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Input Power Factor Correction in Single phase AC-DC Circuit using Parallel Boost Converter

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Abstract: AC to DC Converter is the most important part of any power supply unit used in all electronic equipments which form a considerable part on utility. Power Electronic equipments inject lower order harmonics in the utility. As a result THD is high and input power factor is low. Thus there are many power factor correction schemes being implemented too many power factor near to unity. In this paper a hysteresis control scheme is proposed for Boost Converter. The efficiency is improved using soft switching techniques such as ZVS and ZCS.
Keywords: Power Factor Correction, Boost Converter, Dual Boost Converter, Hysteresis Current Control, Average Current Control.

I. INTRODUCTION

Most applications comprising of *ac-dc* power converters need the output *dc* voltage to be well regulated with good steady-state as well as transient performance. The circuit which was typically favored until recently (diode rectifier-capacitor filter) for the utility interface minimizes the cost, but it severely deteriorates the quality of the supply thereby affecting the performance of other loads connected to it also causing other well-known problems. Furthermore, in order to maintain the quality of the utility supply, several national and international agencies have decided imposing standards along with recommendations for electronic instruments connected to the system. Since the mid-1980's power electronics engineers have always tried to develop new approaches for better utility interface, to meet the above mentioned standards. These new circuits have been collectively known as Power factor correction (PFC) circuits. .

With the increase of consumer electronics in the system the power quality becomes poor. The reactive power drawn from the supply is increasing. This is as a result of the use of rectification of the AC input in addition to the use of a bulk capacitor directly after the diode bridge rectifier so as to reduce the input current harmonics to meet the agency standards that implies improvement of power factor as well. For this reason the publications that are reported in this area have used "Power factor correction methods" and "Harmonic elimination/reduction methods" almost inter changeably well. Several techniques for PFC and harmonic reduction have been reported and a few of them have gained greater acceptance over the others.

II. POWER FACTOR CORRECTION

Reduction of line current harmonics is needed in order to comply with the standard. This is commonly referred to as the Power Factor Correction – PFC, which may be misleading. An electric load with a PF lower than 1 delivers the apparent power to the load greater than the real power that the load consumes. Only the real power is associated with work done, but the apparent power determines the amount of current flowing into the load. For a given load voltage Power factor correction (PFC) is a technique that implies counteraction of the undesirable effects of electric loading that creates a power factor PF less than 1.

A. Power Factor

The ratio of the active power P to the apparent power S is known as the power factor:

$$PF = \frac{Active\ Power}{Apparant\ Power}$$

We also know definition of power factor as Cosine of the angle between Voltage and Current.

$$PF = cos\ \varphi$$

cos φ is called displacement factor. Compensating this displacement factor is nothing but power factor correction.

As the load is non linear, line current is non sinusoidal. For non sinusoidal currents, power factor can be expressed as

$$PF = \frac{V_{RMS} * I_{1\,RMS} * cos\varphi}{V_{RMS} * I_{RMS}} = \frac{I_{1\,RMS} * cos\varphi}{I_{RMS}} = K_p cos\varphi$$

The Total Harmonic Distortion is referred as

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$$THD = \sqrt{\frac{\sum_{2}^{\infty}(I_{nrms}^{2})}{(I_{1rms}^{2})}}$$

Relation between Kp and THD is

$$K_p = \frac{1}{\sqrt{(1 + THD^2)}}$$

B. Benefits of High Power Factor

1) Voltage distortion in the waveform is considerably reduced
2) All the power becomes active that is capable of doing work.
3) Smaller RMS current
4) Higher number of loads can be fed from the same power.

C. Passive PFC

In Passive PFC circuit only passive elements are used along with the diode bridge rectifier, so as to improve the shape of the line current. In order to improve the shape of the line current Passive Power Factor correction circuit simply uses an inductor in the input circuits. The shape of the input current can be further improved by using a combination of low pass input and output filters. To maintain the flow of input current, voltage doublers is inserted to feed the valley fill circuit. Even though line current harmonics are reduced, the fundamental component may suffer an excessive phase shift thereby reducing the power factor. Better characteristics can be obtained by using "Active PFC".

D. Active PFC

Active power factor correction can be accomplished by many ways. The Boost converter operated on the rectified output uses a constant switching frequency PWM and DCM operation reduces the total harmonic distortion of the input current .In a Boost circuit the switching device can handles only a portion of output power which increases the efficiency. The efficiency can be increased by keeping the ratio of output voltage to input voltage closer to unity. The effect of second harmonic in PWM in reducing third harmonic component in the input current is established. In this converter the output is varied by varying the duty cycle keeping the frequency constant. In this, the other converter topologies for a PFC based Sepic topology are reported in, which allow comparison of converter performance with different techniques. The advantages of clamped current control include overall simplicity, relatively low inductive energy storage and stresses on the components, and fixed operating frequency. Another control method, which allows a better input current waveform, is the average current control. In Hysteresis control technique, the switch is turned on when the inductor current goes below the lower reference namely Ivref, and when the inductor current goes above the upper reference, the switch is turned off resul t ing in a variable frequency control. But in Borderline Control approach the switch on-time is held constant during the line cycle and when the inductor current falls to zero the switch is turned on, Thus the converter operates at the boundary between Continuous and Discontinuous Inductor Current Mode (CICM-DICM). The paper presents a new approach for generating reference currents for an active filter and a static compensator. The purpose of the compensating scheme is to balance the load, as well as make the power factor at the supply side a desired value**.** Here a suitable compensator structure is proposed which tracks the reference currents in a hysteresis band
control scheme.

E. EMI Problem

The converters operating in CICM reduces the line current harmonics, but it has some drawbacks, such as: 1) it increases the EMI, due to the high-frequency content of the input current. 2) It introduces additional losses, thus reducing the overall efficiency. However the high frequency EMI can be eliminated by introducing an EMI filter between AC supply and diode bridge rectifier were found in various studies. The second requirement for the EMI filter: the displacement angle Φ must be kept low. The third requirement is related to the overall stability of the system. It is known that unstable operation may occur due to the interaction between the EMI filter and the power stage. However the losses are reduced by inserting an inductor in the series path of the boost rectifier to reduce the di/dt rate during its turn-off. Better characteristics are obtained in Zero Voltage. Transition – ZVT topologies, at the expense of increased complexity.

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F. Switching Losses

In active PFC circuit, switching of semiconductor devices normally occurs at high current levels. Therefore, when switching at high frequencies these converters are associated with high power dissipation. Also, the higher input and lower output voltages bring about very low duty cycles. Hence, the high side MOSFET switch should turn on and off in a very short period of time, which also brings switching losses into picture.

III. BOOST CONVERTER

The Buck converter has step-down conversion ratio. Therefore, it is possible to obtain an output voltage *V2* lower than the amplitude of the input voltage. However, the converter can operate only when the instantaneous input voltage *V1* is higher than the output voltage *V*2. Hence, the line current of a power factor corrector has crossover distortions that are based on a Buck converter. Additionally, the input current of the converter is discontinuous.

Whereas the Boost converter has a step-up conversion ratio; hence the output voltage *V*2 is always higher than the magnitude *V*1 of the input voltage. Operation is possible throughout the line-cycle so the input current does not have crossover distortions. Since the inductor is placed in series at the input, the input current is continuous. Hence, an input current with reduced high-frequency content can be obtained when continuous conduction mode is in operation. For these reasons, the Boost converter is widely used for PFC.

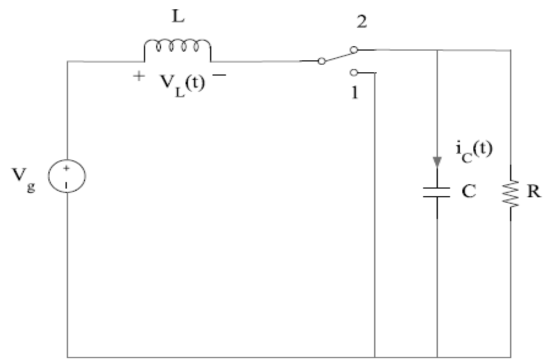

Fig. 1 Example of an unacceptable low-resolution image

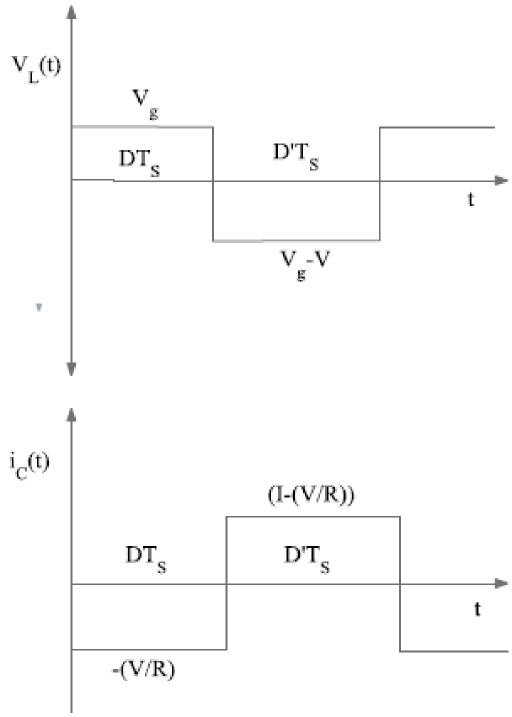

Fig. 1 Example of an unacceptable low-resolution image

IV. CONTINUOUS INDUCTOR CURRENT MODE

An example of control scheme is shown in figure

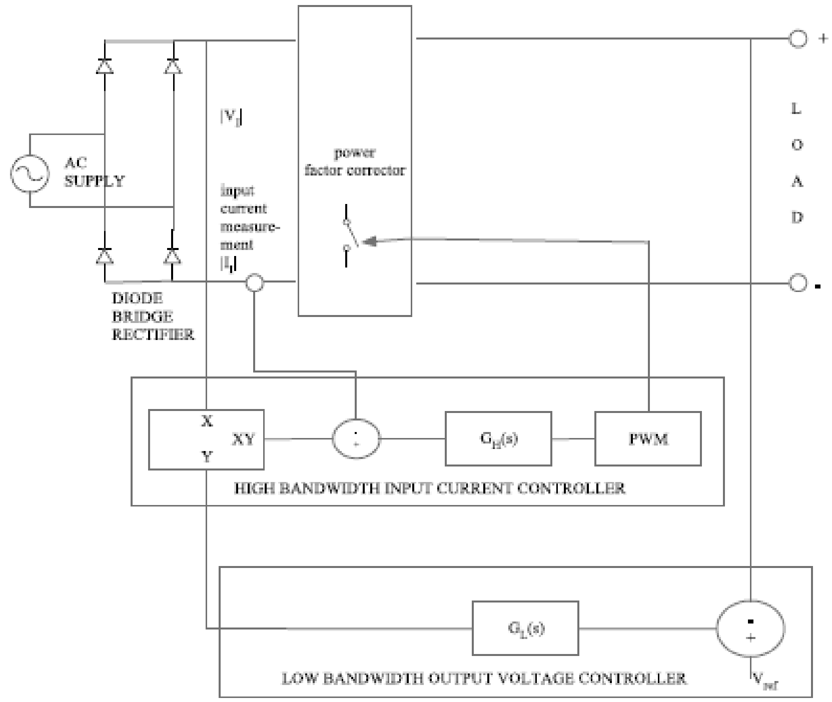

Fig. 3 Example of an unacceptable low-resolution image

A. Hysteresis Current Control

In this type of control two sinusoidal current references IV,ref, IP,ref are generated as shown in Fig 3.2, one is for the valley and the other for the peak of the inductor current. According to this control technique, when the inductor current goes below the lower reference IV,ref the switch is turned on and when the inductor current goes above the upper reference IP,ref the switch is turned off giving rise to a variable frequency control. The switch can be kept open near the zero crossing of the line voltage so introducing dead times in the line current in order to avoid the switching frequency too high.

B. Average Current Control

Another control method, which allows a better input current waveform, is the average current control. Here the inductor current is sensed and filtered by a current error amplifier whose output drives a PWM modulator. In this way the inner current loop tends to reduce the error between the average input current ig and its reference. The same is obtained in the peak current control. The converter works in CICM, so with regard to the peak current control the same considerations can be applied. The technique of average current mode control overcomes the demerit of peak current control mode by introducing a high gain integrating current error amplifier (CA) into the current loop. For optimum performance, the gain-bandwidth characteristic of the current loop can be tailored by the compensation network around the CA. The current loop gain crossover frequency fc can be made approximately the same as compared with the peak current mode control, but the gain will be much greater at lower frequencies.

V. SIMULATION RESULTS

Here Boost converter and Dual Boost Converter are simulated in PSIM with hysteresis as well as Average Current Control.

A. Boost Converter without Hysteresis Controller
B. Boost Converter with Hysteresis Controller
C. Boost Converter with Average Current Controller
D. Dual Boost Converter without EMI filter.
E. Dual Boost Converter with EMI filter.

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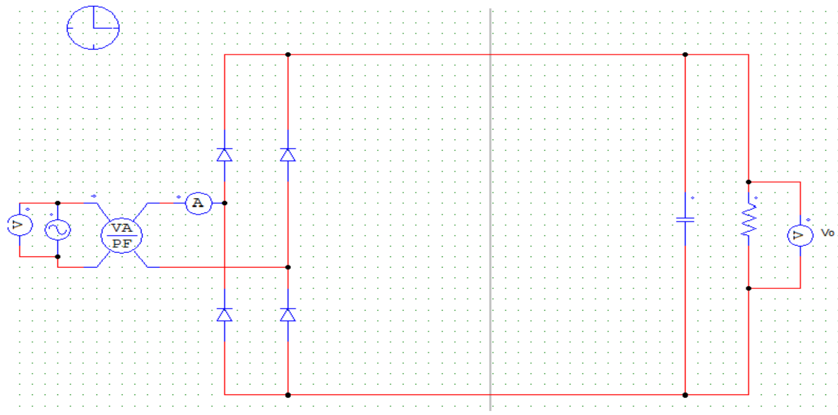

Fig. 4 Boost Converter without Hysteresis Controller

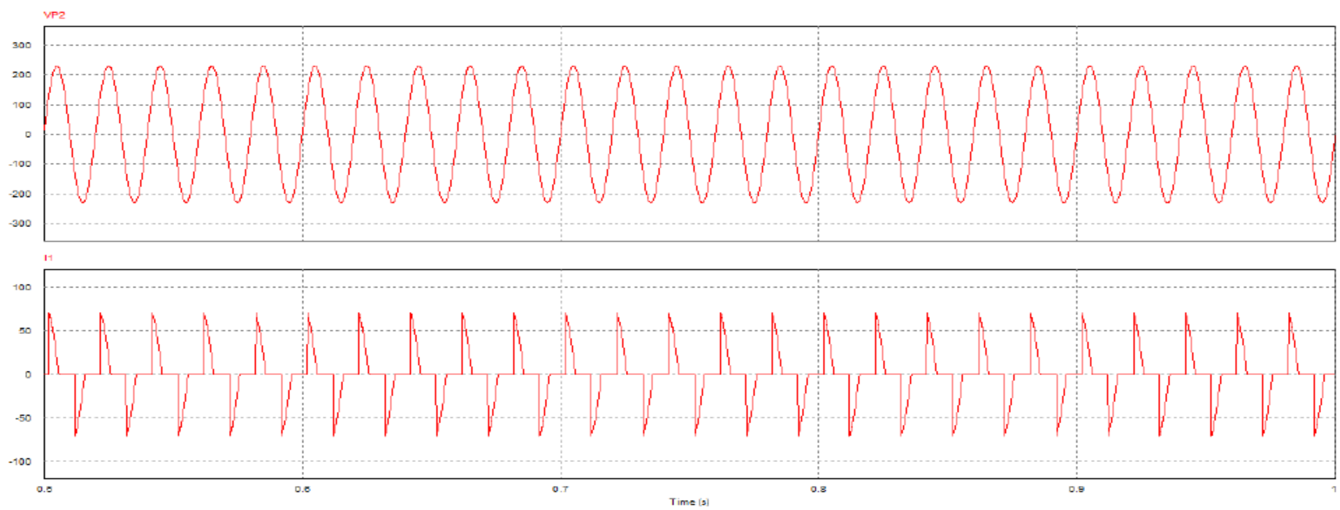

Fig. 5 Current and Voltage waveforms of Boost Converter without Hysteresis Controller

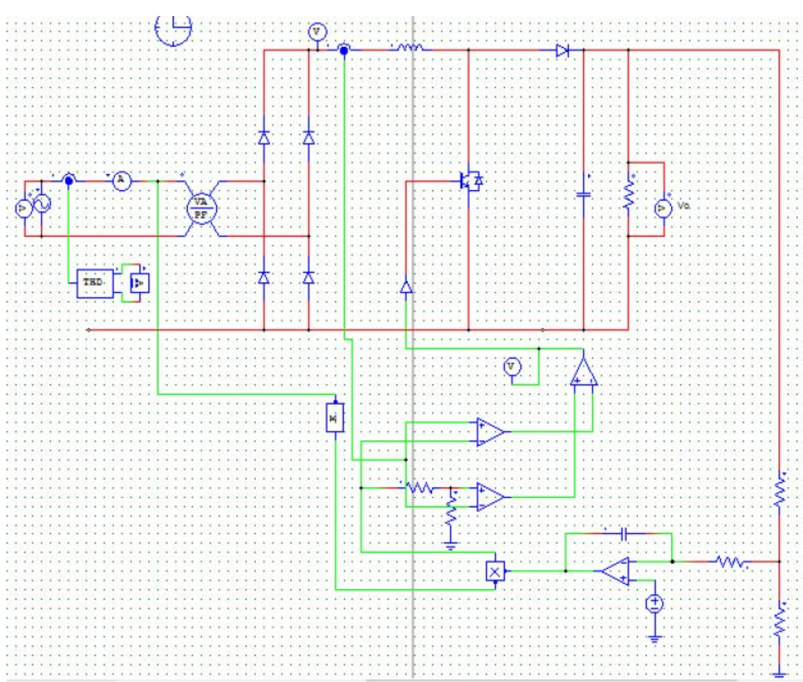

Fig. 8 Boost Converter with Hysteresis Controller

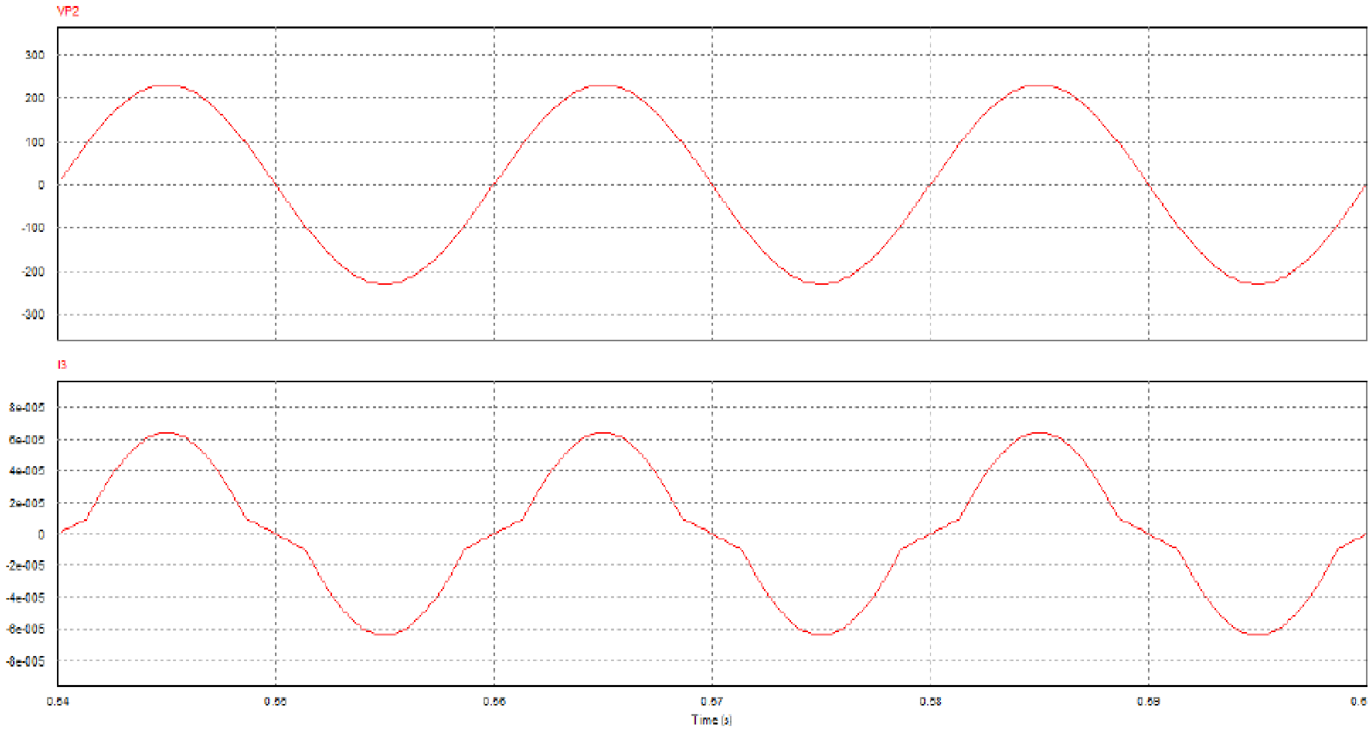

Fig. 9 Current and Voltage waveforms of Boost Converter with Hysteresis Controller

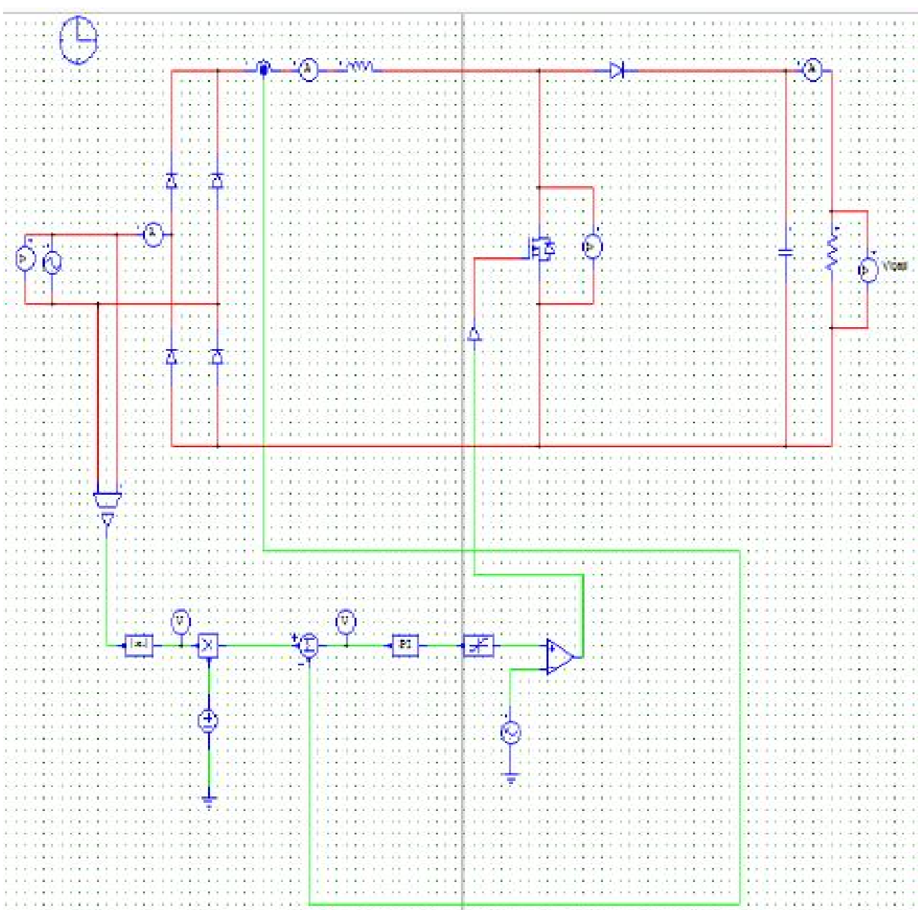

Fig. 10 Boost Converter with Active Current Controller

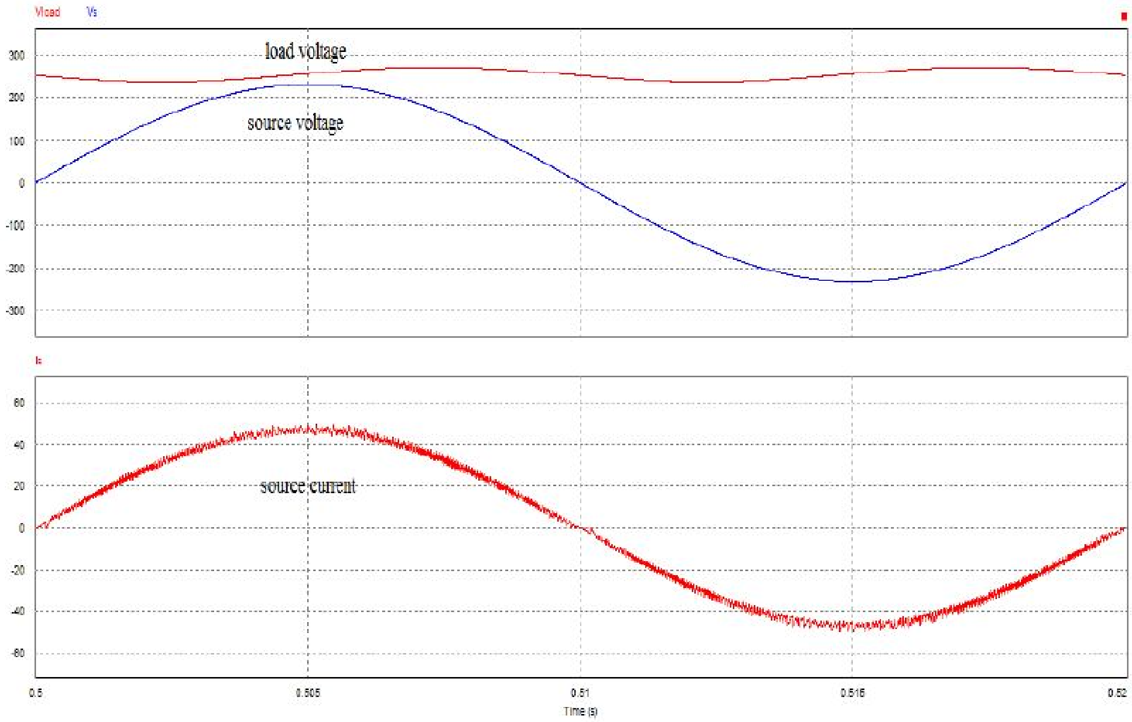

Fig. 11 Waveforms of Boost Converter with Active Current Controller

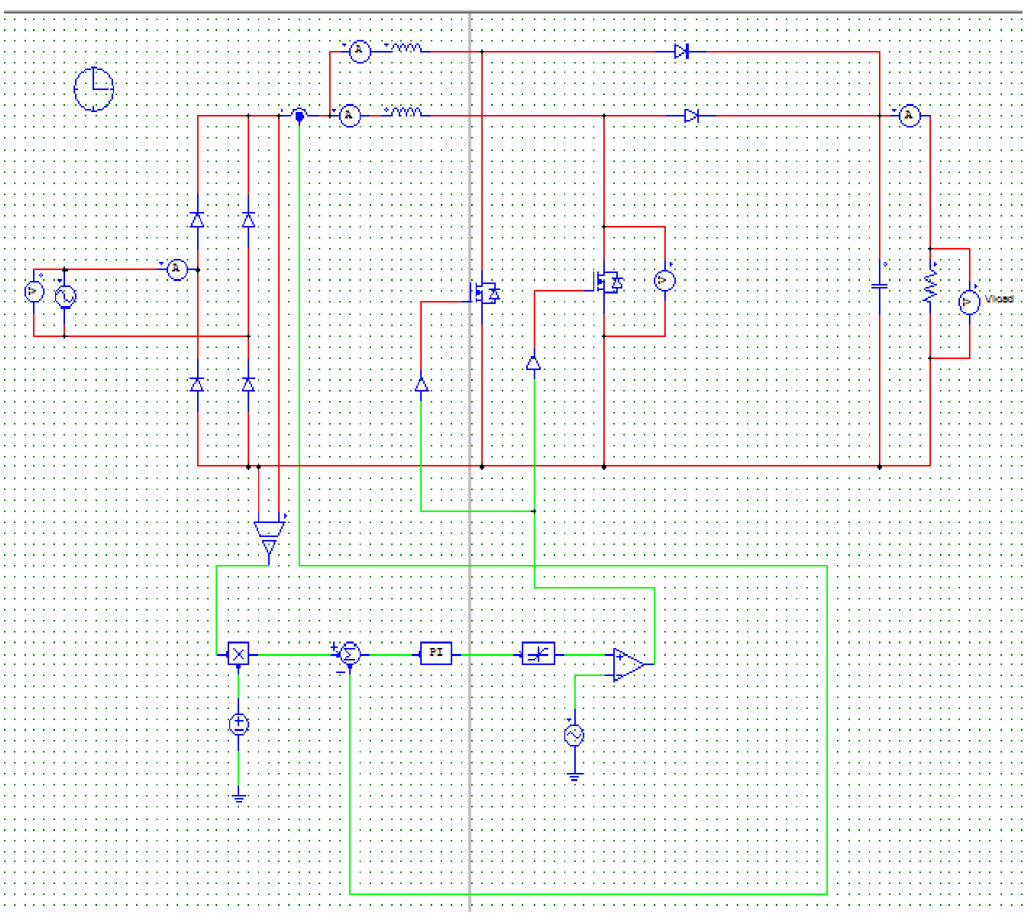

Fig. 12 Dual Boost Converter without EMI filter

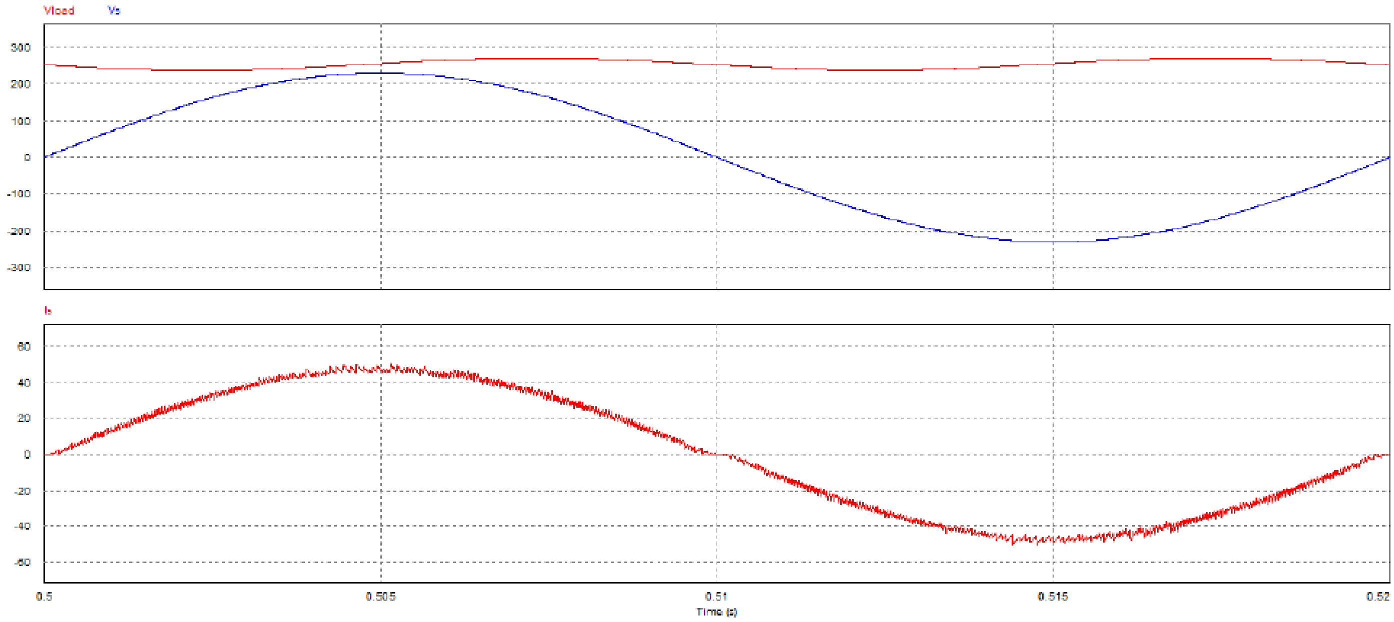

Fig. 13 Waveforms of Dual Boost Converter without EMI filter

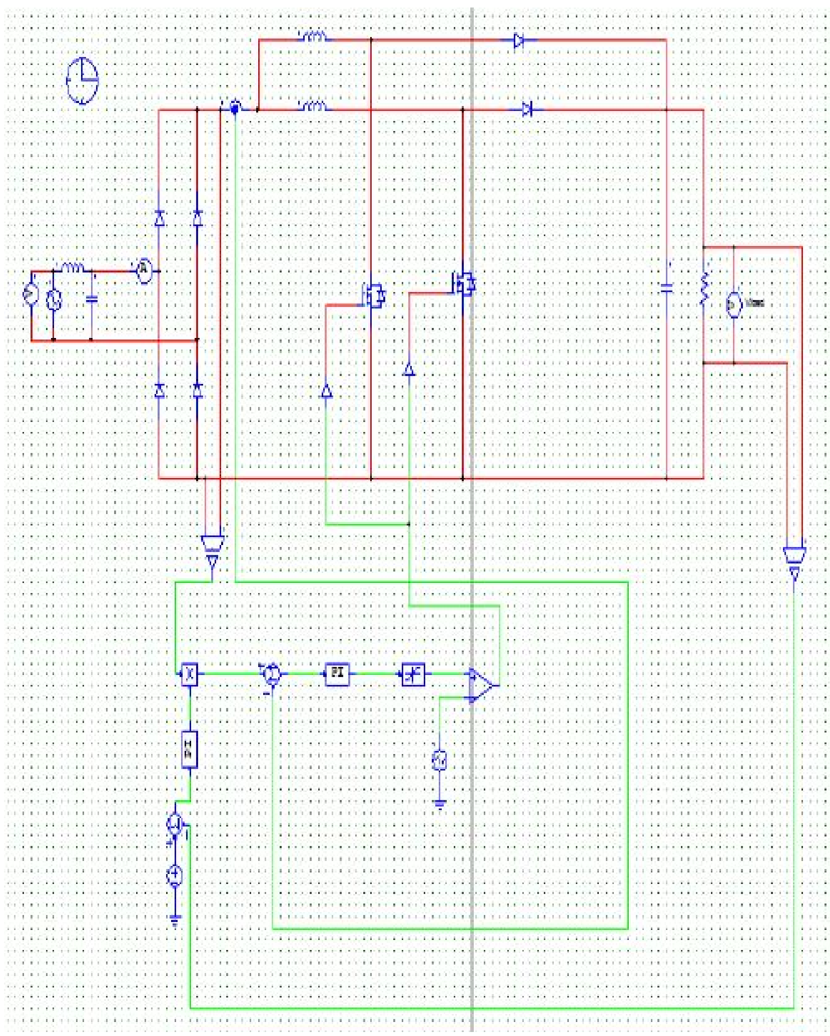

Fig. 14 Dual Boost Converter with EMI filter

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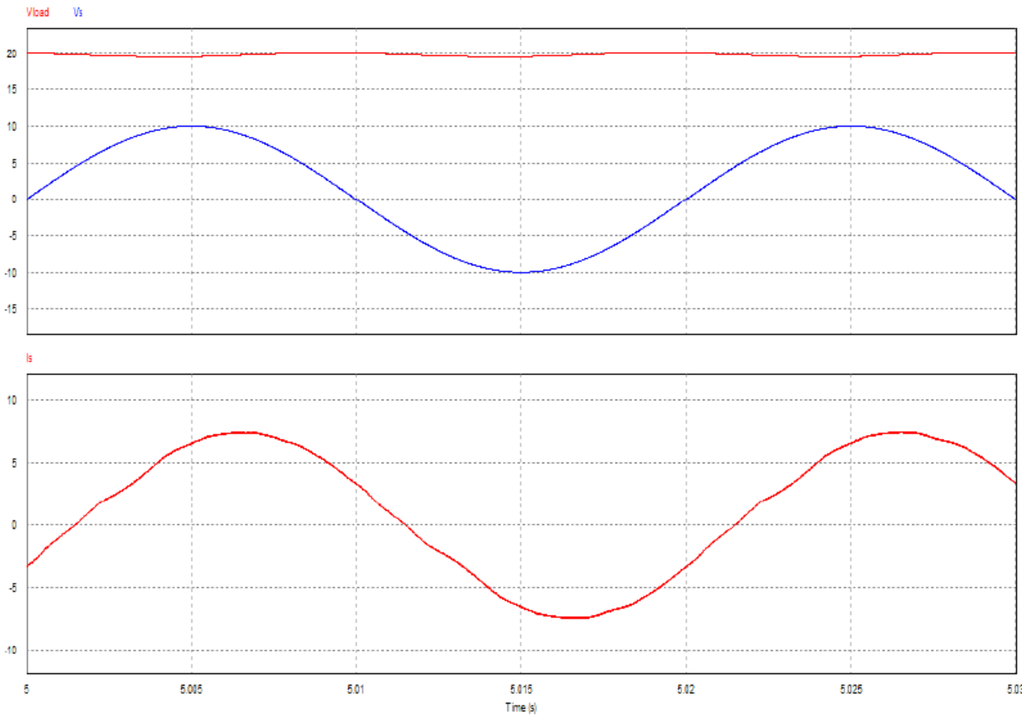


Fig. 15 Waveforms of Dual Boost Converter with EMI filter

VI. CONCLUSIONS

Thus boost converter is preferred over buck converter in single phase power factor correction circuit. Boost converter with hysteresis control technique shows higher input power factor (lower THD).For better input current waveforms and constant switching frequency, we prefer average current control scheme. Further improvement of power factor has been done by using parallel boost converter techniques. EMI filter has been added in order to further decrease the total harmonic distortion. Further improvement can be done by using soft-switching techniques.

REFERENCES

[1] N. Mohan, Power Electronics: Converters, Applications and Design, New York, USA, John Wiley & Sons, Inc, 1995.

[2] Redl, Richard, "Reducing distortion in peak-current-controlled boost power factor correctors", Proc. of IEEE Applied Power Electronics Conference APEC'94. (1994): pp. 576- 583.

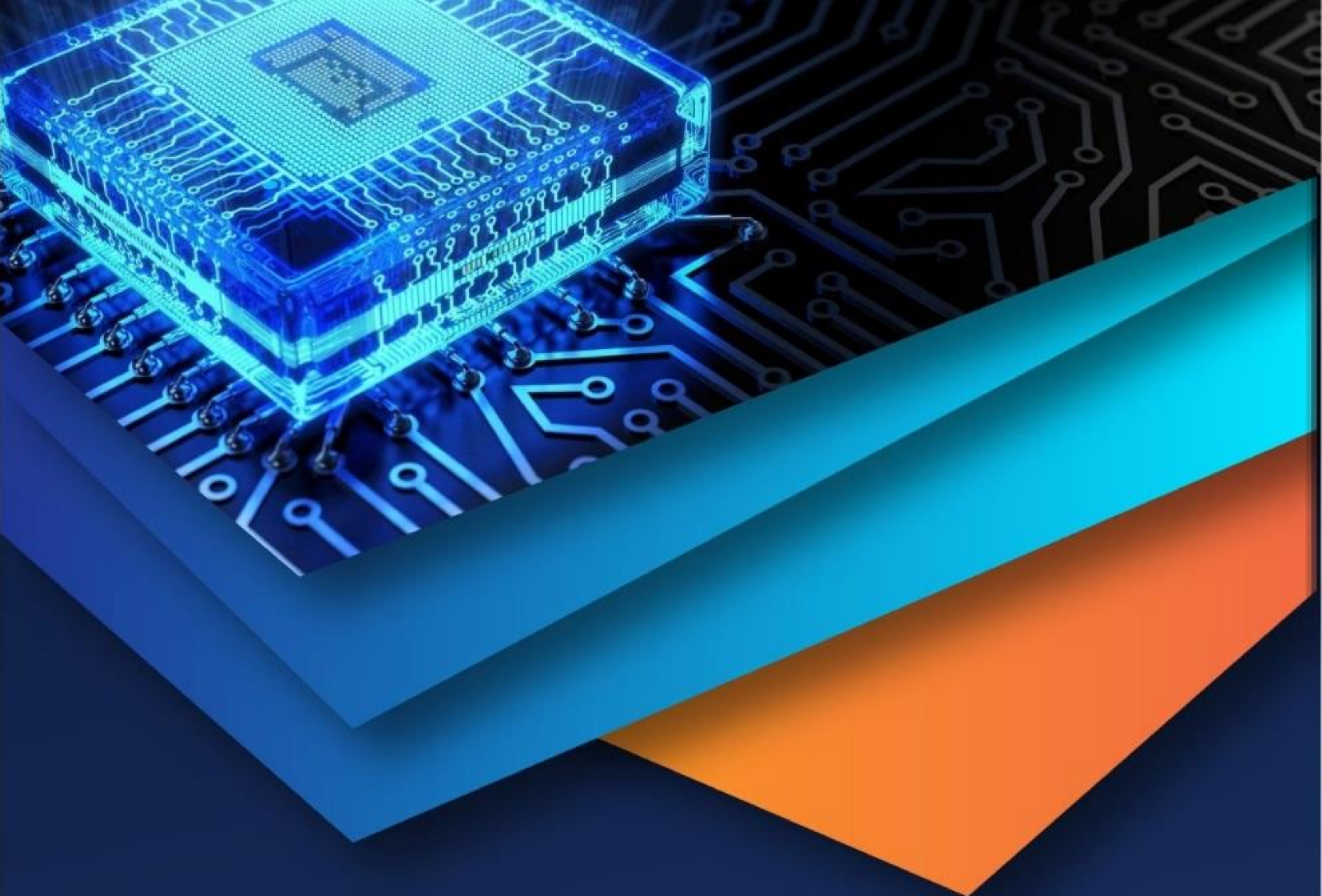
[3] Lai, J. S., "A Design consideration for Power Factor Correction Boost converter Operating at the Boundary of Continuous Conduction mode and Discontinuous Conduction mode" Proc. of IEEE Applied Power Electronics Conference, APEC'93. (1993): pp. 267-273.

[4] Redl, Richard ," Power-Factor Correction with Interleaved Boost Converters in Continuous-Inductor-Current Mode," in Proc. of IEEE Applied Power Electronics Conference APEC'93. (1993): pp.168-174.

[5] R Wu, M. K. W, "A review of EMI problems in switch mode power supply design," Journal of Electrical and Electronics Engineering, Australia. vol. 16, nos. 3&4, (1996): pp. 193-204.

[6] Redl, Richard ," Power electronics and electromagnetic compatibility.," Proc. of IEEE Power, Electronics Specialists Conference, PESC'96. (1996): pp. 15-21..

[7] Vlatkovic, V, "Input filter design for power factor correction circuits," IEEE, Transactions on Power Electronics. vol. 11, no. 1, (Jan. 1996): pp. 199-205.



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