

A Low-Cost Linear LED Driver for Light Bulb Based on Harmonic Standard

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Abstract. Since lighting system is used in every human activity, an electronic device with more power efficient and low cost, rather than electrical equipment, has been developed. HPLED (High Power Light Emitting Diode) has been applied in many aspects to replace the conventional lighting. A significant part of the system is LED Driver, which is important to improve efficiency, adjusted voltage and current output. Some problems may occur and cause harmonic distortion. There are two types of drivers commonly developed such as Linear Driver and Switching Driver. Linear driver is a circuit easier to implement and to find error compared to switching driver. A linear LED driver circuit must fit the Harmonic Standard requirements. In this study, some comparisons and measurements due to IEEE 519-1992 and IEC 61000-3-2 standards were conducted to evaluate the power quality. The results showed that the measurement of Linear Driver using LM 317 and IN4733 in accordance to the Harmonic Standard were PF 0.92, THDi 37.5%, THDv 1.9% for LM317 Driver and PF 0.86, THDi 25.4% and THDv 2.1% for IN4733A, respectively.

1. Introduction

In the next few years, LED lamps will replace the function of traditional lighting devices that commonly use the conventional bulb, incandescent light and fluorescent [1]. Technology Light Emitting diode has been applied to an indoor light system; outdoor lighting system causes LED system to have many advantages such as low cost, less energy consumption, high efficiency, long life cycle (10.000-15.000 hours), and environmental friendly [2]. The experiment showed that HPLED has better efficiency than other lamps. It is also more durable until 50.000 hours better than other traditional lamps with the durability of 1000 hours and fluorescent with 10.000 hours [3]. However, LED Lamps system still has some disadvantages as it may cause harmonic distortion effect. Harmonic distortion is a symptom that causes damage to the electronic devices [4].

The LED driver is critical to LED system as it can improve efficiency, adjusted voltage and current output. However, some problems may occur and cause harmonic distortion. The best value of LED Driver has the low reactive power, constant real power, high power factor, and a value of Total Harmonic Distortion suitable for harmonic standard IEC 61000-3-2 [5] and IEEE 519-1992. This paper presents linear LED Driver with low-cost circuit [6] using LED driver IC LM-317 and Diode Zener 1N4733A as Regulator to build LED Driver. We used Power Harmonic Analyzer to measure LED Driver. This paper is proposed to show LED driver using LM-317 and Diode Zener 1N4733A according to harmonic standard of IEEE 519-1992 and IEC 61000-3-2 class C standards; load LED driver with ten HPLED (High Power LED 1 watt) series. The implementation and measurement of LED Driver system was then



compared to harmonic standard IEC 61000-3-2 and IEEE 519-1992 to compare high performance and power quality [2].

The result in other experimental LED Driver using Low Pass Filter with L and C component for fit with harmonic standard, the odd harmonic standard fit with standard IEC 61000-3-2 class C except fifth harmonic and fit with standard IEEE 519-19992 [7].

2. Basic theories

2.1. IEC 61000-3-2

There are many harmonic standards; one of which is IEC 61000-3-2 to limit harmonic distortion current equipment in the supply to the public. It determines the limit of harmonic current components input that can be generated by the equipment and ensures that the level of harmonic is suitable with IEC 61000-3-2. That standard has been classified into 5 classes; lighting equipment has an active power greater than 25Watt in class C. The maximum value Total Harmonic Distortion to odd multiples of the frequency fundamental is shown in Table 1 or, in other word, the value of third harmonic distortion does not exceed 86%, and the fifth harmonic does not exceed 61% of the fundamental current, Total Harmonic Distortion Current for all orders may not exceed 105%. Standard IEC 61000-3-2 limit for class C is shown in Table 1.

Table 1. IEC 61000-3-2 limit for class C equipment (P<25W) [8].

Harmonic (n)	Class C (% of Fund)
3	30 x Pf
5	10
7	7
9	5
11	3
13	3
15<n<39	3

2.2. IEEE 519-1992

According to IEEE 519-1992, harmonic voltage distortion on power system around 220 Volt is limited to 5.0% and for individual harmonic limited to 3%. Voltage Harmonic Standard is shown in Table 2.

Table 2. Standard IEEE 519.1992 [8].[illegible]

2.3. IC LM 317

IC LM-317 is a regulator chip IC (Integrated Circuit) for positive DC supply, LM-317 has been applied to make voltage variable DC supply with a simple circuit. The LM-317 device has three-terminal input-output and adjuster. An output voltage can be adjusted from 1.25 V to 37 V dependent upon the calculation, and it only requires two external resistors as the component to set the output voltage. The Voltage Regulator can supply current more than 1.5 A. LM-317 has been applied to ATCA Solution, Desktop PC, Finger Print, Hydraulic Valve, Power Bank Solution, Power Quality Meter, Refrigerator, RFID reader and many more [9].

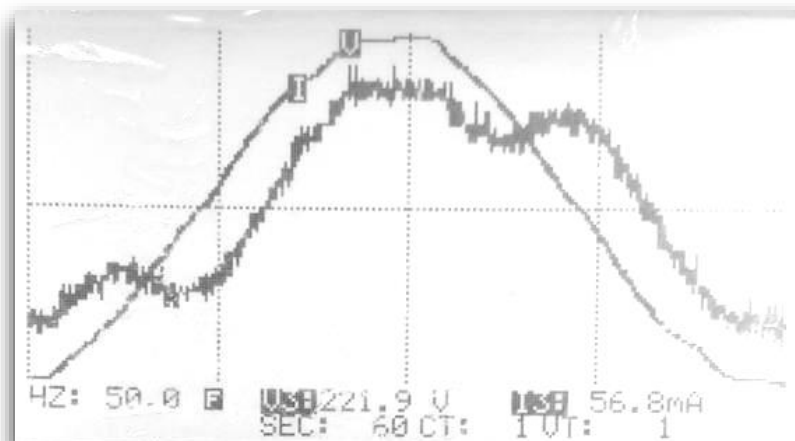
The Equation (1) was to find voltage flexibility LM-317 with $V_{\text{ref}} 1.25$ and I_{adj} has been ignored for causing that microampere current.

Table 3. Harmonic measurement result using LM-317.

Parameter	Result
%THDi (%)	29.1
%THDv (%)	2.1
Vrms (V)	221.9
Irms (mA)	56.6
P (Watt)	10.8
Q (VAR)	6.4
S (VA)	12.5
Phase (ϕ)	26.2
PF	0.86

Table 4. Harmonic measurement result of % THDi using LM-317.

Orde	Result of %THDi
3	28
5	7.7
7	2.1
10	0.8
11	0.9

**Figure 3.** The waveform current and voltage.

The result of power measurement showed the Power Factor of 0.86 and Total Harmonic Distortion of 29.2% that were suitable with the standard IEEE 519-1992 because %THDv below 5%, standard IEC 61000-3-2 except third harmonic but suitable to use cause Total Harmonic Distortion less than 86 %.

4.2. The harmonics measurement of led system lamps using diode zener

The results of experiment using Diode Zener is shown in Table 5, Table 6 and Figure 4. Table 5 shows a measurement LED Lamps system; Table 6 displays the harmonic measurement result of odd current harmonic distortion, and Figure 4 displays the phase of voltage and current using Diode Zener.

Table 5. Harmonic measurement result using diode zener 1N4733A.

Parameter	Result
%THDi (%)	25.4
%THDv (%)	2.1
Vrms (V)	222.8
Irms (mA)	57.6
P (Watt)	11.1
Q (VAR)	6.3
S (VA)	12.8
Phase (φ)	25.8
PF	0.86

Table 6. Harmonic measurement result of %THDi using diode zener 1N4733A.

Orde	Result of %THDi
3	23.3
5	6.9
7	3.9
9	1.7
11	0.6

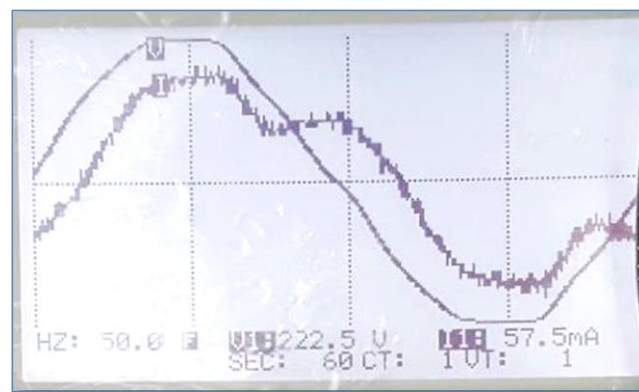


Figure 4. The waveform current and voltage Diode Zener.

Experimental result using Diode Zener had higher Power Factor, low Total Harmonic Distortion. This result is suitable with harmonic standard, odd order harmonic current when compared with standard IEC 61000-3-2 class C and IEEE 519-1992.

4.3. The harmonics measurement using capacitor

The power measurement using LM-317 was not suitable for Harmonic Standard IEC 61000-3-2 Class C for 3rd Harmonic. This experiment did not use a filter for the reduction of harmonic because adding filter could increase the cost. In this case, capacitors were used in parallel with LED Driver used for harmonic reduction for having reactive power since LED Driver load and LED load had inductive Load. Equation (2-4) [11] shows the capacitor value 0.223 μF to increase power factor 0.95 from 0.86 and to decrease Reactive Power with $Q = 3.29 \text{ VAR}$, $f = 50 \text{ Hz}$, and $V_{\text{rms}} = 221.5 \text{ V}$

$$Q = P(\tan\phi_1 - \tan\phi_2) \quad (2)$$

presented in Table 7 and Table 8. Power Quality improved to 0.92 but total harmonic distortion increased to 35.5%. The result is not suitable when comparing with the third harmonic standard IEC 61000-3-2 Class C, but capacitor can improve power factor, and decrease Reactive Power.

5. Conclusions

The purpose of this paper is to design a cost effective and simplicity to implement linear LED driver. The experimental result showed that LED driver using LM-317 and Diode Zener 1N4733A had a normal power quality and fit for harmonic standard IEEE 519–1992 IEC 61000-3-2 Class C. The harmonic value in LED system is suitable with standard IEC 61000-3-2 class C, but the third harmonic did not meet IEC 61000-3-2 class C standard requirement. The experiment using capacitor could improve the power factor up to 0.92, phase current-voltage wave decreased to 142,2o, and current harmonic distortion THDi% increased to 35.7. Reactive power (Q) also decreased as the effect of capacitor addition.

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