Light Emitting Diode

Electrical properties of GaN LEDs & Parallel connections

Table of contents

The part number NSCW215 in this document is the part number of Nichia's product, and does not have any relevance or similarity to other companies' products that may have trademark rights.

1. Overview

For reference on current and forward voltage, please consult Nichia's LED Product Guide 2004. In this example, Table 1 provides the forward voltage of NSCW215 as 3.6V (Typ.), 4.0V (Max.) at I_F=20mA. This indicates for a group of LEDs, the forward voltage - forward current characteristic is not a single fixed value. In a group of LEDs operating at 20mA the voltage will be an average of 3.6 volts with a maximum of 4.0 volts. But for any given LED in the group the VF may be any value between 2.8 and 4.0 volts. Therefore, when constructing a system where GaN-basis LEDs are connected in parallel, please note the following conditions.

・Even if you energize the same voltage to the same product, the current can be different.
・If the current value is different, the luminous intensity is also different.
・If the current value is different, the color can also be different.

Table 1. Forward Voltage of NSCW215 (I_F=20mA)

Forward Voltage V_F (V)	
Typ.	Max.
3.6	4.0

2. Parallel Connection of GaN-basis LED

2.1. Example 1 (A circuit with 2 resistors)

Designing following circuit with LEDs under different forward voltage characteristics.

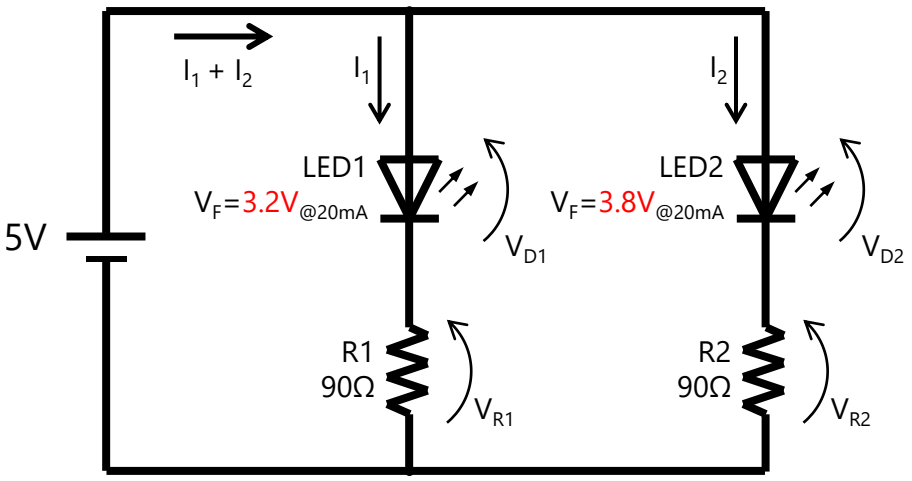

Figure.1: Circuit Diagram

Supposition
Suppose as follows:
Power-supply voltage: 5V
LED1 side: 3.2V at 20mA with 90Ω
LED2 side: 3.8V at 20mA with 90Ω

The current value of I_1 side is calculated as follows.

Postulation#1

I_1 = 10mA

V_{R1} = 10mA × 90 Ω = 0.9 V

V_{D1} = 5 V - 0.9 V = 4.1 V

Refer to Figure 2 which shows: V_F = 3.06V at 10mA

Therefore, V_{D1} should be 3.06V.

As the result, 10mA of Postulation#1 is not correct.

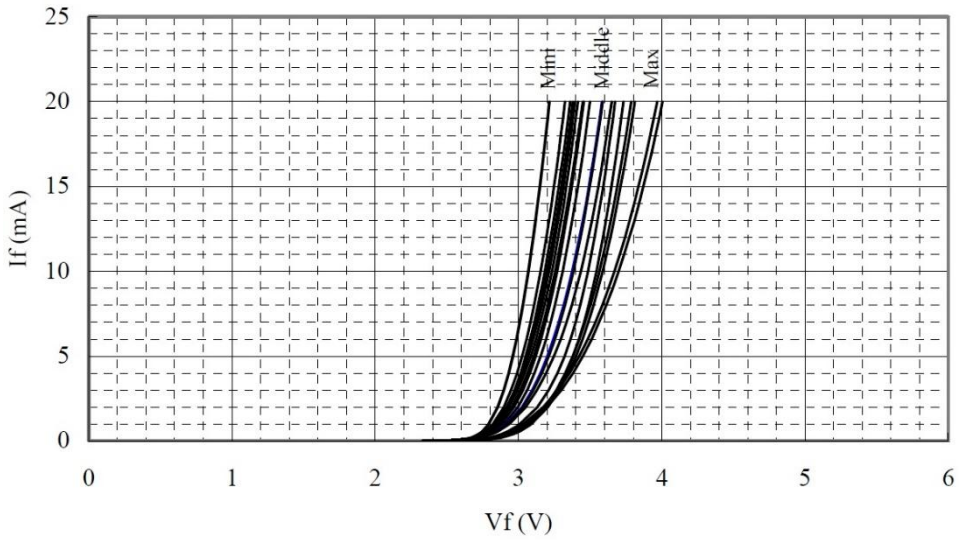

Figure 2. Forward Voltage - Forward Current

Postulation#2

I_1 = 15 mA

V_{R1} = 15 mA × 90 Ω = 1.35 V

V_{D1} = 5 V – 1.35 V = 3.65 V

Refer to Figure 2 which shows: V_F = 3.14V at 15mA

Therefore, V_{D1} should be 3.14 V

As the result, Postulation#2 is not correct but the “15mA“ is more accurate than “10mA”.

Postulation#3

I_1 = 20 mA

V_{R1} = 15 mA × 90 Ω = 1.8 V

V_{D1} = 5 V – 1.8 V = 3.2 V

Postulation#3 equal to the “Supposition”

The same way of calculation will result as I2=15mA.

2.2. Example 2 (A circuit with 1 resistor)

The circuit with one resistance that is cost-effective.

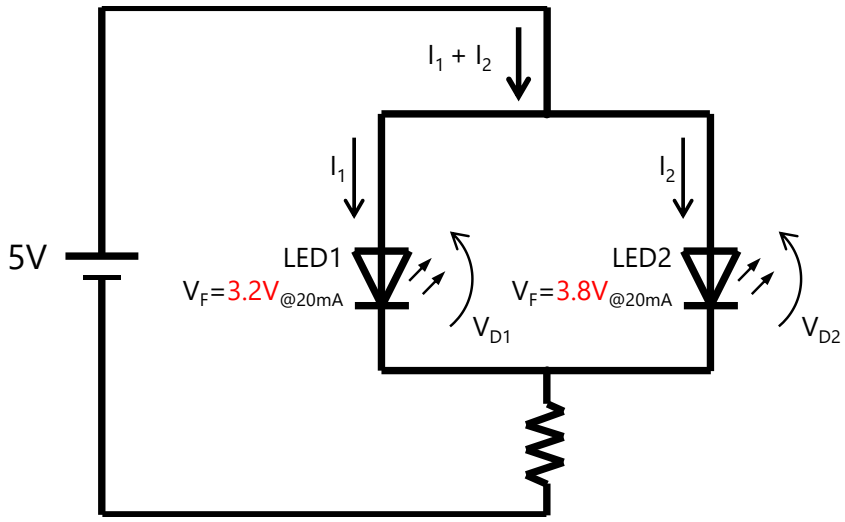

Figure 3. Circuit Diagram

Supposition
Suppose as follows:
Power-supply voltage: 5V
LED1 side: 3.2V at 20mA
LED2 side: 3.8V at 20mA

The current value of I_1 side is calculated as follows.

Postulation#1

I_1 = 20 mA
V_{D1} = 3.2 V
$V_{D1} = V_{D2}$

Therefore, V_{D2} = 3.2 V
The current value of I_2 is 2mA which is derived from Figure 2
Therefore, $I_1:I_2$ =10:1

Postulation#2

I_2 = 20 mA
V_{D2} = 3.8 V
$V_{D2} = V_{D1}$ = 3.8 V

The current, I_1, exceeds the scope of the graph of current vs. voltage shown in Figure 2. An LED used in this manner may also exceed Nichia's defined absolute maximum current. The luminous intensity of LED1 compared to LED2 will be noticeably different.
Please refer to Nichia's product specifications for reference on the maximum allowable forward current.
Please do not exceed the absolute maximum current when using Nichia LEDs.

3. Summary

When two LEDs of similar luminous intensity are driven at the same current, they will appear identical. This can be achieved using a parallel connection where both LEDs are at the same forward voltage. However, if the voltage changes the luminous intensity will change according to the forward current change of each LED.

As shown in Figure 1, adjusting the voltage with separate resistors will reduce variation in forward current resulting giving similar luminous intensity values. For the example of Figure 1, both resistors were the same thus the luminous intensity would not be the same. If the resistors were matched to the VF of the LED, the same luminous intensity could be achieved.

Theoretically one could consider very narrow VF binning as a solution. Practically this is not an answer. When the range of available product becomes small, the ability to ship decreases and the cost drastically increases. The best answer in this case is one which considers VF variation as a function of the product and strives to limit its effect on the system.

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