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Bridgeless Converter For An LED Street-Lighting Applications

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Abstract: As the country is developing the usage of electric energy is increasing and the cost is also increasing with reduced efficiency and the power factor. Since the utility charges for electricity even by considering the power factor so, to improve the circuit, to increase the efficiency and to improve the power factor this model is proposed. For energy savings light emitting diodes are used due to its attractive features. This paper proposes a bridgeless converter circuit for supplying light emitting diode street-lighting module. This converter contains integrated bridgeless converter with half bridge LLC series resonant converter so that we can obtain zero voltage switching across the power switches and zero current switching across the two output rectifier diodes. Here we designed the circuit for supplying 150W with the supply voltage ranging from 200V to 230V. The circuit features are cost-effective, efficiency increases due to one-stage of power conversion and power factor is improved compared to the conventional two-stage circuit. The circuit simulation has been carried out in MATLAB/Simulink.

Keywords: Bridge-less ac-dc conversion, half-bridge type LLC Resonant converter, power factor correction.

I. INTRODUCTION

Electric lighting is most important in our daily lives, the lighting device commonly adopted in street lighting are high pressure mercury lamp and high pressure sodium lamp which works with the high intensity discharge. Recently LEDs have become common in our daily lives and it is used in street-lighting.

Light-emitting diodes have favourable features of smaller in size, life-time is long, and a maintenance cost is lower, high level of brightness, greater ability to withstand damage and mercury free. Because of these features they are becoming most popular in our daily outdoor and indoor lighting, displays, street lighting. Recently LEDs are used in street lighting applications due to their attractive features like saves energy, colour rendering index is good, quickly turn ON and turn OFF. They offer a long lifetime of about 50000hours in comparison with the traditional sources which is having life of about 24000hours like high pressure mercury lamps or high pressure sodium vapour lamp [1].

Power factor is most important factor in the AC supply; the definition of power factor is given as the cosine of the phase angle between input voltage and current or it can be defined as the ratio of real power to the apparent power which is given by cosϕ. The utility charges are based on the power factor and the efficiency of the circuit is also important. Some of the driver circuits which are used are

[2] Presents a high efficiency driver in which it can be used for the power range of 80W to 300W. It uses flyback converter to achieve zero voltage switching the power factor and efficiency measured is about 0.9 and 90% respectively.

[3] Presents a circuit which uses SR flyback converter which uses CRM controller for passing the zero crossing information and to be used as a snubber circuit where this controller generates the gate signals the overall efficiency obtained by using this is 90%. [4] Presents a converter which uses one switch and two inductors which acts as a two buck-boost converters which acts in the input side and in the output side also, here the input inductor is made to operate in the discontinuous mode of conduction such that the power factor has been improved and the efficiency is obtained in the range of 84-85% where the efficiency has been reduced.

[5] Presents the LED driver without the electrolytic capacitor in which it has the three stages of power conversion they are first is power factor correction, second is galvanic isolation provided by an transformer and last one consists of two input buck with the LED strings.

[6] Presents a two-stage of power conversion circuit which is having the boost converter and then the series LLC resonant converter. Here the power factor correction dc-dc converter has a boost inductor, one power switch, one diode and the dc-linked capacitor. The dc-dc LLC series resonant converter consists of two power switches, resonant inductor, magnetizing inductor and resonant capacitor. Then it consists of center tapped transformer with the two output rectifier diodes. Due to the two stage of power conversion the efficiency of the circuit decreases and the cost for implementation is more.

[7] Presents the two-stage converter circuit which is designed to supply for 70W load. Here it consists of interleaved boost power factor correction converter with

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two power switches, two diodes and two inductors with two capacitors and then in the next stage it consists of series LLC resonant converter where the efficiency is limited.

To overcome these problems the converter circuit is proposed in which the power conversion is single stage due to this efficiency increases and the power factor is improved by using the boost inductor.

II. PROPOSED CONVERTER

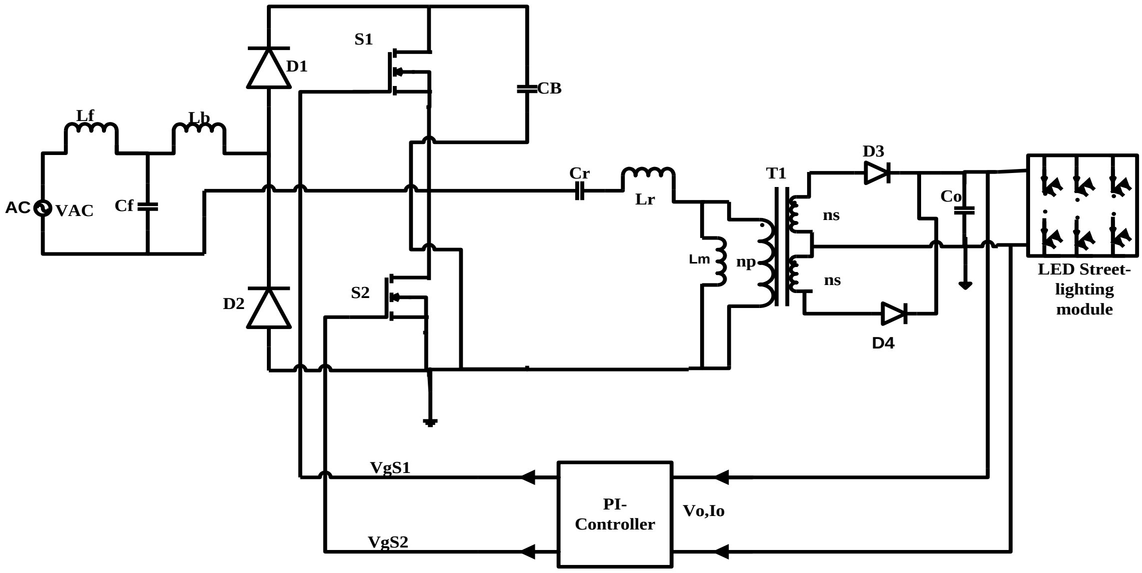

Fig 2.1 proposed bridgeless converter for supplying an LED street-lighting module.

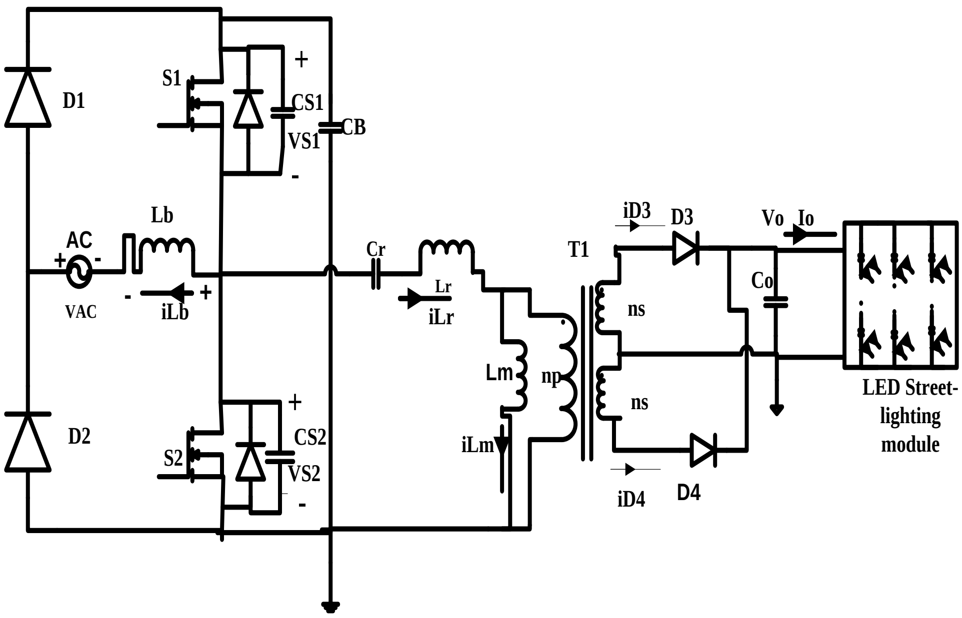

Fig 2.2 Simplified circuit for analysis

The proposed converter saves three diodes and one power switch when compared with the conventional two-stage driver.

The converter circuit consists of AC-DC bridgeless power factor correction converter and then it has series LLC resonant converter. Assumptions made for analysis are

1. Power switches S1 and S2 are made to operate complementarily and the intrinsic capacitor and diodes are considered.
2. The boost inductor Lb is designed to operate in the discontinuous conduction mode.

There are 9 modes of operation for each switching cycle in positive half cycle. The analyzing circuit is given by

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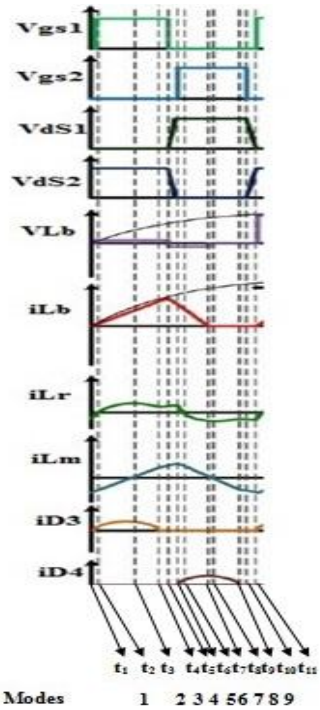

Fig 2.2: Principle waveforms of the proposed LED driver for street-lighting applications

III. FEEDBACK SYSTEM

The output voltage and the current is controlled by taking the feedback and giving the error to the PI-controller which rectifies the error and then it add the output current value to the PI controller by giving Kp and Ki values output which is the current and then that is fed to another PI controller such that it sets the input voltage and by comparing it with the input AC supply voltage then that is compared to the repeating sequence and the duty ratio is changed according to the input voltage error and then the output voltage and current can be made constant for different input voltages.

IV. DESIGN PROCEDURE

1. Input voltage:
VAC-MIN=200V, VAC-MAX=220V
2. Input frequency; f_{AC}=50Hz
3. Rated power of LED Street-lighting module
Po=150W
4. Rated voltage of LED street-lighting module
V_0=36V

a. $Lb = \frac{\eta V^2 AC-max\ D^2 VDC-max}{2Pofs(VDC-\sqrt{2}\ VAC-max)}$……………………..(1)

b. $VDC - min\ \frac{2\sqrt{2} * LbPo\ VAC-min}{(2\ LbPo-\eta\ V^2 AC-min\ D^2 Ts)}$……………..(2)

c. Transformer turns ratio

$n = \frac{DVdc-max}{Vo+VF}$…………………………………..(3)

d. Equivalent load resistance

$Req = \frac{8n^2 * RL}{\pi^2}$………………………………..……(4)

e. Maximum and minimum voltage gain of the resonant network

$M_{v-min}=|M_v(\omega_s)|_{\omega s=\omega r1}=1$……………………..... (5)

$Mv - max = \frac{VDC-max * Mv-min}{VDC-min}$……………….. (6)

Designing LLC resonant converter

a. $L_r= (Q_r * R_{eq})/(2\pi f_{r1})$………………….. (7)

b. $L_m=AL_r$……………………………………………………(8)

c. $C_r=1/((2\pi f_{r1})^2 * L_r)$…………………….... (9)

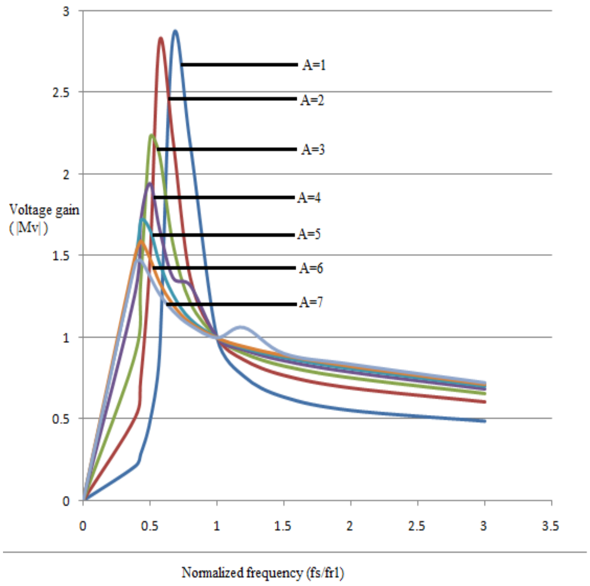

Fig 4.1 voltage gain versus normalized frequency fs/fr1 under different inductance ratios (Q=0.3)

From the equations 1 to 9 the circuit parameters are designed and the specifications are given in the below table

V. MATLAB SIMULINK MODEL

Table 1: Margin specifications

Parameters	Range
Input voltage	220V
Frequency	50Hz
Output power	150W
Output Voltage	36V
Switching frequency	120kHz
Lb	1.225µH
Cr	27nF
Lr	68 µH
Lm	470 µH

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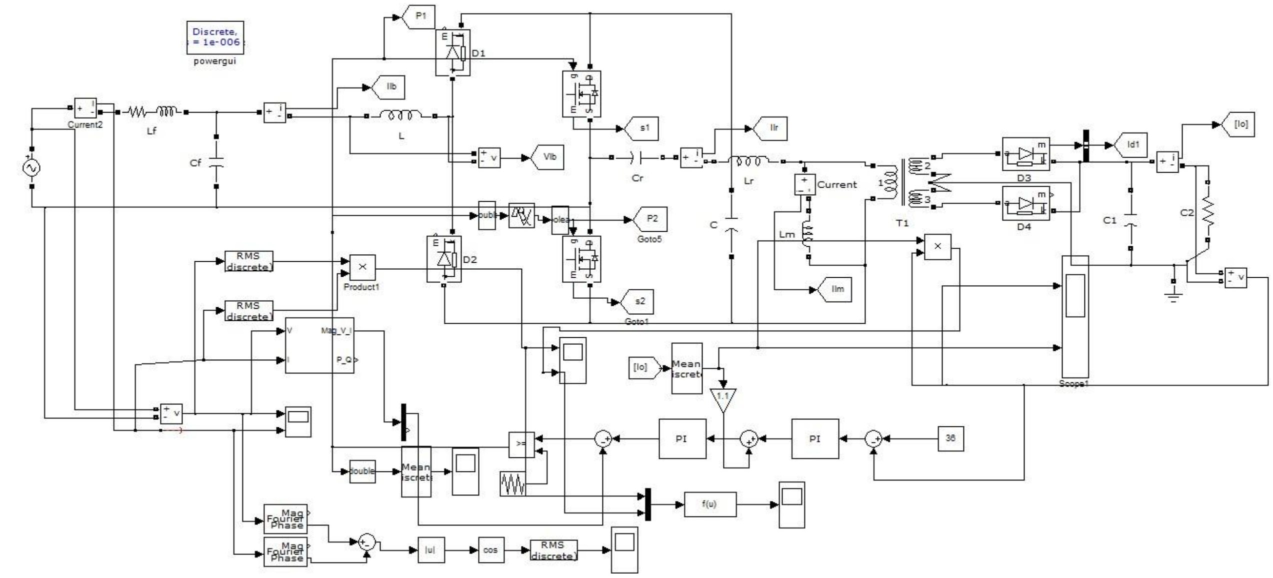

Fig 5.2: Principle waveforms, ZVS and ZCS across the switches and diodes.

VI. RESULTS AND DISCUSSIONS

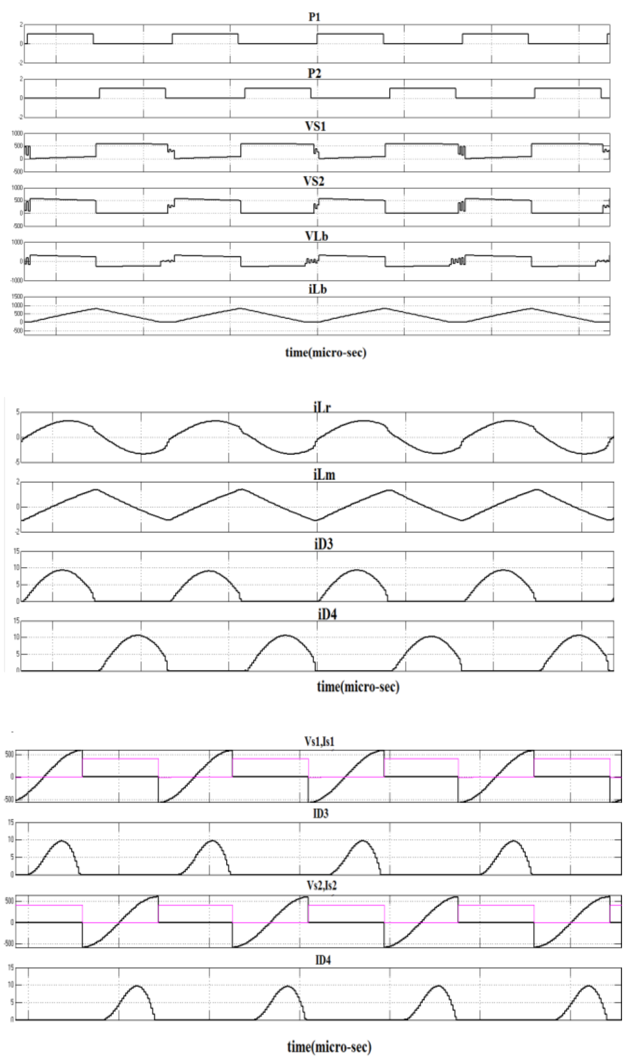

Fig 5.2: Principle waveforms, ZVS and ZCS across the switches and diodes.

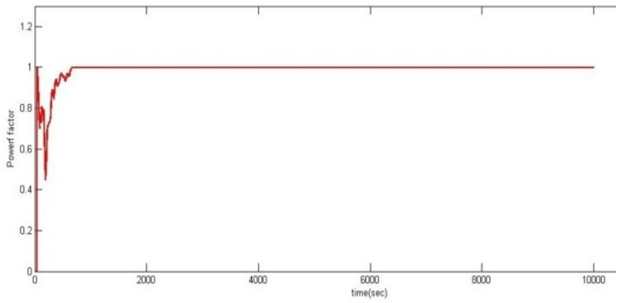

Fig 5.3: Input power factor

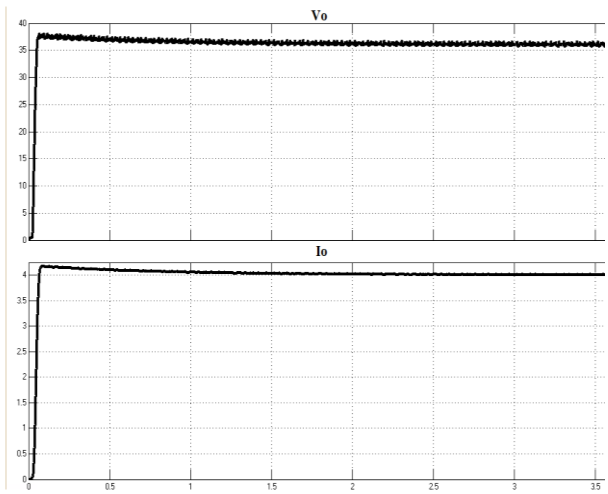

Fig 5.4: Output voltage and current

Table 2: Output voltage, current, power and efficiency of the circuit for different input voltages

Vin	Iin	Pin	Vo	Io	Po	Eff (%)
200	0.742	148.4	36.35	4.01	144.83	97.6
210	0.714	150.1	36.03	4.003	143.86	96.1
220	0.687	151	36.1	4.004	143.86	95.67
230	0.6541	150.44	36.03	4.005	144.13	95.80

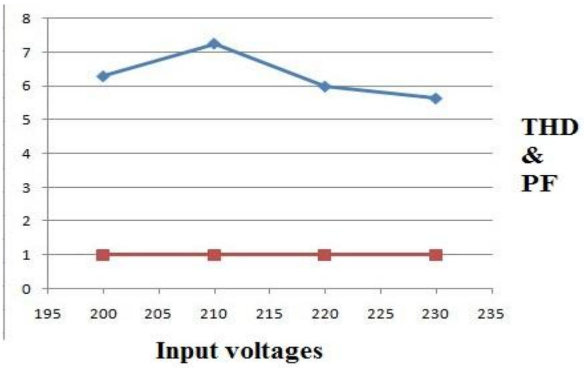

Fig 5.5: THD and PF for different input voltages

Table 3: Output voltage ripple, output current ripple, and THD and power factor

Vin	Iin	Output voltage ripple (%)	Output current ripple (%)	THD (%)	PF
200	0.742	1.94	0.504	6.29	0.9987
210	0.7145	0.5	0.33	7.25	0.999
220	0.687	1.41	0.38	5.99	0.9992
230	0.6541	0.25	0.12	5.64	0.9992

The zero voltage switching is achieved across the two switches and the power factor is has improved, the efficiency of the circuit is increased due to the single-stage of power conversion and the output voltage ripple and current ripple has reduced.

VII. CONCLUSION

This paper proposes the bridgeless converter for LED street-lighting applications. The converter circuit is cost effective with high circuit efficiency, high power factor and the output voltage ripple and the output current ripple has been reduced. The zero voltage switching across the switch S1 and S2 is occurred and the zero current switching across the diode D3 and D4 and is shown in the fig 5.2.

REFERENCES

[1] E. F. Schubert, Light-Emitting Diodes. Cambridge, U.K.: Cambridge Univ. Press, 2006.
[2] G.C. Jane, C.C. Su, H.J. Chiu and Y.K. Lo,"High-efficiency LED driver for streetlight applications."
[3] K.I. Hwu, Y.T. Yau, and L.L. Lee, [2] presents "Powering LED using high-efficiency SR flyback converter."
[4] J.M. Alonso, J. Vina, D.G. Vaquero, G. Martinez, and R. Osorio, "Analysis and design of the integrated double buck-boost converter as a high power factor driver for power LED lamps."
[5] M. Arias, D. G. Lamar, J. Sebastian, D. Balocco, and A. Diallo, "High efficiency LED driver without electrolytic capacitor for street lighting."
[6] Energy-sfficient solutions for offline LED lighting and general illumination. STMicroelectronics Brochure.pp.1-27. [online].
[7] S. Hu. (2010 Nov.). 200W AC/DC LED driver. Texas instruments.
[8] X. Long, R. Liao, and J. Zhou, "Development of street lighting system based novel high-brightness LED modules," IET Optoelectron, vol. 3, no. 1, pp. 40-46, Feb.2009.
[9] R. L. Steigerwald, "A comparison of half-bridge resonant converter topology," IEEE Trans. Power Electron, vol. 3, no.2, pp. 174-182.
[10] C.A. Cheng, H. L. Cheng, C. H. Chang, F. L. Yang, and T.Y. Chung, "A single-stage LED driver for street-lighting applications with interleaving PFC feature," in Proc. IEEE Int. Symp. Next-Generation Electron, 2013, pp.150-152
[11] C.C. Lin, L. S. Yang, and E. C. Chang, "Study of a DC-DC converter for solar LED street lighting," in Proc. IEEE Int Symp. Next-Generation Electron, 2013, pp. 461-464
[12] M. Arias, D. G. Lamar, F. F. Linera, D. Balocco, A. A. Diallo and J.Sebastian, "Design of a soft-switching asymmetrical half-bridge converter as second stage of an LED driver for street lighting applicatio," IEEE Trans. Power Electron, vol. 27, no. 3, pp-1608-1621, March. 2012.