EXPLORING RGB LEDS AND COLOR SCIENCE

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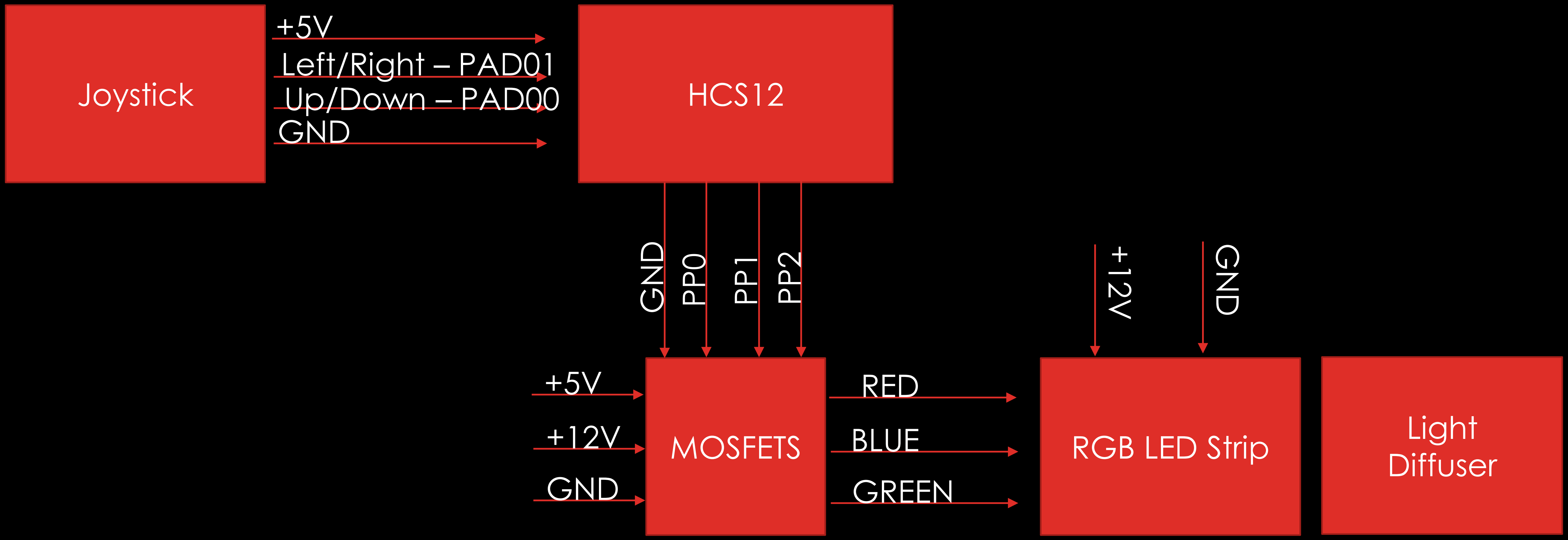
PROJECT OBJECTIVES

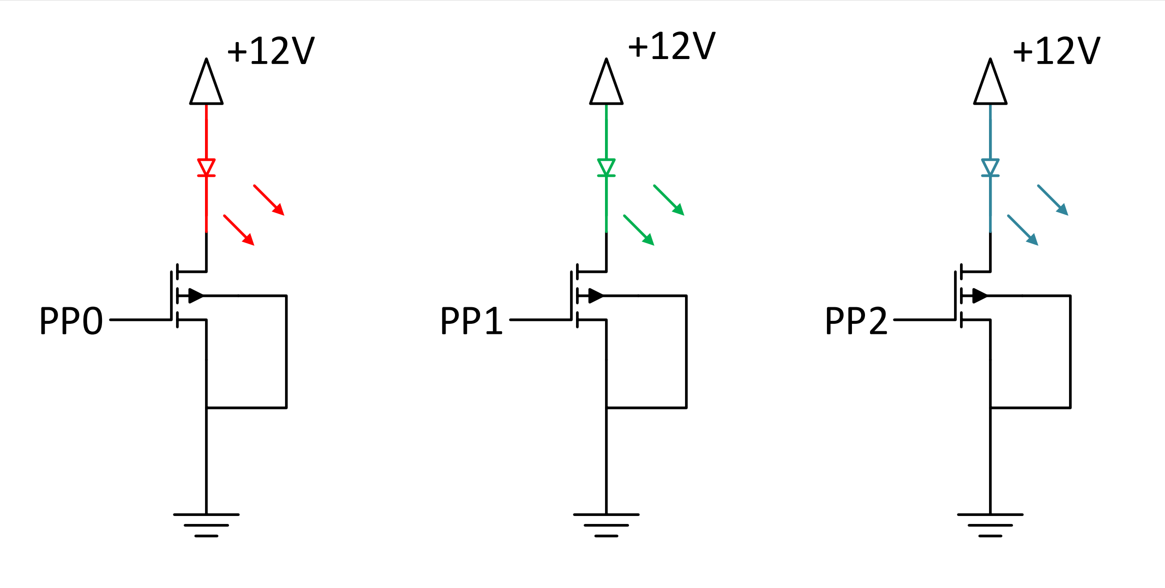
- Implement RGB LED control and explore applications and other concepts.
  - Mode 1: Control the color using the DIP switches (256 choices).
  - Mode 2: Color changes based on measured temperature.
  - Mode 3: Navigate the CIE Chromaticity Diagram.

THE SYSTEM


Joystick
+5V
Left/Right – PAD01
Up/Down – PAD00
GND
HCS12
GND
PP0
PP1
PP2
+12V
GND
+5V
+12V
GND
MOSFETS
RED
BLUE
GREEN
RGB LED Strip
Light Diffuser

RGB LED HARDWARE SETUP

- A common-anode RGB LED strip is driven by 3 MOSFETs.
  - PP0 – PP2 drive the gates of the 3 MOSFETs.
  - LEDs are connected to separate +12V power supply on the drain.
  - The source of each MOSFET is connected to ground.



MODE 1: DIP SWITCH CONTROLLED COLOR

Using the DIP switch to choose between 256 different colors.

MODE 1 – DIP SWITCH CONTROL

- DIP switches are used to change the color displayed by the RGB LEDs.
- Controls modeled after VGA technology control.
  - Switches 1-3 control red.
  - Switches 4-6 control green.
  - Switches 7-8 control blue.

MODE 1 – DIP SWITCH CONTROL

- Implementation of the LED control.
  - Timer + Interrupts method used in this case.
  - "HCYCLES" and "LCYCLES" modified based on switch positions.
  - Interrupts toggle corresponding bits (PORTP(4), PORTP(5), and PORTP(6)).
  - This method has its weaknesses.
    - Interrupts "compete" when 2 + LEDs are on the same duty cycle.
    - At 6kHz, the artifacts of this issue are very visible.

Let's see how it works!

MODE 1 – DIP SWITCH CONTROL

- This method can be improved!
  - Minimize size and number of interrupts.
    - Reduces the probability that a conflict will occur.
  - “Nested” Interrupts
    - Enable interrupts inside another ISR.
    - Can be tedious to implement!

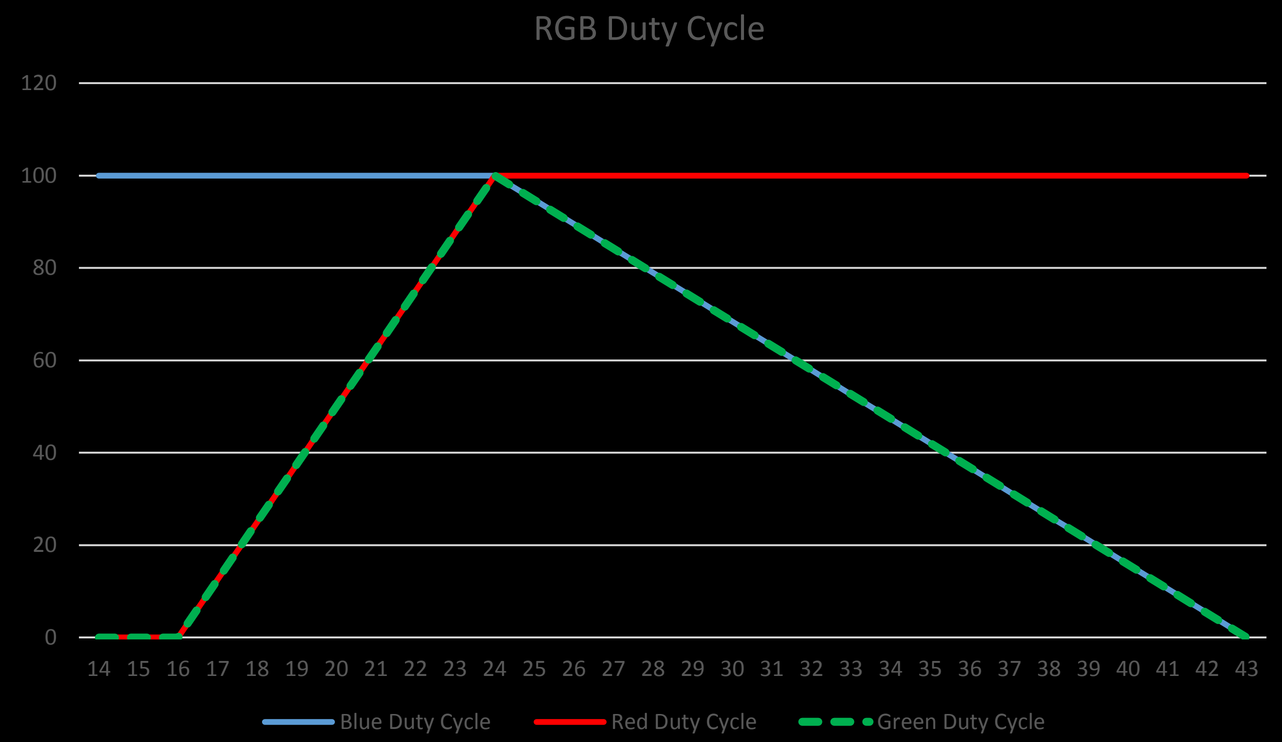
- The natural choice in our case is the use of the PWM channels.

MODE 2: TEMPERATURE CONTROLLED COLORS

Using the On-Board Temperature Sensor to Control the LED Color

MODE 2: TEMPERATURE-DEPENDENT COLOR

- In this mode, we use the on-board temperature sensor to control the color of the RGB LEDs.



MODE 2: TEMPERATURE-DEPENDENT COLOR

- In this mode, we use the on-board temperature sensor to control the color of the RGB LEDs.
- Using the PWM Channels to drive the LEDs.
- Change duty cycle with the following formulas:
  - When the temperature is between 16°C and 24°C….

$$Duty\ cycle\ \% = \frac{temperature\ - 16}{8} \times 100$$

  - When the temperature is between 25°C and 43°C….

$$Duty\ Cycle\ \% = \left(\frac{temperature\ - 24}{19} \times -100\right) \times 100$$

MODE 2: TEMPERATURE-DEPENDENT COLOR

- The color transition is not as smooth as we intended….
- The resolution of the temperature sensor is only 1℃!

Let’s see how it works!

MODE 3: NAVIGATING THE CHROMATICITY DIAGRAM

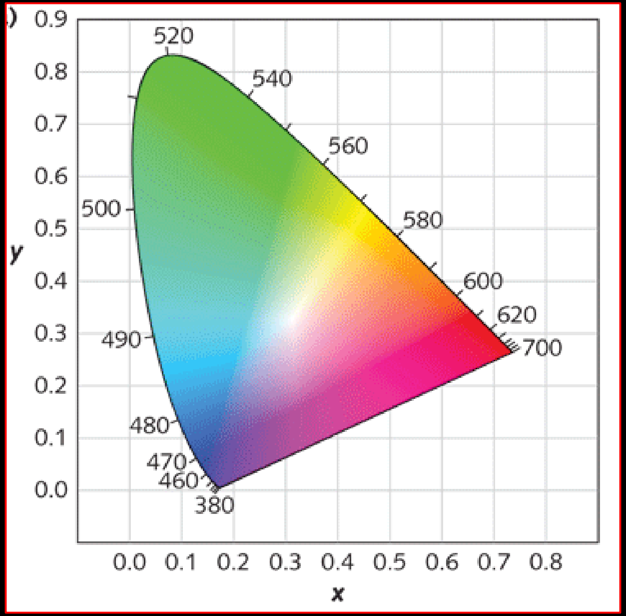
Using a joystick to navigate the CIE 1931 Chromaticity Diagram

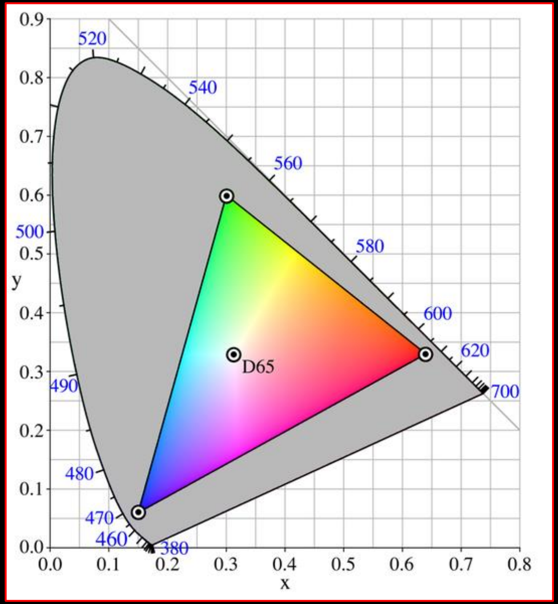
MODE 3: USING A JOYSTICK TO MAP TO THE CIE GRAPH

- The joystick is a 2- axis device
- Each axis is a 10 KΩ potentiometer with common ground
- Supplied by 5 V from the Dragon12 board
- Read by pins PAD 00 and 01
- Converted to digital by the onboard A/D converter
- X – formula: if (x<= 400) then x = x;
-     else
-    x = x * 800/1020

MODE 3: USING A JOYSTICK TO MAP TO THE CIE GRAPH

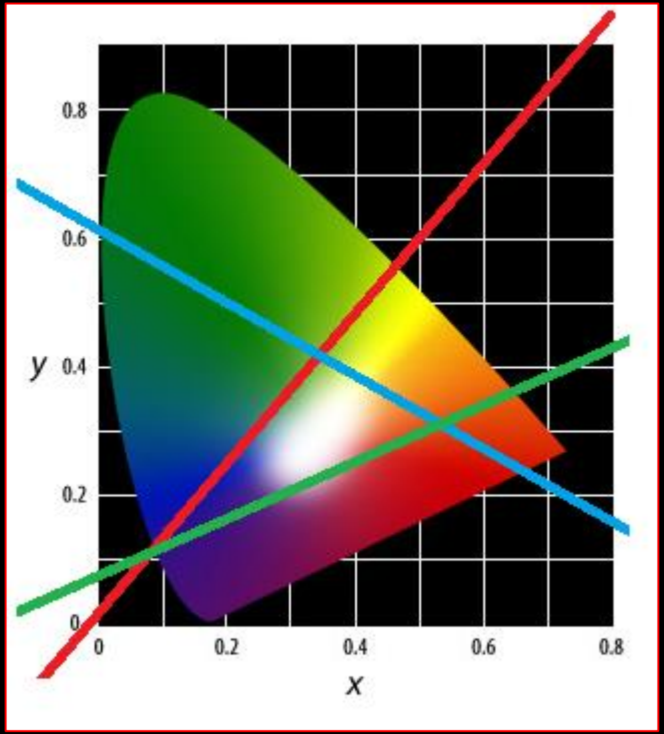
- The CIE Chromaticity Diagram
  - International Commission on Illumination, 1936 Standard
  - The gamut is where the “web safe” colors reside
  - Hue vs. Saturation





MODE 3: USING A JOYSTICK TO MAP TO THE CIE GRAPH

- Calculating the duty cycle of each color at every point.
  - “Divided” the CIE diagram by red, green, and blue.



Chromaticity diagram from http://dba.med.sc.edu/price/irf/Adobe_tg/models/ciexyz.html

MODE 3: USING A JOYSTICK TO MAP TO THE CIE GRAPH

- Calculating the duty cycle of each color at every point.
  - “Divided” the CIE diagram by red, green, and blue.
  - Duty cycle of each color is determined by the distance from each line.
    - Each line represents the dimmest setting of each color.
    - Duty cycle increases with distance from the line.

- Example calculation – Duty cycle of red.

$$Distance\ from\ the\ Line = \frac{|900x + 750y|}{1171}$$

$$Red\ Duty\ Cycle = Distance\ from\ the\ Line \times \frac{100}{250}$$

MODE 3: USING A JOYSTICK TO MAP TO THE CIE GRAPH

Let's see how it works!

APPLICATIONS

- Improved parking lot flow:
  - Light color changes with parking spot availability.
- Stadium lighting aesthetics:
  - Change colors depending on which teams are playing.
- LED Traffic lights:
  - High efficiency and low maintenance.

QUESTIONS?

THANK YOU!

REFERENCES

[1] Nave, R. Hyperphysics- Light and Sound. 4 12 2014. Internet.
[2] Parallax Inc. 4 12 2014. <www.parallax.com/rt>.