Driving Color RGB LEDs with the AAT3123

Application

An RGB LED can be driven with a combined 60mA constant current source supply from an AAT3123. This is accomplished by connecting the four constant current source outputs (D1 to D4) from an AAT3123 and programming the device to output 15mA for each source. This solution is intended to supply up to 20mA maximum to each of the three red, green, and blue LEDs in a common anode configuration. Color balance and intensity is then controlled via PWM signals to MOSFET switches connected to each LED cathode. Refer to the following application circuit (Figure 1):

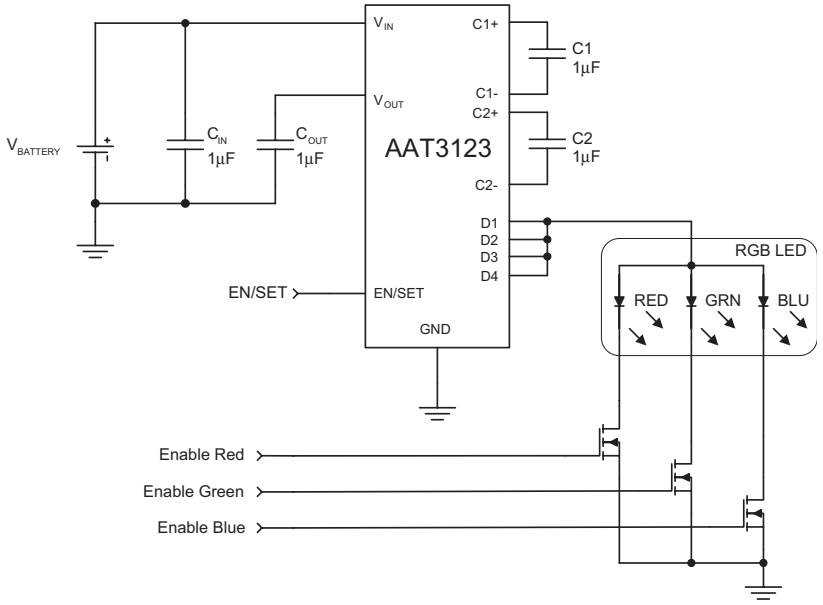

Figure 1: AAT3123 RBG LED Driver Application Circuit.

Application Problem

RGB LEDs have differing forward voltages (V_F) for the red, green, and blue LEDs. When driven from a common 60mA (I_D = 20mA per LED) constant current source, the red LED element of an RGB LED typically has a forward voltage of about 2V. The green and blue LEDs have forward voltage levels of about 3.6V.

Two problems arise with this application. First, the lower V_F LED (red) dominates the circuit; second, when the AAT3123 input voltage drops below 3.2V, the output constant current sources cannot supply the required 3.6V for the green and blue LEDs. This results in a dominating red color because the green and blue LEDs are being under driven. Refer to Figure 2.

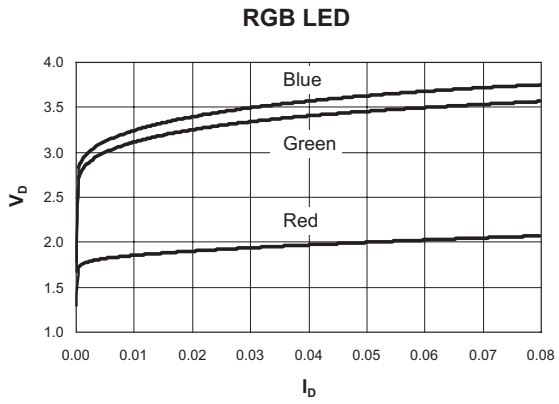

Figure 2: Forward Voltage Versus Current Characteristic Curve for an RGB Color LED Used in this Application Discussion.

Application Solution

The forward voltage drops for each LED within the RGB LED need to be equalized in order to match LED performance over the AAT3123 operating range. Adding a ballast resistor to the red LED will help equalize the LED output red color shift when the AAT3123 is operated in or near the dropout region of its output constant current sources. See Figure 3.

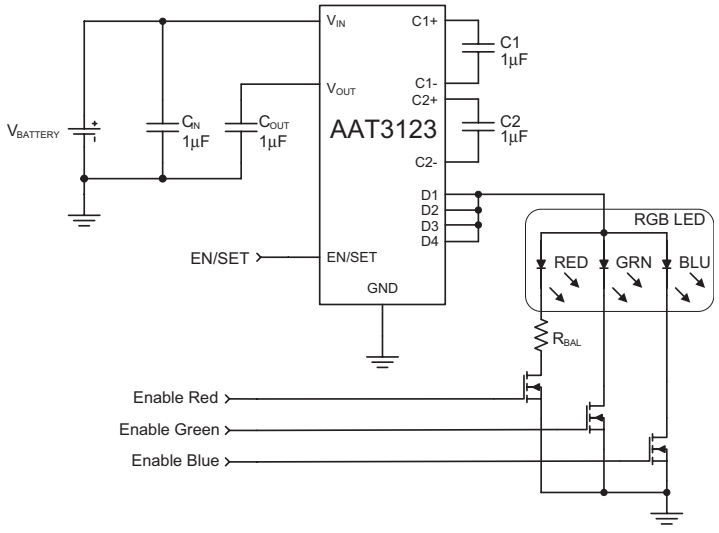

Figure 3: AAT3123 RGB Driver Application With a Color Matching Ballast Resistor for the Red LED.

Determining the Ballast Resistor Value

To obtain equal brightness from each LED within the RGB LED to produce white light, each LED needs to have the same effective V_F to equally divide the 60mA supply current.

Ideally, each LED should be driven with 20mA. The green and blue LEDs have a V_F = 3.6V when I_D = 20mA. The red LED has a V_F = 2.0V when I_D = 20mA. A ballast resistor can be added in series with the red LED cathode to help match the red LED V_F. Refer to the following equation:

$$R_{BALLAST} = V_{F(GRN/BLU)} - V_{F(RED)}/I_D$$

Example, for I_D = 20mA:

$$R_{BALLAST} = 3.6V - 2.0V/20mA = 80\Omega$$

Conclusion: An 80Ω resistor placed in series with the red LED cathode will help match it to the green and blue LEDs and provide even white light over the operating range of the AAT3123.

Support Data

The AAT3123 constant current source outputs were characterized over the V_{IN} operating range of 2.8V to 4.2V for I_{SET} = 15mA per source. This yields a combined output (I_D) of 60mA when D1 to D4 are connected in parallel. Output performance was characterized for simulated forward voltages from 4.0V to 2.0V. Refer to Figures 4 and 5.

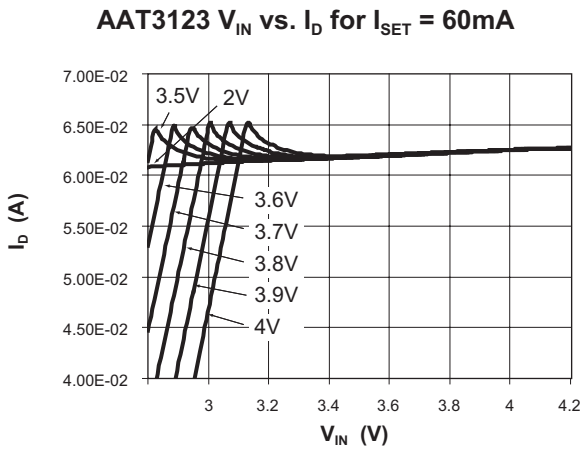

Figure 4: AAT3123 Constant Current Source Output for Given V_Fs with I_D = 60mA.

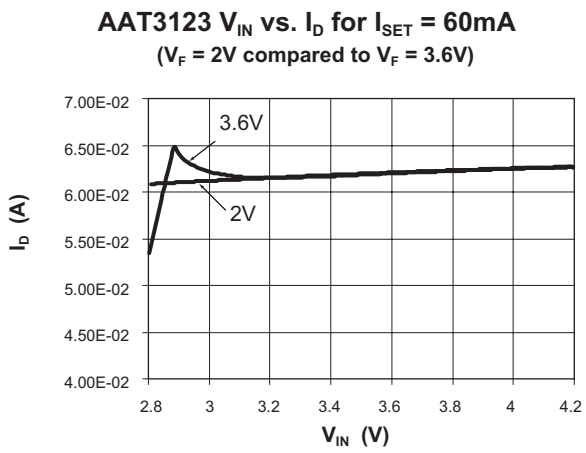

Figure 5: Comparison of V_F = 3.6V and 2.0V to Study the Condition of the Red LED V_F Versus the V_F of Green and Blue LEDs.

Calculation of $R_{BALLAST}$ for this test condition:

$$R_{BALLAST} = V_{F(GRN/BLU)} - V_{F(RED)}/I_D$$

For test condition, I_D = 60mA:

$$R_{BALLAST} = 3.6V - 2.0V/60mA = 26.66\Omega$$

Output performance was characterized over a range of standard resistor values: 22Ω, 25Ω, 27Ω, and 30Ω. Refer to Figure 6. Figure 7 shows the AAT3123 output performance for a simulated V_F = 2.0V with a 25Ω resistor connected in series. The combined constant current source output performance very closely matches the output performance obtained when V_F = 3.6V. The AAT3123 is capable of reasonable performance for a V_{IN} range down to 2.9V under these conditions. The actual application calls for matching a higher V_F of 3.6V to the lower V_F of 2.0V, and a 60mA constant current source needs to be split between three LEDs (20mA each). The addition on the ballast resistor now brings the voltage drop seen across the red LED to the levels seen across the green and blue LEDs over the AAT3123's operating range. Since the actual current through each LED is 20mA, this value should be applied to the actual $R_{BALLAST}$ calculation.

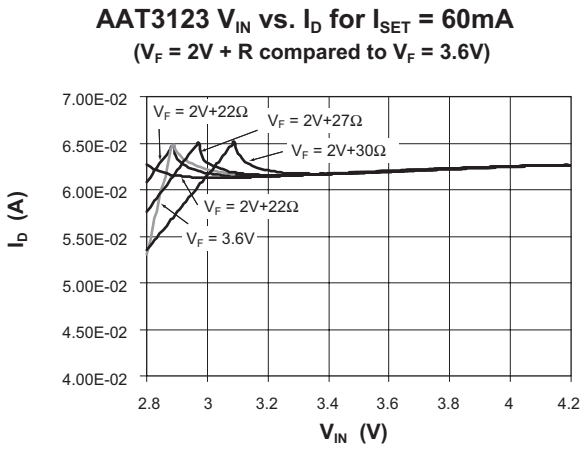

Figure 6: Comparison for V_F = 2.0V with Various Ballast Resistor Values, Matching the 2V V_F to a 3.6V V_F.

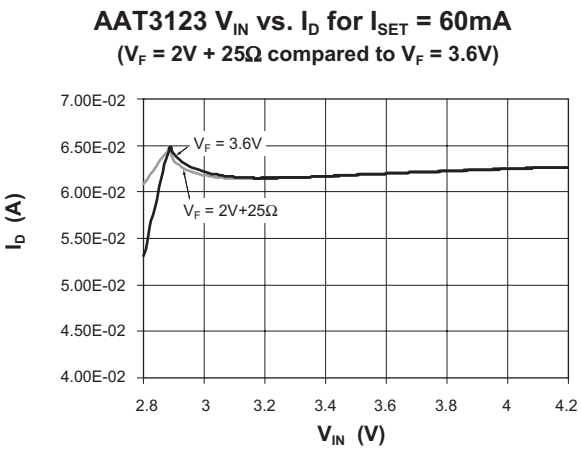

Figure 7: Final Matching of the AAT3123 Constant Current Source Output Performance; V_F = 3.6V Will Match the V_F = 2.0V + a 25Ω Resistor at 60mA.

Advanced Analogic Technologies, Inc.
830 E. Arques Avenue, Sunnyvale, CA 94085
Phone (408) 737-4600
Fax (408) 737-4611