Application Note: AN-123

LED IN PARALLEL APPLICATION

INTRODUCTION

When using multiple LEDs, it is inevitable to consider its connection mode. In general, it can be divided into series connection and parallel connection. For the parallel connection mode of LEDs, although it can be turned on normally, there may be some problems. This Application Note is a brief introduction to the possible problems of LEDs in parallel connection.

CIRCUIT ANALYSIS AND TEST

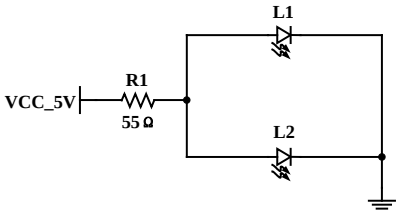

Figure 1 LED Parallel Circuit A

In Figure 1, LEDs Parallel Circuit A, LED L1 and L2 forward voltage is 2.8V hence the total current is set to 40mA by resistor R1. In theory, the current of LED L1 and LED L2 should each be 20mA.

But in reality, the current of L1 and L2 is not equal and as measured in Figure 2 where the current of L1 is 14.2mA, L2 is 25.2mA:

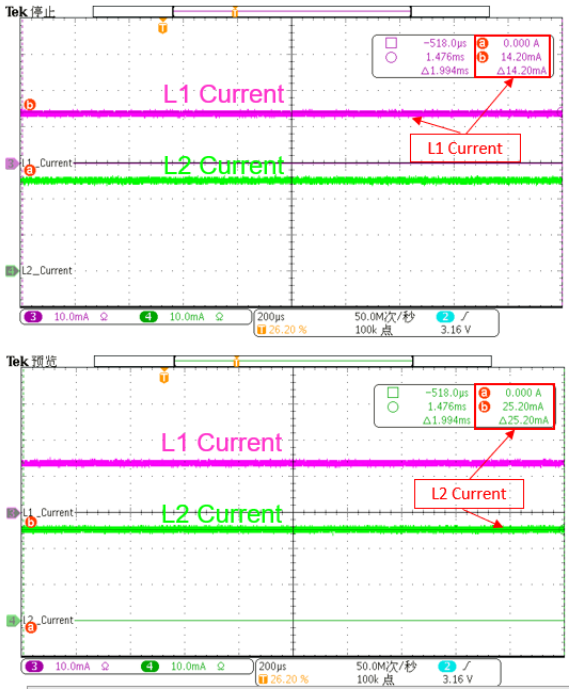

Figure 2 LED Parallel Circuit A: LED Current

CAUSE ANALYSIS

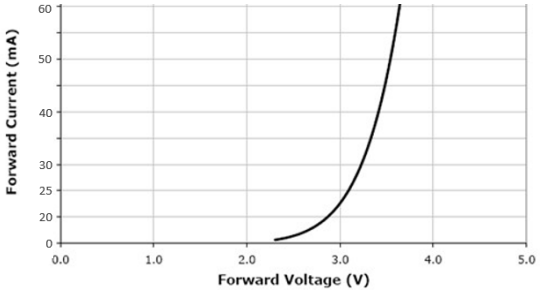

Figure 3: volt-ampere characteristic curve of LED

According to the volt-ampere characteristic curve of the LEDs, the LED current (IF) is related to Forward Voltage (VF) value of the LED.

From LED specifications, forward voltage values of L1 and L2 at 20mA are as follows:

L1 VF: 2.89V@ IF=20mA (White LED)

L2 VF: 2.80V@ IF=20mA (White LED)

When L1 and L2 are connected in parallel, the VF of the two LEDs will be clamped at same voltage. If L1 VF is 2.83V which is <2.89V, then L1 current will be less than 20mA and it was measured as 14.2mA. L2 VF is 2.83V (which is >2.80V), so L2 current is more than 20mA and it was measured as 25.2mA.

According to the above data, the reason for inconsistent current after parallel connection of L1 and L2 is the difference in I/V curve characteristic of the LEDs. In parallel mode, each LED current is not same and results in nonuniform LED brightness.

IMPROVEMENT SUGGESTIONS

SUGGESTIONS 1:

In order to improve the current inconsistency and brightness nonuniformity, the current limiting resistor can be modified to connect on each LED branch separately, as illustrated below LED Parallel Circuit B:

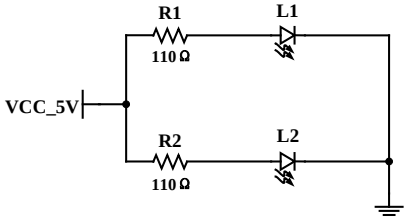

Figure 4 LED Parallel Circuit B

According to the above LED Parallel Circuit B, the current of L1 and L2 is set by resistors R1 and R2 respectively.

For this configuration, suppose the actual VF value of L1 and L2 are as below:

L1 VF: 2.88V (White LED)

L2 VF: 2.80V (White LED)

Theoretical current values of L1:

$$I_{L1} = (5V - 2.88V)/110\Omega = 19.27mA \quad (1)$$

Theoretical current values of L2:

$$I_{L2} = (5V - 2.80V)/110\Omega = 20.0mA \quad (2)$$

But the actual measured current of L1 is 19.4mA and that of L2 is 20.4mA, as below:

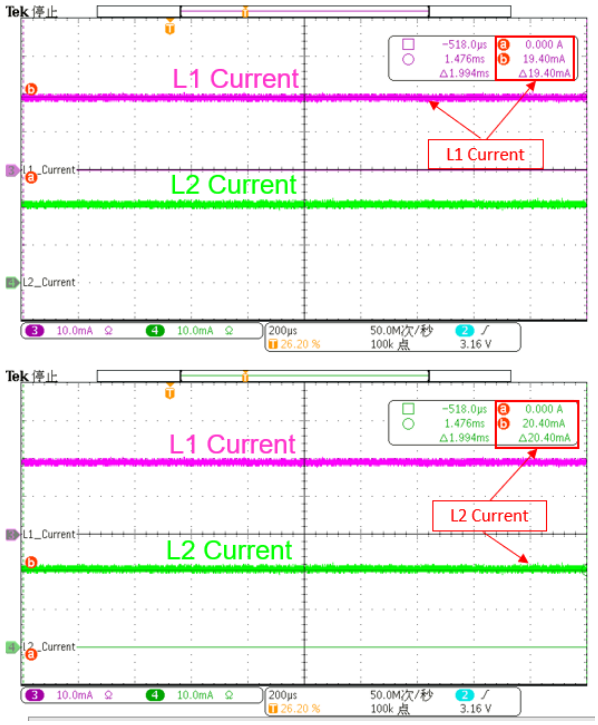

Figure 5 LED Parallel Circuit B: LED Current

Note: Due to the error of resistance value, there is a certain difference between the theoretical current value and the measured current value.

This method adjusts the current of each LED by using a limiting resistance in series with each LED to improve the current inconsistency and brightness nonuniformity.

However, this method also has some other concerns. The resistance and VF will change with the temperature, so the LED current and brightness may fluctuate when the LED is used for a long time.

SUGGESTIONS 2:

In order to ensure LED brightness uniformity, it is recommended to use LED driver chip with constant current feature to adjust LEDs current, as shown in IS31FL3242 application circuit below:

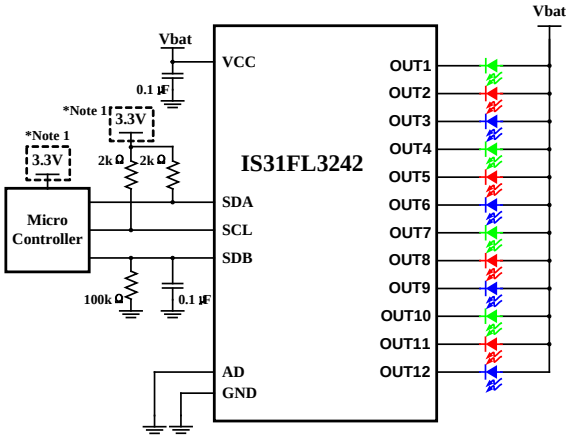

Figure 6 IS31FL3242 Typical Application Circuit

The IS31FL3242 is a 12 LED current sink LED driver programmed via 1MHz I2C compatible interface. Each LED can be dimmed individually with 12-bit PWM data and each current sink has 8-bit DC scaling (Color Calibration) data which allows 4096 steps of linear PWM dimming and 256 steps of DC current adjustment levels. The mismatch of current between each output channel and accuracy between each IC parts is less than ±5%. It can effectively avoid the problem of LED current inconsistency and brightness nonuniformity.

SUMMARY

In parallel connection mode, each LED forward voltage variation, will result in current inconsistency and hence brightness nonuniformity. It is recommended to connect each parallel LED with a resistor in series. Alternatively, a LED driver (like Lumissil IS31FL3242) is recommended to ensure consistent current to each LED.

RESOURCES:

Lumissil Microsystems,
IS31FL3242 4-RGB/12-CH LED DRIVER, https://www.lumissil.com/assets/pdf/core/IS31FL3242_DS.pdf