ON Semiconductor

Is Now

To learn more about onsemi™, please visit our website at www.onsemi.com

AND9690/D

NCV7430 LED Color Calibration

ON Semiconductor®

www.onsemi.com

APPLICATION NOTE

Introduction

Color perception in human subjects varies with the color spectrum in three semi-discrete spectrums of Red, Green, and Blue (RGB). Combinations of these three colors make up the entire color spectrum interpreted by anyone. The NCV7430 device drives three LED sources at different intensities creating an infinite color spectrum.

LED fabrication processes have a variation which can cause the perceived color to also vary. Perceived color variation is different at any defined color. Figure 1 shows the expected noticeable color variation boundary (enlarged by a factor of 10 for emphasis). Each ellipse (MacAdam ellipse) represents the boundary from the center point in which human subjects can expect to see a color variation. Any variation outside the boundaries requires an adjustment to avoid noticeable color differences.

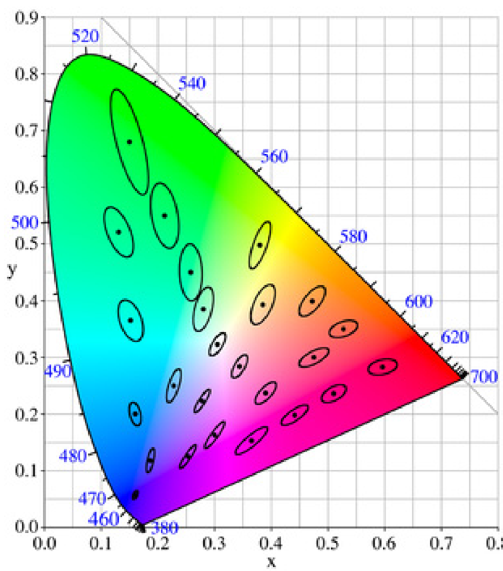

Figure 1. MacAdam Ellipses [1]

Calibration

The NCV7430 device includes an on-chip programmable calibration which reduces system color variation within a module production flow. This is done by defining a device working area such that it is not possible to have any color output from a single varied device in the LED production flow which doesn't reside inside the boundary. By mapping the expected RGB variation in color space we define an internal reference gamut (triangle) in which the LED color operates.

Tactical Calibration

The following 5 step approach highlights how calibration is done using the NCV7430 device. The customer defined XYZ tristimulus values are required for calculating the appropriated calibration factors to be imported into the IC.

Color Calibration Procedure

To calculate the calibration factors, the following steps need to be performed:

1. Determine the reference XYZ tristimulus values of the load LED from the LED datasheet or LED manufacturer.
2. Measure the individual sample RGB LED XYZ values.
3. Calculate calibration factors for the sample RGB LED.
4. Store the calibration factors into the NCV7430 internal registers/OTP memory.
5. Enable calibration functionality to see the results.

Calibration Description

In principle, to be able to generate a particular color by mixing of three given R, G and B colors, the desired color must lie inside the triangle formed by the R, G and B x, y coordinates in the chromaticity diagram (see Figure 2) where the colored circles represent the typical LED color performance. The defined R, G and B colors of the triangle can produce any color inside the triangle with R, G and B primitives in the corners set to the desired magnitude from the LED characteristics from the LED manufacturer.

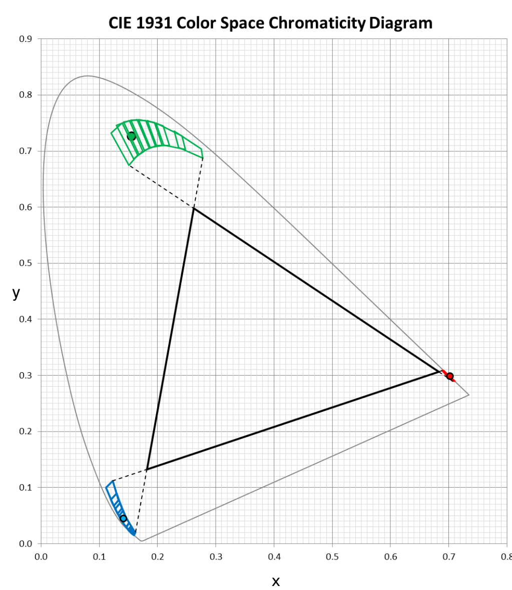

Figure 2. Example of the Reference Gamut

But LED material and process variations produce a spread of each single LED performance. This can be seen in the areas surrounding the RGB colored circles which result in color variation as percieved by human subjects. Consequently, a visible difference in perceived color between sample LEDs is expected.

In order to avoid color differences, we use a limited color space that is covered by every single RGB LED that is expected. This limited color space is an intersection of lines forming a triangle by the combinations of RBG primitives from the expected range. The result is we get the smallest triangle representing the reference gamut in the chromaticity diagram of Figure 2. The easiest way to determine the reference gamut is to define the expected binning from the LED manufacturer and connect the bin's outlines and find the connection lines intersection points.

Luminous Intensity Considerations

The Calibration details described previously focuses on the chromaticity diagram and the reference gamut for color rendering. These include the chromaticity coordinates x,y. The luminous intensities of the individual corners of the reference triangle also impact the final viewable result of the system. This is apparent when considering mixing multiple primary RGB colors. The NCV7430 device includes the capability to include this third component (relative luminance), Y. The fully calibrated device includes all three of the components (x,y,Y).

There is an interesting effect where the minimum reference intensity can be higher than the minimum intensity defined in a datasheet. This is because the calibrated primaries are a mixing of the three main primary colors (gamut corners). Shifting any of the three primary colors requires adding a certain amount of the other two primary colors which can result in a higher reference intensity.

References

[1] Public Domain file from Wikipedia:
The Free Encyclopedia. Wikimedia Foundation Inc.
Retrieved from
https://en.wikipedia.org/wiki/MacAdam_ellipse
File: 325px−CIExy1931_MacAdam.png

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:
Literature Distribution Center for ON Semiconductor
19521 E. 32nd Pkwy, Aurora, Colorado 80011 USA
Phone: 303−675−2175 or 800−344−3860 Toll Free USA/Canada
Fax: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
Email: orderlit@onsemi.com

N. American Technical Support: 800−282−9855 Toll Free USA/Canada
Europe, Middle East and Africa Technical Support:
Phone: 421 33 790 2910

ON Semiconductor Website: **www.onsemi.com**

Order Literature: http://www.onsemi.com/orderlit

For additional information, please contact your local Sales Representative