Balancing White Color

I. Preface

Light's three primary colors are red, green and blue. 

Controlling these 3 colors' luminous intensity of LED can produce various colors.

This note explains how to reproduce white color with Nichia LED.

II. Color Reproduction

The triangle in Figure 1 shows the color reproduction range of color television and LED.

NTSC(National Television System Committee) is the video signal system(method) which is adopted in Japan, the United States, and Canada.

The wider the triangle becomes, the better color reproduction. As you see in Figure 1, color reproduction of LED is closer to the NTSC's than Color TV.

III. White Balance

Reproducing white without close control may become reddish white, bluish white and etc.

To produce the white color by LEDs, one must adjust the luminous intensity of blue, green and red. This adjustment is called “White balance.”

In general, to produce white color \((x=0.33 \ y=0.33)\), the luminous intensity ratio is \(R:G:B=3:7:1\).

(It depends on the color coordinate of each Red, Green and Blue.)

IV. Balancing White Color of Full Color LED

i) Nichia's full color surface mount LED is composed of red, green, and blue elements in 1 package.

The following is an example of full color surface mount LED.

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Condition</th>
<th>Blue</th>
<th>Green</th>
<th>Red</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Voltage</td>
<td>(V_F)</td>
<td>(B,G \ I_F=10(mA)) (R \ I_F=20(mA))</td>
<td>Min. 3.6 Typ. 4.0 Max. 5.5</td>
<td>Min. 3.5 Typ. 4.0 Max. 6.0</td>
<td>Min. 1.9 Typ. 2.4 Max. 3.5</td>
<td>A</td>
</tr>
<tr>
<td>Reverse Current</td>
<td>(I_R)</td>
<td>(V_R=5V)</td>
<td>- - 50</td>
<td>- - 50</td>
<td>- - 50</td>
<td>- - 50 µA</td>
</tr>
<tr>
<td>Luminous Intensity</td>
<td>(I_v)</td>
<td>(B,G \ I_F=10(mA)) (R \ I_F=20(mA))</td>
<td>52 72 144</td>
<td>215 300 600</td>
<td>92 125 260</td>
<td>mcd</td>
</tr>
</tbody>
</table>

Figure 2 Initial Electricity / Optical Characteristic of NECM325C.
ii) Luminous Intensity
Suppose: The luminous intensity of Red: 125mcd. (Typical rating in Figure 2)
The luminous intensity of Green and Blue is derived from the ratio: R:G:B = 3:7:1
More specifically, Green = 125 x 7/3 = 291.6 mcd
Blue = 125 x 1/3 = 41.6 mcd
Therefore, to reproduce white color (x=0.33 y=0.33),
the required luminous intensity is as follows respectively:
Red = 125 mcd
Green = 291 mcd
Blue = 41 mcd

iii) Forward Current
Refer to Figure 2,
a) Red = 125 mcd. The current value is 20 mA.
b) Green
Suppose 300 mcd is as 1.
300/291 = 0.97
The forward current is about 9.8 mA. (See Figure 3)
c) Blue
The same way of calculation result as 4.8 mA

iv) Power Dissipation
When you use full-color LED, total power dissipation must be within the absolute maximum rating.
Figure 4 shows “Ambient temperature” vs. “Power Dissipation” of NECM325C.
Power Dissipation is derived as follows.
P_D[mW] = I_F[mA] x V_F
Power Dissipation for ii) and iii)
P_D[mW] = 20[mA] x 1.9[V] + 9.8[mA] x 3.5[V] + 4.8[mA] x 3.6[V]
= 89.58[mW]
And 89.5 mW exceeds absolute maximum rating in Figure 4.
You must lower the forward current of each die.

Luminous intensity of Red: 60 mcd,
Calculating required luminous intensity of blue and green.
Derived form (Refer to ii).
Green = 140 mcd
Blue = 20 mcd
The approximate current values are derived form Figure 3 at the above luminous intensity.
Red = 11 mA
Green = 3.5 mA
Blue = 1.8 mA
P_D[mW] = 11[mA] x 1.9[V] + 3.5[mA] x 3.5[V] + 1.8[mA] x 3.6[V]
= 39.63[mW]
Total power dissipation of 39.63 mW should be operated within 65 °C from Figure 4.
It is important that the total power dissipation must be within the absolute maximum rating.