Building circuits

Record all measurements made as part of the lab under the relevant section. Graphs of current or resistance versus voltage when relevant are encouraged.

## Basic circuit:

1. Turn on the Raspberry pi (Rpi)
2. Connect one of the 5V pins on the Rpi to the + column on the breadboard
3. Connect one of the ground pins on the Rpi to the - column on the breadboard
4. Run a connector from the + column to one row on the main part of the breadboard
5. Run a connector from the - column to a different (but close) row on the main part of the breadboard
6. If we connected a 1Ω resistor between these two rows - so that it is in a closed loop with the 5V supply from the Rpi, how much current would this circuit attempt to draw across the resistor?

I=V/R=5/1=5 A of current attempted to draw across the resistor

* 1. The Rpi adaptor provides 5V and up to 2 Amps, is this current sufficient?

This current is not sufficient.

* 1. What do you think might happen? Please don’t actually do this.

It could cause the component to overheat, cause it’s trying to draw more component than the Rpi can actually give. This would cause the Rpi to short. It could also be at a level where we could feel the current.

1. Connect a resistor of more than at least 50Ω (Why might this be enough resistance?)

I=V/R=5 V/50 ohms = .1 A

This would be enough resistance cause it’s exponentially smaller than 5 A, and would be 50 times less current drawn from the Rpi than before. It also wouldn’t cause any harm to humans as well.

* 1. If you have a multi-meter able to measure current evaluate the current across the resistor, is it what you expected?

Predicted: I=5/680=.009 A

Given: 10.4 mA from the multimeter. This is around what I expected. The resistor could be slightly less resistant than what it was labelled as leading to the slight current discrepancy, but it is near enough to the calculated current.

## LED in a circuit:

1. Add an LED to your circuit
   1. Put it in series with the resistor and move the +/- connectors to the RPi 5V supply as needed
      1. How does the diode need to be oriented? Which wire on the LED goes to the +5V side and which goes to the GND connector?

The diode needs to have its longer end connected into the same row of the resistor, and the shoter end (the cathode) in another row, connected to the ground side.

* 1. What is the voltage drop across the resistor? Was this what you expected?

The voltage drop across the resistor should be 2.5 V since there’s now two components in series.

The measured voltage drop is 2.515 V with the voltmeter.

* 1. What is the voltage drop across the LED?

It should also be 2.5 V drop for the LED using the same reasoning as above.

According to the voltmeter, it is 2.702 V.

1. Try removing the resistor from the circuit, keeping the circuit closed - the LED is just in series with the 5V supply.
   1. What do you think will happen to the LED brightness?

It would probably get brighter, as there’s more voltage going through it, meaning more energy being output as light.

Removing the resistor, this is exactly what happened.

1. Try including resistors of different values - how does LED brightness change vs resistor strength?

With the resistor of 560 ohms, it was somewhat bright. The 68 ohm resistor made it a little brighter, though it was hard to tell. With the 10K ohm resistor, the LED is very dim. The 120 ohm resistor is slightly less bright than the 68 ohm, but brighter than the 560 ohm resistor.

With increasing resistance, the LED decreases in resistance.

* 1. Do the voltage drops across the resistors and LED change?

With the 10K ohm resistor, voltage drop across the resistor was 2.785 V and the voltage drop across the LED was 2.457 V.

With the 68 ohm resistor, voltage drop across the resistor was 1.911 V and voltage drop across the LED was 3.076 V

With the 120 ohm resistor, the resistor voltage drop is 2.14 and the voltage drop across the LED was 2.945.

There seems to slight change in the voltage, with voltage drop across the resistor increasing with increasing resistor, and voltage drop across the LED decreasing with increasing resistance.

1. Using the configuration with the highest LED brightness now move the 5V connection on the RPi to one of the 3.3V pins.

This is in the circuit where the circuit has only the LED, no resistors.

* 1. What do you expect to happen to the LED brightness?

I expect LED brightness to drop since there’s less voltage going across it, as the applied voltage is now less. This also means there will be less current as well.

This is exactly what happened as well. With 3.3 initial volts, the LED brightness now doesn’t burn my eyes when I look at it.

1. Add a step-up circuit components to increase your RPi voltage from 5V to 10V but do not close your circuit yet

Initially connecting the step-up circuit components led the voltometer to show 2

* 1. Using the dimmest configuration for the LED explored previously (meaning select the appropriate resistor from those you tried previously) now
  2. How will the LED brightness change?

The LED brightness should increase since higher voltage is now being put in (10 V), which means higher current according to Ohm’s Law. I=10/1000=.01 A compared to the original .005 A.

With the 1K ohm resistor, I wasn’t able to see a brightness difference, so I used a 560 ohm resistor to show the brightness change.

When done experimentally, the brightness increased than the original brightness at 5V with the 560 ohm resistor. The voltage drop across the 560 ohm resistor is also 7.23 V and the voltage drop across the LED is 3.015 V.

1. How would you quantify the LED brightness changes?

Ideally, if I had a meter to do, I would examine the power being output by the LED with a light sensitivity sensor which would measure lumens. I could also quantify the LED brightness changes with decreasing or increasing voltage drop across the LED, as brightness changes proportionally with the voltage drop.

1. Do any of these results change with different color LEDs? Specifically do any voltage drop values change, is the relative brightness similar for different color LEDs, etc.

On the 560 ohm resistor while at 5 V:

Blue – Brightness: alright / Voltage drop: 2.702

Yellow – Brightness: Slightly less bright than blue/ Voltage drop: 1.977

Red – Brightness: As bright as blue / Voltage drop: 1.928

Green – Brightness: Brighter than blue / Voltage drop: 2.68

White – Brightness: Brighter than blue, either on the same brightness as green or slightly less than green / Voltage drop: 2.658

Interestingly, despite there being higher or lower voltage drops compared to the blue LED, across different LED colors, voltage drop amount doesn’t really correlate to how bright the different LED’s will be. White has much less voltage go across it than the blue LED, but it was brighter than blue. The materials in the colored cap and LED seem to affect brightness more.

## Photo-diode:

1. Replace the LED with a photo-diode (remove the step-up component as well if you had one included previously)
   1. NOTE: photo-diodes operate in reverse bias mode so you will need to orient the diode accordingly

For my photo-diode, 5 V wasn’t enough to power it so I connected it to the 10 V step-up component instead, at Ms. Hanks behest.

1. What is the voltage across the resistor when you simply connect the 5V supply to close this circuit?

It wasn’t reading anything at 560 ohms of resistance with 5 V, so I put a 100K ohm resistor that was 9.3 mV across the resistor instead. At 10 V, it read 391.3 mV across the resistor.

1. What happens if you cover the photo-diode? What happens if you change the +connector to go to the 3.3V pin on the Rpi?
   1. What is the dark current for this photo-diode?
   2. Is 5V enough supply voltage to see a signal from this diode? Is 3.3V?
   3. What happens if you attach the step-up circuit component to increase the supply up to 10V?
2. What are the dark current and saturation current for the photo-diode?

Unfortunately, we were not able to go over photo-diodes during lab because no matter what the photo-diode was, they were not displaying the correct photo-diode behavior on my circuit.

We used the stellometer (I think that’s how you spell it) and a source of controlled voltage that showed the true behavior of the photodiode, decreasing the voltage immediately to near 0 V when the photodiode was covered.

Dark current was achieved from I=V/R=.34 mV/560 ohm = .000607 mA of dark current.

This was all that was done during the lab due to the photo-diode problem, which must have been a power source problem even though the power source should have been fine?