LED hookup-guide: Circuits (Engn/Phys 207), fall 2020.

Compiled by JE, 28 Aug 2020

This document briefly details how (and why!) to configure different LEDs interfaced to the Adafruit feather 32u4, a 3.3V logic device (Figure 1). Note this is in contrast to the Arduino UNO, which is a 5V logic device. The Feather board's digital outputs act as digital switches, toggling between 0 (LOW) and 3.3V (HIGH) states, which toggles the LEDS off/on, respectively.

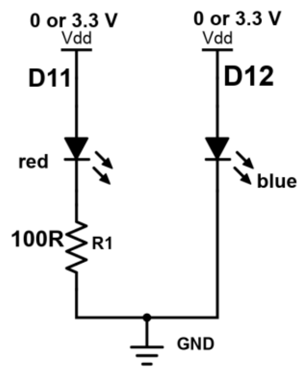
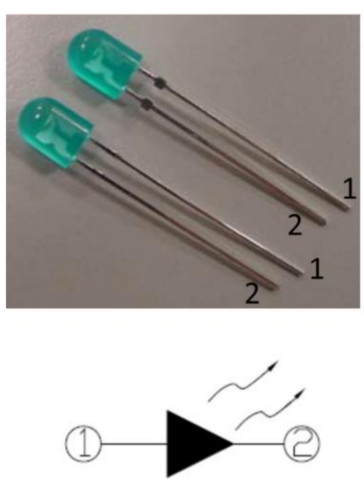


Figure 1. Circuit schematic for interfacing LEDs to Adafruit feather digital outputs that toggle LEDs on and off. The voltage of a digital outputs is 0V in the LOW state and 3.3V in the HIGH state. Note the red LED uses a current limiting resistor of approximately 100 Ohms; the blue LED requires no current limiting resistor in this case.

LEDs in normal operation flow current in one direction—they have polarity (fig 2, left). Blue LEDs have a relatively high turn-on voltage, thus driving them with 3.3V and no current limiting resistor is a safe operation—a limited amount of current will flow (Fig 2, right)



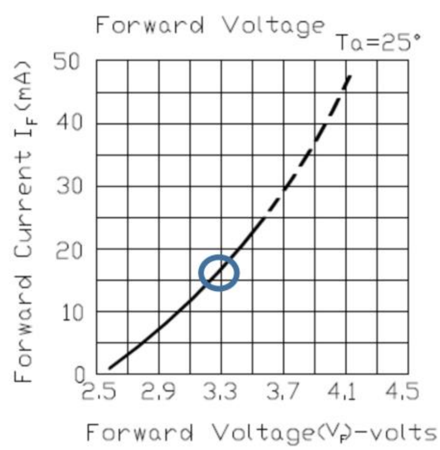


Figure 2. Blue LED infographic. Left: LEDs have polarity; they only flow current in one direction. The longer leg (anode) is labeled 1; the shorter leg (cathode) is labeled 2. Right: Voltage-current relation for a blue LED from the device datasheet (Click on datasheet here: https://www.digikey.com/product-detail/en/everlight-electronics-co-ltd/5484BN-BADC-AGJA-PR-MS/1080-1015-3-ND/4950440). With a voltage of 3.3V across the LED, about 17 mA of current will flow, a safe current that will clearly illuminate the LED under most ambient lighting conditions.

In contrast to blue LEDS, red LEDs have a realtively low turn on voltage and you must use a current limiting resistor (Fig 1) to ensure a safe amount of current flows (Fig 3).

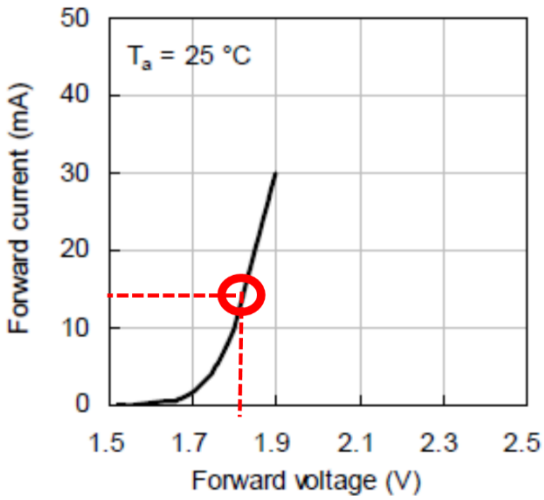


Figure 3. Red LED voltage-current characteristic curve (from the manufacturer datasheet). The device will flow about 15 mA when there is about 1.8V across the LED. When driven by a digital output of 3.3V, we need to dissipate 3.3 – 1.8V = 1.5 V elsewhere. This is the job of the current limiting resistor. Without, we would apply 3.3V across the red LED. Follow the exponential curve in your mind's eye to 3.3V—how much current would flow? LOTS, possibly burning out the LED.

Let's quickly compute a sensible value/magnitude for the current limiting resistor. Let's assume we want to flow about 15 mA of current—this generally results in a brightly illuminated LED in most ambient light conditions. In view of Fig 3, left we require about 1.8 V across the diode. If we have a 3.3V source (digital output on the Feather) driving the LED, we can apply KVL to conclude that need to dissipate 3.3V – 1.8V = 1.5V in another circuit element. This is the role of the current limiting resistor. So now we know we need 15 mA flowing through the resistor (KCL!), and we need it to "drop" 1.5V, in other words, there is 1.5V difference across the resistor. Apply Ohm's Law: R = 1.5V/15 mA = 100 ohms. This value does not need to be exact in this instance. You can use a slightly bigger or smaller resistor. The current will change and illumination intensity will change accordingly, but still maintain the current within safe limits.