Scope International Journal of Science, Humanities, Management and Technology. ISSN : 2455-068X
Vol.2 Issue 2 (2016) 38-42. Submitted 28/03/2016. Published 05/04/2016

A SINGLE STAGE ELECTROLYTIC CAPACITOR LESS AC/DC LED DRIVER USING FUZZY LOGIC CONTROLLER

[1]A.Srinivasan, [2]H.Suresh, [3]M.Vinoth Kumar, [4]R.Thenmozhi, [5]M.Sudhakaran
[1,2,3]Dept of EEE, GTEC , Vellore, India
[4]Asst. Prof, Dept of EEE, GTEC , Vellore, India
[5]Associate Prof, Dept of EEE, GTEC , Vellore, India

Abstract:
Lighting is an important aspect of energy consumption. It consumes about 25% of the world's total electric energy production. Light Emitting Diode (LED) technology has now emerged promising technology to replace conventional lighting devices. LEDs are highly efficient, energy conserving and eco-friendly. The applications of LEDs include in mobile products, and back lighting of Liquid Crystal Display(LCD) panels. LED drivers utilize an AC input source; Power Factor Correction (PFC) control must be imposed in the driver to achieve a high Power Factor (PF). This is a novel two stage LED driver. It consists of a buck-boost converter and a buck converter. The buck-boost converter which serves as a PFC converter to achieve a High Power Factor and low current ripples. The buck converter step down the dc-link voltage to drive high power white LEDs. Operating the active switches at Zero Voltage Switching(ZVS) can effectively reduce the power losses. To achieve the PFC function, it should be designed to operate at Discontinuous-Conduction Mode (DCM). The buck converter can be designed to operate at either Continuous- Conduction Mode (CCM) or DCM.

Keywords: Buck boost converter,Buck converter,Light Emitting Diode(LED),Power Factor Correction(PFC),Zero Voltage Switching(ZVS).

1. INTRODUCTION

LEDs are the fast emerging technology and have a wide range of applications. Due to the increased popularity of LEDs, the LED driver design should be simple [1]. The LED driver may be a single stage driver or a two stage driver. The single-stage approaches are derived by integrating the PFC converter and the DC/DC converter. By sharing one active switch and the control circuit, the single-stage converters have the advantages of less component count and are cost effective solutions. They are less expensive. The two-stage approach includes a PFC semi-stage to shape the input current into a sinusoidal waveform and a DC/DC semi-stage to regulate the output voltage. These two-stage approaches have the advantages of good performance, fast output dynamic response, and easy control. They require two power- conversion processes and are energy inefficient [2-8]. There are many topologies using single stage and two stage converters based on different applications. In both single stage and two stage converters, the active switches are operated in hard switching mode. Hard switching increases the switching losses. Hence the objectives are to improve the power factor of the LED driver system for economical operation and to reduce switching losses by using a suitable technique. To reduce the switching losses soft switching techniques can be employed. By using zero voltage switching, i.e, the voltage across the device is reduced to zero before the current increases, along with the help of phase shift full bridge PWM converter switching losses can be reduced. Therefore, a new two stage topology can be introduced which will improve the PF and reduces the switching losses. A buck converter can be used to drive the LEDs with required voltage [9-11].

2. OPERATION PRINCIPLE

The diode bridge rectifier converts the input AC voltage to DC. The buck-boost converter performs the function of PFC, and the buck converter steps down the dc-link voltageto drive LEDs. Both active switches can operate at Zero- VoltageSwitching-on (ZVS) to effectively reduce the switching losses.To achieve the PFC function, it should be designed to operate at Discontinuous-Conduction Mode (DCM). The buck converter can be designed to operate either in Continuous-Conduction Mode (CCM) or in Dis-continuous Conduction Mode (DCM).Continuous-Conduction Mode (CCM)has the advantage of small current ripple.

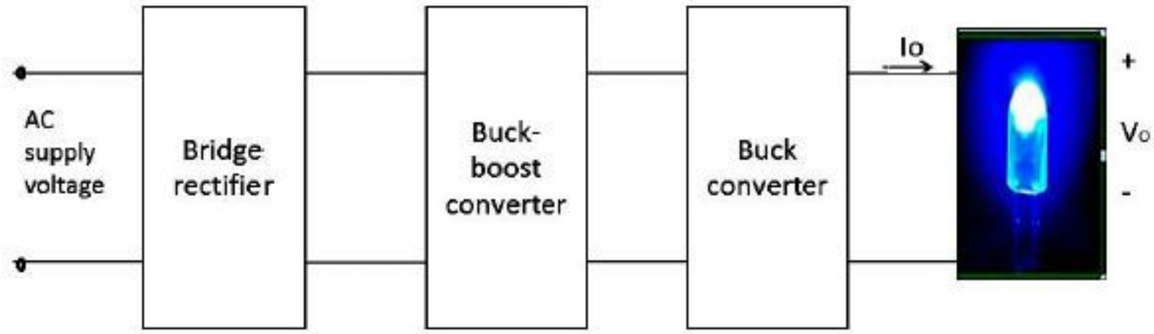

Fig.1.Block diagram

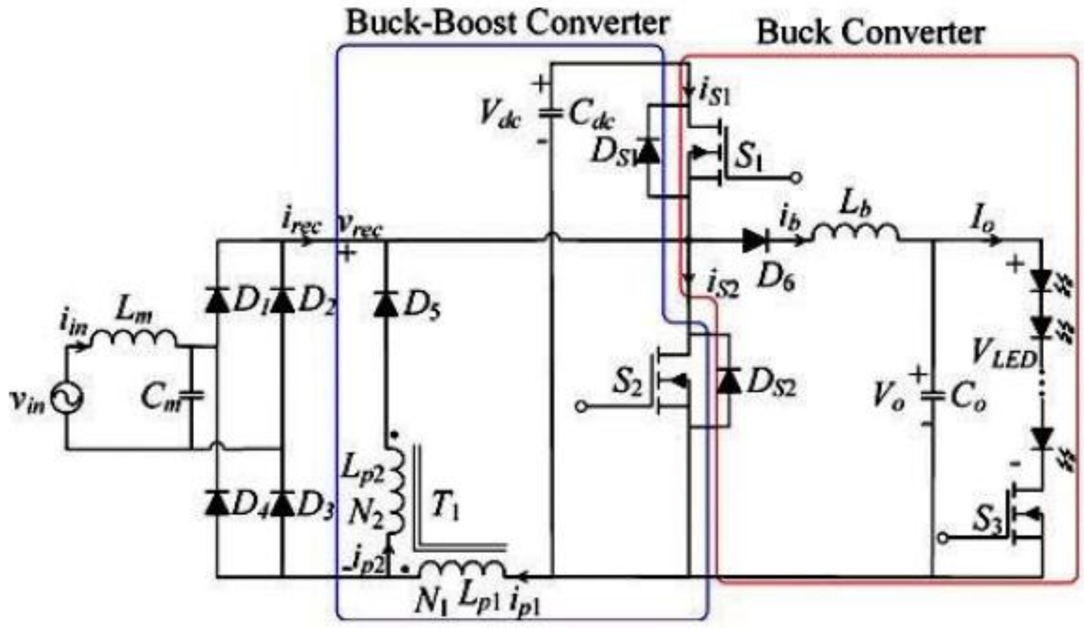

Fig.2.Circuit diagram

At the same time an inductor of higher value is required for operation. Hence the latter method is preferred. The first stage is a buck-boost converter consists of diodes D5 and DS1, an active switch S2, two coupled inductor Lp1 and Lp2, and a dc-link capacitor Cdc. It serves as the PFC circuit by wave shaping the input current to be sinusoidal and in phase with the input line voltage. The second stage is a buck converter consisting of diodes D6 and Ds2, an active switch S1, an inductor Lb, and a capacitor C0. Diode D6 is used to block the reverse current of buck inductor and can be removed when the buck converter is operated at CCM. Instead of using a single inductor, two coupled inductors along with a blocking diode (D3) are used to accomplish buckbuck-boost conversion. The turnsratioof the two coupled inductors is designed to induce voltage on Lp2 to block the current from the line source.A small low-pass filter, Lm and Cm, is used to remove the highfrequency current harmonics at the input line. MOSFETs S1 and S2 are the bidirectional switches. Each switch is composed of a transistor and an anti-parallel diode. The MOSFET's intrinsic body diodes D1. and D2 are used as the anti-parallel diodes. For dimming operation, the active S3 is placed in series with the LED string. Switch S3is controlled by the scheme of low-frequency pulse-width modulation. The active switches S1and S2 are alternately driven by two gated signals, vGS1 and vGS2. They are non-overlapping and complementary rectangular-wave voltages with a short dead time at the high switching frequency fs. The dead time is the time interval when vGS1 and vGS2 are both zero.

3. DESIGN ANALYSIS

The anti-parallel diode of the active switch of one converter serves as the freewheeling diode of the other converter, the features of the buck-boost and the buck converter can be retained. Therefore, the two converters can be analyzed separately. The input voltage is 25 V. The forward voltage drop for 1 LED is 12 V. Hence the output voltage for 4 LEDs is 48 V. From output power and output voltage, the output current can be calculated. The equivalent LED resistance can be obtained from output voltage and output current gives the circuit parameters. The on time of the buck converter is the interval from the beginning of operation Mode IV to the end of Mode VI. During this interval, either S1 or DS1 is on. Hence, the duty ratio of the buck converter is also 0.5. At steady-state operation, the average value of ib is equal to LED current. By diverting the current in one active switch to the anti-parallel diode of the other one is what enables the active switches to achieve ZVS operation. By this way, the anti-parallel diode conducts current prior to the transistor in each MOSFET. The voltage across the transistor is maintained at about -0.7 V when its anti-parallel is on. This small voltage is negligible and the transistor can be turned ON at zero voltage. It means that the turn-on switching loss is effectively eliminated.

4. RESULT ANSLYSIS

The gate pulses shows that switches are operated complementary. Duty cycle is 46% and it is same for both the two switches and the switching frequency is 50 kHz.

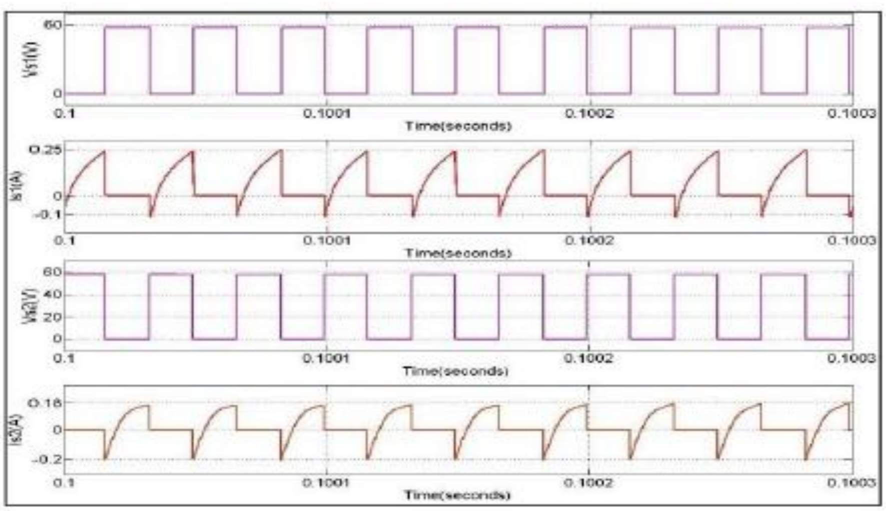

Fig.3.Waveform gatepulses

A short dead time is provided. The voltage across the DC- link capacitor Cdc and current through the primary and secondary winding of coupled inductor is also given in the same figure. According to design criteria magnitude of capacitor voltage should be less than 2Vo and reater than Vo. Here the magnitude is 58 V. Gating pulses for switch S3. The input to the prototype is 25 V AC and is connected to the mains through a single phase auto transformer.

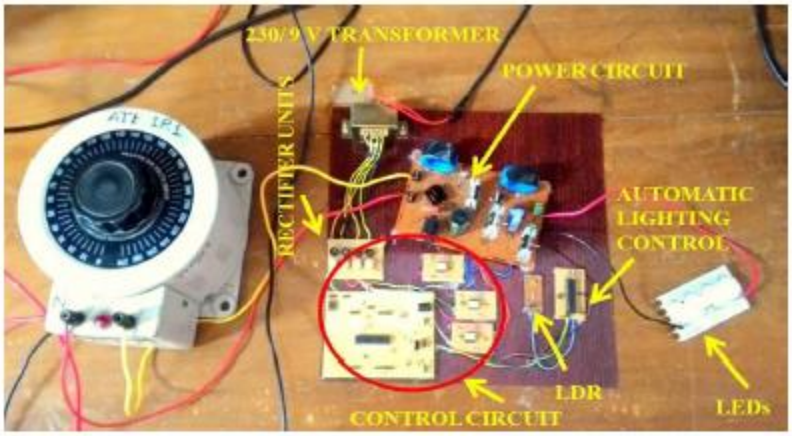

Fig.4.Hardware structure

A single phase step down transformer of rating 230/ 9 V is used for giving supply to the control circuits. The transformer has 4 isolated secondary windings and they are connected to 4 rectifier units. There are three switches in the topology. Two of them (S1and S2) are complementary switches. The digital signal controller dsPIC30F2010 is used for controlling these switches. Gating pulses are generated according to the program written in MPLAB. Working voltage of dsPIC is only 3 V and it is insufficient for driving the switches. Hence an optically isolated gate driver TLP250 is used for this purpose. Three gate driver IC's are required for three active switches. A voltage regulator LM317 is used to drive dsPIC which reduces the 12 V to 3 V. The 4 secondary windings of single phase transformer are connected to three gate driver IC's and to LM317.

CONCLUSION

This is a novel two stage LED driver. It consists of a buck-boost converter and abuck converter. The buck-boost converter which serves as a PFC converter is operated at DCM toachieve a high power factor and low current THD. The buck convertersteps down the dc-link voltage to drive high power whiteLEDs. The circuit operation is described, and design equationsare derived. For achieving the design goals of high power factorand ZVS operation, the output voltage cannot be lower than theamplitude of input voltage. Both active switches can achieve ZVS. Automatic dimming operation is achieved by controlling the duty ratioof the active switch S3 with the help of a LDR. A prototype of 48 V, 40 W is tested and simulation results are obtained by using MATLAB. THD is 22%.

REFERENCES

[1] Rafael A. Pinto, Marcelo R. Cosetin, Alexandre Campos, Marco A. Dalla Costa “Compact emergency Lamp Using Power LEDs” IEEE Trans. Ind. Electron., vol. 59, no. 4, pp. 1728, April. 2012

[2] S. Wang, X. Ruan, K. Yao, S. C. Tan, Y. Yang, and Z. Ye, "A flicker free electrolytic capacitor-less ac–dc LED driver IEEE Trans.-Power- Electron., vol. 27, no.11, pp. 4540–4548,Nov. 2012.

[3] Y. C. Li and C. L. Chen, "A novel single-stage high-power-factor ac-to dc LED driving circuit with leakage inductance energy recycling," IEEE Trans. Ind. Electron., vol. 59, no. 2, pp. 793–802, Feb. 2012.

[4] Banoth Govind Nayak, Harinath saggu, "Implementation of a Zero-Voltage-Switching and Zero-CurrentSwitching Interleaved Boost and Buck Converter" ijecs Volume 3, Issue 10 October, 2014 Page No. 9017-9026

[5] C. S. Moo, K. H. Lee, H. L. Cheng, and W. M. Chen, "A single-stage high power-factor electronic ballast with ZVS buck-boost conversion," IEEE Trans. Ind. Electron., vol. 56, no. 4, pp. 1136–1146, Apr. 2009.

[6] M. A. D. Costa, J. M. Alonso, J. Cardes´ın, J. Garc´ıa, and D. G. Lamar, "A single-stage high-power-factor electronic ballast based on integrated buck flyback converter to supply metal halide lamps," IEEE Trans. Ind. Electron., vol. 55, no. 3, pp. 1112–1122, Mar. 2008.

[7] X. Xie, M. Ye, Y. Cai, and J. Wu, "An optocouplerless two-stage high power factor LED driver," in Proc. IEEE Appl. Power Electron. Conf., 2011, pp. 2078–2083.