International Journal of Computing and Applications | **ISSN: 0973-5704**
Volume 13, Number 1, (January-June 2018), pp 195-200

BOOST PFC USING PEAK CURRENT MODE CONTROL

K.M. Sudharshan[1] and B.P. Divakar[2]

[1]*Associate Professor, Dept. of ECE, REVA ITM, Bangalore. Email: kmsudharshan@gmail.com*
[2]*Professor, Dept. of EEE, REVA ITM, Bangalore*

Abstract: In this paper, switch modelling of boost PFC in peak current control mode is discussed. The input voltage is sine wave with regular line frequency of 50Hz. The output voltage is regulated by the outer loop and input current is shaped by the input current wave shaping network. The circuit discussed here, is single stage boost PFC which uses common control switch for both input current shaping network and the voltage regulation network. The complete circuit is modeled using LT SPICE emphasizing the current sensing in the PFC controller.

Keywords: Power Factor Correction, Peak Mode Current Control, Continuous Conduction Mode.

1. INTRODUCTION

As the applications of power electronics are increasing, in all the day to day products like battery charger, televisions, laptops, electronic gadgets, in addition these circuits also produces low power factor and larger harmonics. There is a need for power factor correction which increases the quality of the power electronic circuit. It uses AC to DC conversion, which is done by a bridge rectifier, input current shaping network, with the ability to make the output DC voltage stable for the entire input voltage. The boost PFC has two loops one voltage loop which is also called as outer loop to take care of the voltage regulation. In addition a current loop which is the inner loop to adjust the current reference which makes the supply current to follow the reference set by the loop. [1]

2. TYPES OF PFCS

There are two types of PFCs, Single Stage PFC and Dual Stage PFC, in Single stage PFC a common control is used for both input current shaping and voltage regulation. In dual stage PFC two stages are used, one will take care of input current shaping and other one will do regulation. Further there are two types of control, namely Voltage Control Mode and Current Control Mode.

3. METHODS OF CURRENT MODE CONTROL

Based on when the current information is sensed, we have three types peak, average and valley mode. In peak mode, the current sensing switch senses the current information, when the boost switch is ON. In case of average mode the current is sensed during both the ON and OFF time. In valley mode the current will be sensed only during OFF time. For our circuit we have considered peak current mode sensing. [3][5]. Out of the methods mentioned, we have used is the peak current mode control method. The block diagram is as shown in Figure 1.

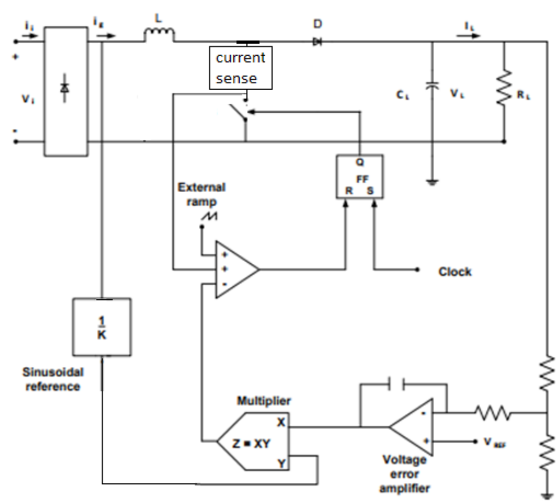

Figure 1: Boost PFC using peak current mode control

4. METHODS OF CURRENT SENSING IN PFCS

The current sensing method plays a very important role in any power management ICs. One of the conventional method is to use resistor in the path where the current is to be sensed. This method consumes more power particularly when the current to be sensed is larger. [16]

(a) Current sensing using series resistor
(b) MOSFET Rds current sensing
(c) Current sensing transformers
(d) Using SENSEFETs

Out of the four methods, discussed above the current sensing using resistor is modeled using LT SPICE tool.

5. MODELLING OF CURRENT SENSE BLOCK USING LT-SPICE:

The current sensing circuit modeling can be done using a behavioral current source available with LT SPICE tool. The Inductor current is very important information for PWM, as the current sensed from the inductor is mandatory to combine with the artificial ramp signal in order to avoid sub harmonic oscillation in current-mode control PWM converter [10]. The current sensed can be adjusted to by setting a proper sense ratio. The current loop stability is done by choosing the suitable loop compensation. To do the loop compensation we have done stability analysis. Based on the pole zero frequencies the type II compensation is used in the current gain block. For the current loop, we have used LT-1215, which is the op-amp from Liner Technology. The gain of the current loop is set by the equation, $G_{cm} = (V_m Lw_c)/(V_{out}R_f)$.[12]

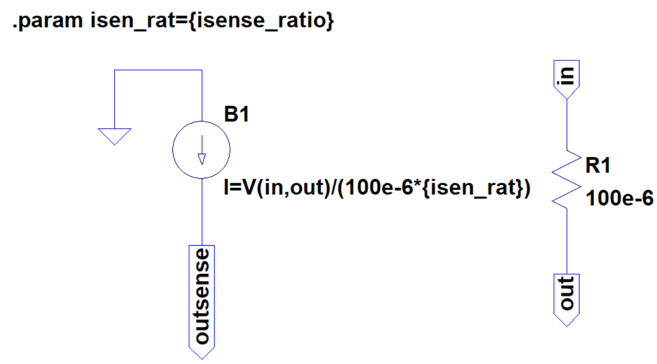

Figure 2: Current sense block modeled using LT-SPICE

6. RESULTS & DISCUSSION

The same current sense block is used in the boost PFC and the circuit is simulated. The results are discussed in the following figures. Figure 3 shows the current sensed using the current sensing block which we have modeled using LT SPICE tool.

Since, the method is used is peak current mode control, the current is sensed during the ON time of the switch. During the OFF time the switch will not sense any information. The same is shown in the wave forms of Figure 4.

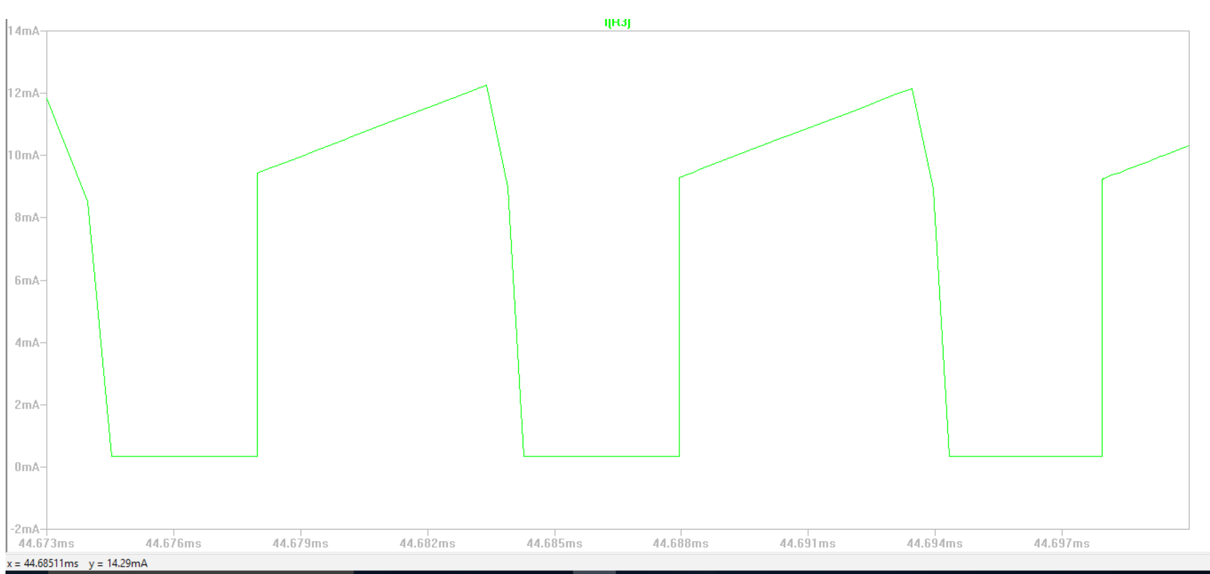

Figure 3: Current sensed through the inductor

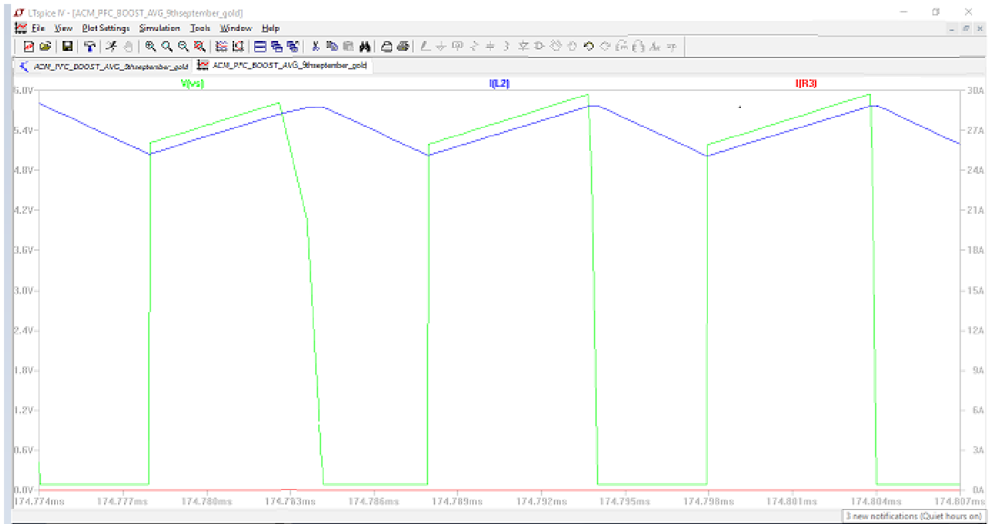

Figure 4: Peak current sensing

The complete circuit is modeled using LT SPICE, the circuit implemented using LT-SPICE is as shown in Figure 5. The simulation results are shown further.

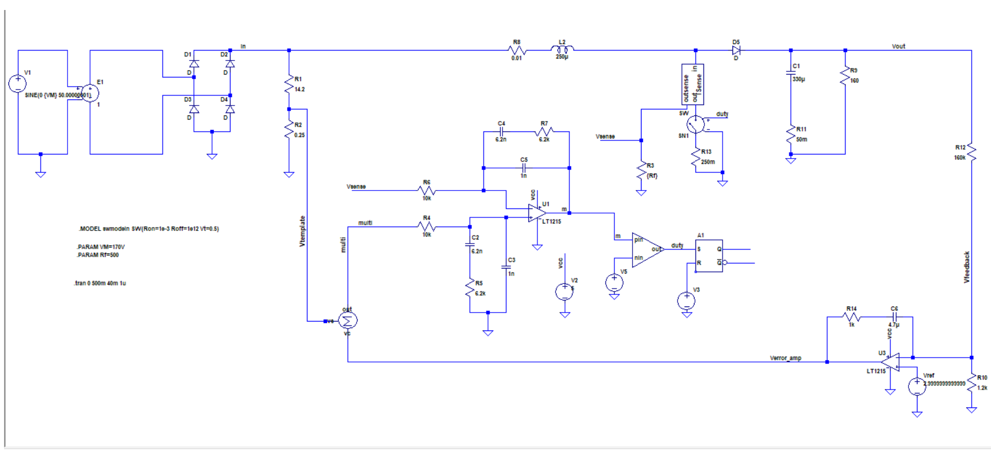

Figure 5: Complete schematic of Boost PFC peak current mode control tool snapshot

The circuit simulated and the results are as shown further, Figure 6 shows the error amplifier input voltage, output voltage and reference the error amplifier.

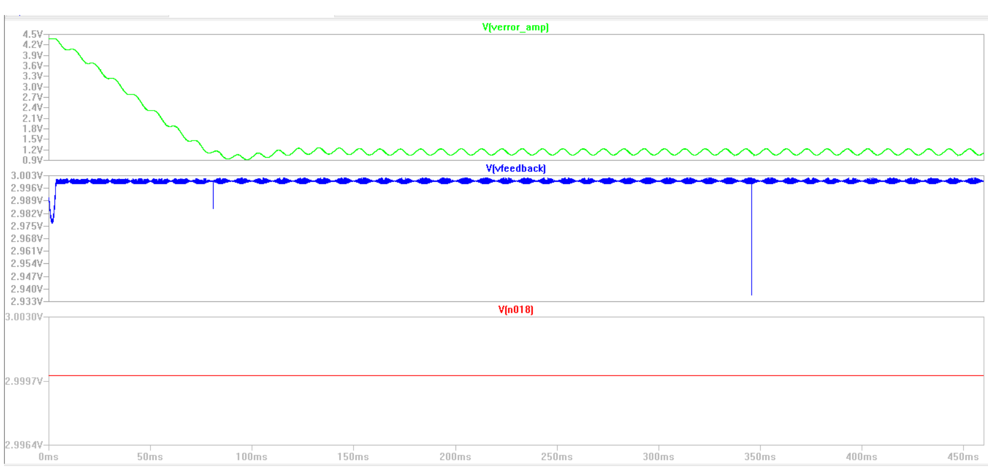

Figure 6: Output of the error amplifier, Feedback Voltage to the Error amplifier, and Reference Voltage

The input voltage to the multiplier, is the template derived from rectified voltage and error amplifier output. The same is simulated and shown in Figure 7.

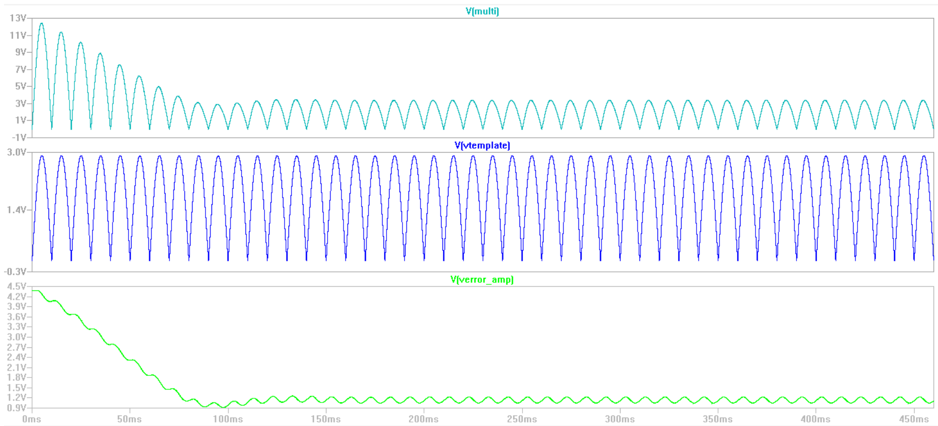

Figure 7: Error amplifier output, template derived from rectifier output, output of the multiplier

The duty cycle is shown in Figure 8, the switching frequency is 100 KHz with a duty of 58%.

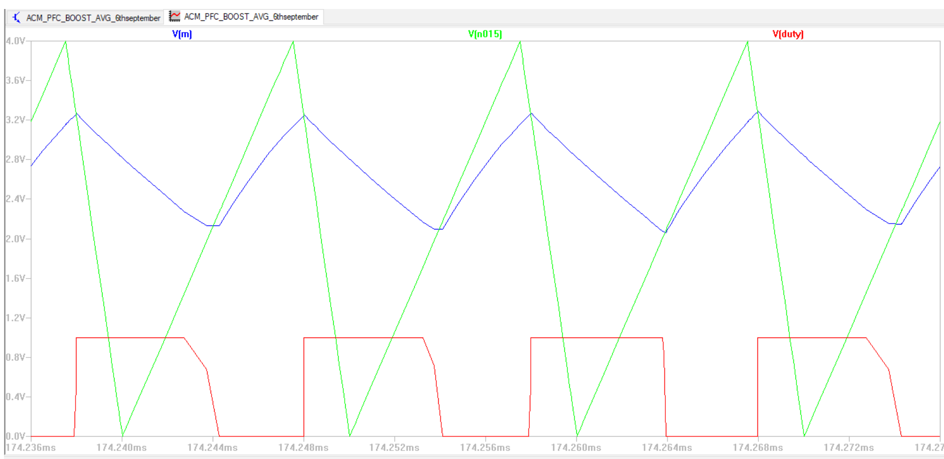

Figure 8: Duty Cycle from the PWM output

Figure 9 shows the dc output voltage of boost PFC taken across the load.

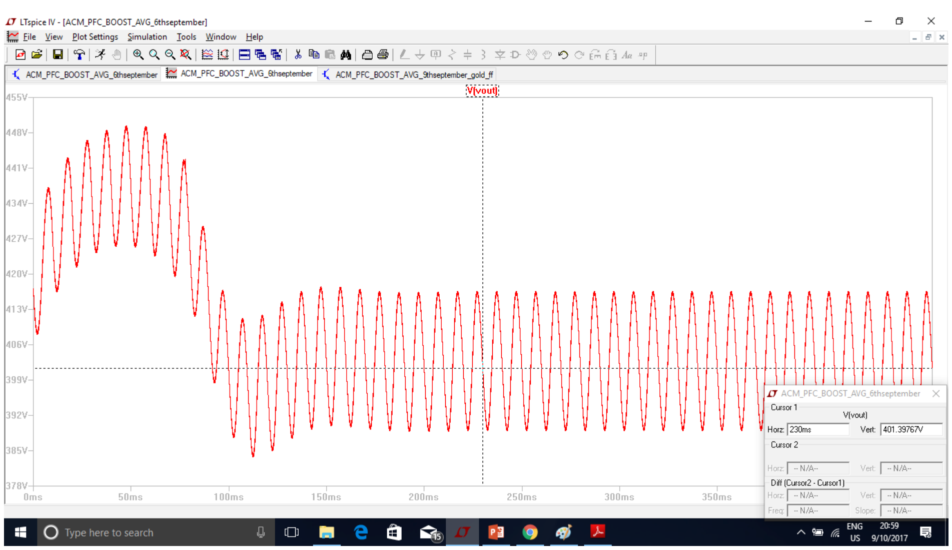

Figure 9: Output Voltage

Figure 10 shows the input voltage and input current which are in phase which is the main objective of PFC.

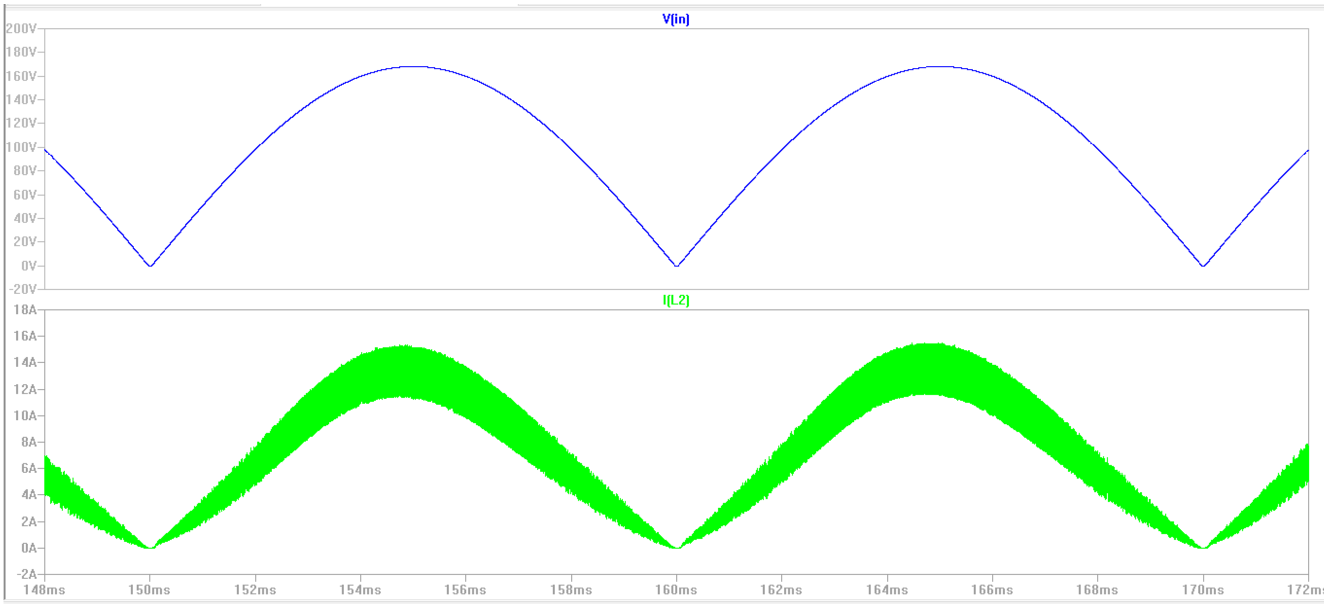

Figure 10: Input Voltage and Current

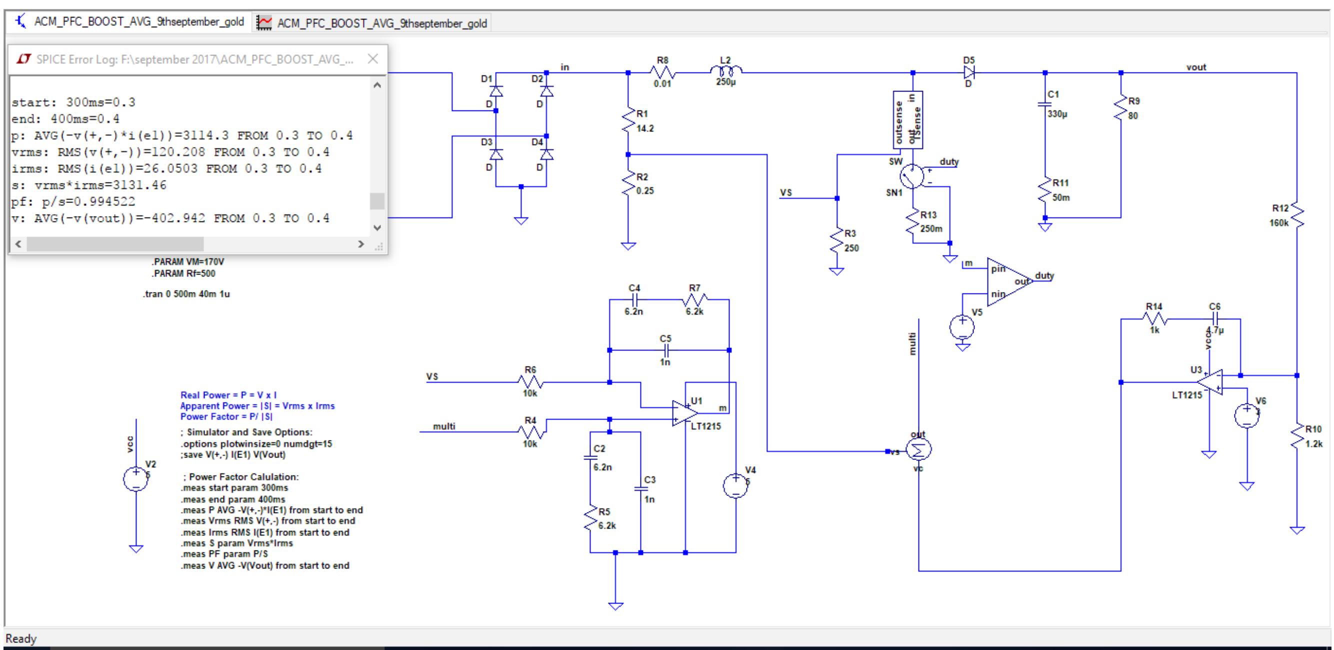

Figure 11: Power Factor Simulated value 0.9945

7. CONCLUSION

The switching model for boost PFC modeled using LT-SPICE tool, it is working in peak current mode control. The current sensing block which we have modeled is able sense the current through the inductor. The single stage PFC is able to give PF of 0.9945, giving a regulation of output around 400V.

References

[1] Poorali, Behzad, and Ehsan Adib. "Analysis of the integrated SEPIC-flyback converter as a single-stage single-switch power-factor-correction LED driver." *IEEE Transactions on Industrial Electronics* 63.6 (2016): 3562-3570.

[2] Mallik, Ayan, Bryan Faulkner, and Alireza Khaligh. "Control of a single-stage three-phase boost power factor correction rectifier." *Applied Power Electronics Conference and Exposition (APEC), 2016 IEEE*. IEEE, 2016.

[3] Wang, Chien-Ming, et al. "Design and realization of a zero-voltage transition pulse-width modulation interleaved boost power factor correction converter." *IET Power Electronics* 8.8 (2015): 1542-1551.

[4] Archana C Shettar, Sudharshan KM, Syed Rehman, "FPGA design and implementation of Digital PWM technique for DC-DC Converters" IEEE International Conference On Recent Trends In Electronics Information Communication Technology, May 20-21, 2016.

[5] Kondo, Ken-ichi, and Jumpei Baba. "Reactive power control by use of boost critical conduction mode power factor correction converter for suppressing voltage rise in distribution network." *Power Electronics and Applications (EPE'14-ECCE Europe), 2014 16th European Conference on*. IEEE, 2014.

[6] Weiping Zhang-Wei Zhang-Jianbo Yang, Faris Al-Naemi, "Comparisons between CRM and CCM PFC", Energy and Power Engineering, 2013, 5, 864-868

[7] António P. Martins and António M. Cardoso, "Input Current Distortion and Output Voltage Regulation of the Boost PFC Converter Operating with Different Control Methods", International Conference on Renewable Energies and Power Quality (ICREPQ-2012).

[8] J. R. R. Zientarski, R. C. Beltrame, D. B. Candido, M. L. Martins, H. L. Hey, "Design methodology for universal line input boost power factor correction magnetics," IET Power Electron., Journal, Vol. 4, no. 6, pp. 715-724, 2011.

[9] Chiu, Huang-Jen, et al. "A single-stage LED lamp driver with low DC bus voltage for general lighting applications." *International journal of circuit theory and applications* 39.11 (2011): 1161-1175.

[10] Jin, Hai-Feng, et al. "High performance current sensing circuit for current-mode DC-DC buck converter." *Transactions on Electrical and Electronic Materials* 11.1 (2010): 24-28.

[11] Power Factor Correction Handbook, - On Semiconductor: Rev. 2, Aug-2004.

[12] Sahid, M. R., N. A. Azli, and N. D. Muhamad. "Study on the performance of the boost power factor correction (PFC) circuit with variable inductor current sense resistor values." *Power Electronics and Drive Systems, 2003. PEDS 2003. The Fifth International Conference on*. Vol. 2. IEEE, 2003.

[13] Switching power supply design information, design tips, frequency response analyzers, and educational material for power supplies can be found at the web site located at: http://www.ridleyengineering.com

[14] C. K. Tse, "Circuit theory of power factor correction in switching converters," Intl. J. Theor. Appln., John Wiley, Vol. 31, pp. 157-198, 2003.

[15] Sahid, M. R., N. A. Azli, and N. D. Muhamad. "Study on the performance of the boost power factor correction (PFC) circuit with variable inductor current sense resistor values." *Power Electronics and Drive Systems, 2003. PEDS 2003. The Fifth International Conference on*. Vol. 2. IEEE, 2003.

[16] Edwin van Dijk, Herman J. N. Spruijt, Dermot M. O'Sullivan, and J. Ben Klaassens "PWM-Switch Modeling of DC-DC Converters", IEEE Transactions on Power Electronics, Vol. 10, No. 6, November 1995.