Comparative Study on LED Drivers using Fly back converter With and without internal power factor correction

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Abstract – *The present days lighting technology has entered a phase. The power LEDs are being widely used for lighting because of its higher efficiency, longer life and durability on comparing with traditional lightings like incandescent lamps. This contains power LEDs hence require special driver circuits. There can be two types of drivers one is AC-DC converter which draws harmonic current from the source decreasing the power factor, the other type is AC-DC converter having an inbuilt power factor correction circuit. The converter with active PFC will provide a pure sine wave with less harmonics and also power factor equal to one. In this paper we will compare a 20W LED driver designed with internal and external PFC. The results obtained were as power factor of 0 .93 and THD as 31.11% while using external PFC circuit. When the internal PFC was implemented the output were obtained as power factor of 0.97 and THD as 10.4%.*

***Key Words*: Power LED driver, fly back converter, Boost converter, power factor correction, Total Harmonic Distortion.**

1. INTRODUCTION

The lighting efficiency has become an important topic as the electrical bill contains 20% on luminaries. The limitation and large consumption of electrical energy has urged the electrical engineers to look on the efficiency and power factor of every small components consuming electricity. There were lots of research were carried out on this topic. In the area of lighting so many varieties of lighting were experimented like incandescent lamps and which is now replaced by power LEDs. The power LEDs have taken over the lighting systems due to its long life, low energy consumption, small size, long durability and reliability on comparing with other lightings.

The power LEDs are occupied with special derivers for power conversion as they draw high current from the source. The AC-DC converter is the main part of an LED driver. In AC-DC converter the converter draws AC current directly from the supply with lots of harmonics. The harmonics reduces the power factor of the input supply. This power factor problem can be resolved by using a power factor corrector along with the converter instead of using AC-DC converter without power factor correction. The power factor corrector removes the harmonic in the input and draws pure sinusoidal making the power factor closer to unity.

In this paper a comparative study between fly back converter with internal PFC and Fly back converter with external PFC is carried to understand which gives perfect power factor correction at lowest total harmonic distortion.

2. POWER LED DRIVERS

During the operation power LEDs draw high power delivering higher heat output. The higher heat decapitated during the operation causes life of the LED. The high heat produced will reduce the life of the LEDs. There is no current control in the system when the heat is increased beyond a limit. For the proper functioning of the LED driver there should be constant current in the system. The efficiency of LED lighting is of higher importance as these lights are meant for energy saving. Hence a power LED without proper driver cannot be used for energy saving purposes. For obtaining the desired output and long life with high power different types of led drivers were designed namely simple resistor, line regulator and switching regulator.

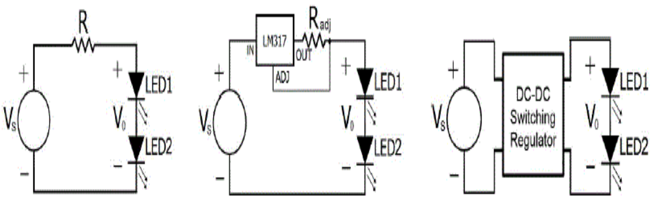

Fig-1: Three basic LED drives simple resistor, line regulator and switching regulator respectively

Simple resistor is the simplest and cheapest LED driver the only disadvantage of this driver is that it can be used only for low power LED drivers. As the main component used for the power regulation is a resistor the losses that occurs during the conversion is high and the current output is not remained constant. Throughout the time current doesn't remains constant it keeps on fluctuating. The brightness of the LED keeps fluctuating due the current variation.

The other simple circuit used for the power conversion is line regulation circuit. The circuit consists of a line regulator. The second driver circuit provides current limiting which provides protection to the LED. Large temperature is produced during operation of power LED due to the line regulation. The efficiency of the circuit is also low because of the power loss occurred at the time of regulation.

The third method overcomes all the drawbacks of the 1st and 2nd method in this method DC-DC switching converters are used for maintain the output current constant. Thus proving LED a constant output current thereby maintains the long life of the LED.

3. AC-DC CONVERTER

An AC-DC converter along with a capacitor filter is known as a conventional AC-DC unit interface [1]. The AC-DC converters draw power directly from the source along with the harmonics which leads to the reduction of the power factor throughout the circuit. The LED driver has to be designed in such a matter that the harmonic level in the circuit must low according to the standards so as to maintain the power factor near to unity. “THD of the input current is defined as the ratio of the sum of the currents of all harmonic components to the current of the fundamental frequency.”

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} I_n^2}}{I_1} \quad (2.1)$$

Where:

n: the order of harmonic;

I_n: nth harmonic component of the current;

I_1: rms value of fundamental components.

The power factor was calculates as the cosine of the angel between the voltage and current. However the actual value of the power factor is the ratio of average power to the product of rms value of voltage and current. When the input wave is sinusoidal with harmonics the power factor depends on both on cosine of the angel between the voltage and current and total harmonic distortion.

$$PF = \frac{cos\emptyset}{\sqrt{1+THD^2}} \quad (2.2)$$

The fig.2 shows the details about the harmonics spectrum the conversion process that is the waveform at each stage of conversion. The basic circuit diagram is also shown. The spectrum makes it clear about the level in which the harmonic needs to be limited so as to get better power factor. The harmonics is inversely proportional to the power factor of a system.

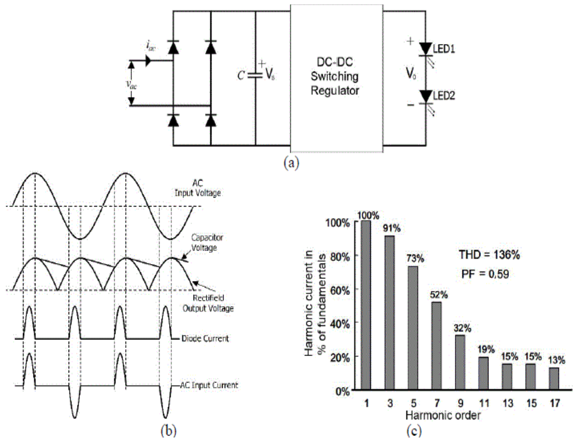

Fig- 2: (a) Circuit diagram, (b) waveform and (c) harmonic spectrum of an AC-DC converter

4. DC-DC CONVERTERS

There are mainly four types of DC- DC converters used as switch mode converters. They are mainly used for the power conversion in power LED drivers so as to obtain power factor close to unity. The four converters used for power conversion in an LED drive are: buck converter, boost converter, buck-boost converter and fly back converter.

The schematic of boost converter is shown in fig-3. The main principle of boost converter is that the inductor controls the variation in the current by creating and destroying the magnetic field. In a boost converter the output is always greater than input. The buck converter converts the input into a high value at the output maintaining the polarity. The output equation is given as

$$V_o = \frac{V_S}{1-D} \quad (3.1)$$

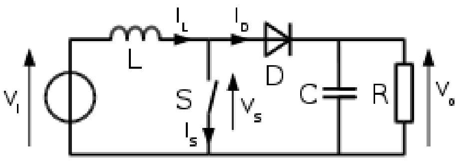

Fig- 3: Schematic layout of boost converter

The Buck converter is the converter in which the output voltage is lesser than the input voltage, shown in fig.4. The buck converter is also known as step down converter. The output equation can be written as:

$$V_o = V_S D \quad (3.2)$$

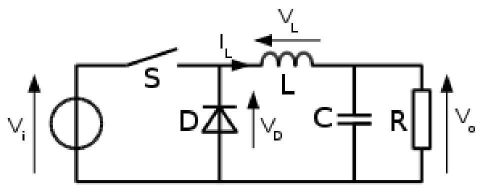

Fig- 4: Schematic layout of buck converter

In Buck-Boost converter the output voltage can be increased or decreased by varying the duty ratio of the converter. The output of the buck boost converter is inverting hence also known as inverting converter. Simply a buck-boost converter is a buck converter integrated with boost converter. Thus the output equation of buck boost converter is obtained as:

$$V_o = V_s\left[\frac{D}{1-D}\right] \quad (3.3)$$

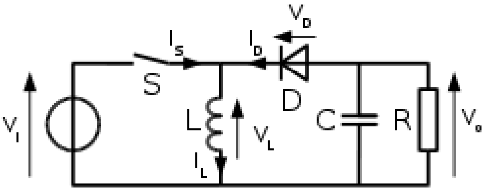

Fig- 5: Schematic layout of buck-boost converter

The fly back converter provides isolation between input and output side of the converter. The fly back converter is similar to a buck – boost converter in which the inductor is replaced with transformer. The circuit provides larger power factor and better performance due to isolation. The output of a fly back converter is obtained using:

$$V_o = V_s\left[\frac{D}{1-D}\right]\left[\frac{N_1}{N_2}\right] \quad (3.4)$$

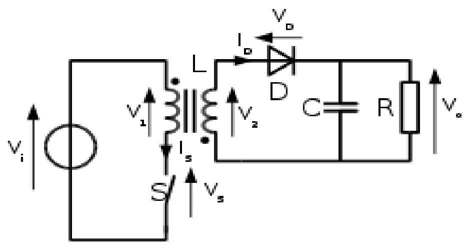

Fig- 6: Schematic layout of Fly back converter

5. LED DRIVER WITH EXTERNAL PFC

The circuit diagram of a power converter with external power correction is shown below in Fig.6

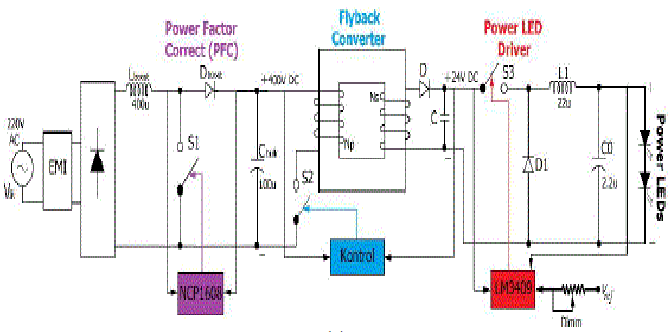

Fig- 7: Circuit diagram of LED driver with external PFC

In the circuit diagram an EMI filter is included at the input so as to compress the electromagnetic interference. The input AC is converted to DC with the help of diode. The input power factor is corrected using the power factor correction circuit, thus obtaining a constant output.

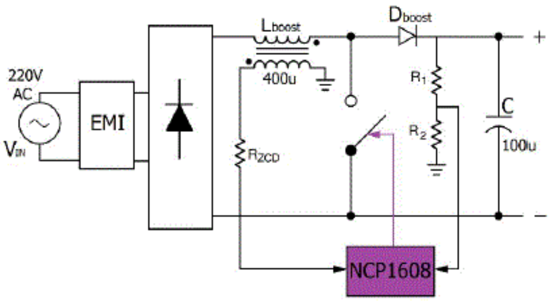

Fig- 8: Power Factor correction circuit.

The power factor correction circuit is used to obtain constant output and to adjust the brightness of the LED.

6. LED DRIVER WITH INTERNAL PFC

A LED driver with internal power factor correction is shown in fig.9 the converter used in fly back converter. The LT3799 is the driver used to drive LED and for controlling fly back converter. The fly back converter has the ability for power factor conversion.

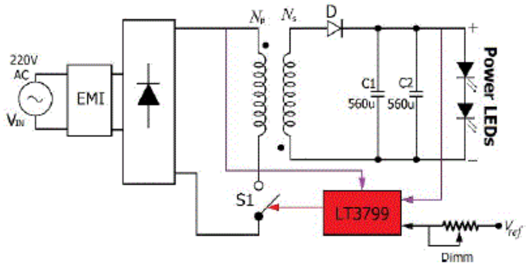

Fig- 9: LED driver with internal PFC.

The switching of the fly back converter happens at high frequency so an EMI filter is inserted in the circuit to supress the EMI. The diode is used for AC-DC converter. The fly back converter controlled using LT3799 the input power factor is corrected and the LED is driven in constant current

7. COMPARISION

Consider the operation of both the circuit with a same load of 20W LED and with two inputs 110V and 220V. The power factor and total harmonic distortion of both the circuits was measured under both the input voltage.

Both the results shows that on comparison with a circuit that does not contains a power factor correction circuit both the converters with internal and external PFC obtained better power factor and lower harmonics. The results are shown in table below.

Table-1: Observation under test condition.

Parameters	Converter with external PFC		Converter with internal PFC	
	110V	220V	110V	220V
PF	0.96	0.93	0.99	0.97
THD	15.3%	13.1%	12.0%	10.4%

From the observations it is clear that a converter with internal power factor correction provides better results on comparison with the converter having external power factor corrector. The converter with internal PFC operated with input voltage of 220V meets the European standards. Therefore fly back converters are wildly used for small power LED applications.

8. CONCLUSION

In the analysis carried out it was observed that the converter with external PFC the power factor corrector and conversion takes place separate circuits. In the converter with internal PFC both power factor correction and conversion happens in a single circuit. The internal PFC circuit can be used for only for low power circuit and it fails for high power circuit due to large EMIs. In large power circuits external PFC circuit provides the better results due to external power factor correction. The internal PFC circuit is limited to 25W and the external power factor circuits are mainly preferred for above 100W.

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