Average Current Control Mode Boost Converter for the Tuning of Total Harmonic Distortion & Power Factor Correction using PSIM

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Abstract

The aim of this paper is to investigate the power factor correction (PFC) of Boost Converter under an average current-mode control. Boost converter topology is used to accomplish this active power-factor correction in many discontinues/ continuous modes. The boost converter is used usually it is easy to implement and works well. In this paper comparative evaluation of different techniques for harmonic reduction in input current of ac-dc converter is presented. Converters employing as side switching and boost converter is simulated in PSIM Software. Average current tracks the current program with a high degree of accuracy. This is especially important in high power factor pre-regulators, enabling less than 5

Index terms— PSIM; average current control; power factor correction; total harmonic distortion (THD).

1 INTRODUCTION

C-DC converters are used in adjustable speed drives, SMPS, UPS etc. Most of power Electronics (PE) system which get connected to AC utility mains use diode rectifier at the input. The non-linear nature of diode rectifier causes significant line current harmonic generation, thus, they degrade power quality, increases losses, failure of some crucial medical equipment and so on. Therefore, stringent international standard are imposed. Hence, harmonic reduction circuits are incorporated in PE system [1].

Earlier expensive bulky inductor and capacitor were installed [2] but they effectively eliminated certain harmonic. Active power line conditioners (APLC) used for harmonic reduction are generally hard switched, which result in low efficiency, low EMI, high component stress etc. Soft switched resonant converter are also used and are usually operated in variable frequency mode and thus component are required to be designed at lowest operating frequency. Active clamped technique is well known for zero voltage switching (ZVS) operation in various converters. Boost converter topology in continues conduction mode (CCM) is used in medium power AC/DC converter, as it gives near unity power factor at ac input [3,4].

Power-factor-correction (PFC) converters are widely used in power supplies for pre -regulating of power factor. Generally speaking, any type of switching converters can be the candidate for PFC purpose [5][6][7][8]. But in practical the Boost converter has been the favorable and popular choice when taking into account the factor of current stress and efficiency. As a typical nonlinear circuit system, PFC Boost converters are recently revealed to exhibit fast-scale instability, such as bifurcation and chaos operation, over the time of line cycle. These complex behaviors implying instability should be avoided from the viewpoint of traditional design principles, which can be realized by the changing of circuit parameters, or enclosing the accessional control method when the circuit parameters are fixed. The basic practical requirement for power supplies is to regulate output voltage. Moreover, this requirement has to be combined with that of power-factor-correction (PFC) in the design of most practical power supplies. Defined as the ratio of the active power to the apparent power, the power factor represents a useful measure of the overall quality level of satisfaction of power supplies and systems in such areas of performance as harmonic distortion and electromagnetic interference. Generally speaking, any type of switching converters can be chosen as a PFC stage. In practice, taking into account the current stress and efficiency, the boost converter has been a favorable and popular choice. The discontinuous conduction mode of operation has the obvious advantage of simplicity since no additional control is required [9].

In a conventional switching power supply employing a buck derived topology, the inductor is in the output. Current mode control then is actually output current control, resulting in many performance advantages [10][11][12]. On the other hand, in a high power factor pre-regulator using the boost topology, theA Global Journal of Researches in Engineering ( ) F Volume XIV Issue V Version I

inductor is in the input. Current mode control then controls input current, allowing it to be easily conformed to the desired sinusoidal wave shape. In high power factor boost pre-regulators the peak/average error is very serious because it causes distortion of the input current waveform. While the peak current follows the desired sine wave current program, the average current does not. The peak/average error becomes much worse at lower current levels, especially when the inductor current becomes discontinuous as the sine wave approaches zero every half cycle. To achieve low distortion, the peak/average error must be small. This requires a large inductor to make the ripple current small. The resulting shallow inductor current ramp makes the already poor noise immunity much worse. The average current mode method can be used to sense and control the current in any circuit branch. Thus it can control input current accurately with buck and fly back topologies, and can control output current with boost and fly back topologies.

2 II.

3 DESIGN OF SYSTEM

I have used average current control Boost Converter for the improvement of power factor and total harmonic distortion. The boost converter is a high efficiency step-up DC/DC switching converter. The converter uses a transistor switch, typically a MOSFET, to pulse width modulate the voltage into an inductor. Rectangular pulses of voltage into an inductor result in a triangular current waveform. For this discussion we assume that the converter is in the continuous mode, meaning that the inductor's current never goes to zero. Some formulas and mathematical notations of Boost Converter are shown below in table 1. The average current mode control method is feedback control for current. I have used two PI controllers to stabilize the system. After using this average current control method, I have taken good results.

4 III. SIMULATION & RESULTS USING PSIM SOFTWARE

I have selected the PSIM software for simulation. Firstly I have explained only the bridge rectifier. Then calculate its THD, which is good because no energy using equipments in the circuit so it's THD is very good. Then I have shown the bridge rectifier using boost converter. The results show that its THD is very high so I have to improve this THD. For this purpose I have selected the average current controlled method. The result shows clearly that a lot of ripples in the waveform. So it must be sure that its THD must be very high. The THD data is shown below in figure (6). We can see clearly that its THD is more than 60% and we see a lot of ripples in the input current so our task is to reduce the ripples and make the THD around 5%. So for this we have to design a controller that gives us good results and improved power factor.

5 c) Average Current Control Method using Boost Converter

The circuit diagram of Average Current Control method using Boost Converter is shown below in figure (7). I have worked on PSIM Software. The value of each component is shown in the circuit. I am using 220 RMS in the input and getting 400V in the output. I have arranged the values according to the circuit like duty cycle of 0.4 and the values of PI controller are set according to the circuit requirement. The table shows the basic components of the circuit Diagram. It can be seen that there is no ripple in the input current, so its THD must be very good. The THD of input current is shown below in figure (11). In the average current control method, we use a feedback circuit diagram as we can see in figure (7). In the feedback circuit diagram, we have the comparison analysis of Inductor Current and Reference Current as shown in figure (12). After applying the variable load, the THD is shown in figure (16) this is good around 4%. IV.

6 CONCLUSION

I have used the Software PSIM, which helped me for the measurement of THD and Power Factor. Firstly I show the results of open loop uncontrolled rectifier and then shows the average current control method. The average current control method improves the results (THD and Power Factor). In the results of uncontrolled rectifier, we can see that harmonics are very high so our task is to reduce the harmonics. I used the close loop controlled rectification and arranging the PI controllers to get the good results. I have also shown the comparison of Inductor current and the reference current which is the comparison of rectified scaled voltage and the output DC voltage. I have also shown the transient analysis of average current control method, which also shows good results. So I got the good THD which is 4.45%.

1

Figure 1: Figure 1 :

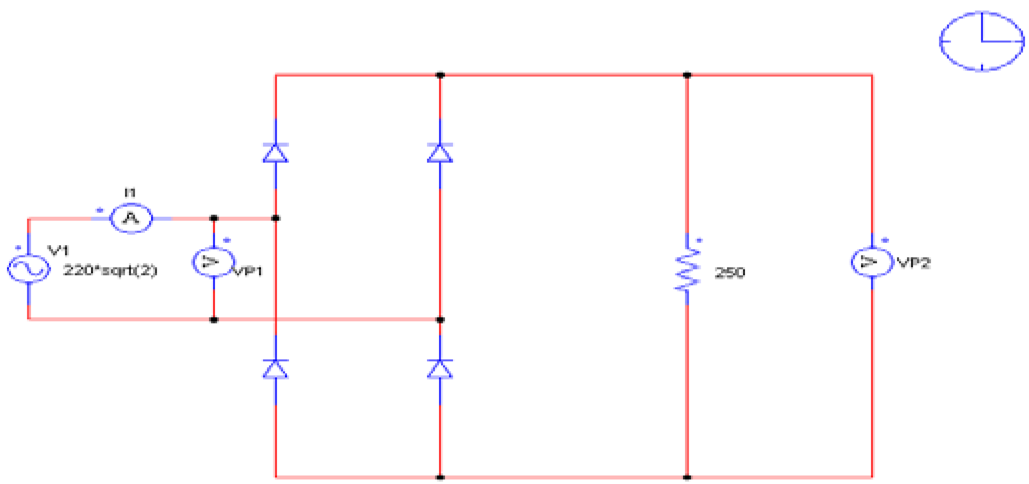

Figure 2:

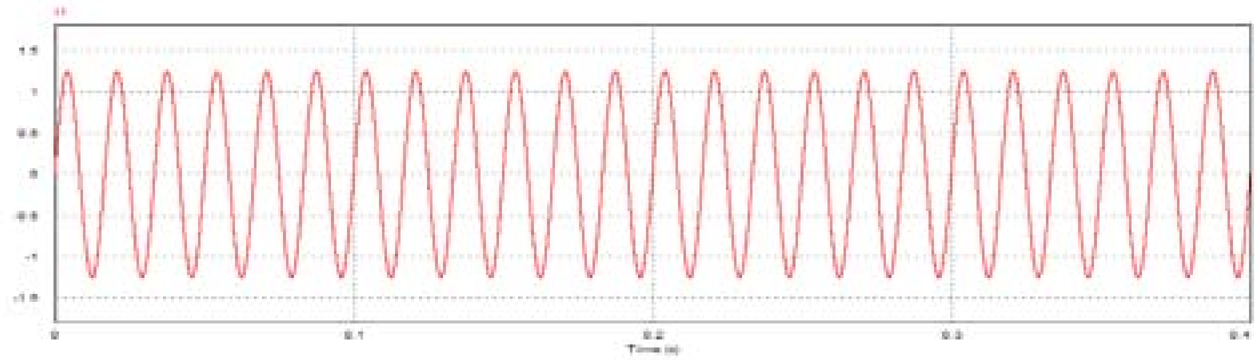

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Figure 3: Figure 2 :

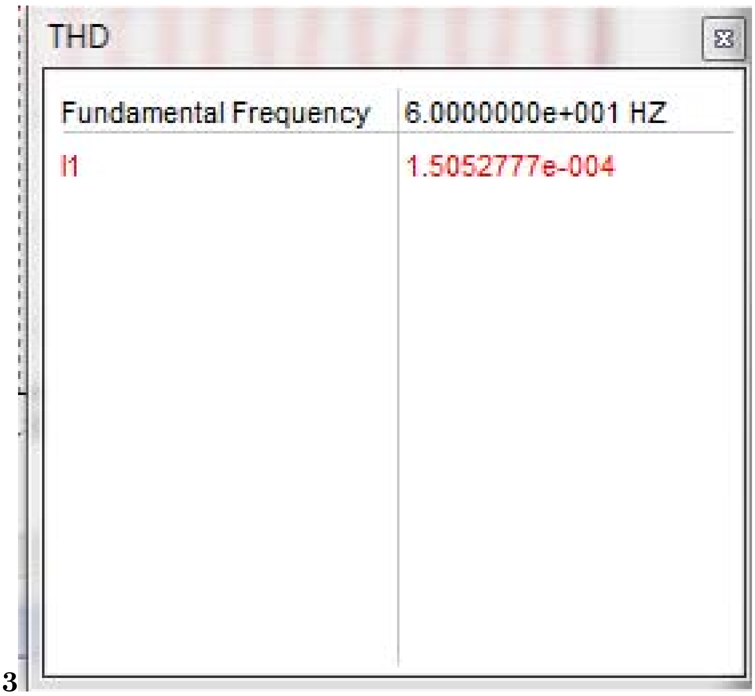

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Figure 4: Figure 3 :

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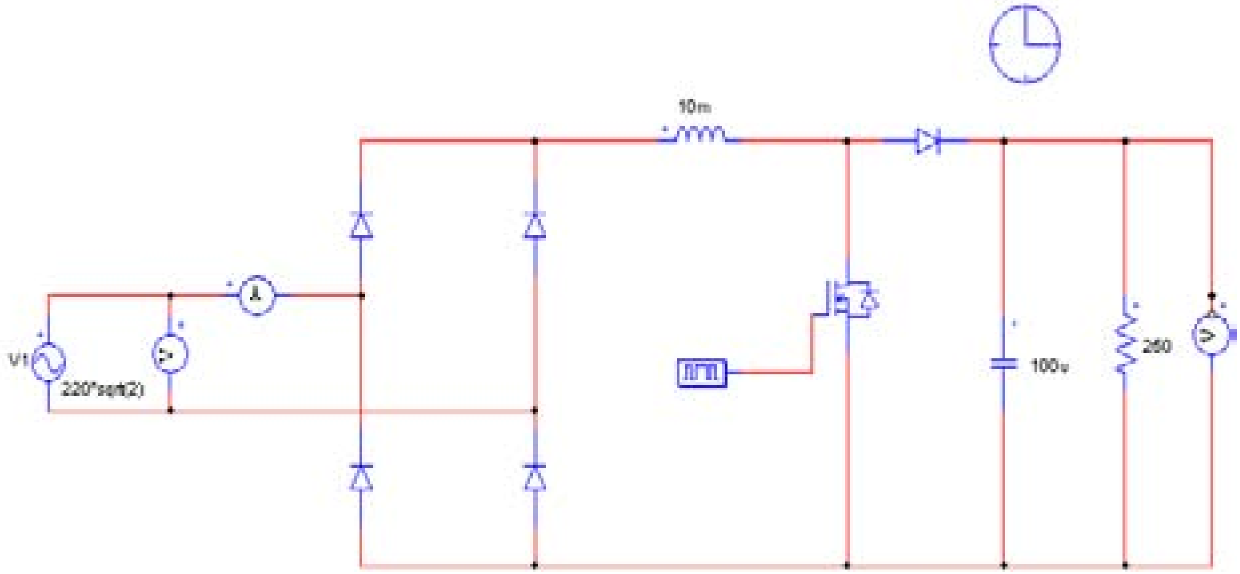

Figure 5: Figure 4 :

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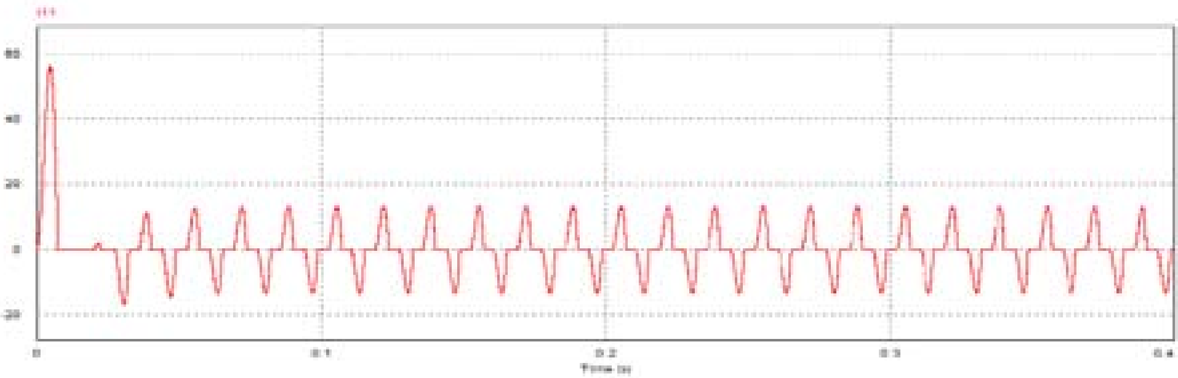

Figure 6: Figure 5 :

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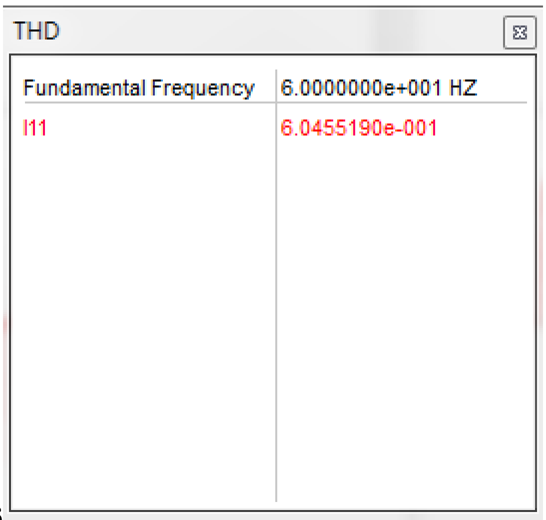

Figure 7: Figure 6 :

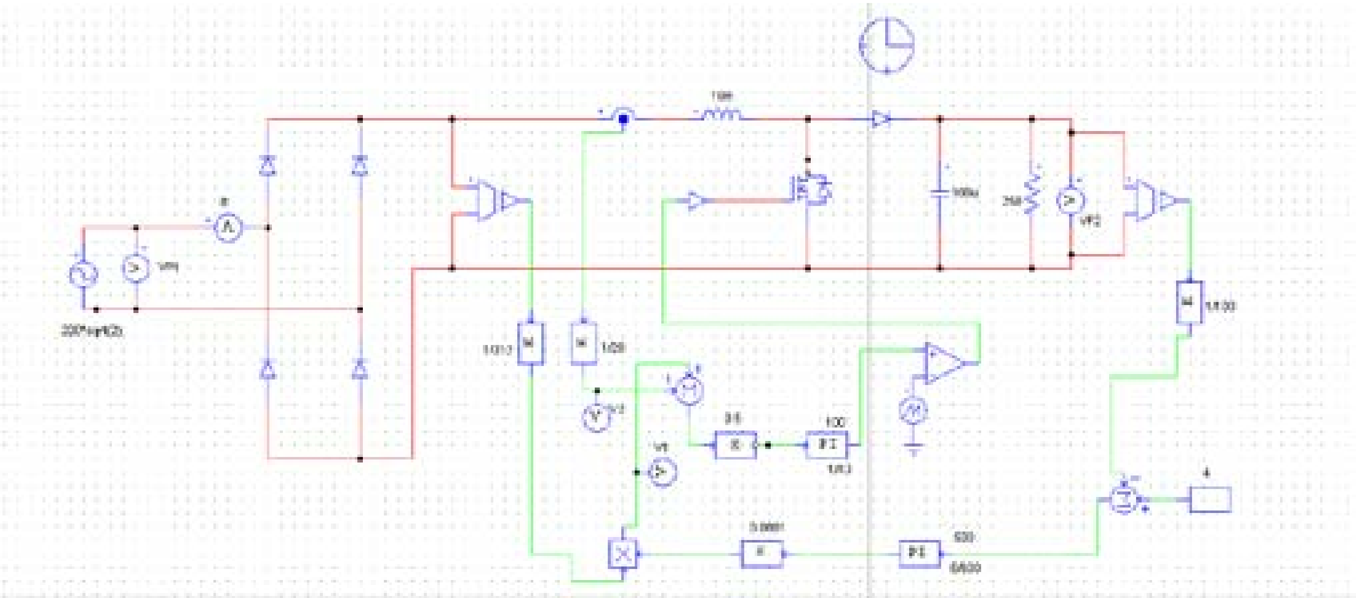

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Figure 8: Figure 7 :

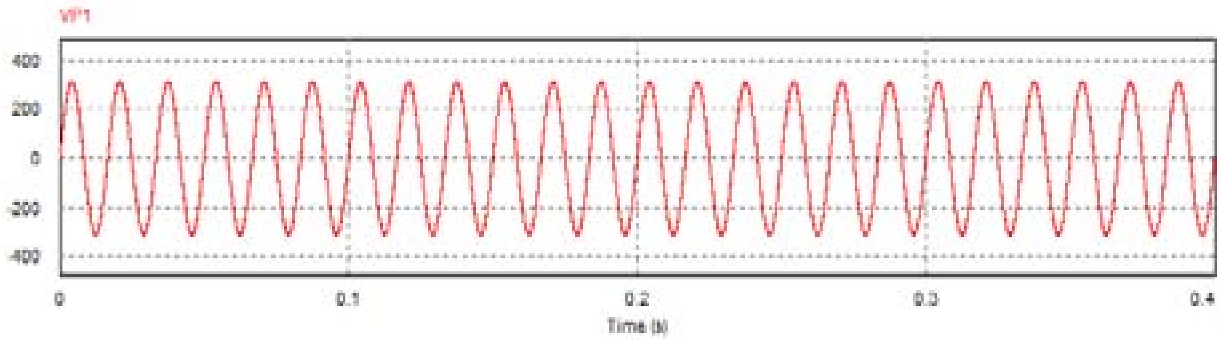

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Figure 9: Figure 8 :

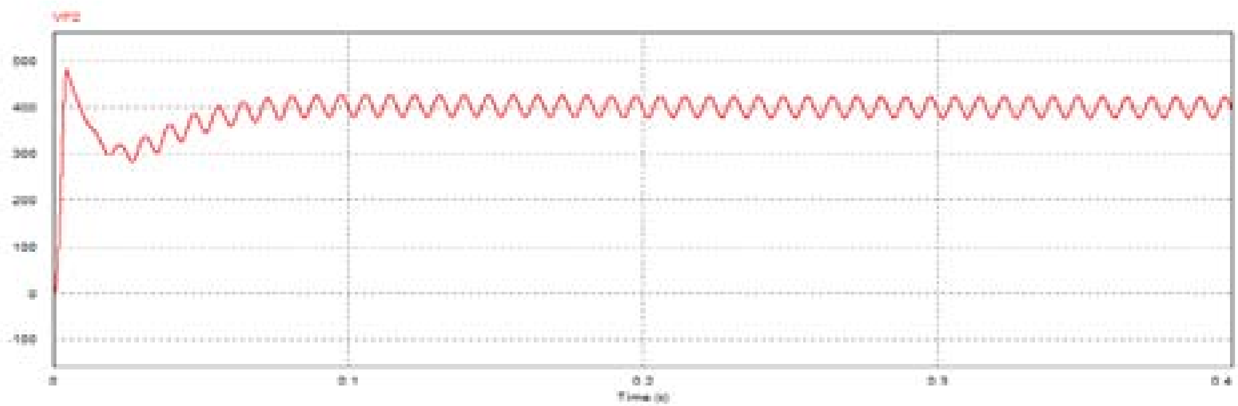

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Figure 10: Figure 9 :

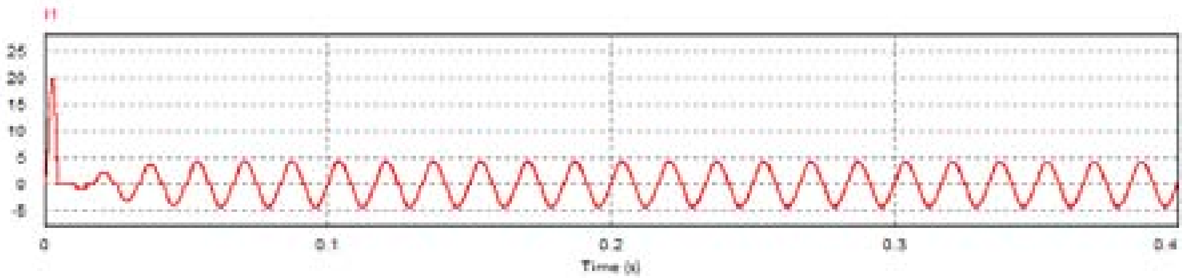

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Figure 11: Figure 11 :

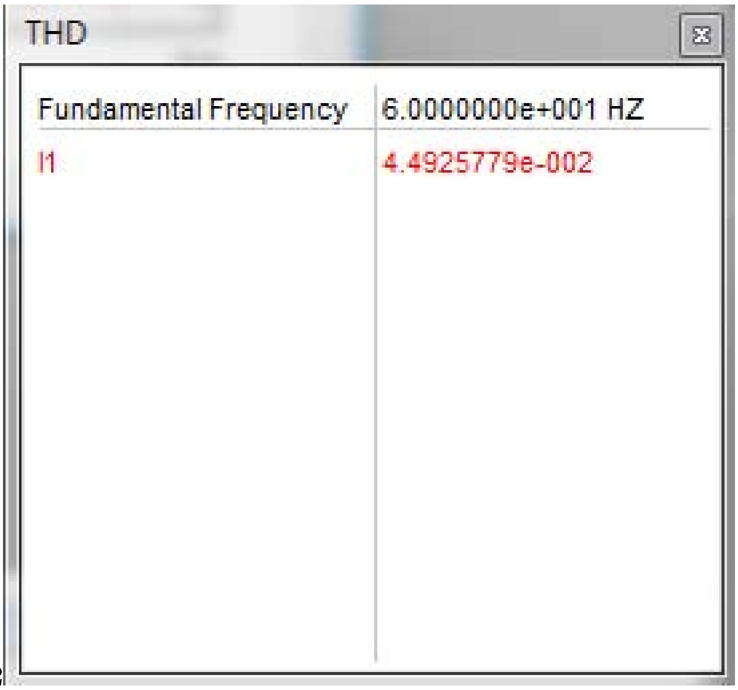

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Figure 12: Figure 12 :

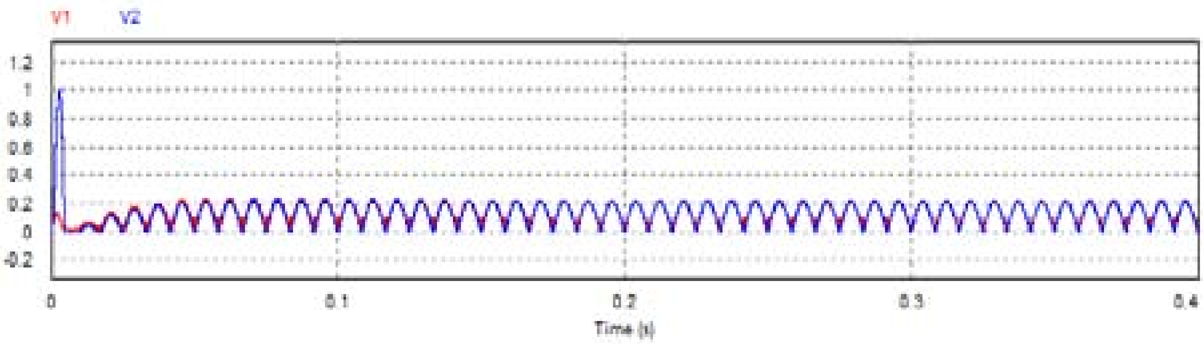

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Figure 13: Figure 13 :

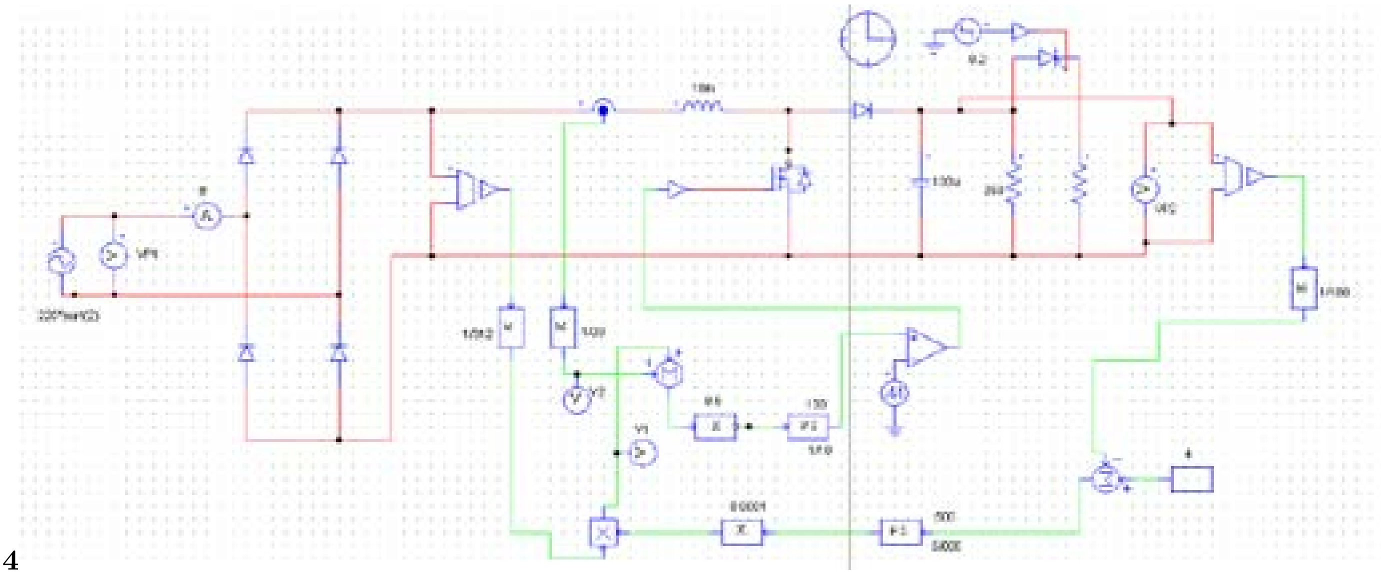

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Figure 14: Figure 14 :

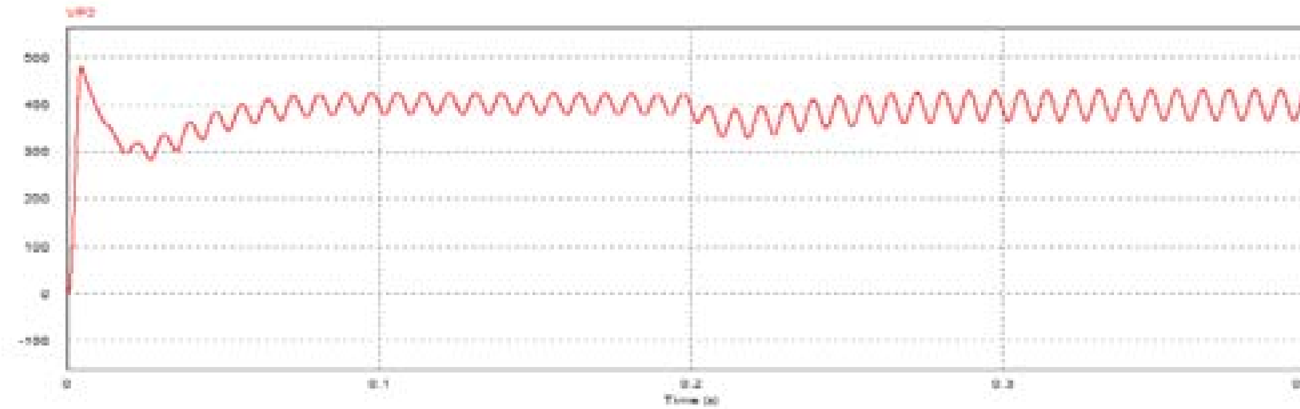

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Figure 15: Figure 15 :

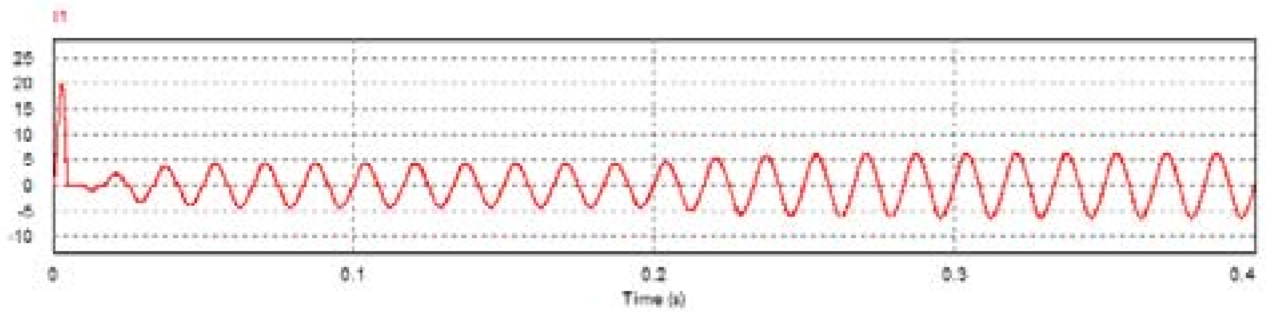

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Figure 16: Figure 16 :

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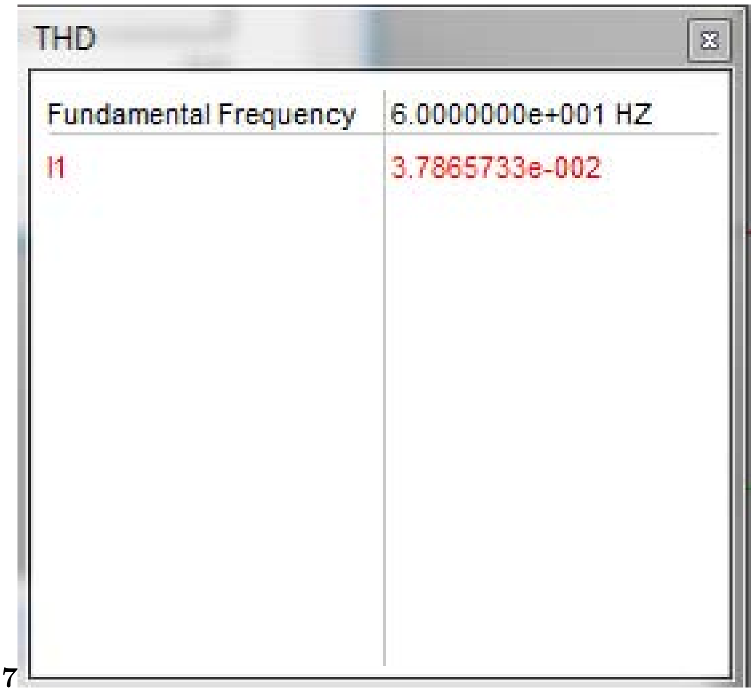

Figure 17: Figure 17 :

1

Components/ Parameters	Formulas
Peak inductor current	
Min inductor current	
Ripple Current	(i i ? = pk ? o i)
Ripple Current Ratio to Average Current	r / ave i i = ?
Off Duty Cycle	

[Note: pk i o i]

Figure 18: Table 1 :

2

Components/ Parameters	Values
Input Voltage	220V RMS
Duty cycle	0.4
Inductor	10 mH
Capacitor	100 uF
Resistor	250 ?
Switching Frequency	100 KHz
Reference Voltage	400 V

Figure 19: Table 2 :

V. [1]

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I will take this opportunity to express my deepest regards and thanks to my professor, without his guidance I would not be able to complete this paper. His attitude and guidelines during this paper is very valuable and helpful for me. During this paper I have explore new horizon of this field and I am confident that with the guidance of my professor I will excel in this field.

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