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DESIGN OF A PWM BASED BUCK BOOST DC/DC CONVERTER WITH PARASITIC RESISTANCE SUITABLE FOR LED BASED UNDERGROUND COALMINES LIGHTING SYSTEM

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Abstract

This paper develops a light emitting diode (LED) driver circuit based on buck-boost converter including parasitic resistance. The efficiency and ripple calculation of the buck boost converter and whole system has been obtained by considering parasitic resistance of the component because the resistance of an LED varies with temperature, making the circuit unstable. The forward bias of the LED used was 3.0V~4.5V, and the forward current was 0.6A. An array of five and eight white-light LEDs were driven as per the proposed circuit. In an LED only 15% to 25% of electrical energy is converted into light; the rest is converted into heat, which increases its temperature. In some typical application like designing of lighting system for underground coalmines this change in resistance can cause hazardous effect. Hence, LED must be operated at constant current for constant illumination for at least 10-12 hours without failure. Therefore, a closed-loop control system has been designed in this paper to increase output voltage stability. It has been observed that at 600mA and at 12V LEDs are operated efficiently. The driver circuit is operated in continuous buck-boost mode and the results are then simulated using PSIM software.

Keywords: Buck-Boost, PWM ,MATLAB, PSIM, LED

I. INTRODUCTION

In general the power management of a LED can be divided into two main parts, namely, optimization of LED light output and efficient supply of power to the LED's. First, based on the LED characteristics and LED configuration different level of brightness could be obtained for the same amount of power. Hence, the term Luminous Efficiency which is defined as the ratio of luminous flux emitted from a light source to the electric power consumed by the source plays an important role governing overall efficiency. Second, an efficient conversion of the limited battery power to the useful form for LED's to emit proper amount of light is of significant importance. This conversion of power is often achieved using voltage regulators as LED drivers and present enormous system and circuit level issues which have been a topic of interest to the researchers [1][2][3]. In general, LED luminance is found to be directly proportional to its drive current [4] and hence in some applications like backlight, and flash the desired LED brightness is achieved by controlling the LED drive. Under the condition where desired brightness cannot be obtained using a single LED, additional LEDs can be placed either in parallel or series [5]. Low power LED has been used for battery powered applications for decades [6][7][8]. These applications include cell phone handsets, digital still cameras, automotive lighting, emergency lighting, and LCD backlighting, and so on. With the advancement of new materials and manufacture process, a new lighting source, that is, high brightness white (HBW) LED is now attracting more and more attention from both academia and industry [9][10][11][12].This arrangement of multiple LEDs plays a significant role in defining the amount of current drained from the battery. In case of underground coalmines mine workers are very much dependent on visual cues to recognize underground mining hazards. On the other hand, illumination plays a critical role in miners' safety. Some hazards are located in the miners' peripheral field-of-view off-axis (10° to about 60°) or on-axis (0°)[13]. Closed-loop buck-boost converter for driving LED has been designed in which output voltage of 48 V has been maintained and it is independent of input voltage and load change[14].

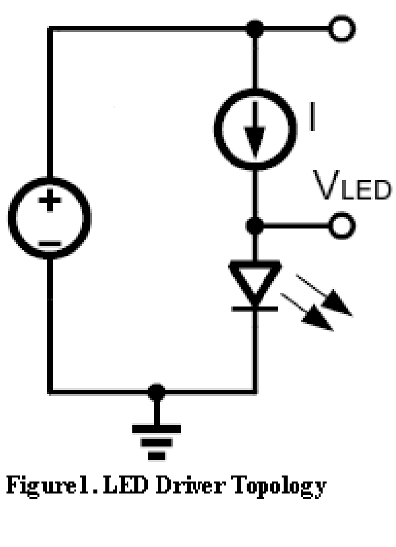

Figure1. LED Driver Topology

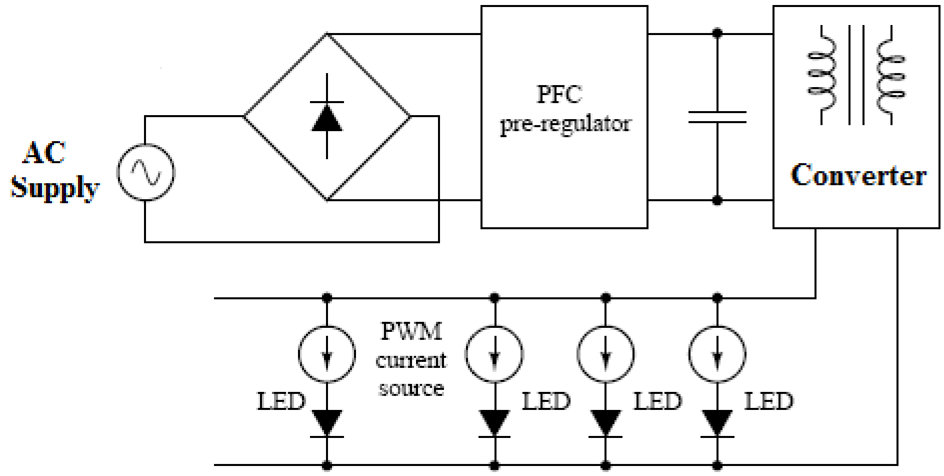

Figure 2. Load Current regulated driver circuit for LED with Power Factor Correction

Fig.1 shows the simplest and the most basic LED driver. Fundamentally, a constant current is provided directly to the LED from the battery. However, this LED driver suffers from several drawbacks. First, in order to provide output current, I, the architecture requires the battery voltage to be always greater than the LED forward voltage plus the minimum headroom voltage required to support the current source. Second, efficiency of the driver decreases as the difference between the battery voltage, V_{in}, and the LED forward voltage, V_{LED}, increases. This difference is dissipated as the headroom across the current source. Figure 2 shows a PWM based driver circuit for LEDs with load current regulated.

2. CLOSED LOOP BASED SYSTEM FOR DRIVING LED

As per the recent literature survey [15] it has been suggested by the authors that as shown in figure 3, PWM based buck boost converter having higher stability is most suited for driving LED in case of a typical environment like underground coalmines. In this paper result has been observed for the proposed system[15]. By using MATLAB Simulink model has been developed for closed loop system. In the developed model MOSFET has been used as switching device because that is suitable for low power application and capable to operate at higher frequency. Figure 4 shows the developed model for the complete system.

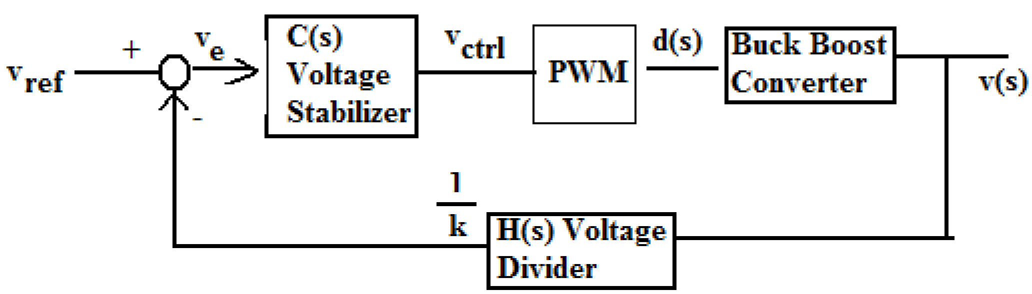

Figure 3 : Block Diagram of closed loop buck boost based control system

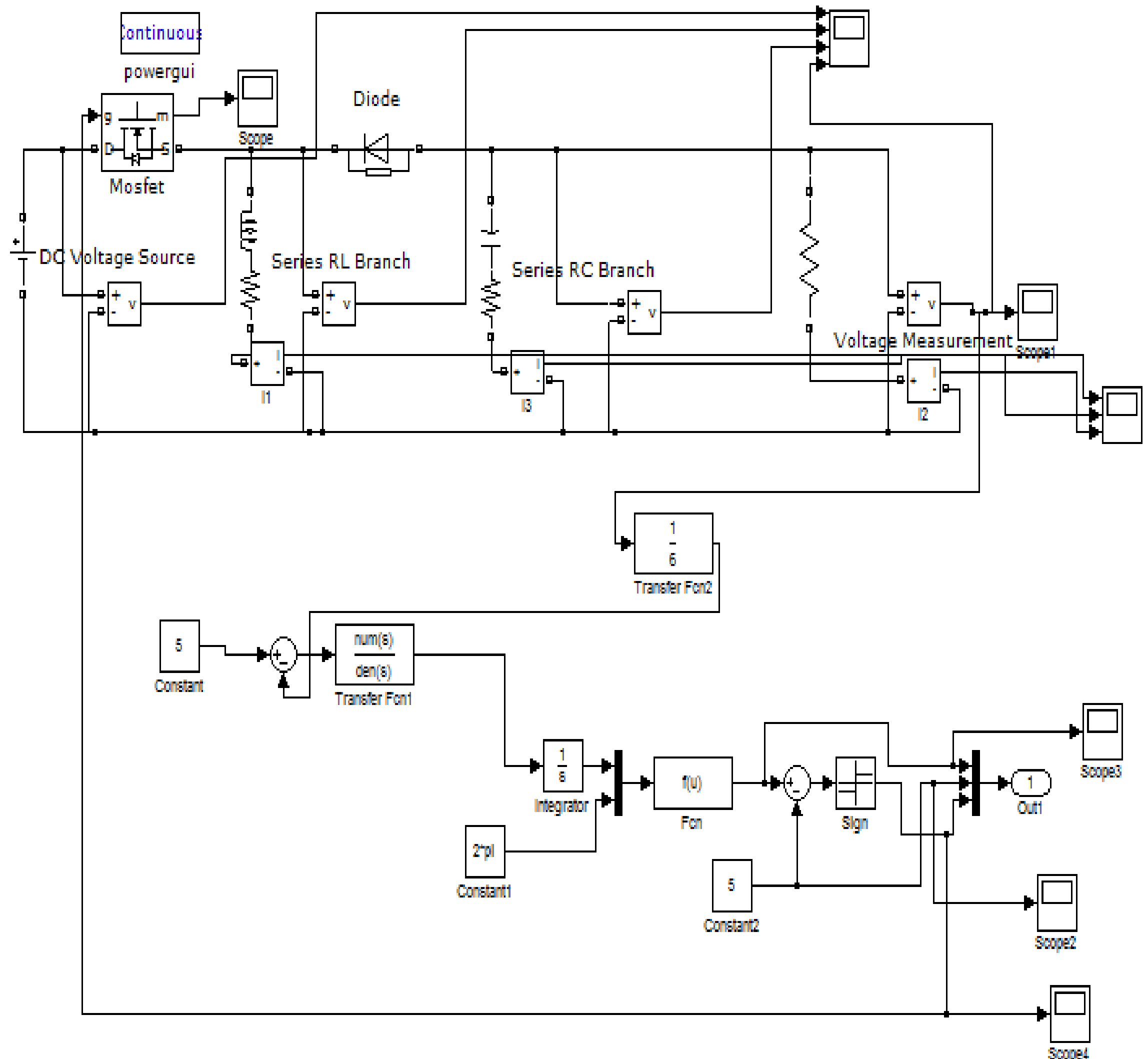

Figure 4 : Simulink model of proposed scheme

3. RESULT AND DISCUSSION

After simulation result has been observed and tabulated as per table 1 to table no.4. Mosfet has been switched on and off by PWM based circuitry at different duty cycle so that LEDs can be operated at constant illumination. Figure 5 to figure 10 shows the different result obtained by MATLAB. Figure 11 to figure 15 shows the result simulated by PSIM for variation in load and variation in supply voltage and it has been observed that by closed loop system requirements for constant illumination of LEDs has been maintained.

Table 1: For array of five LEDs [without controller (duty cycle = 70%)]

Sl. No.	Input voltage (volts)	Input current (amp)	Inductor current (amp)	Capacitor current (amp)	Load current (amp)	Output voltage (volts)	Voltage ripple (%)	Current ripple (%)	Effici-ency (%)
1	8.0	1.90	1.90	-1.25	-0.60	12.0	0.0233	0.00336	68.0
2	8.5	2.00	2.00	-1.35	-0.65	13.5	0.0233	0.00343	73.7
3	9.0	2.15	2.15	-1.45	-0.70	14.0	0.0233	0.00378	72.3
4	9.5	2.25	2.25	-1.50	-0.75	15.0	0.0233	0.00400	75.2
5	10.0	2.40	2.40	-1.60	-0.75	15.5	0.0233	0.00406	69.2
6	10.5	2.50	2.49	-1.70	-0.80	16.5	0.0233	0.00427	71.8
7	11.0	2.65	2.60	-1.75	-0.85	17.5	0.0233	0.00450	73.0
8	11.5	2.75	2.75	-1.80	-0.90	18.0	0.0233	0.00480	73.2
9	12.0	2.85	2.85	-1.85	-0.95	18.5	0.0233	0.00520	73.4
10	12.5	2.95	2.95	-1.90	-1.00	19.0	0.0233	0.00545	73.6
11	13.0	3.10	3.10	-2.05	-1.00	20.0	0.0233	0.00550	71.0
12	13.5	3.20	3.25	-2.15	-1.05	21.0	0.0233	0.00560	73.0
13	14.0	3.35	3.25	-2.20	-1.10	22.0	0.0233	0.00588	73.7
14	14.5	3.45	3.40	-2.25	-1.15	23.0	0.0233	0.00610	75.5
15	15.0	3.60	3.50	-2.30	-1.20	24.0	0.0233	0.00630	76.2

Table 2: For array of five LEDs [with controller]

Sl. No.	Input voltage (volts)	Input current (amp)	Inductor current (amp)	Capacitor current (amp)	Load current (amp)	Output voltage (volts)	Voltage ripple (%)	Current ripple (%)	Effici-ency (%)
1	8.00	1.90	1.90	-1.25	-0.6	-12	0.0233	0.00336	68.0
2	8.25	1.75	1.75	-1.15	-0.6	-12	0.0226	0.00368	73.3
3	8.50	1.80	1.75	-1.15	-0.6	-12	0.0226	0.00370	69.2
4	8.75	1.70	1.70	-1.05	-0.6	-12	0.0220	0.00390	73.3
5	9.00	1.70	1.70	-1.05	-0.6	-12	0.0220	0.00410	71.3
6	9.50	1.55	1.55	-0.90	-0.6	-12	0.0210	0.00440	77.6
7	10.0	1.45	1.45	-0.85	-0.6	-12	0.0203	0.00470	81.4
8	10.5	1.45	1.45	-0.85	-0.6	-12	0.0200	0.00504	78.8
9	11.0	1.38	1.35	-0.75	-0.6	-12	0.0193	0.00530	81.7
10	11.5	1.38	1.35	-0.75	-0.6	-12	0.0190	0.00560	79.6
11	12.0	1.30	1.30	-0.70	-0.6	-12	0.0180	0.00590	84.0

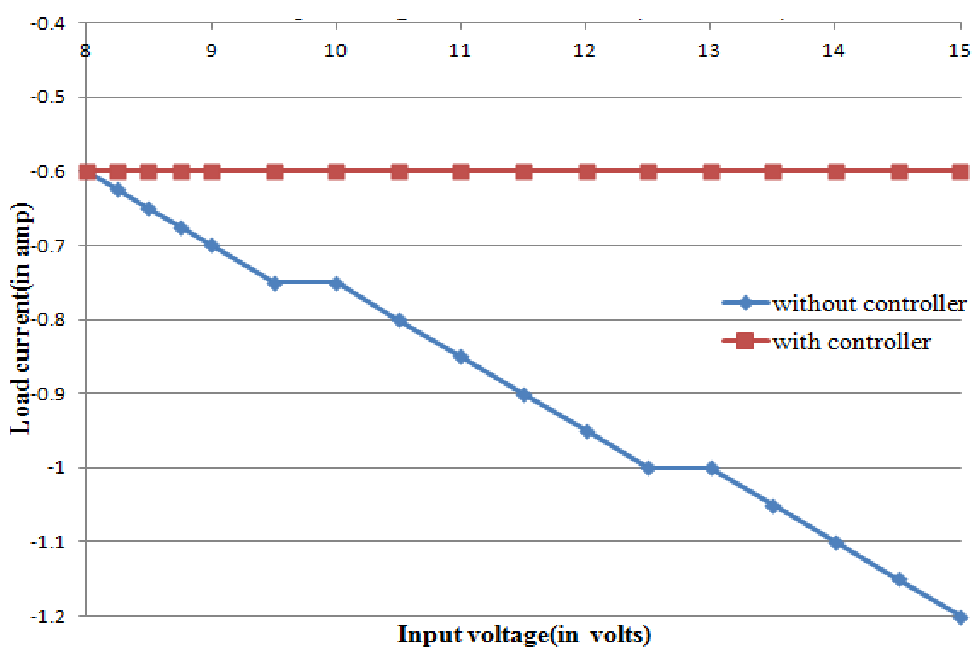

Figure 5 : Input Voltage Vs. Load Current with and without controller for array of five LEDs

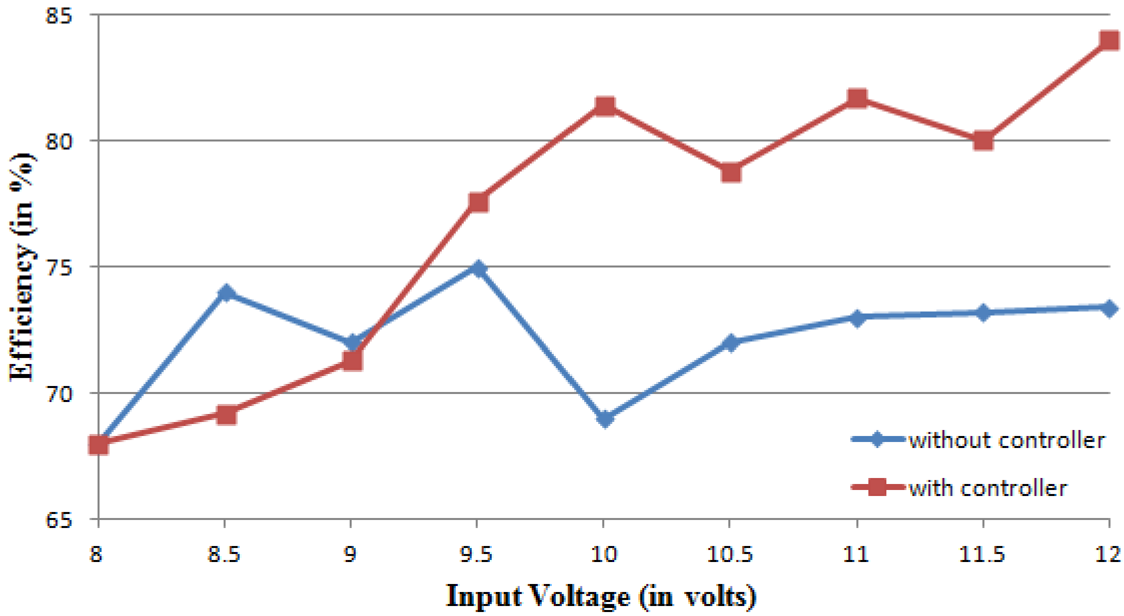

Figure 6: Input Voltage Vs. efficiency with and without controller for array of five LEDs

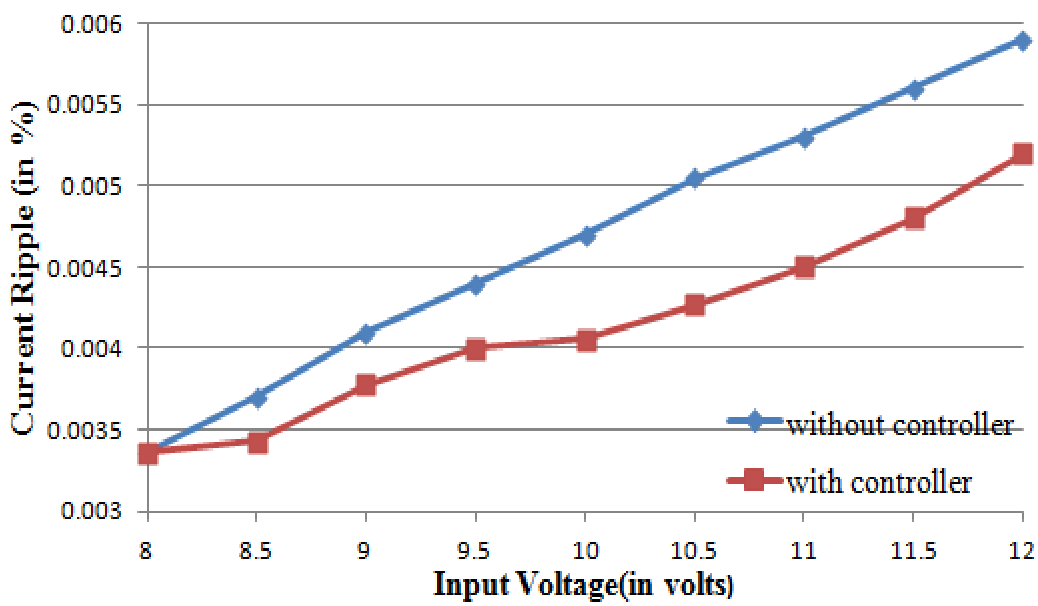

Figure 7: Current ripple vs input Voltage for array of five LEDs with and without Controller.

Table 3: For array of eight LEDs [without controller (duty cycle = 70%)]

Sl. No.	Input voltage (volts)	Input current (amp)	Inductor current (amp)	Capacitor current (amp)	Load current (amp)	Output voltage (volts)	Voltage ripple (%)	Current ripple (%)	Efficiency (%)
1	8.00	1.48	1.45	-1	-0.45	-13.5	0.0155	0.00336	73.3
2	8.25	1.55	1.50	-1.02	-0.48	-14	0.0155	0.00356	75
3	8.50	1.575	1.55	-1.075	-0.5	-14.5	0.0155	0.00369	77.36
4	9.00	1.7	1.70	-1.15	-0.52	-15	0.0155	0.00393	72.8
5	9.50	1.75	1.75	-1.2	-0.55	-16.5	0.0155	0.00400	78
6	10.0	1.82	1.8	-1.25	-0.575	-17	0.0155	0.00426	76.7
7	10.5	1.86	1.85	-1.3	-0.6	-18	0.0155	0.00441	79
8	11.0	2	2	-1.35	-0.65	-19	0.0155	0.00474	80.2
9	11.5	2.2	2.15	-1.4	-0.7	-20	0.0155	0.00507	79
10	12.0	2.3	2.2	-1.5	-0.72	-20	0.0155	0.00544	74.5

Table 4: For array of eight LEDs [with controller]

Sl. No.	Input voltage (volts)	Input current (amp)	Inductor current (amp)	Capacitor current (amp)	Load current (amp)	Output voltage (volts)	Voltage ripple (%)	Current ripple (%)	Efficiency (%)
1	8	2.75	2.75	-2.15	-0.6	-18.5	0.0267	0.00249	63
2	8.25	2.5	2.5	-1.85	-0.6	-18.5	0.0260	0.00275	69
3	8.5	2.45	2.4	-1.75	-0.6	-18.5	0.0256	0.00290	69.2
4	9	2.25	2.25	-1.65	-0.6	-18.5	0.0250	0.00330	73
5	9.5	2.15	2.1	-1.5	-0.6	-18.5	0.0240	0.00360	74.4

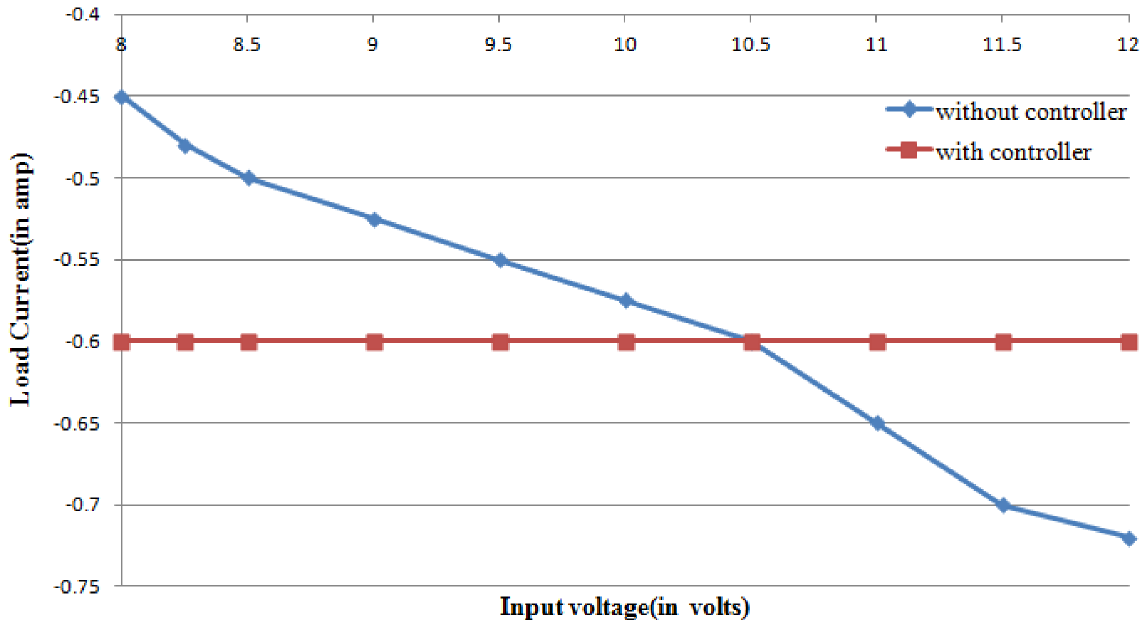

Figure 8 : Input Voltage vs Load Current for array of eight LEDs with and Without controllers

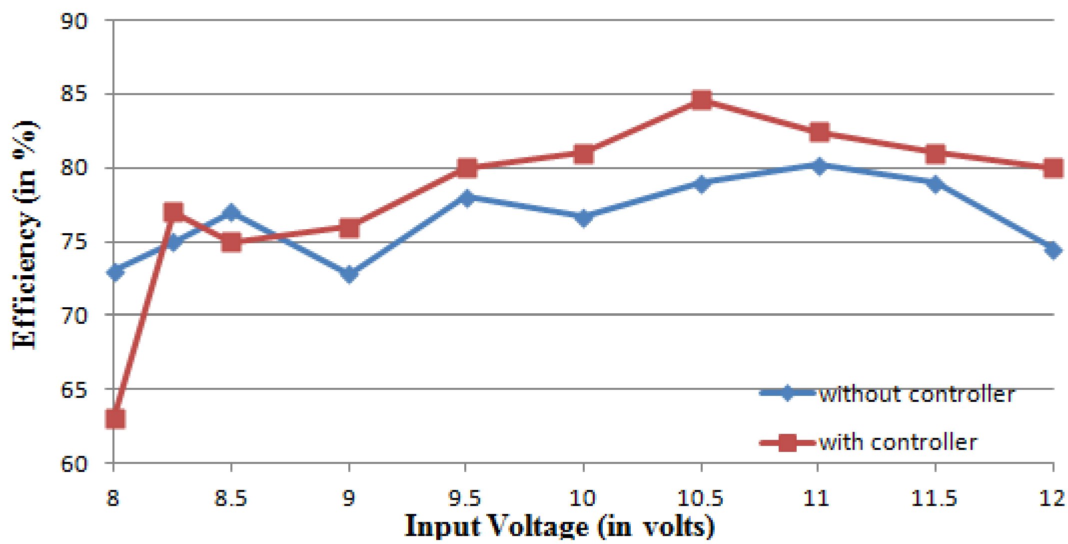

Figure 9: Input Voltage Vs Efficiency for array of eight LEDs with and without controller

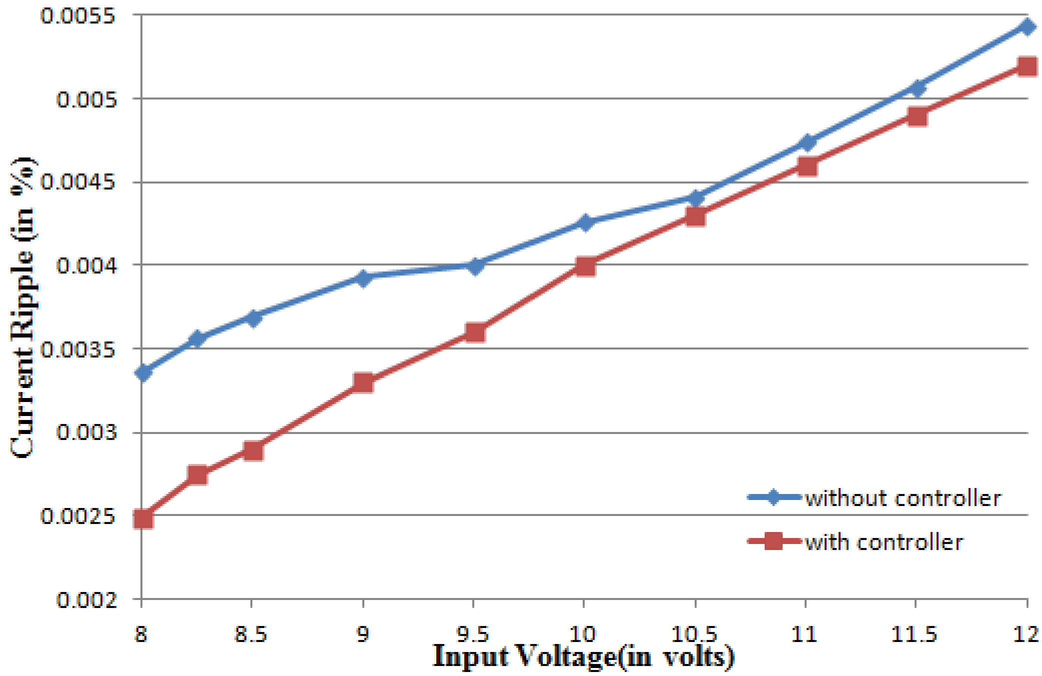

Figure 10 Input Voltage vs current ripple for array of eight LEDs with and without controller

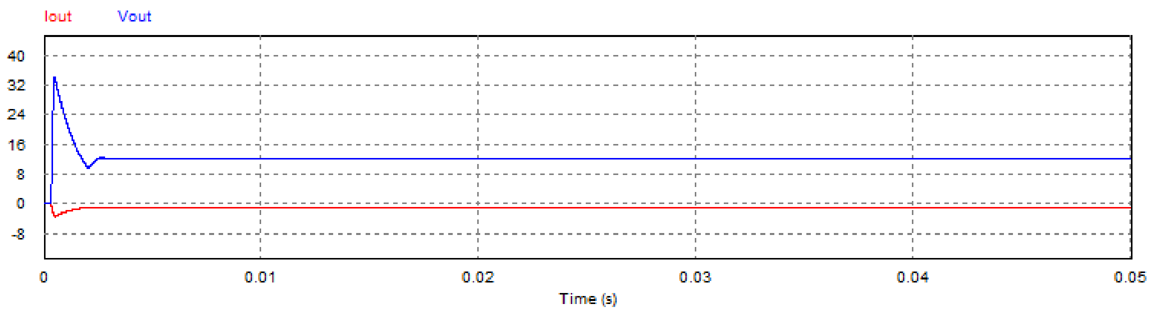

Figure 11. Simulated waveform at load resistance 10 ohm and Supply voltage 12 V

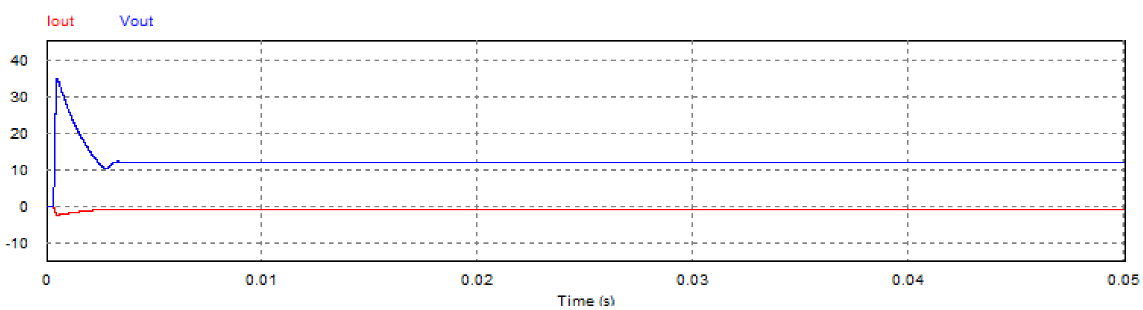

Figure 12. Simulated waveform at load resistance 15 ohm and supply voltage 12 V

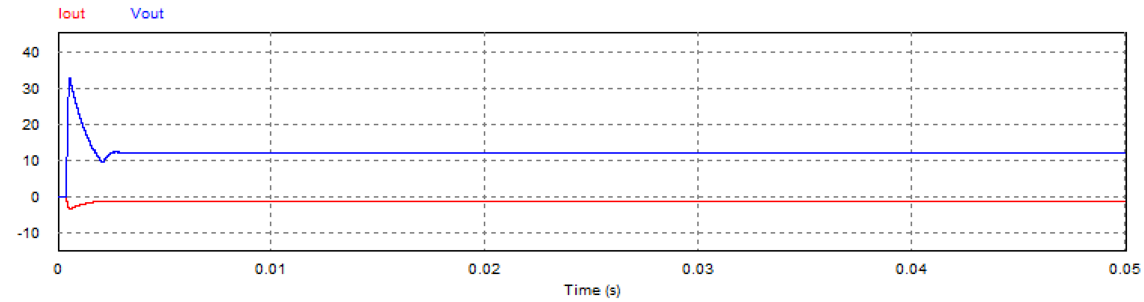

Figure 13. Simulated waveform at load resistance 10 ohm and supply voltage 10 V

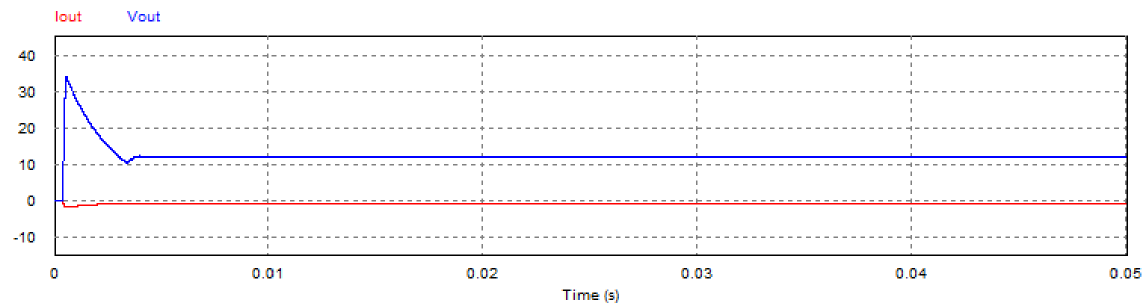

Figure 14 . Simulated waveform at load resistance 20 ohm and supply voltage 10V

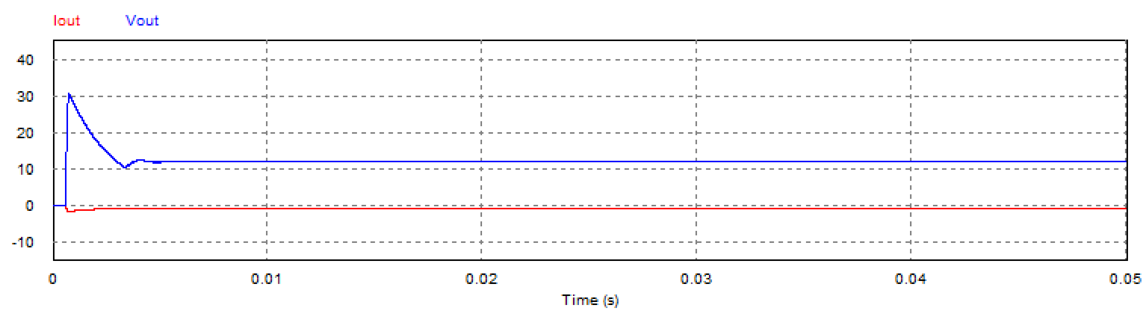

Figure 15. Simulated waveform at load resistance 20 ohm and supply voltage 6 V

4. CONCLUSION

In the present paper simulation of PWM based buck boost converter has been done for powering LEDs. Array of LEDs has been tested such that the lighting system provides constant illumination. Analysis of ripples has been done with and without controller. Converter takes care of variation in input voltage as well as variation in load because, LEDs having non- linear characteristics. Based on the result obtained from the system it has been observed that t at 600mA and at 12V LEDs are operated efficiently. The driver circuit is operated in continuous buck-boost mode and the results are then simulated using MATLAB and PSIM software.

5. REFERENCES

[1] T. F. Pan, H. J. Chiu, S. J. Cheng, and S. Y. Chyng, "An improved single- stage flyback pfc converter for high-luminance lighting led lamps," Electronic Measurement and Instruments, pp. 212-215, Aug. 2007.

[2] H. J. Chiu and S. J. Cheng, "Led backlight driving system for large-scale lcd panels," IEEE Transactions on Industrial Electronics, vol. 54, no. 5, pp. 2751-2760, Oct. 2007.

[3] Y. H. Fan et al., "A simplified led converter design and implement," Joint Conference on Information Sciences, pp. 8-11, Oct. 2006.

[4] Philips Electronics, part number LXCL-PWF3, Power light source LUXEON Flash.

[5] Y. Hu and M. M. Jovanovic, "A novel led driver with adaptive drive voltage," Applied Power Electronics Conference and Exposition, pp. 565-571, Feb. 2008.

[6]. Zheludev, N. The life and times of the LED - a 100-year history. Nature Photonics 1 (4): pp 189–192. doi:10.1038/nphoton.2007.34.

[7]. F. S. Kang, S. J. Park, and C. U. Kim, "ZVZCS single-stage PFC AC to-DC half-bridge converter," IEEE Trans. Ind. Electron., vol. 49, no. 1, pp. 206–216, Feb. 2002.

[8]. Huang-Jen Chiu, et al, LED Backlight Driving System for Large-Scale LCD Panels, IEEE Trans on Industrial Electronics, Vol.54, No.5, 2007, pp2751-2769.

[9]. Z. Ye, Fred Greenfeld, George Liang, Design consideration of SEPIC converters for high brightness LED applications, IEEE PESC 2008, June 2008, Greece, pp 2657-2663.

[10]. MUTHU, S.; GAINES, J. Red, Green and Blue LED-Based White Light Source: Implementation Challenges and Control Design. Conference Record of the 38th IAS Annual Meeting, v. 1, p. 515 – 522, Oct. 2003.

[11]. Clauberg et al., Light Emitting Diode Driver, United State Patent US 6,853,150 B2, February 2005.

[12]. Manuel Rico-Secades, Antonio J. Calleja, et al, Evaluation of a Low-Cost Permanent Emergency Lighting System Based on High-Efficiency LEDs, IEEE Trans on Industry Applications, Vol. 41, NO. 5, Sept/Oct 2005, pp1386-1390. 11.

[13] R.P.Gupta, U Prasad, P.K.Sadhu and N.pal " Efficient Lighting System for Underground Coalmines Using LED" Page 21-24 Volume 91, August, 2010, Journal of The Institution of Engineers(India)-MN.

[14] Chi-Jen Huang; Ying-Chun Chuang; Yu-Lung Ke; " Design of Closed-loop Buck-boost Converter for LED Driver Circuit" Industrial and Commercial Power Systems Technical Conference (I&CPS), 2011 IEEE PP-1 – 6, Baltimore, MD ,1-5 May 2011

[15] R P Gupta etal Design and analysis of buck boost converter based LED Driver for Enhancing the stability " Journal of electrical engineering , Volume-12/2012, Edition-3, Page 117-124.