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# Design And Implementation of High Power Factor Power Supply For Leds Based On Integrated Converter

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***Abstract :*** The Proposed converter consists of one switch, two inductors and two conductors. From ac mains,it is able to supply a lamp which is providing good efficiency, high power factor and less total harmonic distortion. In this paper, Linear Peak Current Mode Control (LPCMC) a control technique is presented which is a simplified power factor correction technique for single stage AC to DC converters. From the ac mains, the Integrated Double Buck Boost converter (IDBB) will power the LED lamps which provides low ripple current through LED, less total harmonic distortion and high power factor. Converter operation is equivalent to the cascade connection of two buck–boost converters, by using only one controlled switch between two stages. Converter operating in universal range of voltage (90V-230V), 50Hz has been designed and implemented using MATLAB/Simulink, results of this converter comply with international regulatory standards (IEC 6100-3-2 and IEEE 519-1992). Experimental results conform and validate the analysis.

***Keywords :*** IDBB converter, LED Lamp, Linear peak current mode control.

## 1. INTRODUCTION

LED is a semiconductor device which emits the visible light when current passes through it and it converts the electric current into light. The lamps are having good efficiency, mercury free and long lasting.LED gives control over light distribution with lenses or small reflectors and provides flexibility in lighting fixtures designing.

LED's cannot be supplied from direct ac or dc input voltage because of their constant-voltage behavior. In order to limit current through a discharge lamp a current-limiting device must be used similarly to the ballast. Under strict operating conditions only, the efficiency of power LEDs can be maintained high, which include low junction temperature and low direct current.[9]

An Integrated double buck–boost (IDBB) converter topology is proposed in this paper in order to supply LED lamps from ac mains by providing less ripple current, low total harmonic distortion and high power factor.

The operation of converter is equivalent to cascade connection of two buck–boost converters, at which only one switch is connected between the two stages. The proposed converter thus proposed includes two capacitors and two inductors which features good reliability and less cost for LED applications.

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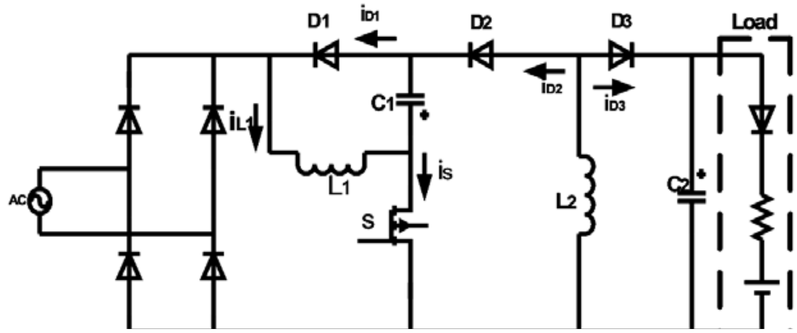


**Fig. 1. IDBB converter block diagram.**

In order to provide well- regulated drive current and to control the current through LED for different input voltage long lifetime LED drivers are required. These may also have specialized dimming control protocols to interface with building control systems. For this peak current mode control techniques is proposed.

The block diagram representation of an IDBB converter is shown in Fig.1. A diode rectifier is used which converts ac to dc, while according to its reference the controller will operates the switch properly to shape the input current.

## 2. CONVERTER DESIGN

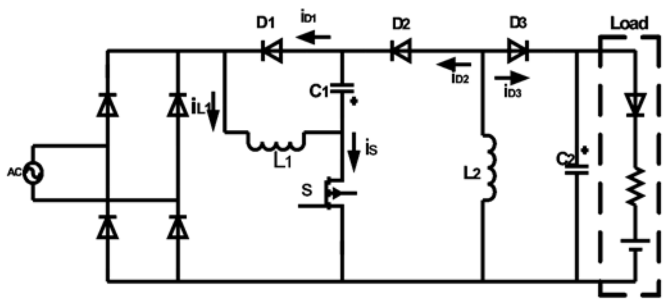


**Fig. 2. IDBB converter circuit diagram.**

The converter behaves as combination of the two buck–boost converters. By elements $L_1$, S,$D_1$ and $C_1$ the input side buck–boost converter is made and the output side buck–boost converter is made up of $L_2$, $D_2$, S, $C_2$, and $D_3$. Reversing polarity in capacitor $C_1$ in first converter can be corrected by means of second converter, which gives output voltage as positive with reference to ground which simplifies load current measurement for operation of closed loop, thus cost can be reduced.

In Discontinuous conduction mode (DCM) input inductor $L_1$ is operated at which the line voltage will be proportional to average current of the line, thus nearly a unity PF is providing .Inductance of output side $L_2$ can be operated either in DCM or continuous conduction mode. When it operates in DCM, even it is having the advantage of providing a bus voltage across $C_1$ independent of the duty cycle and output power, it requires a higher output capacitance value in order to obtain less ripple current through load.

For a reduced capacitance value at output, output inductor is operated in CCM. In addition, the low-frequency ripple voltage will be reduced by operating the second stage in CCM with a duty cycle below 0.5. The film capacitor which has high life rating compare to electrolytic capacitors are used as output capacitor.

## 3. ANALYSIS OF IDBB CONVERTER

Equivalent circuits for the proposed converter operation within specific switching interval are shown. Operation is explained in three intervals.

### 3.1. Interval I [0 < *t* < DT*s*]

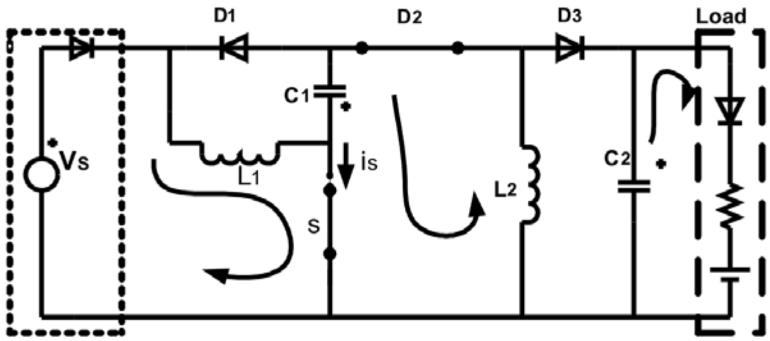


**Fig. 3(*a*). Equivalent Circuit of IDBB Converter in Interval I.**

In this interval, switch S is ON, the input inductor $L_1$ is charged to $VL_1$, such that $VL_1$ = Vs. At that time the capacitor $C_1$ is discharged through $L_2$ and $D_2$, such that $VL_2 = VC_1$ .And output voltage V0 is supplied by the output capacitor $C_2$

### 3.2. Interval II[DT*s* < *t* < (DT*s* + *t*1)]

In this interval S switch is turned OFF and through $D_1$ ,input inductor L1discharges to $C_1$. Through diode $D_3$ the charge saved in the output inductor $L_2$ is given to load and output capacitor $C_2$.

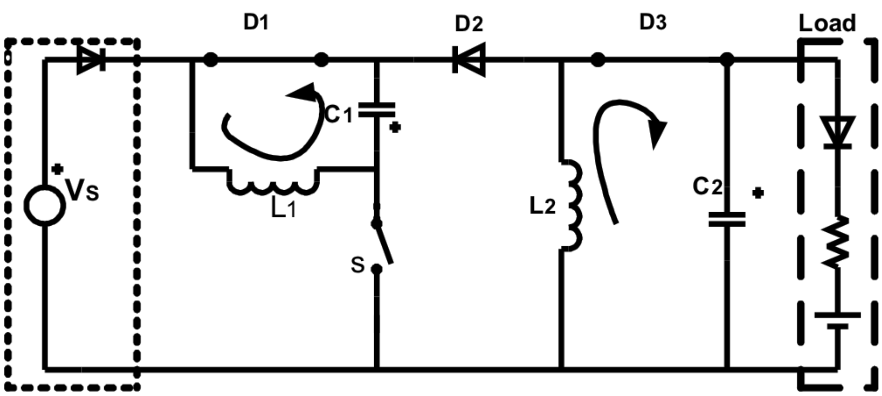


**Fig. 3(*b*). Equivalent Circuit of IDBB Converter in Interval II.**

### 3.3.INTERVAL III [$(DT_S + T_1) < T < T_S$]

In third interval switch S remain OFF. The input inductor $L_1$ completely discharges and the input inductor current becomes zero. The diodeis turned OFF. Through the diode, charge saved in output inductor $L_2$ is given to load and output capacitor $C_2$.

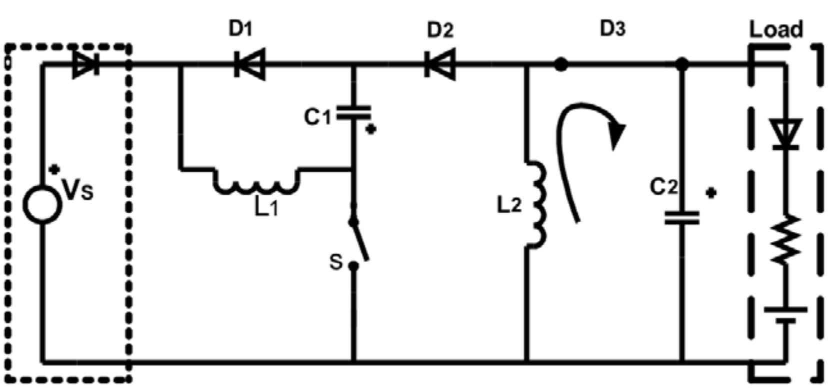


**Fig. 3(*c*). Equivalent Circuit of IDBB Converter in Interval III.**

## 4. DESIGN EXAMPLE

Input inductance L1can be calculated for a given output power as

$$L_1 = \frac{D^2 V_g^2}{4P_0 f_s} \tag{1}$$

In order to limit ripple of low-frequency the $C_1$ can be calculated as

$$C_1 = \frac{D^2}{8V_B \pi L_1 f_s f_L \Delta V_{B\_LF}} V_g^2 \tag{2}$$

$L_2$ and $C_2$ are calculated by using expressions of buck–boost converter

$$L_2 = \frac{DV_B}{0.5\,\Delta I_{L\_HF} f_s} \tag{3}$$

$$C_2 = \frac{DV_O}{\Delta I_{O\_HF} f_s} \tag{4}$$

Where $\Delta IL_{O\_HF}$ represents peak-to-peak ripple current of high-frequency, IO is load current and $\Delta V_{O\_HF}$ is peak-to-peak output ripple voltage of high-frequency,.

At 230V rms line voltage and with a frequency of 50-Hz. The load current is 350 mA, for 70 W output power. By assuring constant current through the load, the converter must admit line voltage variation of 10%. By selecting 40% of duty cycle for nominal operating point, by using above formulae the parameters are calculated.

| | | |
|---|---|---|
| Switching frequency | = | 50 kHz |
| Input Inductance Li | = | 2.5 mH |
| Input Capacitance C1 | = | 80µF |
| Output inductance L0 | = | 9mH |
| Output capacitance Co | = | 40µF |
| Load Resistance R | = | 570 Ω |
| Equivalent voltage of LED load Vγ | = | 170 V. |

## 5. CONTROL STRATEGY FOR THE INTEGRATED DOUBLE BUCKBOOST CONVERTER

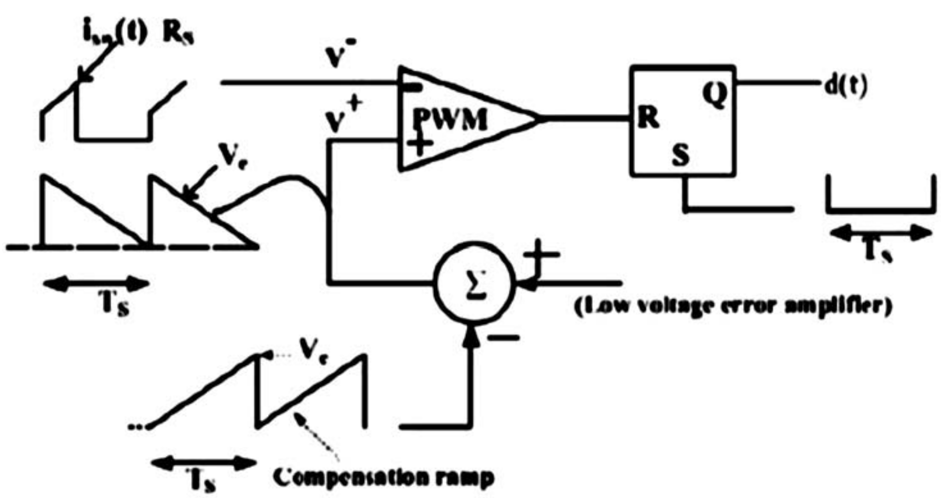


**Fig. 4. Implementation of linear peak current mode control.**

In order to eliminate sub harmonic oscillations the usual control technique in CCM is by using a current control loop with a compensating ramp and to gain stability consequently [3]. In this Control to ensure the stability of feedback loop and to obtain PF correction a compensating ramp issued.

In this control technique a current loop is designed whose gain is dependent upon the off duty-cycle of switch linearly. Thus, the input voltage is proportional to the gain of the current loop and current loop inherently controls the current through inductor. Reference current is obtained by multiplying a gain is set by the controller output of the voltage error amplifier which subtracts from the compensated ramp. Fig. 5 Shows LPCM implementation [4].

The advantages of Linear Peak Current Mode Control technique is it eliminates the controller multiplier,implementation is easy by using less cost PWM control current loop unconditional stability and input voltage sensing circuits.

## 6. SIMULATION RESULTS

For the proposed converter simulation, parameters of different circuit components are taken as:

Input power factor is as shown in the fig 5.

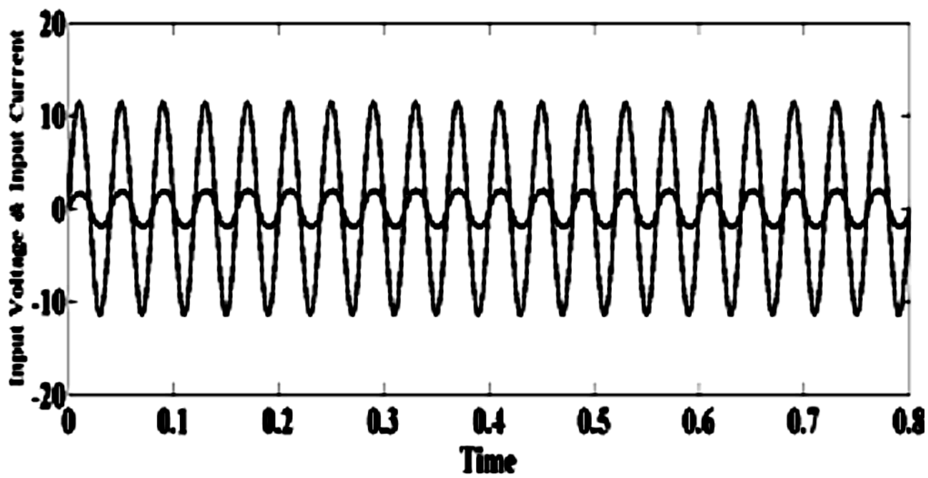


**Fig. 5. Power Factor representation.**

The output current and voltage waveforms when peak current mode applied are as shown in the fig 6 and fig 7.

For 230*v* supply voltage output voltage, output current waveforms are as shown in fig 6*a* and fig 6*b*.

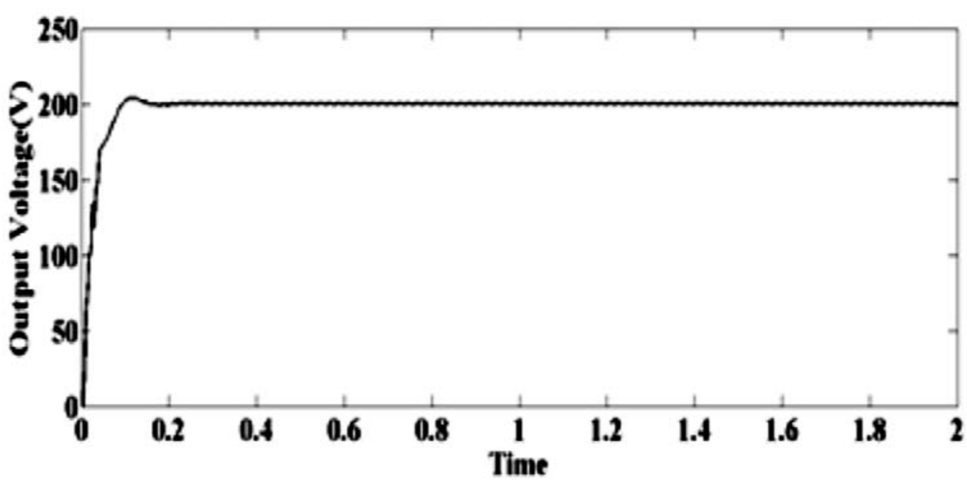


**Fig. 6(*a*). Output voltage at 230*v* supply voltage.**

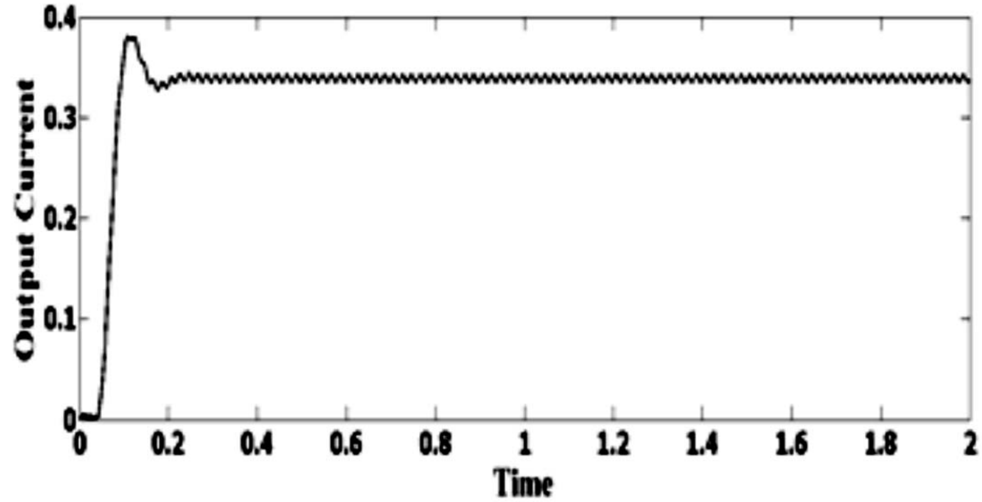


**Fig. 6(*b*). Output current at 230*v* supply voltage.**

For 190v supply voltage the output voltage ,output current waveforms are as shown in the fig 7*a* and fig 8*b*

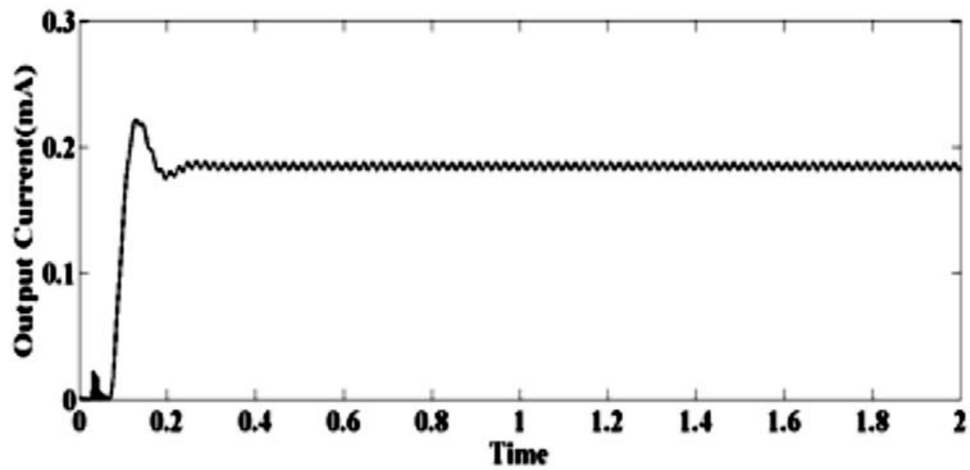


**Fig. 7(*a*). Output current at 190*v* supply voltage.**

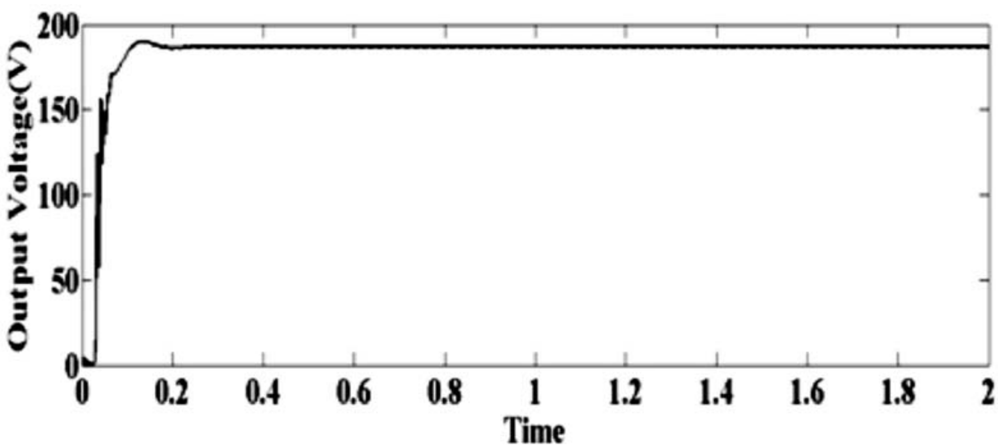


**Fig. 7(*b*). Output voltage at 190*v* supply voltage.**

The THD of IDBB converter for peak current control mode for 230v and 190vare shown in the fig8 and fig9

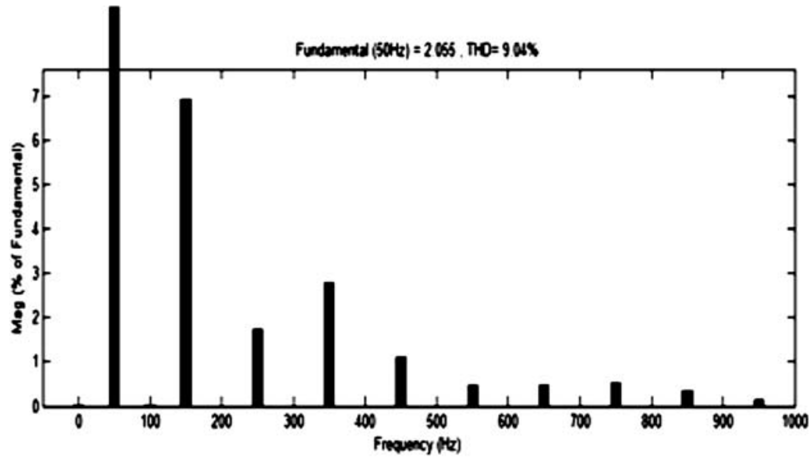


**Fig. 8. THD representation for 230*v* supply voltage.**

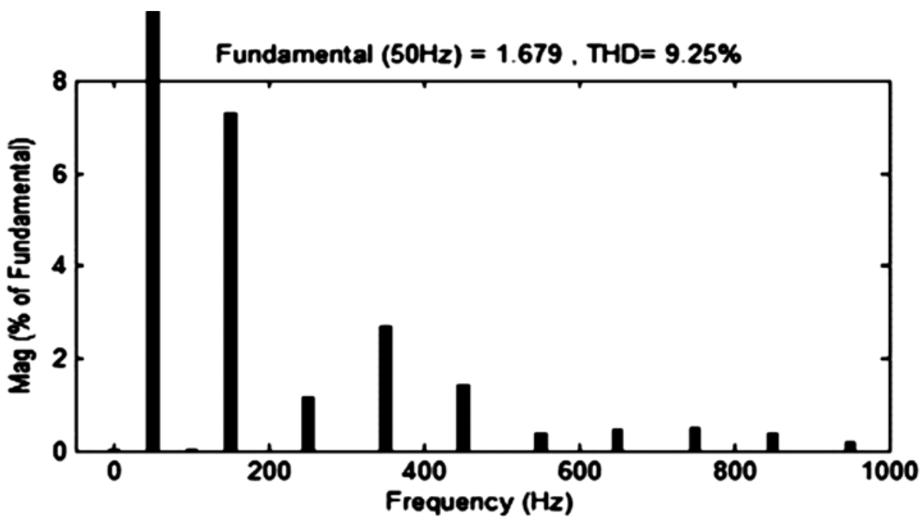


**Fig. 9. THD representation for 190*v* supply voltage.**

## 7. EXPERIMENTAL RESULTS

Hardware setup was implemented in the laboratory as shown in the Fig. 10 to investigate the performance of the proposed controller for the IDBB converter. Fig.11 and Fig.12 shows the source voltage and current waveforms at supply voltage of 230V, 50Hz at rated load.In Fig. 13 is the pulse signal generated from the Linear peak current controller to the control switch used in IDBB converter

**Fig. 10. Hard ware model of LPCM controlled IDBB Converter.**

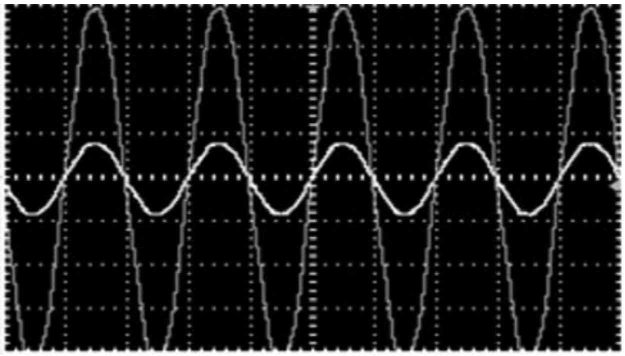

Fig. 11. Input Voltage and Current.

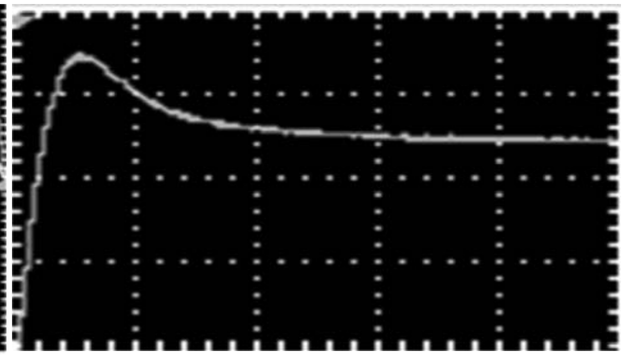

Fig. 12. Load Voltage.

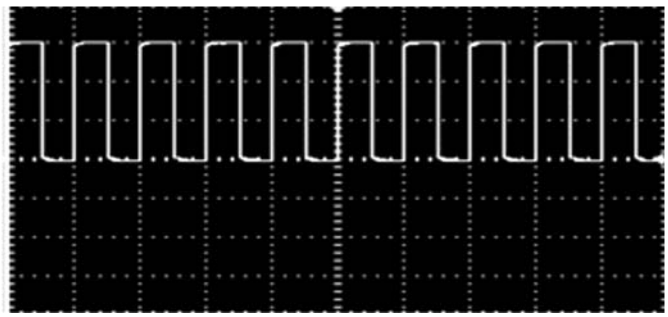

Fig. 13. Pulse Signal.

The variation of output voltage $V_0$, output current Io, THDwith respect to different supply voltages for peak current mode control is as shown in the tabular form 1

**Table 1. For Linear Peak Current Mode control.**

| V | 190 | 200 | 210 | 220 | 230 |
|---|---|---|---|---|---|
| $V_O$ | 186.6 | 190 | 193.5 | 197 | 200.6 |
| $I_O$ | 0.18 | 0.22 | 0.26 | 0.301 | 0.341 |
| THD | 9.25 | 9.20 | 9.15 | 9.09 | 9.04 |

Variation of THD for different supply voltages are as shown in fig 11

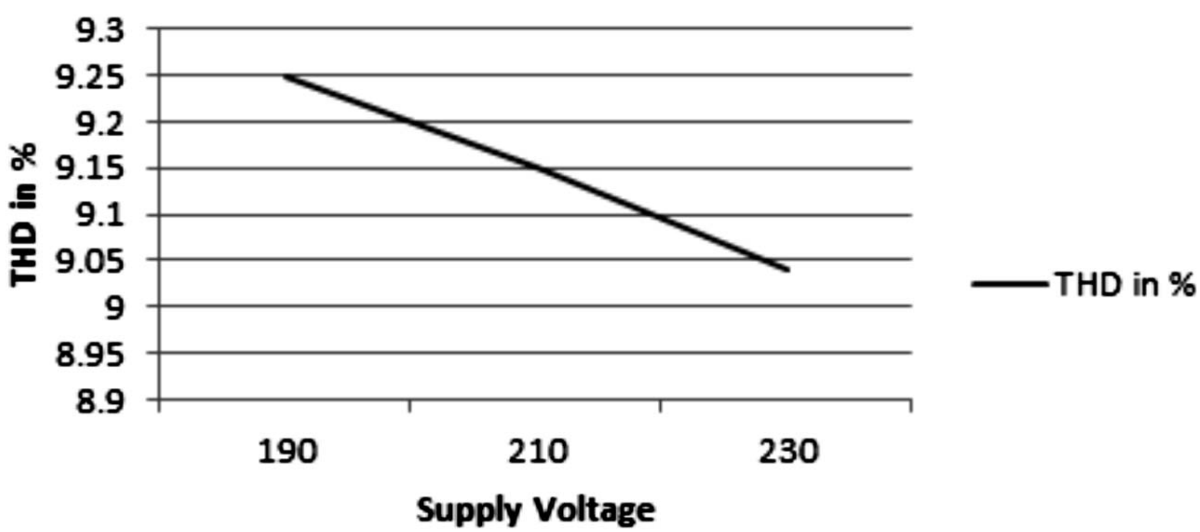


Fig. 14. Variation of THD for peak current mode control.

Variation of Power factor for different supply voltages are as shown in fig 15

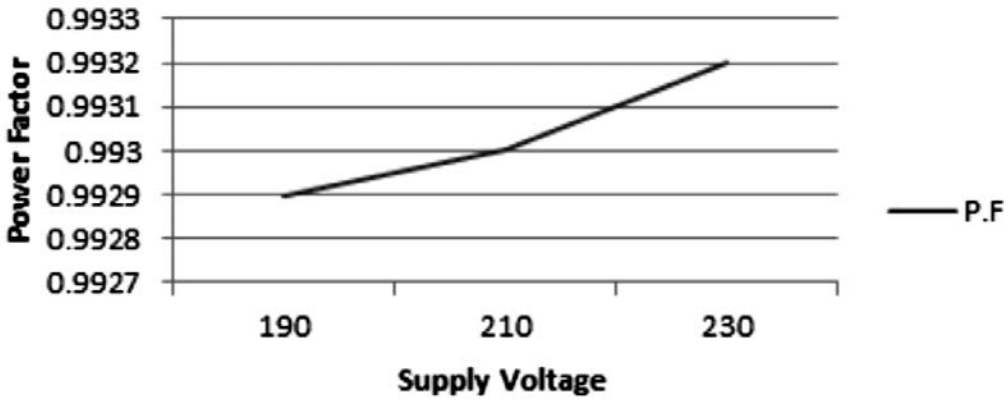


**Fig. 15. Variation of power factor for peak current mode control.**

## 6. CONCLUSION

The Integrated Double Buck- Boost Converter has been proposed for LED lighting applicationsin order to supply power to them. Two buck– boost convertersareconnected by means of only one switch. A high PF at input can be obtained by operating converter at input stage inDCM.Low LED ripple current can be obtained by operating the second stage in CCM without using a high output capacitance value. By using only film capacitors the converter can be implemented and avoided the use of electrolytic capacitors. It increasesmean time of converter between failures. Thus proposed converter with the linear peak control technique can provide low total harmonic distortion and high power factor.The proposed control scheme applied to the converter and implemented in MATLAB/ Simulink tool, their performance was evaluated both in steady state and dynamic conditions. Experimental results validate the satisfactory with simulation results.

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