTRODUCTION

Switch mode power supplies (SMPS) design by including full wave rectifier having large energy storage capacitor. When mains instantaneous voltage exceeds voltage across capacitor, SMPSs draws current. The capacitor delivers energy to the power supply for remaining portion of the AC cycle. As a outcome, High harmonic content in input current waveform of basic SMPS and hence reduces power factor. Filter is used to remove harmonics but it expensive.. Extra circuits are required to neutralize the effect of the brief current pulses. Putting a current regulated boost chopper stage after the off-line rectifier can correct the power factor.

In 2001, the European Union fixed the standard IEC/EN61000-3-2 to fixed limits on the harmonics of the AC input current up to the 40th harmonic for apparatus above 75 W. To get these requirements, modern SMPSs normally include an additional power factor stage (PFC). Due to switching action in chopper stage switch mode power supplies generate high frequency noise i.e. electromagnetic interference(EMI). EMI produced due to the current being switched on and off sharply. Hence EMI filters and RF shielding are needed to reduce the interference.

Literature deals with EMI concerns in Power Electronic Converters are given by "Ref. [4]". Design of Boost PFC Converter using genetic algorithms is given in "Ref. [5]".Analysis of EMI Conduction in boost PFC Converter is existing given in "Ref. [3]". A technique for EMI analysis in PFC rectifier is given in "Ref. [4]". Soft switching methods in PWM converters are presented in "Ref. [2]"and model of inductor design is presented in "Ref. [1]" .In the literature stated above, the hardware of boost converter using Atmel microcontroller is not existing. This paper design hardware and MATLAB Simulink model for microcontroller based boost converter as well as use of single phase model in three phase circuit.

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2.EXPERIMENTAL SECTION

This paper work is focused in the area of active PFC approach and boost topology is employed for research on AC-DC PFC pre-regulator system for the improvement of quality of power.

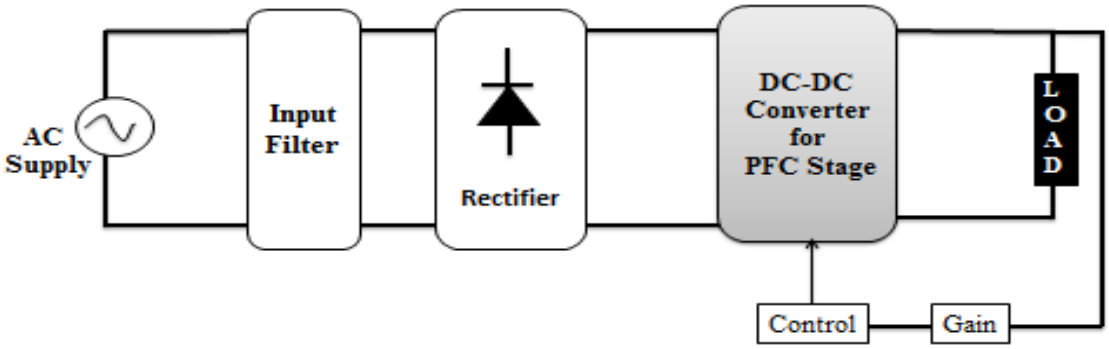

Fig: 1 proposed system

Fig. 1 shows that the PFC technique improves the input current taken from the mains supply and minimizes the DC bus voltage ripple. The target of PFC is to make the input current waveform in phase to the voltage and in view of power supply like a simple resistor.

A] Design of DC to DC converter for PFC stage

Fig. 2 shows the Boost Power Factor Correction converter. It involves boost inductor, switching device, diode rectifier, boost output voltage and boost diode capacitor.

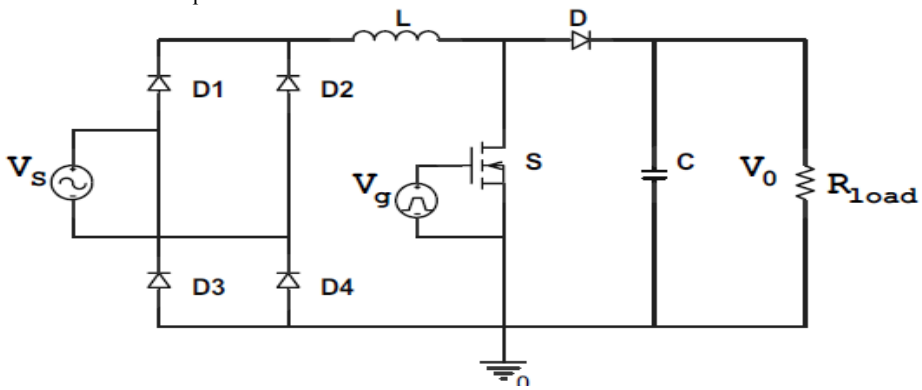

Fig. 2 Boost PFC Converter

The detail explanations of the proposed Boost PFC converter are as follows

MOSFET is used for switching purpose .Inductor and capacitor are select by using following equation "Ref. [6]".

$$L = \frac{Vs*D}{\Delta I_l * f} \quad , \quad C = \frac{Io*D}{f*\Delta Vc}$$

Output voltage equation for boost converter is $Vo = \frac{Vd}{1-\propto}$ Where $\propto$ = delay angle of the boost converter. The output voltage ideally rises from 0 to infinity , as Threshold angle rise from 0 to 1.Hence it is called as boost converter.

B] Design of EMI filter

The Electromagnetic Interference is spread in two types first one radiation and second one is the conduction. Electromagnetic noise is created in the source because of rapid current and voltage changes, and spread through the coupling mechanisms. Since breaking a coupling path is important at either the start or the end of the circuit. Hence to break coupling path EMI filter is used between ac source and bridge rectifier.

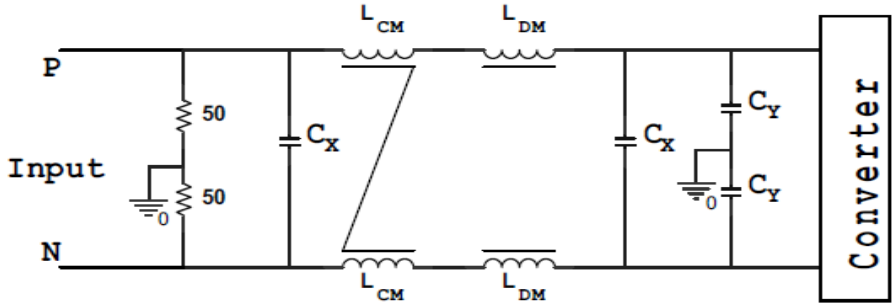

Fig. 3 EMI Filter

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EMI filters can help in bypassing EMI or improving RF immunity. The filter consists of inductors and capacitors as shown in figure3. In EMI filter inductor is used to reduce the di/dt rate during its turn-off and capacitor is used to for purpose of decoupling. Resistors is used to control rise time of high speed signal.

3.SIMULATION RESULT

MATLAB Simulink is used to simulate this proposed system. The simulation circuit of PFC boost converter with constant output voltageand EMI filter is shown in Figure 4.Interference is create by using an additional source connected in series with main ac source.

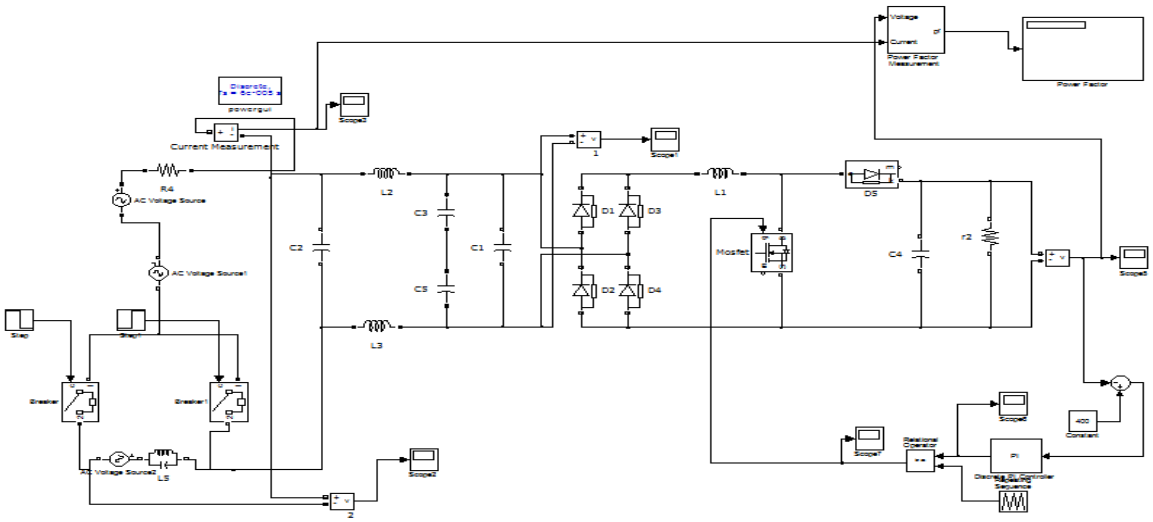

Fig.4 : PFC boost converter with constant output voltage and EMI filter

Distorted input Voltage before EMI is shown in Figure 4(a). The voltage waveform follows EMI filter is shown in Figure 4(b).Control pulses for the MOSFET are shown in Figure 4(c). Error signal for closed loop system is shown in Figure 4(D). The output voltage of closed loop system is shown in Figure 4(e). FFT analysis of input current waveform is shown in figure in 4(f).

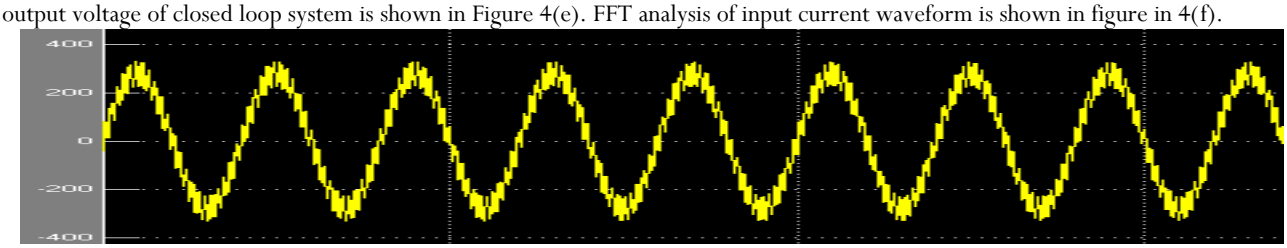

FIG. 4(A): Input voltage before EMI filter

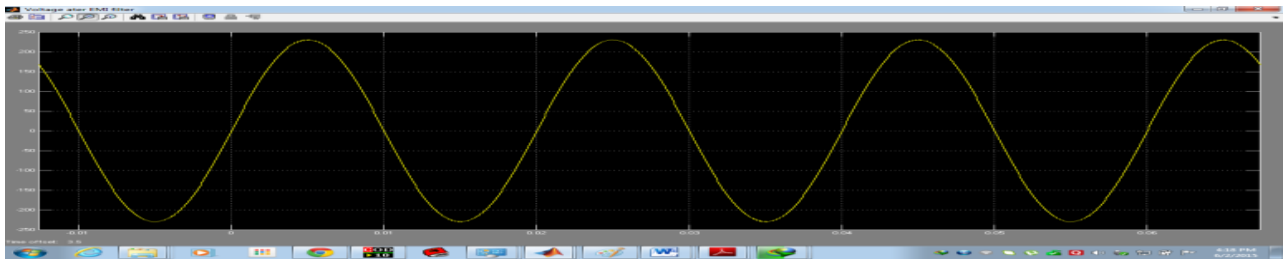

FIG. 4(B): voltage after EMI filter

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Fig. 4(c): Driving pulses for mosfet

Fig. 4(d): Error signal for closed loop system

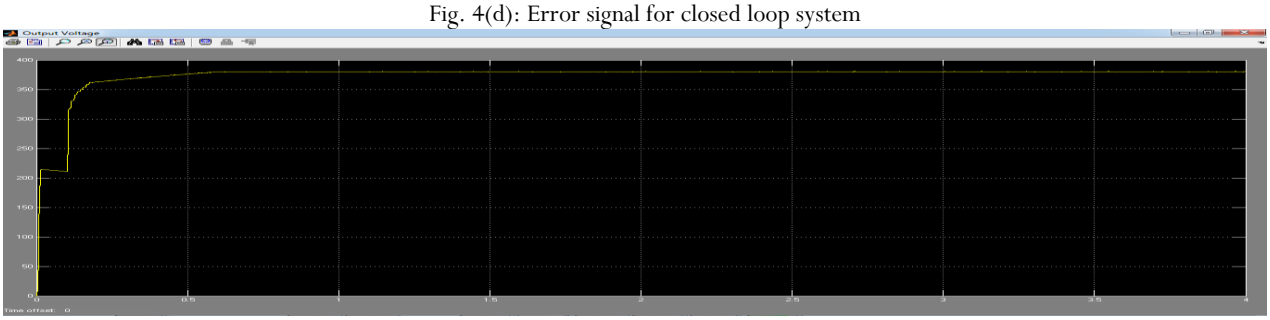

FIG.4 (e): Output voltage with closed loop system

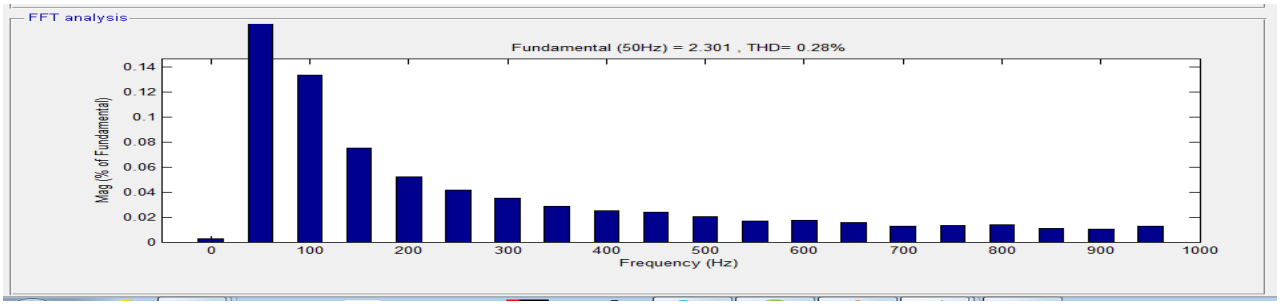

FIG.4(f): FFT analysis of input current waveform

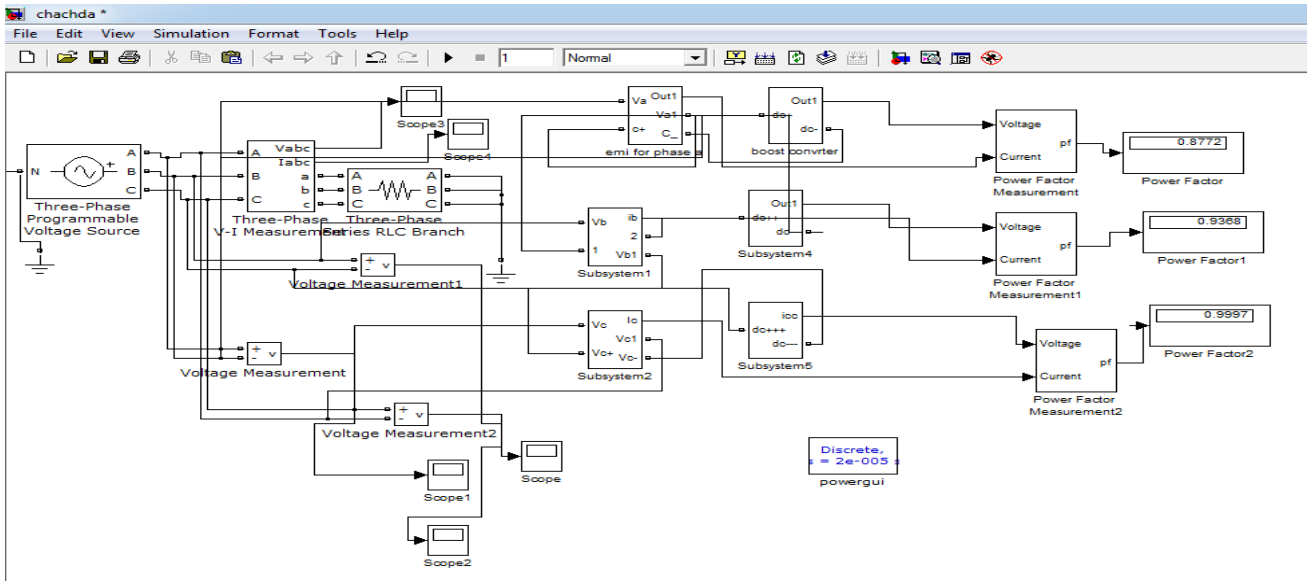

Fig.(5): USE OF SINGLE PHASE MODEL IN THREE PHASE CIRCUIT

Single phase circuit used in each phase of common three phase source and observe the result. It can be seen that it provides approximately unity power factor and constant boosted output voltage for each phase.

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4.EXPEREMENT RESULT

Hardware of proposed system is shown in Fig. 6. Hardware consist of four stages i.e. EMI filter, signal conditioning, boost converter and microcontroller with driver circuit. Microcontroller PIC16F877 is used to generate control pulses that amplified by driver circuit upto 20V which is used to applied the gate of MOSFET. The experimental results are gained and presented here. The constant boosted output voltage is shown on LCD

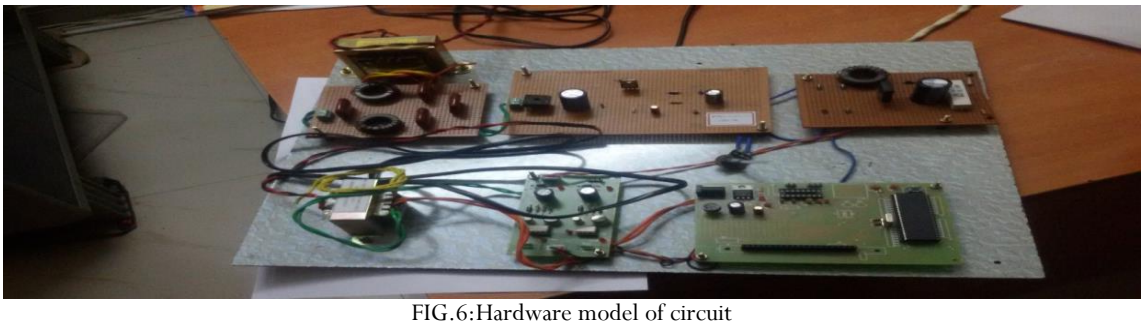

FIG.6:Hardware model of circuit

5.CONCLUSION

This paper gives the result of constant dc boosted output voltage with less harmonics and approximately unity power factor. Simulation and design of PFC boost converter with constant output voltage and EMI filter is studied, simulated and fabricated. From the simulation results, it is cleared that the best power factor can be achieved. In Simulink, this model provide approximately unity power factor while using it in each phase of common three phase source. The simulation studies prove that this model is a alternative solution for power factor improvement. The circuit is tested with resistive load. The experimental results given in this paper. The experimental results match up with the simulation results.

6.ACKNOWLEDGMENTS

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