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LED Driver Circuit Powered By Direct AC

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ABSTRACT: This paper proposes a drive circuit for ac-direct LED lamps. The proposed circuit consists only of a line filter, an LED bridge, a load inductor, a bidirectional switch, and a switch-control circuit. The switch connects the LED Bridge to the power line directly. Each leg of the LED bridge consists of LEDs and a protection diode, all connected in series. The load inductor limits the bridge current. The switch operates at a zero current switching condition, so the circuit has high power efficiency. The circuit can operate at a free-volt input condition ($85<V_{in,rms}<265V$). For all input voltage conditions the circuit had PE >89%, luminous efficiency ∼90 lm/W, power factor >0.9, and 120-Hz flicker index ∼0.3. The circuit satisfies the IEC 61000-3-2 Class C and the EN 55015 regulations. The proposed LED driver is well suited for use in household LED lamps.

KEYWORDS*:*Active circuits, current control, light-emitting diodes (LEDs), lighting, power electronics.

I.INTRODUCTION

In outdoor lighting applications where the effect of flicker at 120/100 Hz from commercial AC mains can be neglected, AC-powered LED drivers are more attractive than switch mode LED drivers since they simplify the design as well as reduce the cost of lighting module. Recently, there have been studies of high PF, low THD AC-directly-powered LED drivers can achieve a very high performance, and they also have several short comings. With the design proposed, it is constructed with a lowest number of components; however, as the number of LED strings increases, the design shows a difficulty of realizing the switching function. Another design reported shows a high PF with a dimming feature; however it is very complicated in implementing the design with expensive blocks which degrades its robustness. As the most effective design, the technique reported can gain a high, very high PF and a low THD using self-adaptive soft-switching method without any additional control circuit as well as can be customized to balance the requirements of performance and cost. However, with these AC LED drives, dimming function using TRIAC dimmer can be challenging. All of these design cannot be performed properly with the conventional TRIAC dimmer as in switch-mode LED drivers because of the two main problems. Degrade the PF due to current chopping, (2) Increase the flicker because of the dead zone of the LED current which might result in negative effects on the health

Therefore, a new and effective design of a dimmable AC-direct LED driver for outdoor applications is needed. In this paper, an on-chip step-dimmer using analog dimming method in accompany with the novel self-adaptive power processing core is proposed for regulating simultaneously LED brightness as well as maintaining a high power factor and a low total harmonic distortion via simple concept. Furthermore, there is no need of any external passive components, thereby enhancing the lifespan of an overall LED module as well as achieving a solution of a fully integrated circuit of the design.

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II.CIRCUIT DIAGRAM

The figure.1 and Fig.2 shows the block diagram and circuit diagram of Direct AC LED Driver circuitrespectively.The proposed circuit consists only of a line filter, an LED bridge, a load inductor, a bidirectional SW, and a switch control circuit. The line filter prevents injection of the high frequency switching noise to the line. The SW powers the LED Bridge periodically. The ith leg of the LED bridge has an LED string (LED i, i = 1, 2, 3, and 4) connected in series with a protection diode (Di). The load inductor (L) limits the bridge current. The load current iL is measured using a Vsense coil, which is wound over L. SW operates at a switching period TS = $1/f_s$ (where f_s is switching frequency) with a duty factor of D, and controls i_L. The control circuit measures i_L and generates the gate voltage vg for SW.

$$I_L(t_1) =[(V_{IN} - 2VF)/L]DT_S \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The working diagram is shown in fig.3.at t = t_1 should flow through the bridge, where D ≡ $(t_1 - t_0)/T_S$. Two currents paths are created by the bridge: LED3–D3–LED1–D1–L and LED4–D4–LED2–D2–L. In this case, the turn-on voltage of two LED strings determines V_L, so $V_L = -2VF$ and $i_L(t)$ decreases to zero with a slope of $-2VF/L$.$i_L(t)$ is given as

$$i_L(t) = i_L(t_1) - (2VF/L)(t - t_1)$$

$$=((V_{IN} - 2VF)/L)DT_S - (2VF/L)(t - t_1) \ldots\ldots\ldots (2)$$

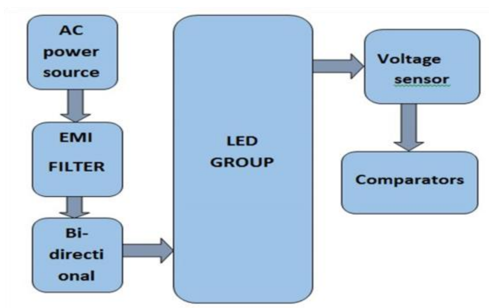

Fig.1 Block Diagram

because$i_L(t)$ should be continuous at t = t_1 . Mode 2 ends at t = t_2 when $i_L(t)$ = 0. So from (2),t_2 is given as

$$t_2 - t_1 = ((V_{IN} - 2VF)/2VF)DT_S \equiv DaT_S \ldots\ldots\ldots (3)$$

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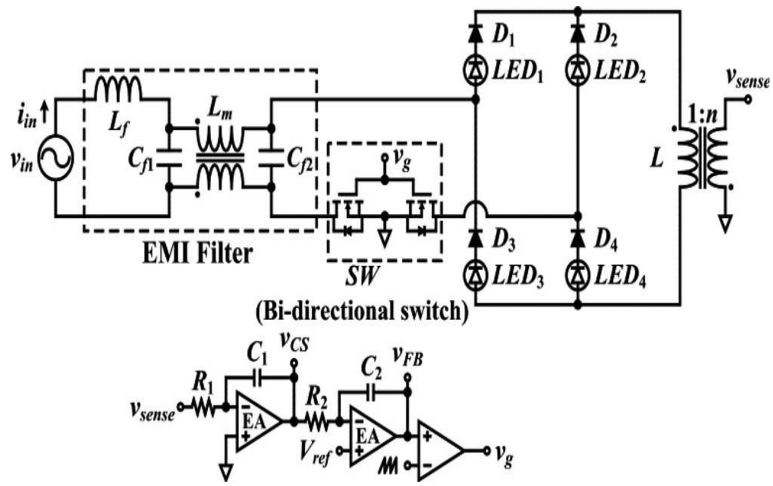

Fig.2 Circuit Diagram

For t_2 -t –t_3 , SW remains OFF and $i_L(t) = 0$, so all LEDs are turned off [Mode 3 in Figs. 2(c) and 3]. This mode guarantees a reliable operation of the circuit. Without this mode, $i_L(t)$ _= 0 at t = t_3 . So, SW is turned ON before D2 and LED2 are turned OFF completely on the next switching cycle. The input is temporarily short circuited when this occurs, and a large current can flow through the path Vin–LED1–D1–D2–LED2–SW, circuit failure could result.

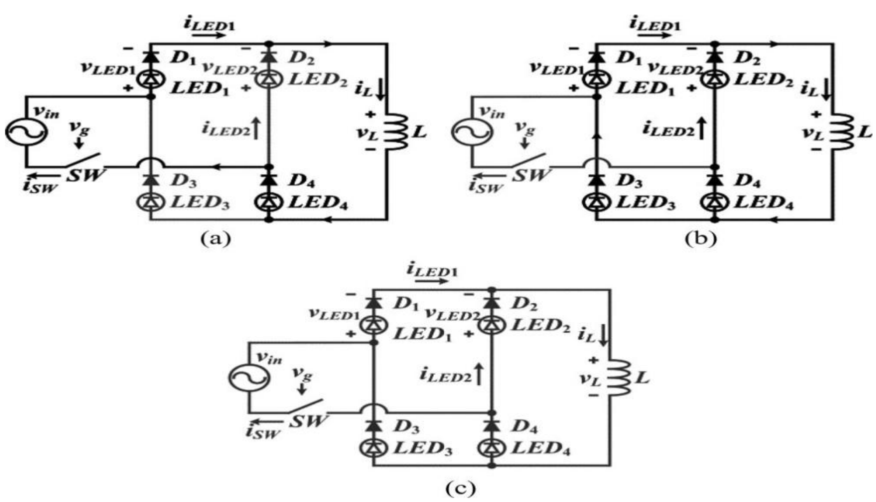

Fig.3 Working Diagram

Using Vin,max =(√2/) Vin,rms ,the maximum value of D for a reliable operation of the circuit is determined from (3) as

$$D \leq DMAX = (\sqrt{2})VF/Vin,rms$$

The operation of circuit for the negative half of 60-Hz input voltage is the same as the above described operation of circuit for the positive half cycle, except for Mode 1 at which LED2 and LED3 are turned ON but LED1 and LED4 remain OFF.

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III. DESIGN

The control circuit uses a current mode feedback to keep the output power P constant for a free-volt input (85 V $< V_{in,rms} <$ 265 V). It consists of a v_{sense}coil which is wound over L, two integrators, and a pulse width modulation generator. The v_{sense}coil produces a voltage signal

$$v_{sense}(t) = -nv_L(t)$$

where$n$ is the turn ratio of the coil. Because $i_L(t_0) = 0$ and $v_L(t) = L di_L(t)/dt$, the first integrator with a time constant R_1C_1 produces

$$\begin{aligned} v_{CS}(t) = & \frac{n}{R_1C_1}\int_0^t v_L\,dt = \frac{nL}{R_1C_1} i_L(t) \\ \equiv & \frac{nL}{R_1C_1}\left(i_{L,avg} + \tilde{i}_L(t)\right) \end{aligned}$$

where$i_{L,avg}$is the average of i_L, and$\tilde{i}_L$is the ripple component of i_L. The second integrator outputs a feedback signal

$$\begin{aligned} v_{FB}(t) &= V_{ref} + \Delta V_{FB} - \frac{1}{R_2C_2}\int_0^t (v_{CS}(t) - V_{ref})dt \\ &= V_{ref} + \Delta V_{FB} - \frac{t}{R_2C_2}\left(\frac{nL}{R_1C_1} i_{L,avg} - V_{ref}\right) \quad (4) \end{aligned}$$

WhereΔV_{FB} istheinitialvoltageofC_2,which has been adjusted to produce a desired D for a given $i_{L,avg}$. The third term of (4) adjusts D to provide negative feedback such that.

$$i_{L,avg} = \frac{R_1C_1V_{ref}}{nL}$$

The power consumption P of LEDs is

$$P = \frac{2Vf}{T}\int_0^T iL(t)dt = \frac{2R1C1VfVref}{nL} \quad (5)$$

which as desired for a free-volt input operation, is independent of $V_{in,rms}$. This equation also shows that LEDs can be dimmed by decreasing either R_1 or V_{ref}because light output of the circuit is proportional to P. The averaged value of $i_{SW}(t)$ over one switching period determines the line current $i_{in}(t)$ approximately, because the proposed circuit uses a line filter which prevents an injection of high-frequency switching noise into the line. So $i_{in}(t) = 0$ when $v_{in}(t) \leq 2V_F$ and expressing $i_{in}(t)$ with a Fourier series, the rms values of $i_{in}(t)$ and the 60-Hz component of $i_{in}(t)$ (I_S and I_{S1}) are obtained as

$$Is = \frac{\sqrt{2}\times D\times DVf}{\pi LfsDmax}\left(\frac{\pi}{2} - \sin^{-1} Dmax - Dmax\sqrt{1 - Dmax\times Dmax}\right) \quad (6)$$

The power P that is delivered to the LED load by the circuit is calculated using (6) as

$$P = Vin.rms \times Is = \frac{2}{\pi Lfs}\left(\frac{DVf}{Dmax}\right)^2 \times \left(\frac{\pi}{2} - \sin^{-1} Dmax - Dmax\sqrt{1 - Dmax \times Dmax}\right) \quad (7)$$

The maximum deliverable power P_{MAX} occurs at D =Dmax

V. PROTEUS SIMULATION AND RESULTS

For simulating the platform used is PROTEUS 8 and the circuit is drawn in the untitled and the simulation results are obtained.

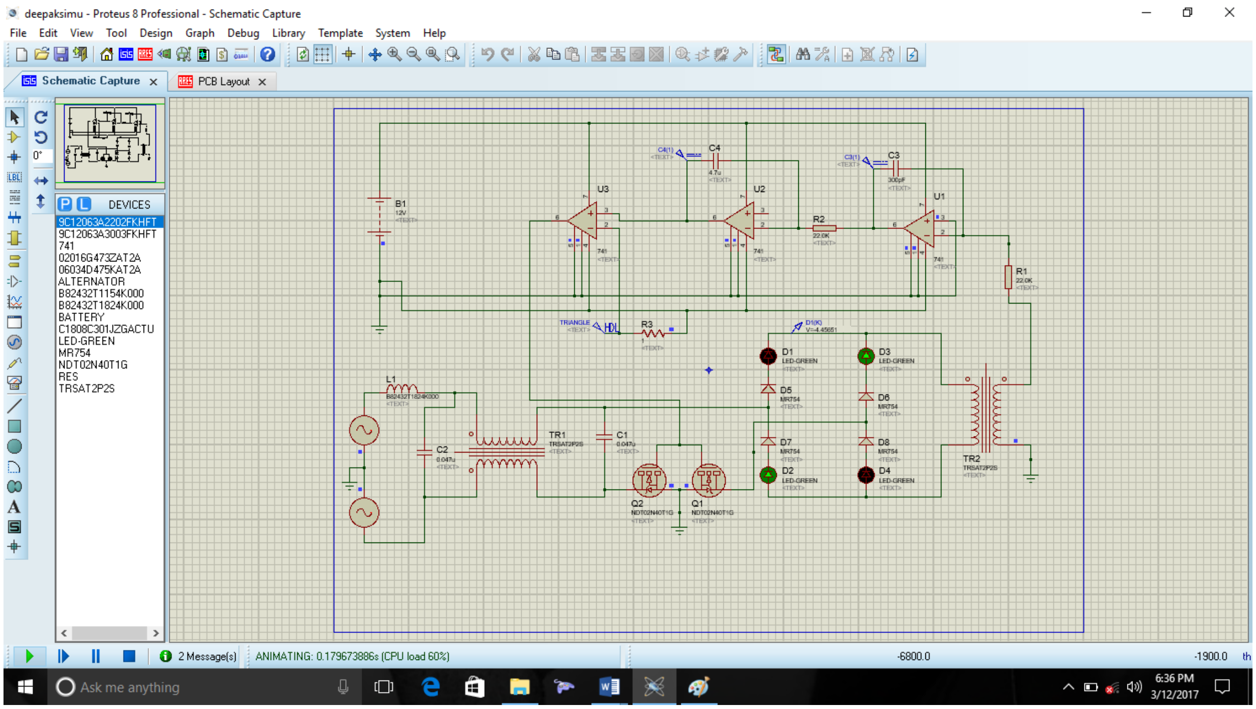

Fig.4 Proteus simulation

The circuit gives the basic circuitry of the Direct AC led driver circuit. The supply is given from the alternator which is converted using a transformer and the bidirectional switch circuit. The comparator compares the voltage and supplied to the LED and the output is obtained across the led lights.

VII. CONCLUSION

An inexpensive ac-direct LED drive circuit is proposed. It consists of only a line filter, an LED bridge, a load inductor, a bidirectional SW, and a switch-control circuit. This circuit requires few components and can operate at a free-volt input condition. The PE was >89%, the LE was ~90 lm/W, the PF was >0.9, and the 120-Hz flicker index was ~0.3 for all input voltage conditions (85 <$V_{in,rms}$<265 V). The circuit satisfies the IEC 61000-3-2 Class C and the EN 55015 regulations. The circuit can be implemented at lower cost than the multiple-string LED driver. The proposed LED driver is well suited for use in household LED lamps. The main advantages of this system is that it will give high p.f for the system and also low

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THD. The overall cost is reduced and efficiency is increased. The main applications comes in the field of lighting which includes street lighting using LED bulbs and tubes, it can also be used in architectural lightings consumes less electricity.

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