An Interleaved single stage Flyback Ac/Dc converter for outdoor LED Lightning

Ashish Chaudhari[1], Khushbu Rana[2]
[1, 2] Department of Electrical Engineering
[1, 2] CGPIT

Abstract- *In this Paper due to High reliability and luminous efficiency LEDs are becoming very popular in lighting applications, So their power supplies also require the same reliability and efficiency. There are two types of LED drivers are available depending upon the output power. This paper mainly focused on an LED driver. It deals with an interleaved single stage flyback ac-dc converter to drive an LED for high and low power applications.. This converter can provide a regulated output to power an LED for wide power applications. this converter shows a High Power factor and low total harmonic distortion (THD) in MATLAB based simulations are carried out for open loop and closed loop.*

Keywords:- LED(Light emitting diode),THD(Total Harmonic Distortion),SMPS(switch mode power supply), PFC(Power factor correction), PF (Power factor)

I. INTRODUCTION

This paper, The use of high-brightness light-emitting diode is increasing in a lot of outdoor lighting applications such as street lights, floodlights, beacon lights, tunnel lights, and security lights, because of its high luminous efficiency, easy to drive, long lifetime

In outdoor lighting systems, according to the output power rating, the power stage to drive an LED can be classified into single stage and two-stage structures. the fig 1(a)shows the single stage structure In single-stage structure for an LED power supply unit combines the power factor correction (PFC) part and the dc–dc converter part into one stages . the fig 1(b) shows the in the two-stage structure. In two stage structure the first stage is the ac–dc converter for PFC and the second stage is the dc–dc converter for regulating the output voltage or current. In two-stage structure, two power stages can be controlled separately so that it is easy to optimize and it can handle high power applications. the two-stage structure needs a large number of components and two kinds of control ICs so that it costs a lot and shows low efficiency due to the two processes of the input power. So that for high power an interleaved single stage fly back ac/dc converter proposed here.

In this work flyback converter are used due to low number of components as compared to switch mode power supply. Flyback converter are used as buck converter with inductor spilt to form as a transformer and it provide galvanic isolation.

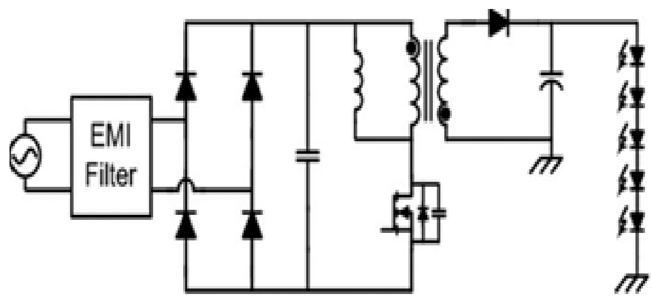

Figure 1(a) Single Stage Structure

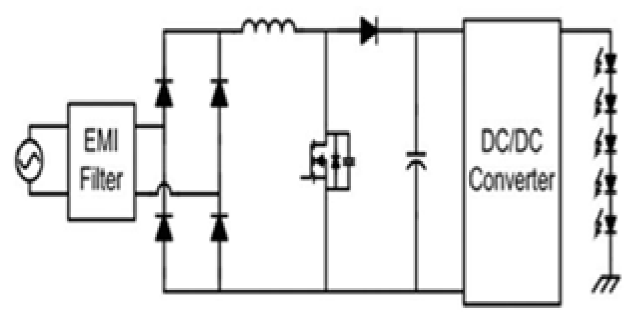

Figure 1(b) Two stage Structure

II. AN INTERLEAVED SINGLE STAGE FLY BACK AC/DC CONVERTER

As shown in fig 2,the interleaving control method provides small input and output filters, low voltage stress on the main switch and a low profile design when compared to non interleaving methods. . While the CRM interleaved flyback converter has high efficiency, but shows poor PF and THD under light load condition, the discontinuous conduction mode (DCM) interleaved flyback converter has good PF and THD under light load condition, but shows low efficiency due to its high rms current. To achieve THD in wide output power range, this paper proposes a pulse duty cycle pulse frequency modulation (PDPFM) control method for an interleaved single-stage flyback (ISSF) converter.

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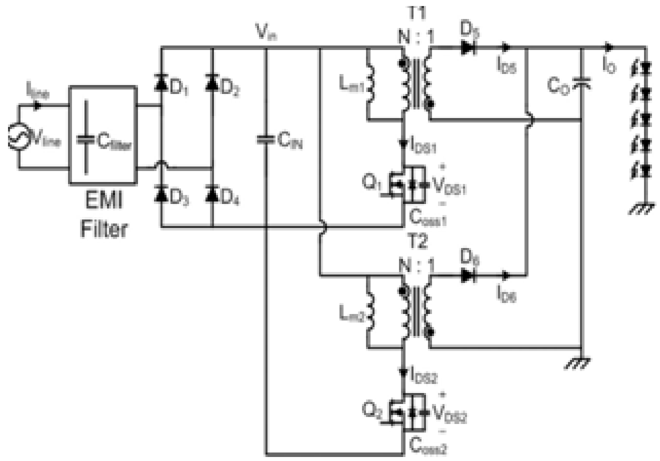

Figure 2 An interleaved single stage flyback AC/DC converter

III. PROPOSED CONTROL SYSTEM AND PROPOSED CONTROL METHOD

In proposed system the single phase ac supply is given to an EMI filter to filter out the noises. Then it is given to the rectifier to convert it in to dc. The output of rectifier is given to the interleaved flyback converter. Flyback converter is controlled by pulse width modulation. The regulated dc output is given to the LED string.

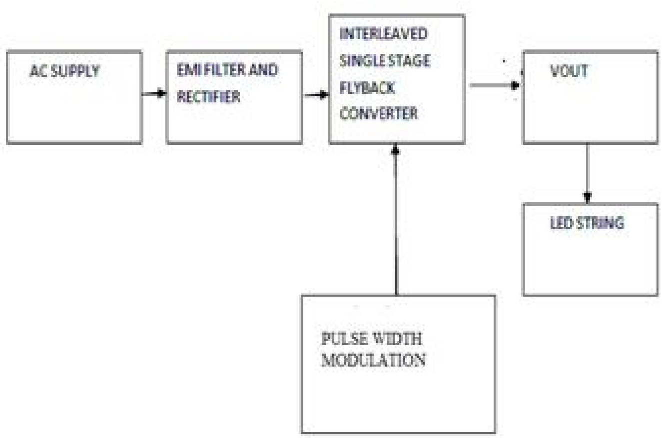

Figure 3 Block diagram of Proposed system

PROPOSED CONTROL METHOD

In fig 4 shows the key waveform of the proposed control method. The proposed control method adopts DCM operation which can achieve good PF for wide output power range. In the proposed method, the interleaved DCM flyback converter is basically controlled by pulse width modulation (PWM). the turn-ON time corresponds to the device. so the stress on the switch device is less and efficiency will be more. The main advantages of PWM is that power loss in Switching device is very less.

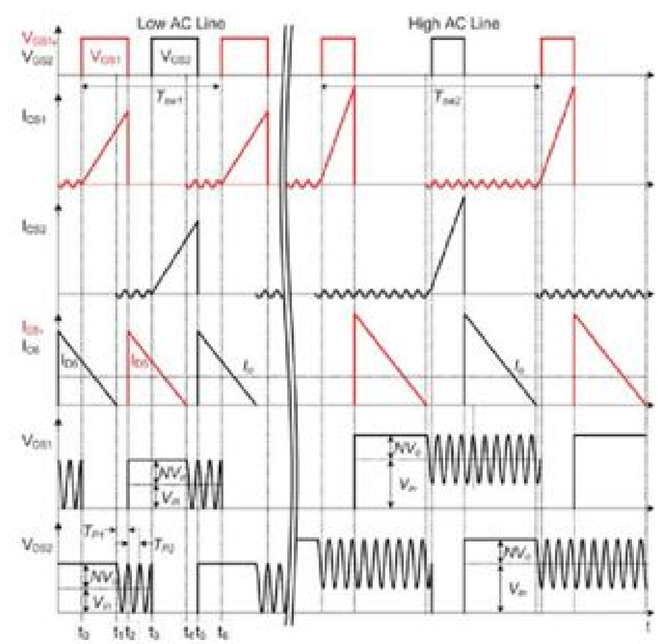

Figure 1 Key waveform of Proposed control method

A. Operating principle

In fig 4, shows the key waveforms of an interleaved DCM fly-back converter with the proposed method. The switching period is subdivided into six modes. Since operation modes 1–3 are similar to modes 4–6, only the first three operation modes are describe.

The main equivalent circuits for the operation modes are shown in fig 5, To simplify the analysis of the circuit operation, the following assumptions are made:

[1] The leakage inductance of the transformer is neglected.
[2] The line frequency is much lower than the switching frequency of the flyback converter so that the input voltage V_{in} can be regarded as a constant during each switching period;
[3] The EMI filter capacitance C_{filter} is greater than C_{IN} , including the equivalent capacitance of the bridge diodes;
[4] The magnetizing inductances $L_{m\,1}$ and $L_{m\,2}$ are identical;
[5] The line voltage V_{in} is positive. Thus, diodes D_1 and D_4 are conducting.
[6] The two switches, Q_1 and Q_2 , operate 180° out of phase.

Mode 1: As can be seen in Fig. 12(a), Q_1 is turned ON and the energy is built into the magnetizing inductor $L_{m\,1}$, and the energy stored in $L_{m\,2}$ is transferred to the output. The drain current $I_{D\,S\,1}$ of Q_1 increases with the slope of V_{in} / $L_{m\,1}$, and the diode current $I_{D\,6}$ decreases with the slope of $N^{2}\,V_o / L_{m\,2}$. This mode ends when $I_{D\,6}$ decreases to zero.

Mode 2: When $I_{D\,6}$ equals zero, this mode begins. In Fig. 12(b), the magnetizing inductor of T_2 starts to resonate with the output capacitor $C_{o\ ss2}$ of the switch Q_2 . Because Q_1 is still ON, the diodes D_1 and D_4 are conducting. Thus, most of the resonance currents flow through D_1 , D_4 , and the electromagnetic interference (EMI) filter. The resonance period $T_{P\ 1}$ and ID_{s2} can be expressed as

$$TP_1 = {}_{2\pi}\sqrt{Lm_{2}\cdot\frac{(C_{filter+C_{In}})\cdot C_{oss2}}{(C_{filter+C_{In}})+C_{oss2}}}$$

$$I_{DS2} = -\frac{NV_0}{\sqrt{\frac{Lm_2}{C_{oss2}}}}\ \sin\frac{2\pi}{TP_1}(t-t1)$$

When C_{filter} is greater than C_{In} and C_{oss2}.

Mode 3: Begins when Q_1 is turned OFF. As can be seen in Fig. 12(c), the diode current $I_{D\ 5}$ decreases with the slope of $N^2 V_0$ / lm_1. Because Q_1 is turned off, D_1 and D_4 are no longer conducting .thus, the resonance current flows through C_{In} and the resonance period T_{P2} can be expressed as

$$T_{P2} = {}^{2\pi}\sqrt{l_{m2}}\cdot\frac{C_{in+C_{oss2}}}{C_{in+C_{oss2}}}$$

If C_1 is greater than C_{oss2} , the resonance period T_{P2} almost the same as T_{P1}.In high ac line, the waveforms are similar except for the switching period, the turn-ON time, and the duty cycle. The switching period $T_{sw\ 2}$ increases and the turn-ON time and the duty cycle decreases to reduce the switching frequency variation and the switching loss in high ac line.

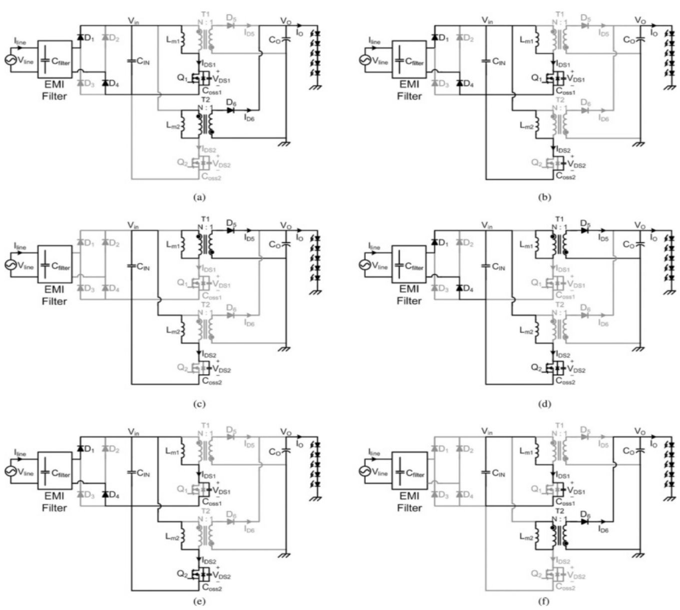

Figure 5 Equivalent circuits during one switching cycle

B. Advantage of interleaved topology

- Interleaved topology can reduce the size and cost of power filtering components and also enhance dynamic load performance
- It is an appropriate choice for high power applications.
- Because of parallel power stages, the transformer peak and RMS currents are reduced by a factor of 2.
- Reduction of EMI energy due to lower peak currents.
- Output capacitor is larger than input capacitor that suppresses the ripple content in the output voltage.

IV. OPEN LOOP SIMULATION

The system proposed can be simulated with MATLAB software. The components and various parameter used in simulation given below.

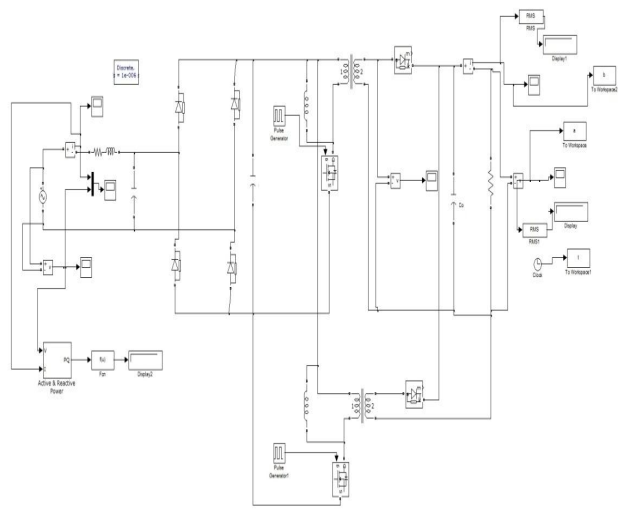

Figure 6 Open loop simulink model

The input and output voltage and current waveform for open loop simulation are shown below. It will give high power factor and low THD.

Items	Values
v_{in}	230 ac
v_o	88.7
I_o	0.52
c_o	100
$L_{m1} = L_{m2}$	215μH
R_o	100Ω
PF	0.95

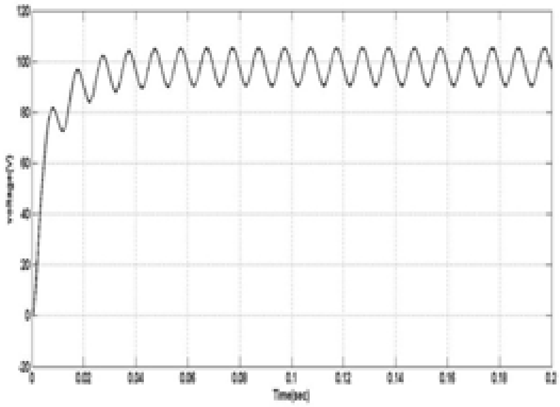

Figure 7 Output voltage waveform

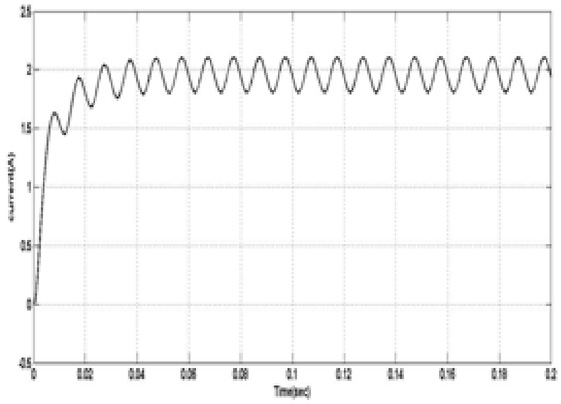

Figure 8 Output current waveform

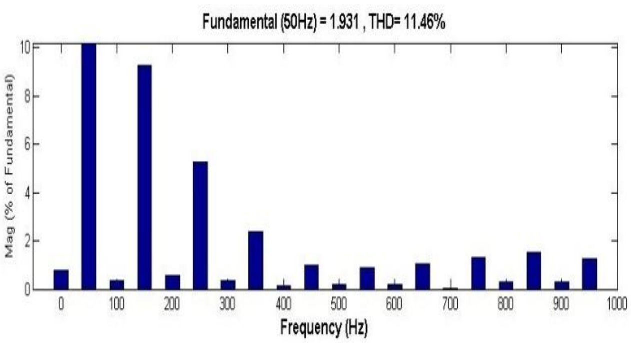

Figure 9 Harmonic Spectrum

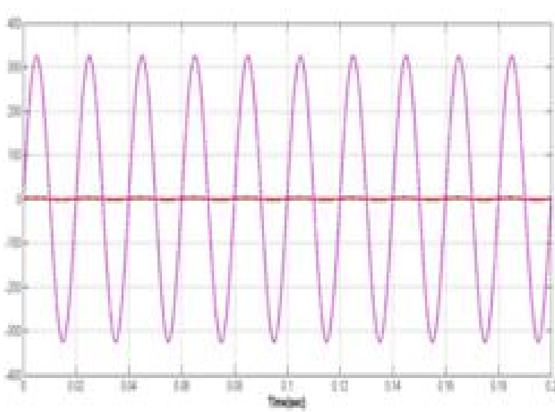

Figure 10 Input Power factor

V. CLOSED LOOP SIMULATION

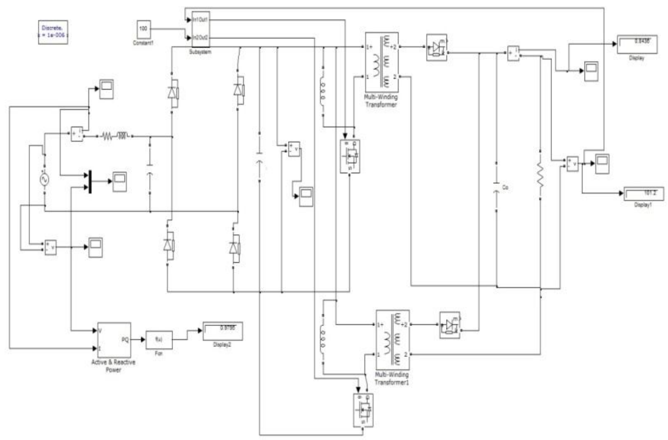

Figure 11 Closed loop simulation

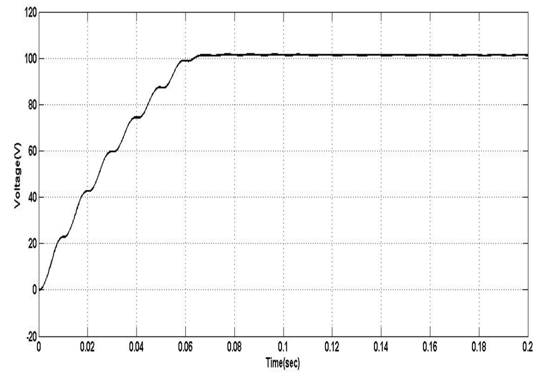

Figure 12 output voltage waveform

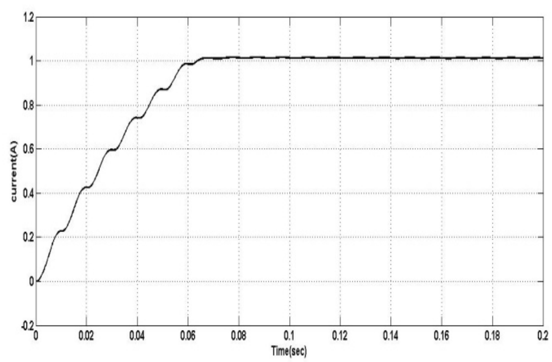

Figure 13 output current waveform

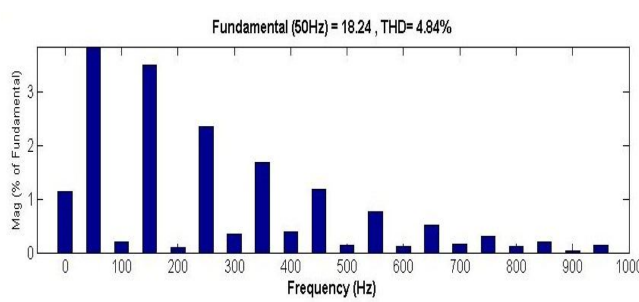

Figure 14 Harmonic Spectrum

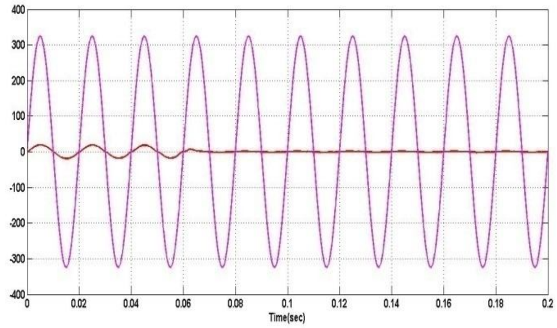

Figure 15 Input Power Factor

VI. CONCLUSION

In this work, LED driver for outdoor lighting system is presented. The proposed control method increases the output voltage as well as output current also. Therefore, proposed converter is operated in DCM so that it can achieve lower THD for wide output power range. The results show that the proposed converter gives low THD and high power factor. Therefore, the proposed converter is considerably suitable for wide output range LED applications.

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