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***Research Article***

# A NEW TWO SWITCH TOPOLOGY BUCK BOOST CONVERTOR IN UNIVERSAL INPUT PFC APPLICATION

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**ABSTRACT**
A detailed analysis of the operation and the component stresses in the BOIBB converter, as well as design guidelines and practical implementation techniques in universal-input PFC applications. Operating modes and basic steady-state characteristics of this converter and Operation of the BOIBB converter as a PFC rectifier together with an analysis of the switch and inductor stresses and conduction losses and also comparison with the converters, describes an experimental 100-W, 200-V dc output, universal-input BOIBB PFC rectifier, with experimental results shown over the universal-input ac line voltage range.

## INTRODUCTION

It is well known that the boost converter topology is highly effective in power factor correction (PFC) rectifier applications, provided that the dc output voltage is close to, but slightly greater than, the peak ac line voltage (Erickson and Maksimovi 2006). In universal-input applications, with the root-mean-square (RMS) input line voltage in the 90–260 V range, the output voltage of the boost converter has to be set to about 400 V. At low line (90 V), the switch conduction losses are high because the input RMS current has the largest value, and because the largest step-up conversion is required (Ned and Wiley, 2008). The inductor has to be oversized for the large RMS current at low line input, and for the highest volt–seconds applied throughout the input-line range (Agrawal, 2009). Boost converter designed for universal-input PFC applications is heavily oversized compared to a converter designed for a narrow range of input ac line voltages (Pressan, 2004). Furthermore, because of the large energy storage filter capacitor at the output, the boost converter has the inrush current problem that can only be mitigated using additional components (Sinha and Chandrakasan, 2008).

In universal-input PFC applications, the capability of providing both step-up and step-down conversion is attractive because the output dc voltage can be set to any value. However, conventional single-switch buck-boost topologies, including the buck-boost, fly back, SEPIC, and Cuk converters, (Uceda, 1997) have greatly increased component stresses and component sizes compared to the boost converter. In general, if their conversion characteristics meet the input/output specifications, the boost converter (for voltage step-up) or the buck converter (for voltage step-down) feature the smallest component stresses. This is a result of the direct energy transfer path from the input to the output in one of the switching subintervals in these two converter topologies. The boost and the buck converters require the minimum indirect energy delivery and therefore have the minimum component stresses for a given voltage conversion ratio. Based on this observation, it is of interest to investigate buck-boost converter topologies with two independently controllable switches that can operate as boost (for voltage step-up) or as buck (for voltage step-down) converters during portions of an ac line cycle (Rai, 2012).

In Buck boost converters for power-factor-correction (PFC), the universal-input capability. (Erickson, 2006) In this paper, we propose a new two-switch topology, boost-interleaved buck-boost (BoIBB) converter, which can offer significant performance improvements over single-switch buck-boost converters or other two-switch buck-boost converters in universal-input PFC applications. High efficiency (over 93%) throughout the universal-input ac line voltage range is demonstrated on an experimental 100-W, 200-V dc output and universal-input BOIBB PFC rectifier.

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**RESULTS AND DISCUSSION**

In contrast to the cascaded topologies, such as the converters where the buck and the boost converters are simply connected in series, in the BoIBB converter the boost.

Let $d_1$ and $d_2$ be the duty ratios of the switches $Q_1$ and $Q_2$ respectively. In continuous conduction mode (CCM) the volt – second balance relation for the two inductors the overall dc voltage conversion ratio M = V/ $V_g$ for the BoIBB converter.

$$M = d2 + \frac{d1}{(1-d1)}$$

(1)

The proposed boost-interleaved buck-boost (BoIBB) converter with two controllable switches ($Q_1$ and $Q_2$) is shown in Figure 1 If $Q_2$ is always on, $d_2 = 1$, $M = \frac{1}{(1-d1)}$ and the converter operates in the boost mode, which is shown in Figure 4(a). The average voltage across $C_1$ is zero. In this mode, the input current is divided through $L_1$ and $L_2$. If $Q_1$ is always off $d_1 = 0$, M = $d_2$ the converter operates in the buck mode, as shown in Figure 1. $L_1$ and C1 form a low frequency filter. The average current through and is zero and the voltage across C1 is equal to the difference between the input and the output voltage. The inductor in the $L_2$ buck mode has the same role as the inductor in the simple buck converter.

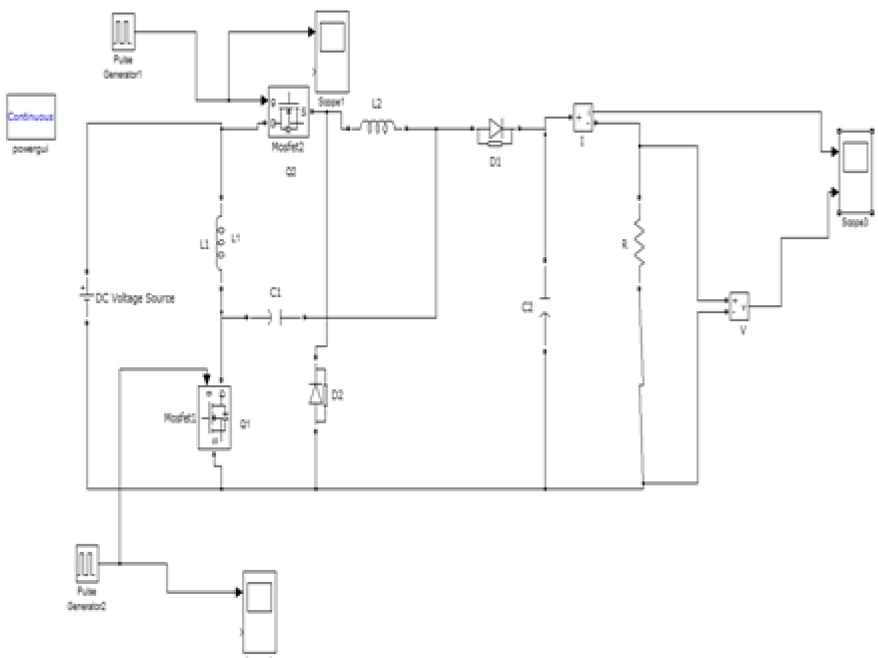


**Figure 1: Matlab diagram of Boost-interleaved buck-boost (BOIBB) converter**

***Operation of the Boibb Converter as Ideal Rectifier***

In this section, we analyze operation of the BoIBB converter as an ideal PFC rectifier. Expressions for the switch and the in- ductor RMS currents, and the volt-seconds applied to the inductors are derived, so that conduction losses and magnetic sizes can be evaluated. We also compare the total switch and inductor RMS currents of the BOIBB converter with the three converters shown in Figure 1. In PFC rectifier applications, the rectified input voltage is

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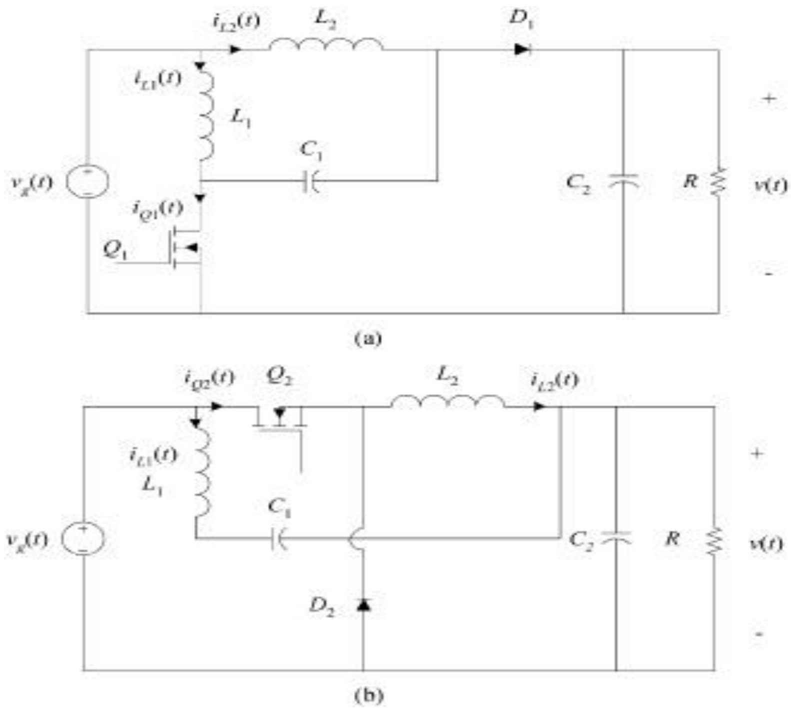


**Figure 2: Operating modes of the BOIBB converter**

$$Vg (t) = VM \mid \sin (\omega t) \mid \quad (2)$$

In an ideal PFC rectifier, the output voltage is regulated at a constant value V, and that input current $i_g(t)$ is proportional to the input voltage

$$i_g(t) = \frac{v_g(t)}{Re} \quad (3)$$

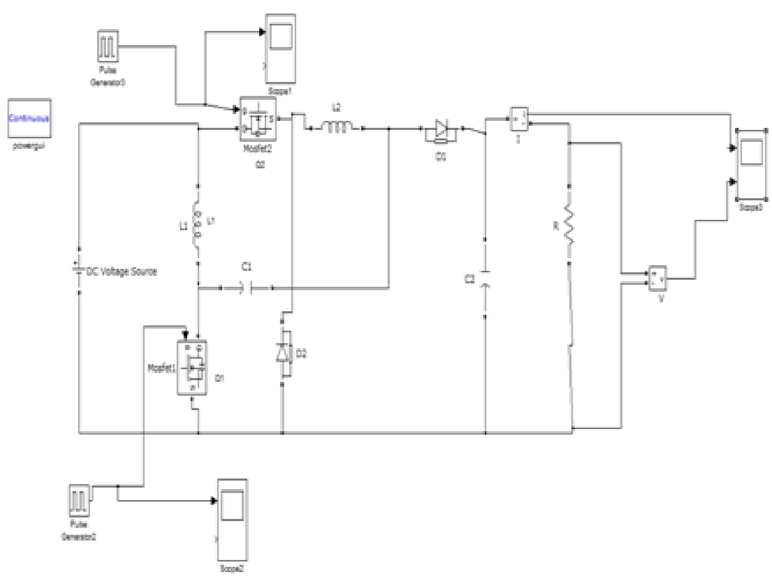


**Figure 3: BOIBB in boost mode operation**

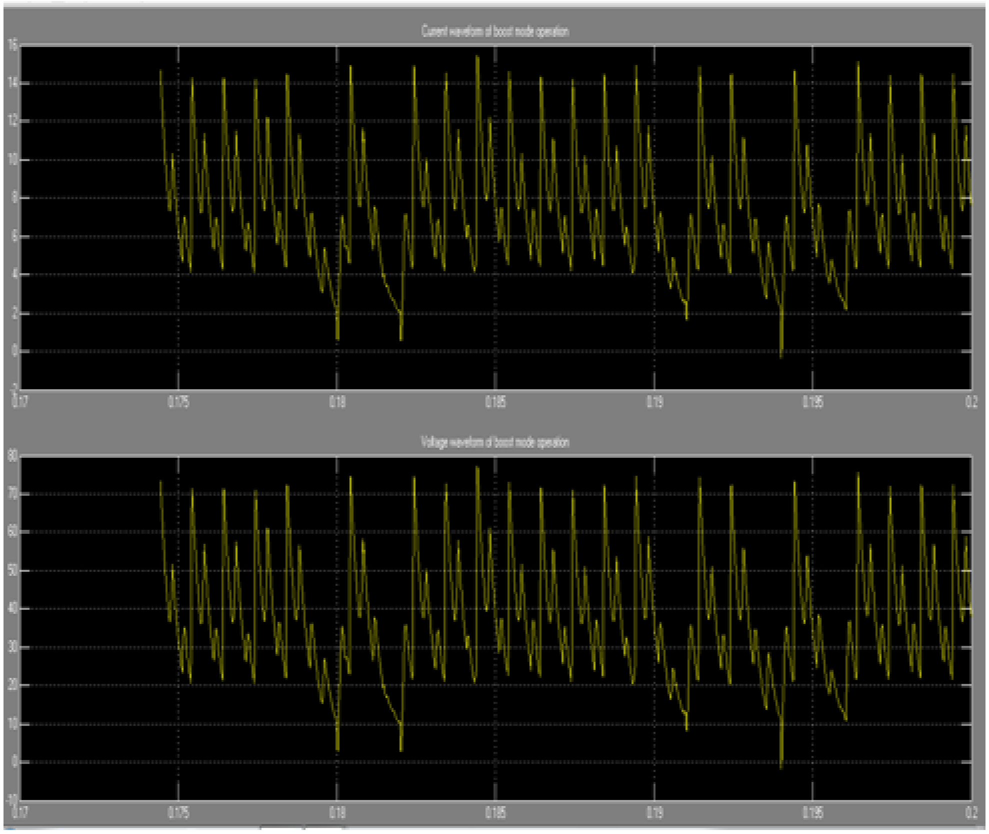

**Figure 4: BOIBB Current & Voltage waveform in boost mode operation**

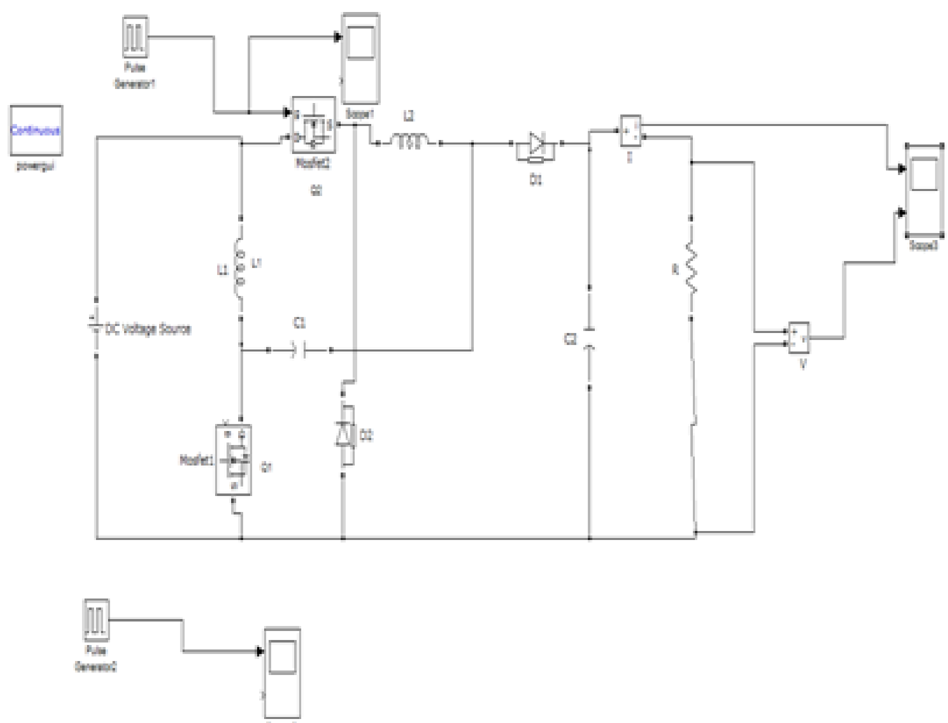

**Figure 5: BOIBB in buck mode operation**

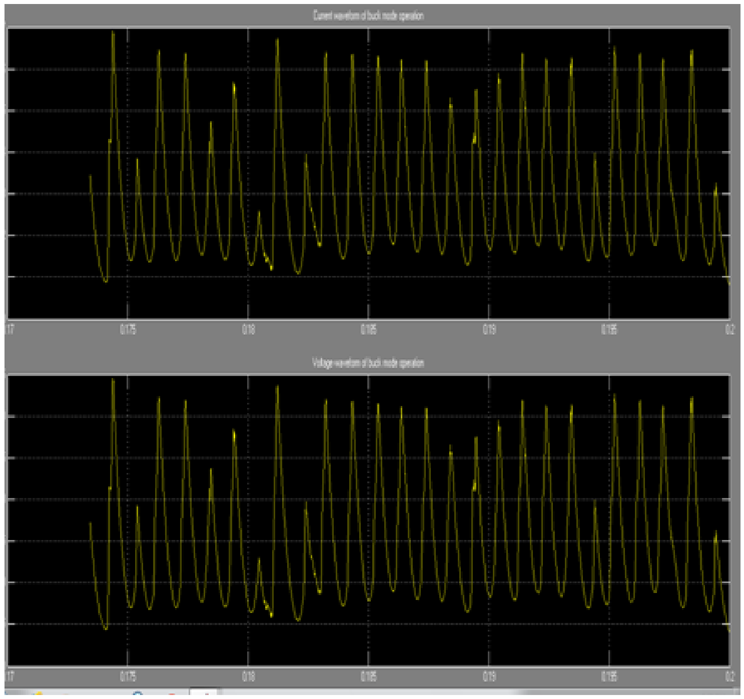

**Figure 6: BOIBB Current & Voltage waveform of boost mode operation**

***Analysis of Stresses***

***Boost Mode:*** In the time interval [0, $t_m$] as shown in Figure 7 the input voltage is lower than the output voltage, and the converter operates in the boost mode: the boost switch cell ($Q_1$ and $D_1$) is active, while the buck cell ($Q_2$ and $D_2$) is inactive ($Q_2$ is always on). In the case when the output voltage is higher than the peak of the input voltage, the converter operates in the boost mode always. In this case, the results of this section still apply. One only needs to replace $t_m$ with $T_{ac}/4$. The converter switching frequency is much higher than the ac line frequency.

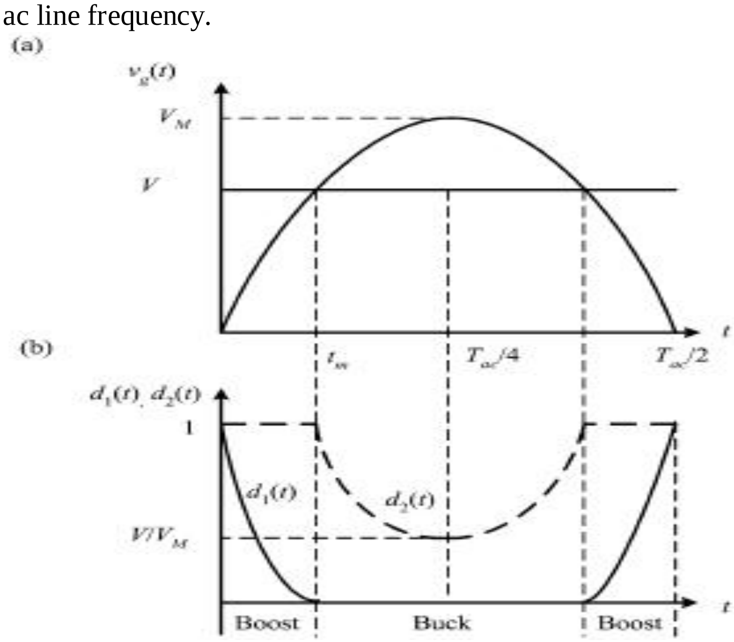


**Figure 7 (a): Waveforms of the rectified input voltage and the dc output voltage and (b): duty ratios of the boost and the buck cells in the BOIBB converter operated as an ideal PFC rectifier.**

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## CONCLUSION
Experimental results are provided to verify the validity of the new topology. High efficiency (over 93% throughout the whole ac line voltage range), and low current harmonic distortion at both high and low line inputs are demonstrated

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