A Modified Inverted Buck Converter based AC-DC LED Driver for Lighting Applications

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Abstract*— *Traditional light sources like incandescent and fluorescent lamps have been substituted by the Light-emitting diodes (LEDs) in many lighting utilizations as LEDs have a broad color spectrum, a long duration, a high luminous efficiency and are eco-friendly. In the proposed design, the inverted buck converters which is connected in parallel considerably condenses the mean voltage and two inverted buck converters consist of single switch reduces the cost of the circuit. The proposed design can accomplish an information input PF higher than 0.98 and efficiency is greater than 98%. The stress of the voltage and the extent of the storage capacitor, empowering the utilization of a film capacitor rather than electrolytic capacitor. To deal with the power variation amongst the twice-line-frequency input power and the uninterrupted LED power, two inverted buck converters are used. One is used to deliver energy from input ac supply to storage capacitor simultaneously performing the power factor correction (PFC) operation. Another inverted buck converter supplies consistent current to the LEDs to provide continual illumination. Although the past research methodology deals with minor power factor (PF) than traditional two-stage method which consist of PFC boost converter. Simulation work is carried out with MATLAB software.

***Index Terms*— Boost converter, Buck converter, Light emitting diode, LED driver, Power factor correction, Rectifier**

I. INTRODUCTION

Lighting is especially noteworthy in any one's lives. In the non-appearance of light, it is hard to move and do the things. Without lights, it is tough for the human to perform the work appropriately. The progression of LEDs is increasing day by day. The modernization of LEDs led to a new epoch in lighting gadgets. LEDs are becoming the light source of alternative for numerous general illumination applications because of its extended life expectancy, color scales, eco-friendly, high speed switching (turn ON and turn OFF capability), minor in dimensions and maintenance price is very less. The light emitting diode is a device made of semiconductor material that discharges light when a flow of electric charges passes through it. In numerous lighting applications the incandescent and fluorescent lights are supplanted by LEDs as a result of their extensive variety of shading, long life, high glowing productivity and nature-friendly well-disposed. One type of LED driver consists of boost converter, filter and N-channels of LED loads, other sort of driver also consists of boost converter and N-channels of LED loads along with controllers. Because of N-channels of LED driver result in power loss and hence the efficiency of the circuit is reduced. To overcome the above stated problem this project is proposed which consists of two inverted Buck converters, Electromagnetic Interference Filter, full bridge Rectifier and Controller ICs. This converter increases the efficiency of the circuit, power factor and maintain constant brightness in LEDs. The objective is to

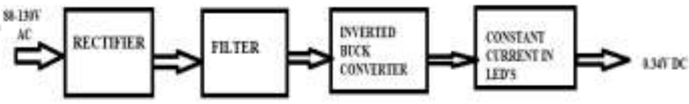

Fig 1: Block diagram of converting AC-DC

build an AC-DC LED driver by regulating the LED current to deliver constant luster in the LEDs and simultaneously it needs to conduct the PFC with better efficiency and high-PF and to minimize the switch so that switching losses, cost, the switching harmonics will be condensed and lessens the design complication of the driver circuit by means of inverted buck converter.

The block diagram of converting AC-DC is shown in Fig 1 where AC supply is given to the rectifier converts AC to DC is given to the filter circuit which consist of capacitance and inductance suppress the noise or harmonics in the circuit. The inverted buck converter maintains consistent brightness in the LED and PFC.

A 15 W sample LED driver [1] been employed and verified to justify the strategy of the proposed ac-dc LED driver, demonstrating a power factor reaches to near unity i.e. 0.94 and efficiency is 85.4% along with current ripple of LED of 6.5%. In numerous lighting applications the incandescent and fluorescent lights are supplanted by LEDs because of their extensive variety of shading, long life, high glowing productivity and nature-friendly well-disposed. The single-stage off-line LED driver topology [2] is more compatible because of its simplicity. The main drawback of this kind of topology is that it exhibits light unsteadily and supplies a large number of LED current ripple. The two-stage LED Driver has PFC stage to accomplish maximum power factor. The main cons of this type are the life time of electrolytic capacitor is reduced and a lesser amount of storage capacitor is utilized. The two-stage LED Driver has PFC stage to accomplish maximum power factor. The odd harmonic signals such as third and fifth or third harmonics can be inserted to the supply current to minimize incoming current in the form of pulses and hence lessens the LED current ripple and attains high pf [3]. The control is problematic and can't be appropriate for application of high power. To condense the output current ripple is the feed-forward control scheme [4], where the switching frequency is modulated and the electrolytic capacitors can be replaced. The usage of modest PFC pre-regulators [5] as single-stage LED drivers makes available a virtuous complete efficiency, but flickering is the disadvantage. Comparatively with further control process, the charge and the intricacy can be upgraded. The investigational results illustrate that the catastrophe mode [6] is unexpected failure and the main failure in non-isolated topology is control chip. The insignificant cost bulk capacitors are utilized to eliminate the undesirable harmonics at inexpensive budget which outcomes in disproportionate temperature and substantial ripple produces in little life expectancy of the capacitor. The tentative outcomes are presented in [7] demonstrate that driver can create a sinusoidal input current with unity power factor and instantaneously deliver persistent current for the LED load. It attains unity pf but not nearly equivalent to one and continual current flowing over the LEDs but give rise to proportioned ripple current initiates to flickering.

In view of the above problem the proposed buck topology along with AC-DC LED driver is designed as shown in fig 2.

II. EXPERIMENTAL SET UP

Fig 2 signifies AC DC LED driver. This driver comprises of single switch, inverted buck topology, control circuit, Electro Magnetic Interference (EMI), filter and rectifier. The rectifiers which is connected to AC supply converts into DC. The EMI filter consists of capacitor and inductor which is employed to suppress the noise present in the circuit. The inverted buck converter which is connected at the top conducts PFC operation conveys energy from the supply to the storage capacitor (C_{STO}). The lower inverted buck converter carries consistent current to the LEDs to withstand a continual illumination. The design parameters for the proposed circuit is shown in the section III

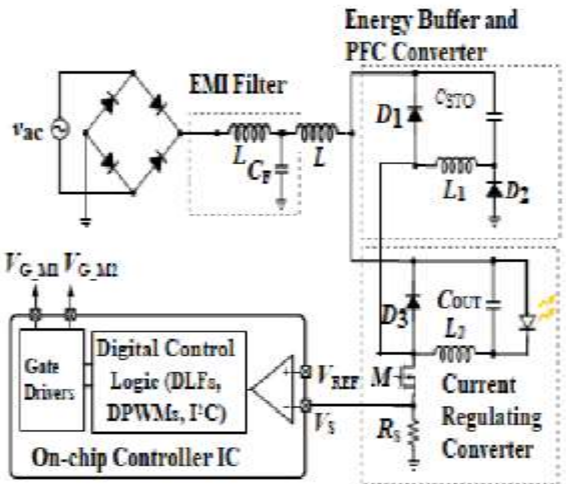

Fig 2: The proposed buck topology along with AC-DC LED driver

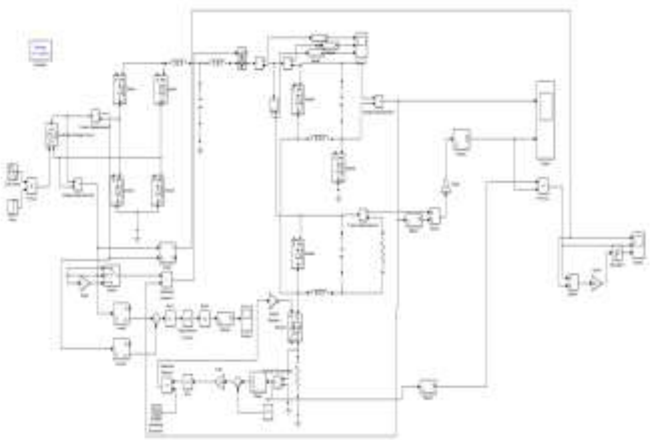

Fig. 3: Simulink model of AC-DC LED Driver in MATLAB

III. DESIGN PARAMETERS

Input data for designing the AC-DC LED driver for input voltage supply ranging from 80-132V with supply frequency of 100KHz.

Calculation of design parameters

Chosen value of V_{in} =132V

V_0=43.7V

P_0=15.3W

The power equation is given by

$P_0=V_0*I_0$

$I_0=P_0/V_0$

I_0=0.35A

F_S=100KHz

The duty ratio is given by

$D=V_0/V_{in}$

D= 43.7/132=0.33

$\Delta I_L= 0.2*I_0=0.2*0.35$

ΔI_L = 0.07A

$L_1= ((V_0-V_{in}))/(\Delta I_L*F_S) *D$

L_1= ((132-43.7) * 0.33)/ (0.07*100*10^3)

L_1=4.16mh

$C=\Delta I_L/(8*F_S*\Delta V_0)$

ΔV_0 = 1% of V_0

C= 0.07/ (8*100* 〖10〗^3*0.437)

C=0.2µF

$L_2 = (V_0*(1-D))/(2*I_0*F_S)$

L_2 = (43.7(1-0.33))/ (2*0.07*100*10^3) = 0.42mH

The proposed circuit operates in four modes. These four modes of operation are explained in section IV

IV. MODES OF OPERATIONS

A. MODE-1

V_{ac} is the supply voltage flowing through the rectifier. i_{in} is the input current flowing from the supply. i_1 and i_2 is the input current flowing through the inverted buck converter. L_F and C_F are the filter used to eliminate the harmonics. i_{L1} and i_{L2} are the inductor flowing through the inductor L_1 and L_2.

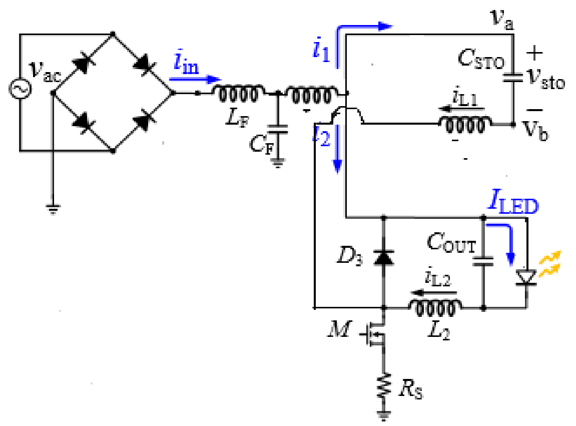

Fig 4: MODE-1

For the duration of mode1, when Vac is greater than Vsto, the switch M is turned on and the current i_{L1} flows throughout the inductor L_1. As and when the switch is turned on the LED starts glowing. Nearly a small amount of energy will be deposited in the inductor L_2.

B. MODE-2

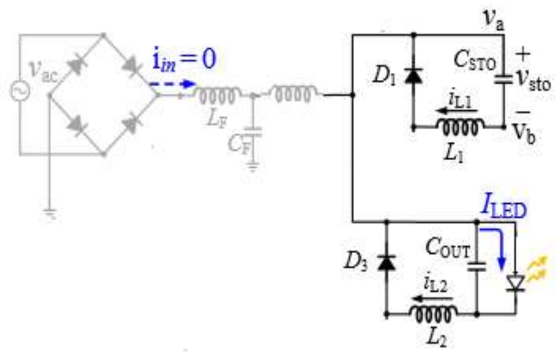

Fig 5: MODE-2

For the duration of mode2, when Vac is greater than Vsto, the switch M is turned off and the energy is deposited in the inductor L_1 will forward biases the diode D_1 and charges the capacitor, once the capacitor is fully charged, hence the capacitor starts discharging. The energy which is stowed in the inductor L_2 forward biases the diode D_3. As and when the current reaches the LED, the LED bulb starts glowing continually.

The equation for mode 2 is given by

$$V_0 = V_L - V_C$$

$$I_O = I_L - I_C$$

C MODE-3

For the duration of mode3, when Vac is lesser than V_{STO}, the switch M is turned on and the current i_{c1} flows throughout the LED and the energy will be deposited in the inductor L_2.

The equation for mode 3 is given by

$$I_0 = I_{C1} - I_{C2}$$

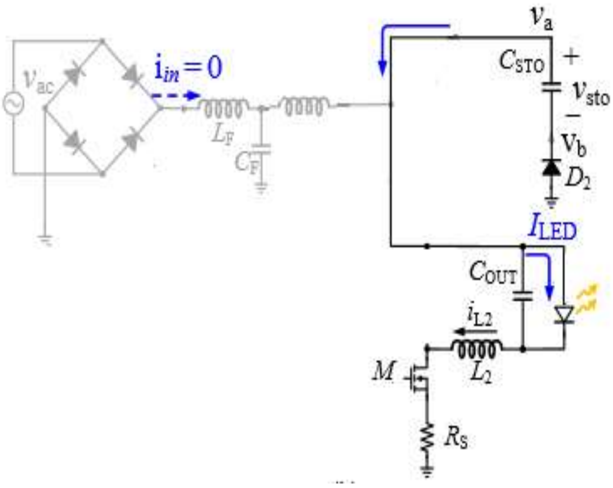

Fig 6: MODE-3

D. MODE-4

For the duration of mode4, when Vac is lesser than V_{STO}, the switch M is turned off and the energy which is placed in the inductor L_2 during mode 3 charges the inductor L_1 and capacitor C_{STO} and henceforth the capacitor current flows through the LED.

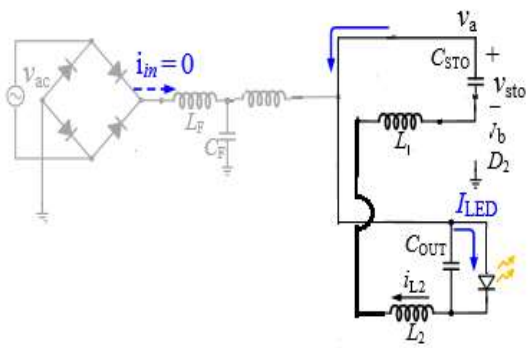

Fig 7 MODE-4

The simulation results for the proposed circuit is shown in section V

V. SIMULATION RESULTS

The simulation results are carried out by using MATLAB software. In MATLAB the model can be clearly and easily designed. The simulation results of the circuit shown in Fig 8 – Fig 12 is shown below. Fig 8 shows the resultant waveform of the current flowing through the circuit. Fig 9 indicates the results of input power, output power and efficiency. Fig 10 represents the waveform of power factor, Fig 11 represents the capacitor voltage and Fig 12 shows the simulation results of current flowing through the LED.

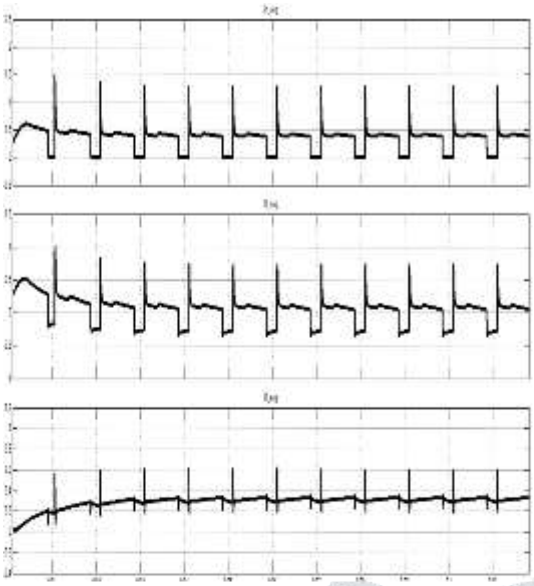

Fig 8: Current waveform

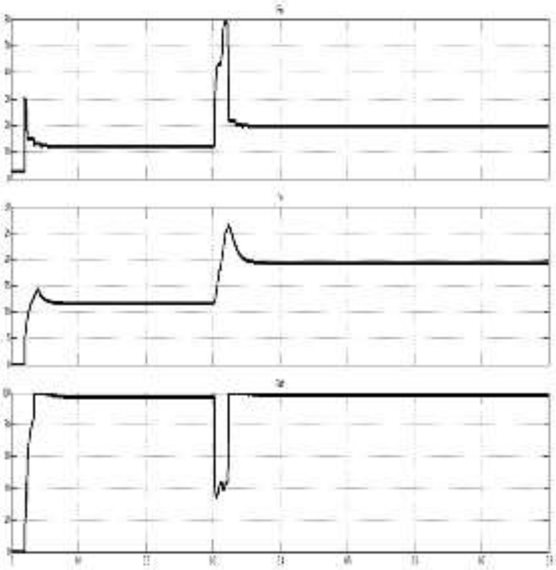

Fig 9: Input power, output power and efficiency

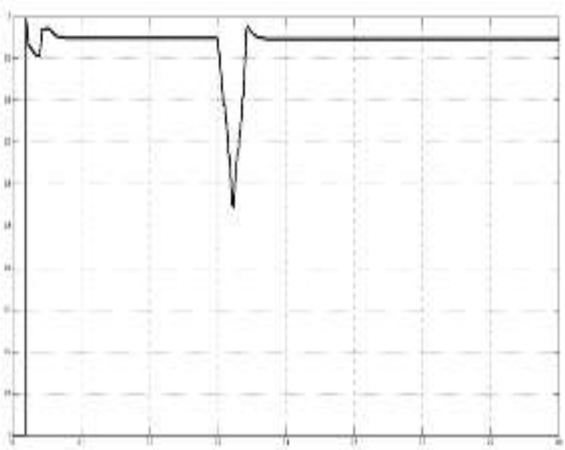

Fig 10 Power factor

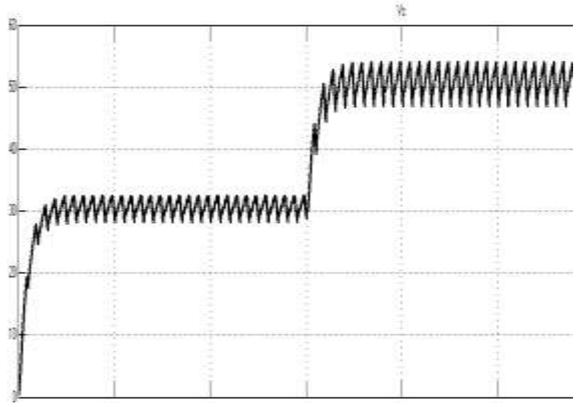

Fig 11 Capacitor Voltage

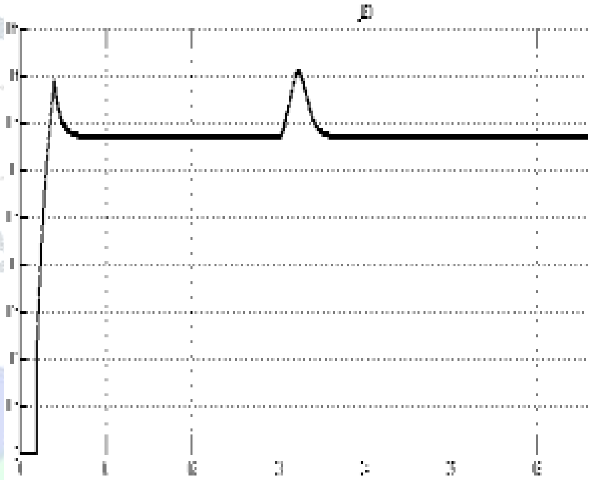

Fig 12 Current through LED

VI CONCLUSION

In the proposed inverted buck converter, the LED driver stabilizes the LEDs to withstand a persistent brightness to insignificant the flickering of light to condense the hazard levels. A dual inverted buck converter is proposed in which switch has been reduced to accomplish higher efficiency and power factor. The planned architecture with dual inverted buck converters in parallel suggestively decreases the average voltage. Further in addition with the two inverted buck converters consume a low-side switch that diminishes the design complication of gate driver circuit. However, the additional approach engaging an RCC, necessitates a transformer or coupled inductor with numerous other apparatuses. Since by reducing the switch, effectiveness can be improved and switching loss can be condensed. The proposed architecture diminishes the stress of the voltage and the level of the storage capacitor, permitting the consumption of a film capacitor relatively than electrolytic capacitor. A 9W prototype LED driver has been implemented and substantiated to authorize the approach of the projected ac-dc LED driver, representing a power factor influences to near unity factor i.e. 0.98 and efficiency is 98.4%. The simulation results are tested in MATLAB. Simulation results validates that losses are compact. Demanding a low voltage MOSFET, present sense resistor and uncertain control circuit, the equipment price is kept very low. Restricted power loss mains to an efficiency drop of lesser than 1% when linked to conventional LED drivers.

VII FUTURE WORK

Future work can be carried out by using Insulated Gate Bipolar Transistor (IGBT) as the primary switch which is suitable to acquire ultimate power, extreme efficiency with PFC requirement.

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