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Design of Flicker-Free Electrolytic Capacitor-Less Ac-Dc Led Driver

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Abstract: *The life of LED driver is mainly dependent on the component used in it. Elimination of electrolytic capacitor is done so that the life of LED driver will increase, if an ac-dc LED driver with power factor correction control is used than the output will be a pulsating current for driving the LED. Since the pulsating current will introduce light flicker that varies double the power line frequency. In this paper, A flicker-free electrolytic capacitor less single-phase ac-dc driver for LED lighting is presented. The component used are PFC converter and bidirectional converter, which serves to absorb the ac component of the pulsating current of the PFC converter, leaving only a dc component to drive the LED. The output filter capacitor of the bidirectional converter is intentionally designed to have a large voltage ripple, thus its capacitance can be greatly reduced. Consequently, film capacitors can be used instead of electrolytic capacitors, leading to the realization of a flicker-free ac-dc LED driver that has a long lifetime*

Keywords: *Light Emitting Diode, Bidirectional Converter, Electrolytic Capacitor, Flicker, LED Driver.*

I. Introduction

In todays world saving of energy is one of the important aspect considered. The main objective is to save energy by using LED as a lighting appliances. The innovation for green energy saving lighting has become an important pursuit throughout the world. The new light sources should be highly efficient, energy conserving, pollution free. Light emitting diode has all the properties of the above mentioned. From the last few year there is a rapid development of LED in Market. It is widely used in mobile products and back lighting of LCD panels. Presently the use of LED lighting are mainly concentrated in two aspects. One aspect is for low brightness illumination for example, the screen back lighting of notebook, computers and mobile phones, and the other is for high brightness illumination such as general lighting, vehicle lighting, and back lighting of large television panels. The efficiency of conventional LED drivers involving resistor based current limiters, linear regulators, and charge pumps is quit low[1-3].

For simple LED drivers that utilize an ac input source, then power factor correction control must be imposed in the driver to achieve a high power factor to meet harmonic. In the case of unity power factor, a pulsating power will be seen at the input side of the driver, but the output power is made constant to drive the LEDs. To balance out the instantaneous power difference between the pulsating input and the constant output, a storage capacitor with large capacitance is required. Normally, for storage capacitors with such a large capacitance, electrolytic capacitors will be used. The lifetime of an electrolytic capacitor is nearly 5000 hours. On the other hand, the estimated useful lifetime of LEDs is about 50000 hours. It is general expectation that LED drivers should have a life expectancy close to the lifetime of LEDs[1].

The expected lifetime of LED driver is increased by removing electrolytic capacitor There are three ways of removing the electrolytic capacitors. One approach of achieving this is through a new driver topology which uses magnetic energy storage instead of electrolytic capacitor based storage. While it was found that such an approach leads to the tradeoff of a significant increase in the size and weight of the driver [1].

Another approach of eliminating electrolytic capacitor is through the reduction of the pulsating component of the input power by sacrificing the input power factor. The basis of these methods is to intentionally distort the input current such that there is little low frequency power ripple component being generated at the input, and hence, there will be little low frequency ripple reflected at the output voltage. Hence the required storage capacitance can be reduced to the extent that long lifetime capacitors such as film capacitors or ceramic capacitors can be used instead of electrolytic capacitors. The third approach is through the insertion of an active filter to isolate the energy storage capacitor from the input and output terminals of the driver[1],[4]. This will allow the presence of a larger capacitor voltage ripple which means that the required capacitance can be reduced and be replaced by non electrolytic capacitors. The three approaches discussed above are applicable to LED drivers which drive the LED using a constant current.

Pulsating current can also be used to drive LEDs. The ac variation of the current will have no effect on the average illumination generated by the LED. The output current of electrolytic capacitor-less LED driver is pulsating with a large ac second-harmonic ripple component that is varying at twice the power line frequency. When passed into the LED, the pulsating current is directly converted into pulsating light of the same frequency[7]. Since the frequency of the pulsating light is higher than that of the human visual persistence, the human may not be consciously aware of the light flicker. However, in environments where light flickers, the human visual system has to constantly adjust itself to maintain the clarity of the images at the retina. Prolonged activities will severely strain the human eyes and causes great fatigue to the individuals working in such environments. Hence the use of such electrolytic capacitor-less LED drivers, which produce pulsating current to drive the LEDs, may not be suitable for many applications. Considering the above drawback , a flickerfree electrolytic capacitor-less single-phase ac-dc LED driver is presented, which converts the ac power source into a constant direct current for driving high-brightness LEDs[1],[4]. Since the presented LED driver contains no electrolytic capacitor, it has a much longer lifetime than conventional LED drivers. It is to be noted that the presented driver adopts the concept of active filter using a bidirectional buck-boost converter.

In this paper, design and simulation of Flicker free electrolytic capacitor less LED driver is presented. The flyback converter and bidirectional buck boost converter is designed as per the requirement of LED driver, for that purpose its equivalent parameters are determined. The brief outline of this paper is as follows. In Section II, brief overview of LED drivder and its components is presented. Various method to drive the LED is also shown. Section III, presents the simulation results followed by conclusion in Section V.

II. Led Driver And Its Components

A flicker free electrolytic capacitor-less ac-dc LED driver comprises a PFC converter and a bidirectional buck boost converter is as shown below

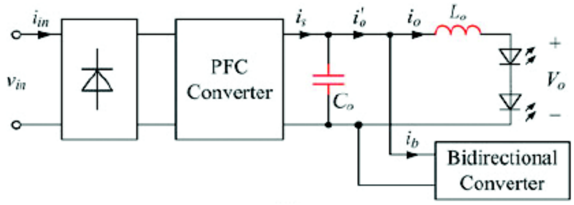

Fig. 1. Flicker-free electrolytic capacitor-less ac-dc LED driver

As shown in the schematic given below there is a filter induction and a capacitor. The function of filter inductor Lo is that it act as a low pass filter in preventing the harmonics. The filter inductor is connected in series with the LED string. The function of filter capacitor Co is to only filter the high frequency harmonics ripple and not the second harmonic ripple. The filter capacitor present here does not act as a storage capacitor. Hence, Co is very small, which offers the possibility of adopting film capacitors or ceramic capacitors instead of electrolytic capacitors. The absence of electrolytic capacitor will significantly increase the lifetime of the PFC converter.

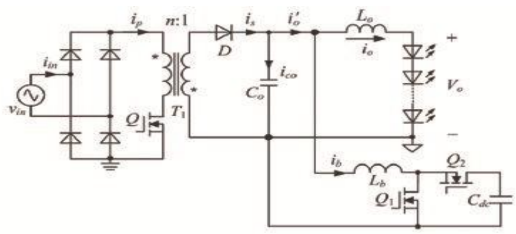

Fig. 2. Detailed schematic of Flicker-free electrolytic capacitor-less ac-dc LED driver

Objective

As flickering of light is not acceptable more than 8%, when the lamp is operated on 50 Hz frequency. On 60 Hz frequency, the percentage flicker should be less than 10%. Human visual may not recognize flicker above 75 Hz than also it harms the human eyes because it has to maintain the image at the retina which causes headache[6]. Generally Flicker does not occurs when current output i.e Light is 100 %, while when we dim the light source by reducing the current, flicker occurs[8]. Also Flicker occurrence will be different with different methods of operation like Pulse width modulation and Constant Current Reduction[10-11].

Pulse Width Modulation

LED Power Supplies dim the light by rapidly switching the current on and off to the LEDs. The ratio of time on to time off determines the brightness of the LED. Pulse width modulation LED Power Supplies may not exhibit objectionable flicker when current is at 100%, but when dimmed, flicker may become apparent.

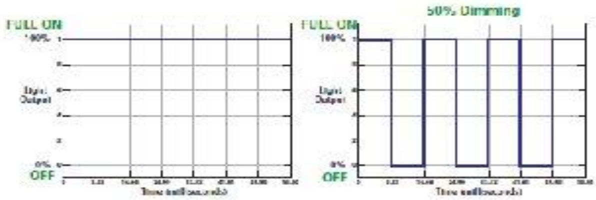

Fig. 3. 100 % and 50 % Light output with Pulse width

Constant Current Reduction

Constant current reduction LED Power Supplies dim the light by reducing the amount of current delivered to the LED. The LED does not turn on and off but its brightness increased or decreased as required [6]. Constant current reduction LED Power Supplies may exhibit a ripple on the output current signal.

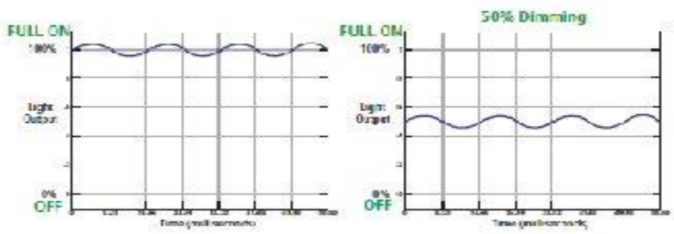

Fig. 4. 100 % and 50 % Light output with Constant current reduction

III. Simulation Result

The Simulation of flicker free electrolytic capacitor less LED driver is simulated in MATLAB. The Voltage output and current output are 48 V and 0.7A respectively. MATLAB simulation with fly back converter and bidirectional buck boost converter is as shown in Fig. 5 for output voltage and in Fig 6 for output current. When we apply PID controller in LED driver and if output load fluctuates, then also the output light remains constant at desired level .Fig. 7 shows the output voltage waveform and Fig. 8 shows the output current waveform when PID controller used in LED driver.

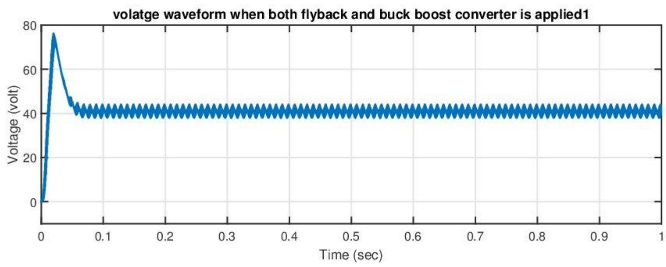

Fig. 5. Output voltage *vo* when PID is absent.

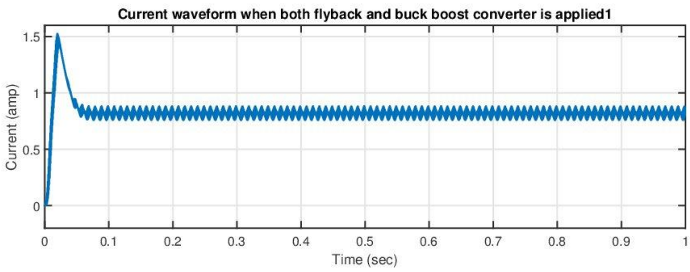

Fig. 6. Output current *io* when PID is absent.

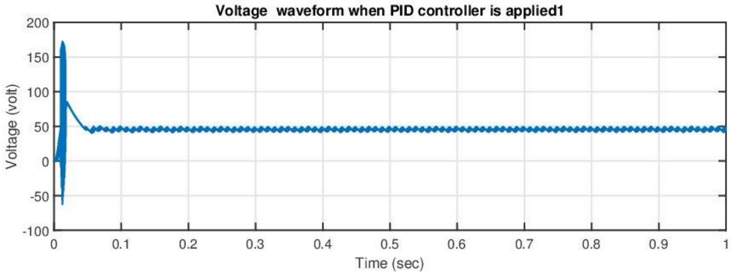

Fig. 7. Output voltage *vo* when PID is present.

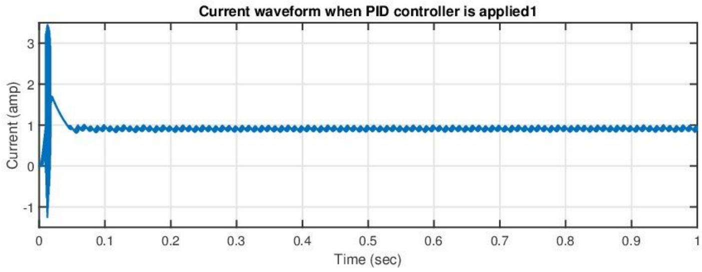

Fig. 8. Output current *io* when PID is present.

IV. Conclusion

In this paper, we have concluded the occurrence of flicker is mainly from different control method viz Pulse width modulation and Constant control reduction. A lamp will be flicker free if operated in full load but when it has to be dim, flicker may occur. In Constant current reduction method the flicker is very less as compared with the Pulse width modulation method. Effect of Flickering of light on human being is not acceptable because working in such environment severely affect the human eyes and cause headache. Two converter i.e Flyback and buck boost converter is used in order to remove the flicker to its best possible value. When only flyback converter was used, the light output was pulsating light because the current given to LED was pulsating current which cause flicker. Therefore to avoid the pulsating light, Bidirectional buck boost converter was used to prevent from flicker.

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