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# LM317 Constant Current White LED Driver in the Temperature Study

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## ABSTRACT

The purpose of this paper is to explore the relationship between the driving method and temperature of high brightness white LEDs today. The temperature of high brightness white LEDs varies depending on the driving method, but this variation also affects the life of high brightness white LEDs. However, this variation also affects the life time of high brightness white LEDs. The best driving mode is found in the constant current driving method in LM317.

***Keywords:*** White LED, LM317, constant current driving method

## 1. INTRODUCTION

In recent years, the industrial development of countries, the earth's available energy is becoming less and less, in the current situation of renewable energy is still not very common, effective use to improve its conversion efficiency is a matter of urgency.

White LEDs are used in lighting, and they have a much longer life and are more energy efficient than the current general light sources, and they can solve the environmental problem of mercury in waste lamps. In terms of lighting, incandescent lamps, although cheap, but the luminous efficiency is very poor, short life, fragile and other disadvantages. Fluorescent lamp contains harmful substances such as mercury, which can cause pollution to the environment.

LEDs have low power consumption, high directivity, long life, dimmability, small size, and high color rendering. In addition to the continuous improvement of process technology, the development of white light emitting diode (Light emitting diode, LED) is becoming more and more mature. It has the advantages of high luminous efficiency (commercial specification can reach more than 100 lm/W), long life (L70 standard can reach more than 35000 hours), energy saving and environmental protection (mercury-free), small size, fast response time, etc. It has gradually replaced traditional lighting systems, such as incandescent bulbs, fluorescent tubes, etc. This makes high brightness white LEDs available for residential, industrial and commercial applications. In view of this, this study uses LEDs as an indoor lighting source to replace incandescent bulbs and fluorescent lamps [1-8]. Figure 1 shows the LM317 constant current driver circuit diagram.

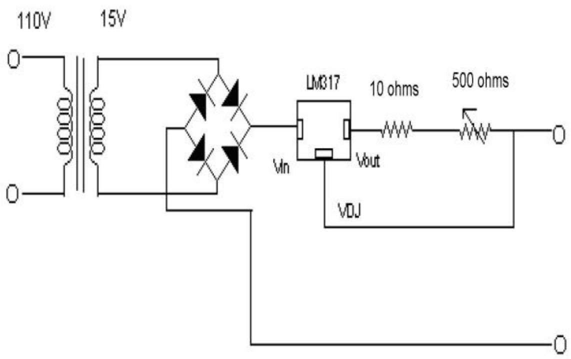


**Figure 1: LM317 constant current driver circuit diagram**

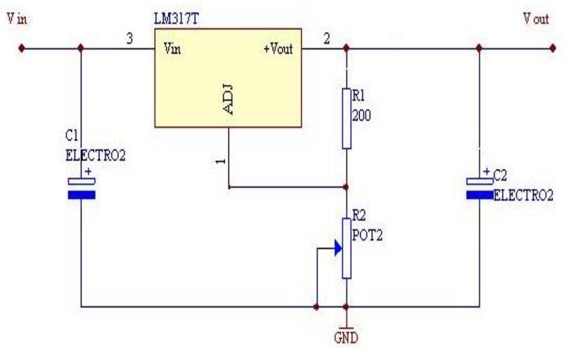


**Figure 2: LM317 standard circuit diagram for voltage regulation**

## 2. THEORETICAL STRUCTURE

As shown in Figure 2, the LM317 is a three-terminal adjustable voltage regulator IC from National Semiconductor. Other major IC manufacturers have similar products available, and they are widely used as voltage regulators [9-11].

The output voltage of LM317 is determined by R1 and R2, Vout=1.25 × (1+R2/R1), and many manufactures use variable resistors in R2 to fine tune the output voltage. However, it is recommended in the literature not to use variable resistors because the stability of variable resistors is not as good as fixed resistors. Often due to oxidation of the contact points, the center point is not well contacted, thus suddenly outputting high voltage, which may cause the equipment to burn up. Therefore, it is recommended to calculate the R1 and R2 that should be matched with the output voltage and use precision resistors to install them.

The LM317 has an output voltage range of 1.2V to 37V and a maximum load current of 1.5A. It is very simple to use and requires only two external resistors to set the output voltage. It also has better linear regulation rates and load regulation rates than standard fixed voltage regulators. LM117/LM317 are equipped with various protection circuits such as overload protection and safety zone protection [9-11].

Its features are described as follows: (1) Adjustable output voltage down to 1.2V. (2) Guaranteed 1.5A output current. (3) Typical linearity adjustment rate of 0.01%. (4)Typical load adjustment rate 0.1%. (5)80dB ripple rejection ratio. (6) Output short circuit protection. (7) Over-current and over-temperature protection. (8) Safe working area protection for adjusting tube. (9) Standard three-terminal transistor package [9-11]. The voltage range is described as follows: (1) The minimum input/output voltage drop is 0.2V. (2) The LM317 is continuously adjustable from 1.25V to 37V.

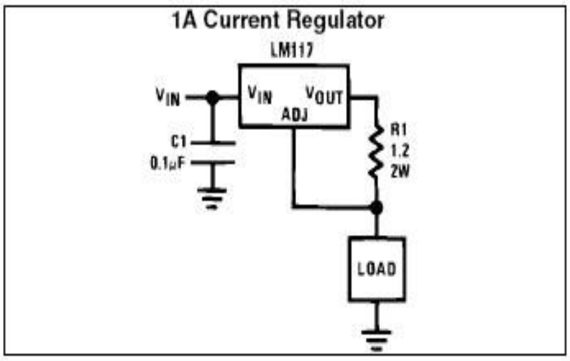


**Figure 3: LM317 constant current standard circuit diagram**

In addition to being a voltage source, the LM317 is also a useful constant current device. Figure 3 shows the circuit provided in the data sheet. The current formula is $I_{out} = 1.25 / R_1$. To pay attention to the power of the resistor $R_1$ (number), if the need for a larger output current, we must use a higher number of resistors. For example, if the output current is 1A, then

$$P(R_1) = VI = 1.25 \times I = 1.25(W)$$

So $R_1$ should pick more than 1.25W.

Why should we use a current-limited circuit? For the most common white LED, as long as we know its operating voltage and current, we can calculate the amount of resistance that should be connected in series. For example: the specifications of the commonly used white LEDs are as follows: The forward voltage is 3~3.8V (3.2V is best) and the forward current is 20mA~35mA.

If we use 12V as the power source, how do we connect it? With 3.2V working voltage for each LED, we can connect 3 in series, so the working voltage becomes 3.2V*3=9.6V. Since they are connected in series, so the working current is the same, we use 30mA to calculate. We set the voltage drop on the 3 series LEDs to 9.6V, so the voltage drop on R is 12V-9.6V=2.4V, in order to make R flow 30mA (0.03A) current to the LED power supply, the current formula I=V/R to see, I=0.03A, V=2.4V, so R=V/I= 2.4V/0.03A=80 (ohm). So we can find a similar resistance to use, such as 82 ohms.

Since the current flowing through the resistor is only 0.03A, his power only consumes 0.03*2.4V=0.072W only, so the W number of the resistor is not too important.

The above means that the current flowing through the LED can be similar to the value we calculated when the supply voltage is completely stable. However, in practice, if our power supply voltage is unstable, such as in a motorcycle, the battery may reach 13.5V when it is fully charged, and when it is started, the generator on the car will charge the battery, so the voltage must be higher, and the voltage will go up and down due to the engine speed. If we do a good job on the LED to the car, the current may fluctuate, very unstable, so the LED life is inevitably shortened! So this time the current limit is good to use, as long as the voltage is higher than the operating voltage of the LED, its current will maintain the current we set, will not exceed, if the voltage is less than the operating voltage, its current also as long as the reduction, so there is no concern about burning the LED.

How to use it? we still use a real example to illustrate, we use multiple LEDs to illustrate this time, the first default use of 18 LEDs, connected to the array in Figure 4.

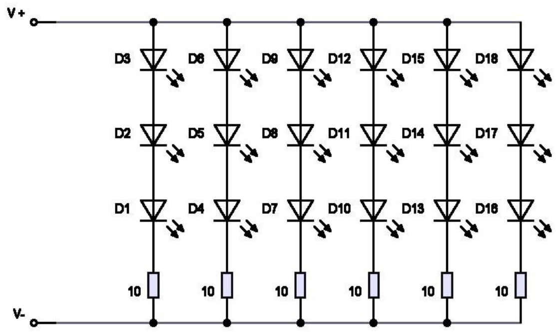


**Figure 4: Standard circuit diagram with 18 LED arrays**

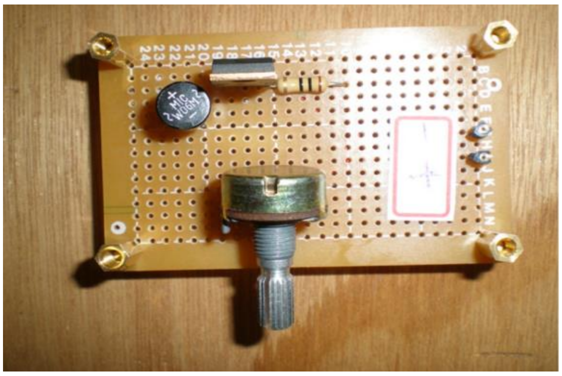

**Figure 5: The finished constant-current circuit**

Each string (3 LEDs) should consume 30mA of current; there are 6 strings, so the total current of 180mA will be consumed. Resistor R is to make the string LED more than once with the protection, I set to use 10 ohms, so there will be 10 * 0.03A = 0.3V voltage drop on R. So in Figure 4, the voltage should be 9.6+0.3=9.9V, and the voltage of a normal lead-acid battery is about 13.5V. It is 13.5V-9.9V=3.6V higher than the voltage we want to use, which already meets the specification of Vout-Vin>3V in LM317.

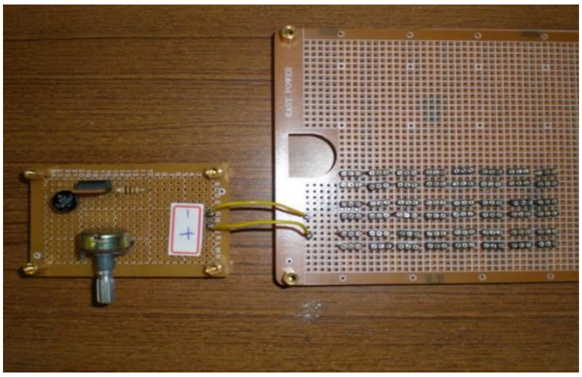

**Figure 6: The constant-current circuit wiring**

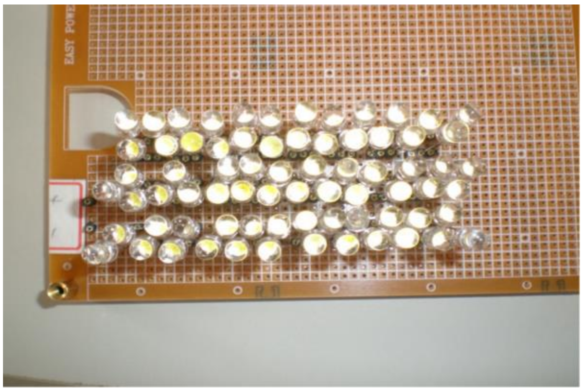

**Figure 7: The LED arrangement**

So the total current of Figure 4 is 180mA (0.18A), we first determined, so to use LM317 to limit the current, we will calculate how to configure, we will follow the previous current limit formula to calculate: $I_{out} = 1.25 / R_1$, 0.18A=1.25/R1, so R1=1.25V/0.18A=6.95Ω. Resistive power = 1.25V*0.18A = 0.225W. We kindly use 1/4W or more of resistive power. See if the precision resistance can find the same or similar value, if we can't find the right resistance value, we can also get the resistance in series or parallel by ourselves. Figure 5 shows the finished constant-current circuit. Figure 6 shows the constant-current circuit wiring. Figure 7 shows the LED arrangement.

## 3. MEASURED OUTPUT POWER

**Table 1: Comparison of constant current power**

| Comparison of power of constant current drive circuit (W) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 par. | 6 par. | 9 par. | 12 par. | 15 par. | 18 par. | 21 par. | 24 par. |
| 0.61 | 1.32 | 1.4 | 2.96 | 3.91 | 4.94 | 6.05 | 7.25 |

Table 1 and Figure 8 shows the comparison of constant current driving power, where the LEDs are arranged in series of three to form a series and three in series to form a parallel. The specifications of commonly used white LEDs are as follows: Forward Voltage is 3~3.8V (3.2V is best), Forward Current is 20mA~35mA. 3 par. represents for three parallels, 6 par. represents for six parallels, and so on.

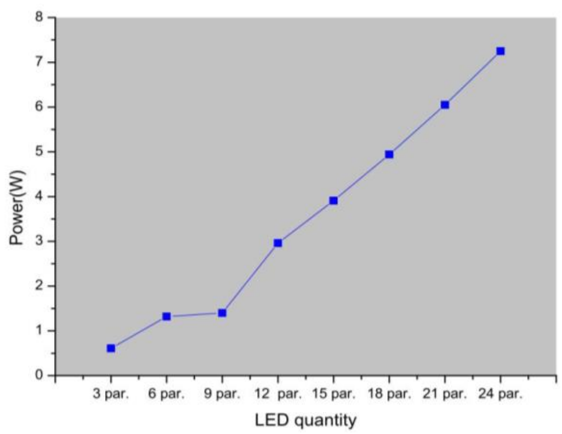


**Figure 8: The comparison of constant current driving power**

**Table 2: Comparison of constant current temperature**

| Temperature comparison of constant current drive circuit (℃) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 par. | 6 par. | 9 par. | 12 par. | 15 par. | 18 par. | 21 par. | 24 par. |
| 26 | 28 | 28 | 29 | 31 | 31 | 33 | 34 |

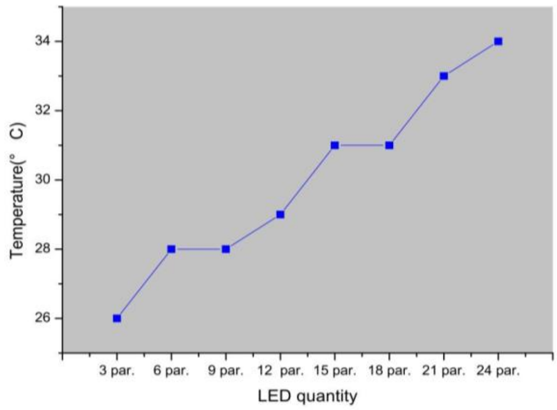


**Figure 9: The comparison of constant current driving temperature**

Table 2 and Figure 9 shows the temperature comparison of the constant current driver circuit. The curves are measured at a constant temperature of 27 ℃and an illumination of 800lux, and the LEDs are arranged as three pieces in a series and three series in a parallel.

In the measurement, the temperature change with a constant current drive method rises quickly and is the most unstable, and the life is most likely to be shortened.

Table 3 and Figure 10 shows the voltage comparison of the constant current driver circuit. The LEDs are arranged as the LEDs are arranged as three pieces in a series and three series in a parallel.

**Table 3: Voltage comparison of constant-current driver circuits**

| Voltage comparison of constant-current driver circuits (V) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 par. | 6 par. | 9 par. | 12 par. | 15 par. | 18 par. | 21 par. | 24 par. |
| 8.35 | 9.12 | 9.74 | 10.31 | 11.05 | 11.52 | 12.05 | 12.54 |

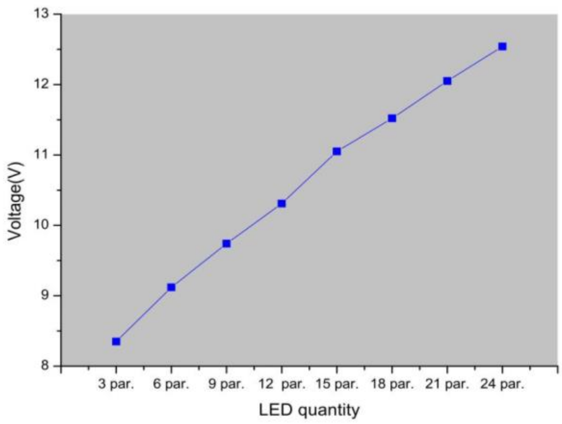


**Figure 10: Voltage comparison of constant-current driver circuits**

Table 4: Current comparison of constant-current driver circuits

| Current comparison of constant-current driver circuits (mA) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3 par. | 6 par. | 9 par. | 12 par. | 15 par. | 18 par. | 21 par. | 24par. |
| 8.02 | 9.67 | 10.16 | 11.15 | 12.02 | 13.12 | 14.05 | 15.01 |

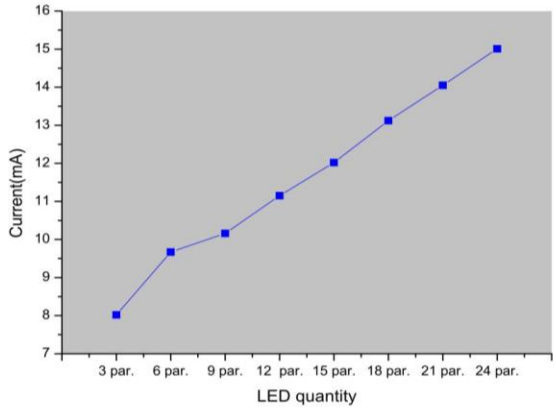


**Figure 11: Current comparison of constant-current driver circuits**

Table 4 and Figure 11 shows the current comparison of the constant current driver circuit. The LEDs are arranged the LEDs are arranged as three pieces in a series and three series in a parallel.

## 4. CONCLUSION

The electrical characteristics of white LED are very discrete, and white LED is a solid-field electric light source and a semiconductor lighting device. It has a small size, mechanical strength, low power consumption, long life, easy to adjust and control and pollution-free features, is a new light source products with great prospects for development. However, due to the steep forward current-voltage characteristics of white LEDs, it is difficult to supply power to them. Smaller fluctuations in the operating voltage of white LEDs can cause dramatic changes in operating current and may even burn out the LED. In order to keep the LED operating current stable and ensure the LED can work properly and reliably, the driver circuit design is very important. Figure 5 to Figure 11 show the hardware results of this paper. In this paper, a set of circuits satisfying the above-mentioned functions is implemented, and the results are used to verify the operation of the designed circuits and the functions satisfying the requirements.

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**Conflict of Interest:** None

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