COMPARATIVE STUDY OF MODES NON INVERTING BUCK BOOST POWER FACTOR CORRECTION CONVERTER

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Abstract— This paper presents a non-inverting buck-boost based power-factor-correction (PFC) converter. Unlike other conventional PFC converters, the proposed non-inverting buck-boost based PFC converter has both step-up and step-down conversion functionalities to provide positive DC output-voltage. Total harmonic distortion is reduced in boost mode of operation.

Keywords— Power factor correction (PFC) Total harmonic distortion (THD)

INTRODUCTION

In the world today, dc power supplies are extensively used inside most of electrical and electronic appliances such as in computers, monitors, televisions, audio sets and others. The high power nonlinear loads (such as static power converter, arc furnace, adjustable speed drives etc.) and low power loads (such as fax machine, computer, etc.) produce voltage fluctuations, harmonic currents and an imbalance in network system which results into low power factor operation of the power system [1].

There is a need of improved power factor and reduced harmonics content in input line currents as well as voltage regulation during power line over-voltage and under voltage conditions. The uninterruptible power supplies (UPSs) have been extensively used for critical loads such as computers for controlling important processes, some medical equipment, etc. The traditional UPS draws harmonic currents. The uncontrolled diode bridge rectifier with capacitive filter is used as the basic block in many power electronic converters. Due to its nonlinear nature, non-sinusoidal current is drawn from the utility and harmonics are injected into the utility lines. The nature of rectifiers either it is conventional or switch mode types, all of them contribute to low PF, high THD [2] and low efficiency to the power system [3]. It is well known that these harmonic currents cause several problems such as voltage distortion, heating, noises, reducing the capacity of the line to supply energy. Owing to this fact there's a need for power supplies that draw current with low harmonic content &also have power factor close to unity [4]. So far, a variety of passive [5] and active PFC techniques have been proposed. While the passive PFC techniques may be the best choice at low power, cost sensitive applications, the active PFC techniques are used in majority of the applications owing to their superior performance.
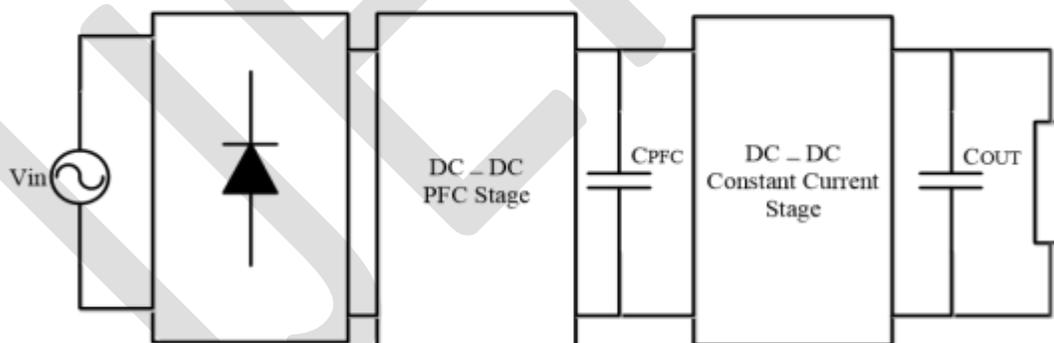
Fig.1 Two stage PFC circuit

In general, the use of two power stages is a good way to implement power factor correction and to balance the input and output powers but it increases the cost. Single power stage with charge pump PFC has been used in the fluorescent AC-DC-AC ballast. For a single power stage AC-DC-DC converter with PFC, it is hard to balance the input and output powers. Also, there are high voltage and current stresses on the power components. An AC-DC-DC Converter draws power from AC mains and supplies a DC current to the LED string. The driver needs a DC-DC converter to convert the input voltage into a DC current source and it limits the effectiveness of a charge pump.
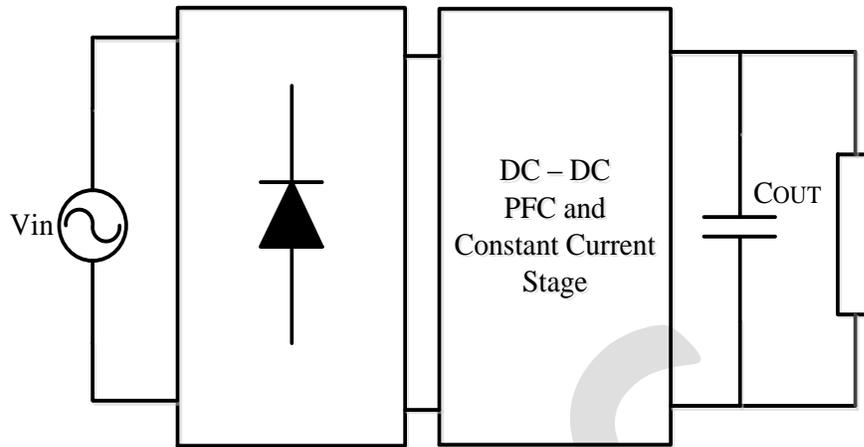
Fig.2.Single stage active PFC circuit

For low power applications, single-stage PFC converter is a better choice considering cost and performance. In single switch topologies, a PFC cell is integrated with a DC/DC conversion cell and both cells share active switches and controller. But those topologies suffer from high voltage and high current stresses. But most of those methods will bring high distortion to line current waveform, resulting in reduced power factor. So in this paper a new single stage converter is presented. The proposed non-inverting buck-boost based PFC converter has both step-up and step-down conversion functionalities to provide positive DC output-voltage.

BASIC PRINCIPLES AND MODES
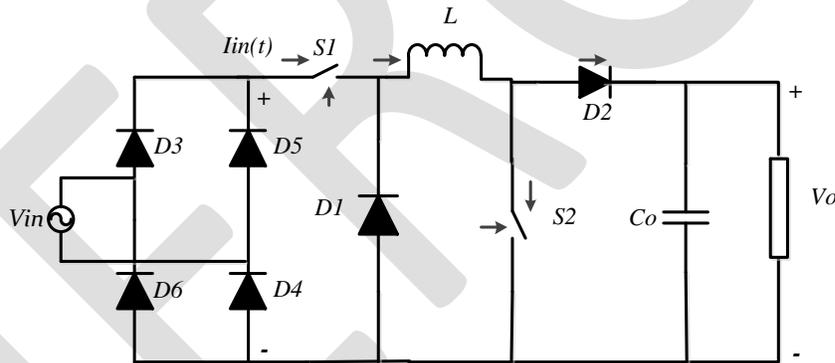
Fig 3.Non inverting buck boost converter

$$V_o < \sqrt{2}V_{in,rms}$$
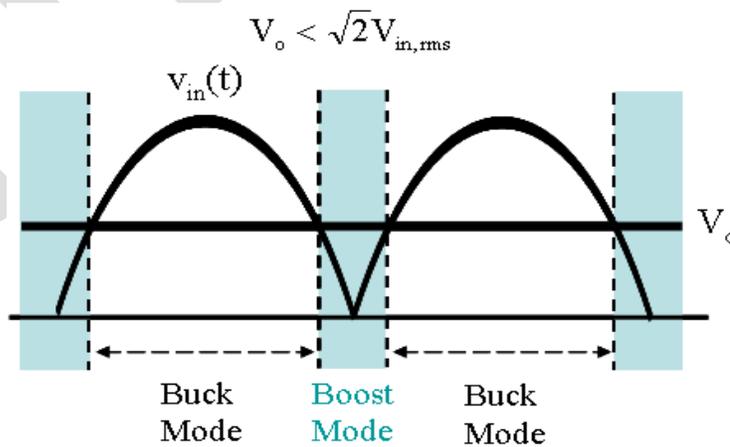
Fig. 4.Buck+boost mode

Boost Mode

When input supply is given the diode bridge rectifier it rectifies ac-dc and is given to converter. There are two modes of operation. When switch S_1 and S_2 is on input current linearly rises according to the value of inductor and energy is stored in output capacitor and load. This time diode D_1 and D_2 remains reverse biased. When switch S_1 and S_2 is off input current will not flow to inductor and load. Energy is stored in output capacitor freewheels through the load. This time diode D_1 and D_2 remains forward biased. Both time we get positive output voltage.
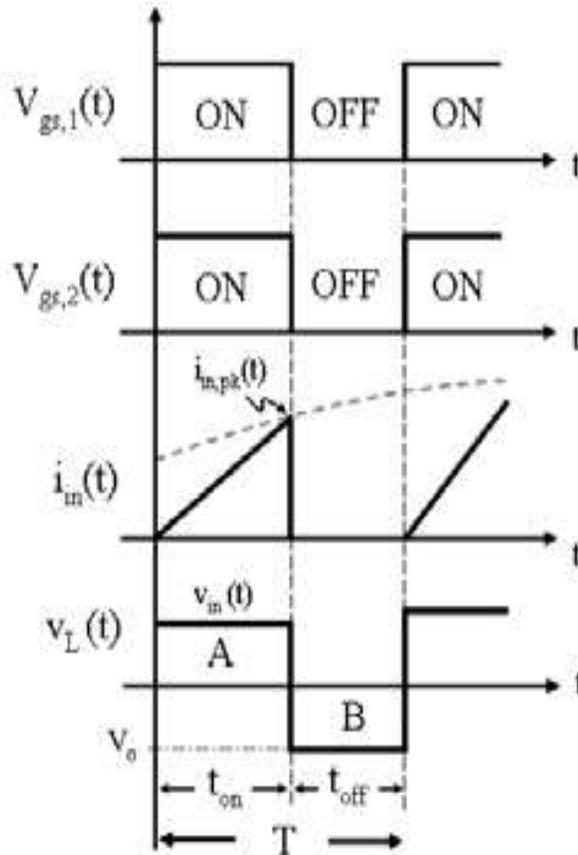
Fig .5.Waveforms of boost mode

Buck mode

In buck mode, the switch S_2 is off for entire time period. When input supply is given the diode bridge rectifier it rectifies ac-dc and is given to converter. When switch S_1 is input current linearly rises according to the value of inductor and energy is stored in output capacitor and load. This time diode D_1 and D_2 remains reverse biased. When switch S_1 is off input current will not flow to inductor and load. Energy is stored in output capacitor freewheels through the load. This time diode D_1 and D_2 remains forward biased. Both time we get positive output voltage.
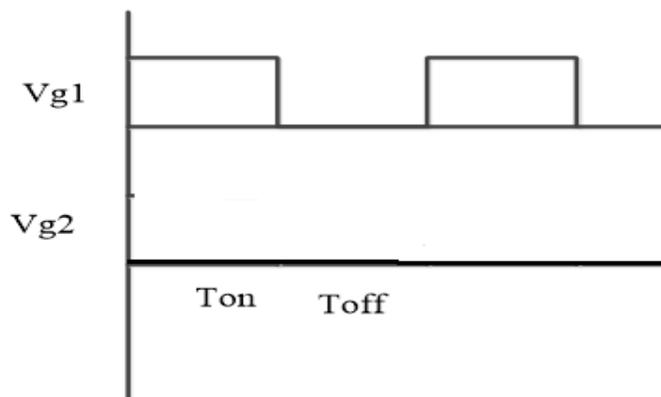
Fig .6.Waveforms of buck mode

POWER FACTOR CORRECTION AND TOTAL HARMONIC DISTORTION

In electrical engineering, the power factor of an AC electrical power system is defined as the ratio of the real power flowing to the load to the apparent power in the circuit, and is a dimensionless number in the closed interval of -1 to 1. A power factor of less than one means that the voltage and current waveforms are not in phase, reducing the instantaneous product of the two waveforms (V x I). Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power. A negative power factor occurs when the device (which is normally the load) generates power, which then flows back towards the source, which is normally considered the generator.

Total Harmonic Distortion

The total harmonic distortion, or THD, of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. On other words we can say that, when a signal passes through a non-ideal, non-linear device, additional content is added at the harmonics of the original frequencies. THD is a measurement of the extent of that distortion.

Design considerations

Assuming sinusoidal input voltage,

$V_{in} = V_m \ \text{sinwt}$

I_{pk} - Peak inductor current

$$I_{pk} = \frac{V_{in} * T_{on}}{L_i} = \frac{V_m * D * T}{L_i} * \text{sinwt} \ \ \text{........ (1)}$$

$$T_d = \frac{V_{in} * T_{on}}{V_o} \ \text{...................... (2)}$$

I_{in} - Line current

$I_{s2} \ (avg)$ - Average inductor current during on time

$I_{d2} \ (avg)$ - Average inductor current during off time

$I_{in} = I_{s2} \ (avg) + I_{d2} \ (avg) \text{.................(3)}$

From (1)

$$I_{s2}\ (avg) = \frac{I_{pk}}{2} * \frac{T_{on}}{T} = \frac{V_{in} * D^2 * T}{2L_i}$$

From (2)

$$I_{d2}\ (avg)\ = \frac{I_{pk}}{2} * \frac{T_d}{T} = \frac{V_{in}^2 * D^2 * T}{2L_i * V_o}$$

During positive half cycle,

$$I_{in} = I_{s2}\ (avg) + 0 = \frac{V_{in} * D^2 * T}{2L_i}$$

$$L_i\ = \frac{V_{in} * D^2 * T}{2 * I_{s2}\ (avg)}$$

$$V_o\ = \frac{V_{in} * D}{(1-D)}$$

$$C_o\ = \frac{V_{in} * D}{f * \Delta Vo}$$

where ΔVo – out put voltage ripple

SIMULATION RESULTS
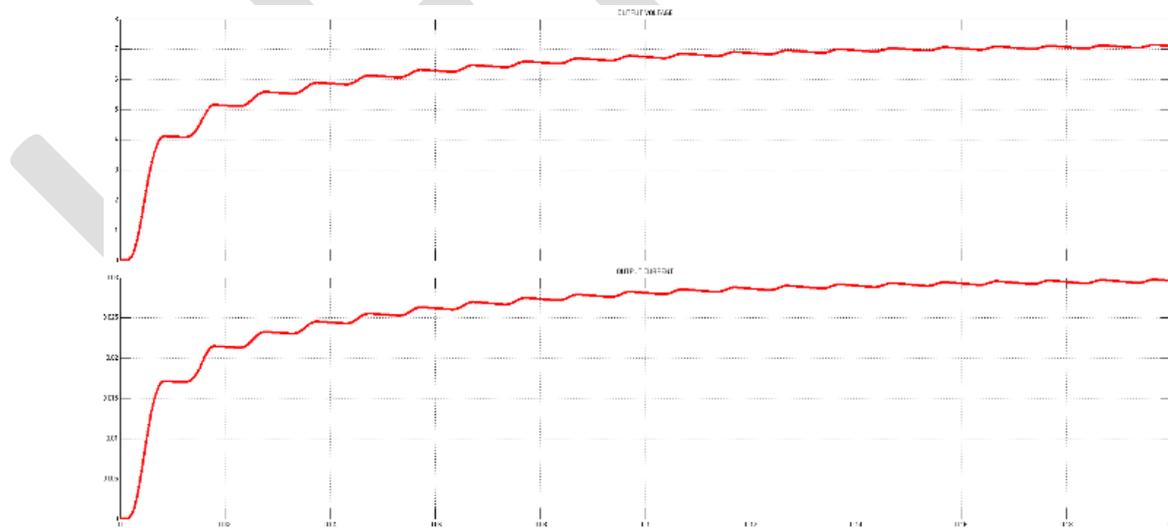
Fig.7 waveforms of output current and voltage of buck mode
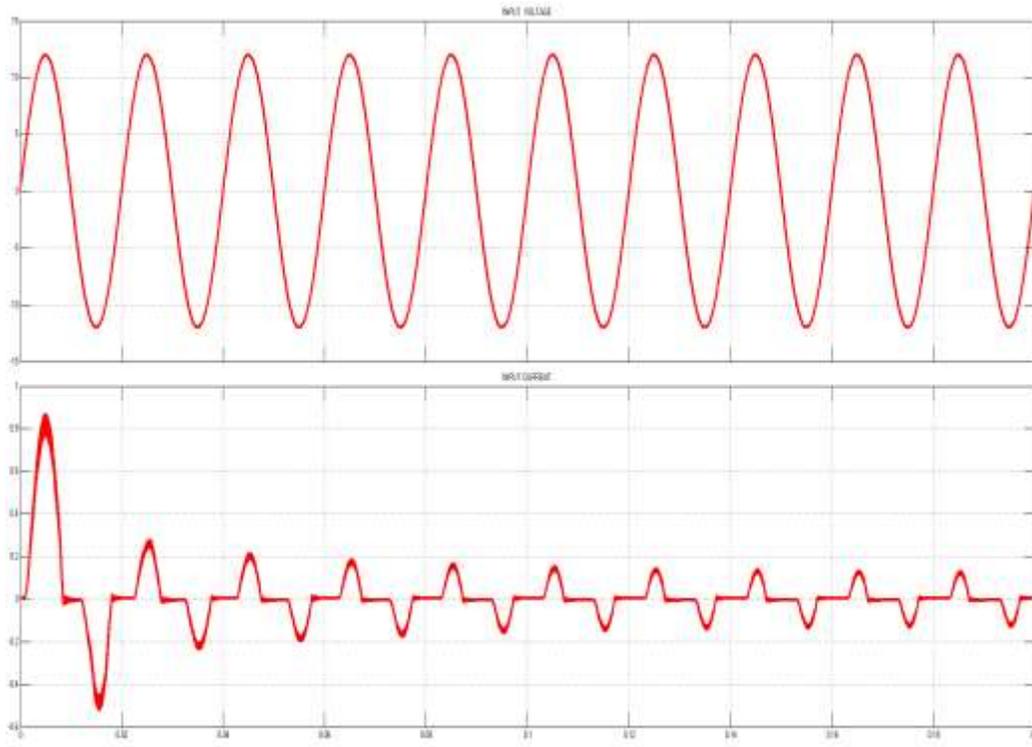
Fig.8 waveforms of input current and voltage of buck mode
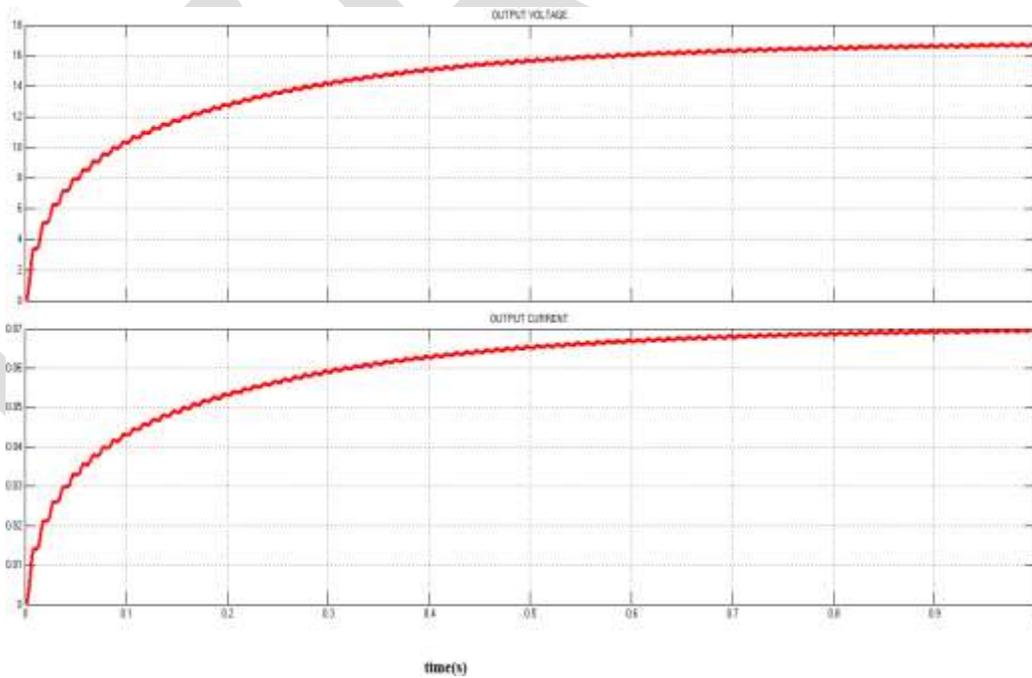
Fig.9. waveforms of output current and voltage of boost mode
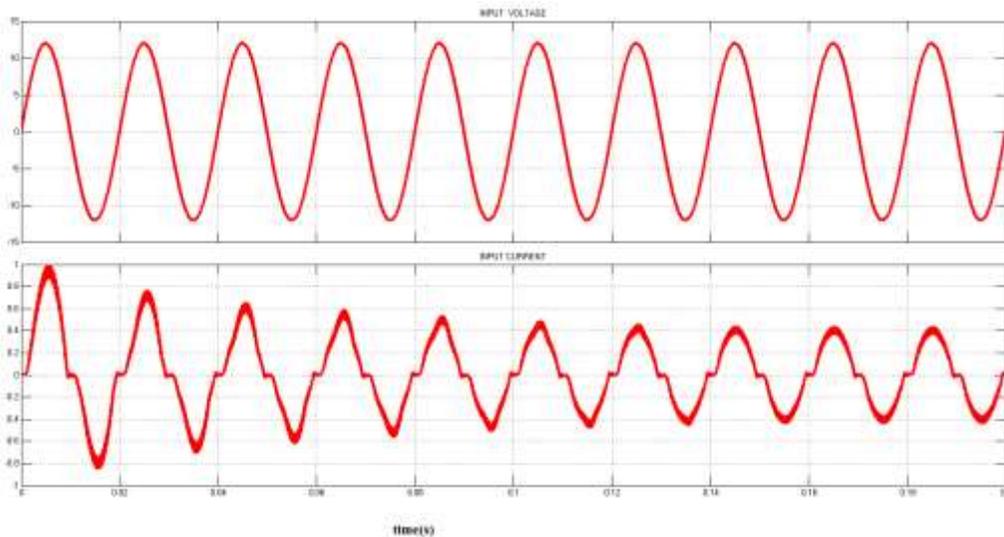
Fig.10. waveforms of input current and voltage of boost mode

HARMONICS IN INPUT CURRENT FOR BOOST MODE
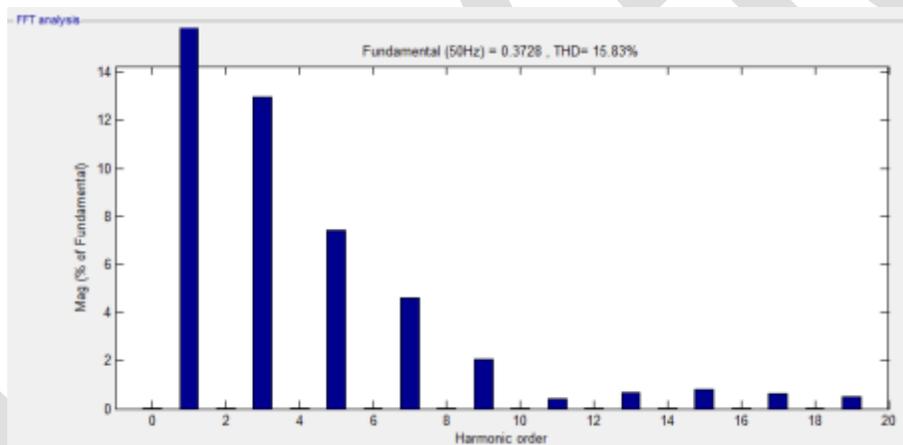
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CONCLUSION

   Non inverting buck boost topology is analyzed and stimulated. The proposed converter reduces no: of stages. Power factor is increased to 0.9982. THD is reduced to 15.07% in boost mode of operation than in buck mode of operation.

REFERENCES:

[1]   IEC 61000-3-2 International Standard. Limits for Harmonic Current Emissions, Third Edition. 2005-11.

[2]   T. Nussbaumer, K. Raggl, and J. W. Kolar, "Design Guidelines for Interleaved Single-Phase Boost PFC Circuits" IEEE Trans. On Industrial Electronics, vol. 56, no. 7, July 2009, pp. 2559-2573.

[3] S. Busquets-Monge, J.-C. Crebier, S. Ragon, E. Hertz, D. Boroyevich, Z. Gurdal, M. Arpilliere, D.K. Lindner, "Design of a Boost Power Factor Correction Converter Using Optimization Techniques", IEEE Trans. on Power Electronics, vol. 19, no. 6, November 2004, pp. 1388- 1396.

B. A. Canesin and F. A. S. Goncalves, "Single-phase High Power- Factor Boost ZCS Pre-regulator Operating in Critical Conduction Mode" in Proc. IEEE ISIE, June 9-11, 2003, pp. 746-751

[4] M. M. Jovanovic, D.M.C. Tsang, and F.C. Lee, "Reduction of Voltage Stress in Integrated High-quality Rectifier-regulators by Variable frequency Control," in Proc. IEEE APEC, February 13-17, 1994, pp. 569-575.

[5] D.S.L Simonetti, J. Sebastian, and J. Uceda, "Single Switch Three phase Power Factor under Variable Switching Frequency and Discontinuous Input Current," in Proc. IEEE PESC, June 20-24 1993, pp. 657-662.

[6] K. H. Liu and Y. L. Lin, "Current waveform distortion in power factor correction circuits employing discontiuous-mode boost converters," in Proc. IEEE PESC'89, 1989, pp. 825–829.

[7] Chen, D. Maksimovic, and R. Erickson, "Buck-Boost PWM Converters Having Two Independently Controlled Switches" in Proc. IEEE PESC, June 17-21 2001, pp. 736-74