Lab #3c: Using inputs to control LEDs with the Arduino

Purpose:
In this lab you will build a control circuit with a button to control the flashing of some LEDs. few external circuits and interface these with the Arduino.

What you will need:
1. Arduino board (and USB power cable)
2. Breadboard for building external circuits
3. Circuit components: jumpers, LEDs, resistors, button
4. Digital voltmeter (DVM)

Online resources:
1. https://learn.adafruit.com/all-about-leds/the-led-datasheet

Tasks:
1. Build four LED circuits, one for each color: red, green, yellow, and blue are standard colors, though you might have a clear/white LED in there as well. Make each LED independently controlled via digital pins on the Arduino.
    a. Each LED should have a resistor in series with it.
    b. A common ground connection can be (must be) used with each LED circuit.

2. Build a control circuit with a push-button.
    a. The button is essentially a wire that can either make contact (closed, effectively no resistance) or not (open, large resistance). When it is closed the button itself does not offer any resistance, therefore in order to limit the current flowing through the Arduino we must use a resistor with it.
    b. We want to monitor the status of the push button by measuring the voltage at the button by sending that voltage to one of the digital pins on the Arduino.

3. Configure the Arduino to control the LEDs using output signals, and to measure the voltage at the button using an input signal.
    a. This must be done in the setup function.

4. Instead of having the loop function continually repeat the blink pattern, we want to modify that so that it now causes the LEDs to blink together in some particular pattern for a set amount of time. You need to do a few things to modify the code appropriately.
    a. The first thing to do is to make sure that within the loop function you are continually looking to see if the button is pressed. On every loop of the program you want to check the value of your input pin and see if that button has been pressed. When it is pressed you want to initiate a set of commands that go through a blinky process for both LEDs. This sounds an awful lot like a conditional (if) statement.
    b. Once you have detected a butt press event, you want to run through a series of commands that cause the LEDs to blink. All of the code that does this stuff should be located **inside** of that conditional statement you just wrote.

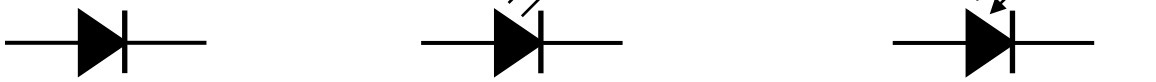
c. Previously, the blink pattern just ran endlessly, but now you need to tell it to stop at some point. There are a lot of ways that you can do this. One way is that you could write something like a loop that runs for a number of times so that you get one full on-off blink cycle. You can do such thigs by using a “for” loop.

5. **Bonus**: Further develop your code so that the blink pattern does something more complicated than reproducing the same pattern for each LED. In addition to documenting your work by providing the code you will need to provide an explanation of what you did here and why it works in the setup part of your lab report.

Lab report:
Now that we have concluded a fairly major bit of hardware and software development we will be writing up this project in a report. The goal of this report is to demonstrate your understanding of this system by illustrating your knowledge of (i) circuit design principles and (ii) computer programming. Your lab report should have all of the standard parts: introduction, setup, data analysis, and conclusions. The following notes provide a few more details about particular sections of the report.

**IMPORTANT: Make a short video recording of your Arduino with the flashing lights and upload that with your report.

The circuit symbol for diode-like devices is as follows:



Regular diode Light-emitting diode (LED) Photodiode (light sensor)

Setup
Please provide the following:

1. A circuit diagram for each circuit involved. Make sure to label each object in the circuit diagram, and label the pins/voltage source/ground to which each side of the circuit is connected.

2. Justify the use of our 220 Ω resistor by presenting a short calculation showing what value of resistance is need to produce a current of about 20 mA.

3. Present another calculation to show what value of resistance we want to use with the button to get a current of about 0.5 mA.

4. Attach a copy of your Arduino code at the end of the report or as a separate file.

Data analysis

We don't have much actual data to use here, so this section will be more about answering a number of questions that we explored in the process of creating this lab. For each question, provide a complete and sufficient answer.

1. Describe the basic rules for wiring things correctly using a breadboard.

2. What does LED stand for?

3. What two types of materials are used to make an LED, and what is a "hole" in this context? Hint: review chapter 24 if you aren't sure where to start. What happens when an electron and a hole combine?

4. Why is it important to have a resistor in series with an LED? If we left out the resistor what would happen?

5. Measure the voltage across each of the four LEDs and report these values here.

6. What happens when you wire two LEDs of different color parallel to each other? Make voltage measurements and explain what is happening.

7. Make a calculation of the current flowing through each of the LEDs given the prior information and your circuit diagrams from the setup section.

8. Describe what happens to your LED if you double the resistance in the circuit (you need only do this for one of them). You can double the resistance by using two of the 220 Ω resistors in series.

9. Explain whether the order and direction of the resistors and components in a circuit matters. What is the same and different about a series configuration of an LED and resistor?

10. Describe why the voltage between the button and the resistor changes values when you press the button.

Conclusions

There aren't any major conclusions here since we have not made any measurements that require serious reflection. However, I want you to do this as a final experiment: splash a small drop of water on your computer screen (don't flood it, just a drop, and make sure it doesn't get on any electronics). Put a white background behind the water drop. Describe what you see.

Now reflect on this: current computer monitors may have resolutions of about 1080 pixels horizontally by 1920 pixels vertically. If the computer updates the images at 60 Hz (known as the refresh rate), and each pixel is composed of a triplet of LEDs (what colors are these?), calculate how many calculations per second your computer is having to do to set the color of each pixel.

Conclude with an outlook to what you would have to do to extend what you have done here to create a large, full-color, LED light display system.