

CS 257 Lesson 2

Activity 1: Learning to Breadboard & Use Ohm's Law

Working with current-limiting resistors

Adapted from "What's a Microcontroller" by Andy Lindsay of Parallax.

Introducing Resistors & LED's

Resistors are used to adjust the voltage and current in a circuit. The higher the resistance value, the more electrons it blocks. Thus, higher resistance will lower the amount of current available to a component. In our case, we will use a resistor to control the flow of current (electrons) through an LED (light-emitting diode). Resistors come in standard values so you choose the one which is close to your calculated value.

Table 2-1 Resistor Color Code Values	
Digit	Color
0	Black
1	Brown
2	Red
3	Orange
4	Yellow
5	Green
6	Blue
7	Violet
8	Gray
9	White

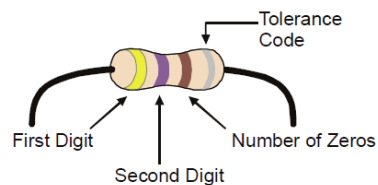


Figure 2-3
Resistor Color
Codes

CS 257 Lesson 2

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Figure 2-4 shows an LED's schematic symbol and part drawing. An LED has two terminals. One is called the *anode*, and the other is called the *cathode*. In this activity, you will have to build the LED into a circuit, paying attention to make sure the leads connected to the anode and cathode are connected to the circuit properly. On the part drawing, the anode lead is labeled with the plus-sign (+). On the schematic symbol, the anode is the wide part of the triangle. In the part drawing, the cathode lead is the unlabeled pin, and on the schematic symbol, the cathode is the line across the point of the triangle.

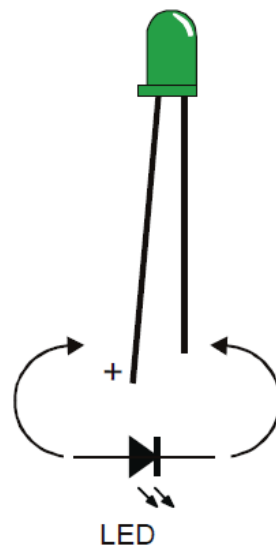


Figure 2-4
LED Part Drawing and Schematic
Symbol

*Part Drawing (above) and schematic
symbol (below).*

*The LED's part drawings in later
pictures will have a + next to the
anode leg.*

This figure shows a schematic of our circuit on the left and the actual components connected on the right. In this diagram, $V_{dd} = 5\text{VDC}$ (5 volts dc) and $V_{ss} = \text{ground}$ (0 VDC). This image is the breadboard that comes with the Boe-Bot. If you are using that breadboard, then it should be using the batteries on the bottom of the bot which add up to 6VDC. The BOE (board of education) converts that to a steady or regulated 5 Volts. However, LED's can use different voltages as well. They work well with 9 or 12 volts also.

The resistor controls the amount of current through the LED to keep it from burning up. The LED's you are working with use about 1.7 volts. This is called the forward voltage. The LED should be limited to less than about 15 mA to keep it safe. It will be plenty bright if you only give it 7 mA also.

To figure out which resistor to use, we need to know the LED forward voltage (let's say 1.7), the forward current we want it to draw (assume 7 mA), and our supply voltage (assume 5 V). The formula is

$R = \text{Supply voltage} - \text{Voltage the Led} / \text{MAX LED current we want}$ (Ohms law says $R = V/I$)

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Remember, the formula uses Amps not milliamps. So divide your desired current on the LED by 1000. (7mA = .007 amps.)

Now, substitute the values in our formula: $R = 5 - 1.7 / .007$ Amps

The answer is $R = 471$ ohms. So we can use a 470 ohm or the next higher one, a 560 ohm.

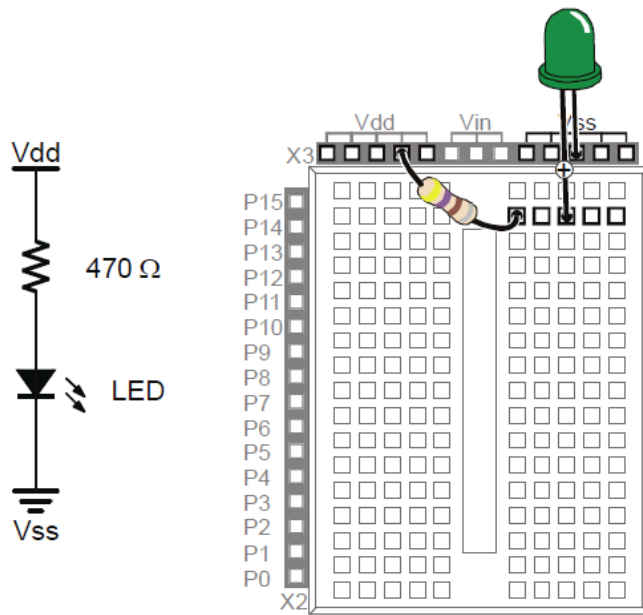


Figure 2-6

LED On, wired directly to power

Schematic (left) and Wiring Diagram (right).

Note that one resistor lead and the green LED's anode lead are plugged into the same 5-socket group. This electrically connects the two components.

The traditional explanation for this circuit goes like this. When the power is on, current flows from the positive (Vdd) pin through the resistor, LED, then to ground. You need to know that in reality, electrons flow from the negative to positive terminals. But Ben Franklin did not know this. So we use his established explanation to be consistent.

If you are using a different bread board or are using the Digi Designers in class, make sure to connect your B+ power where the Vdd is shown in the diagram and connect circuits to ground when you see Vss. The terms Vdd & Vss come from the type of components there are inside integrated circuits. You just have to remember Vdd is the + power source and Vss is ground.

CS 257 Lesson 2

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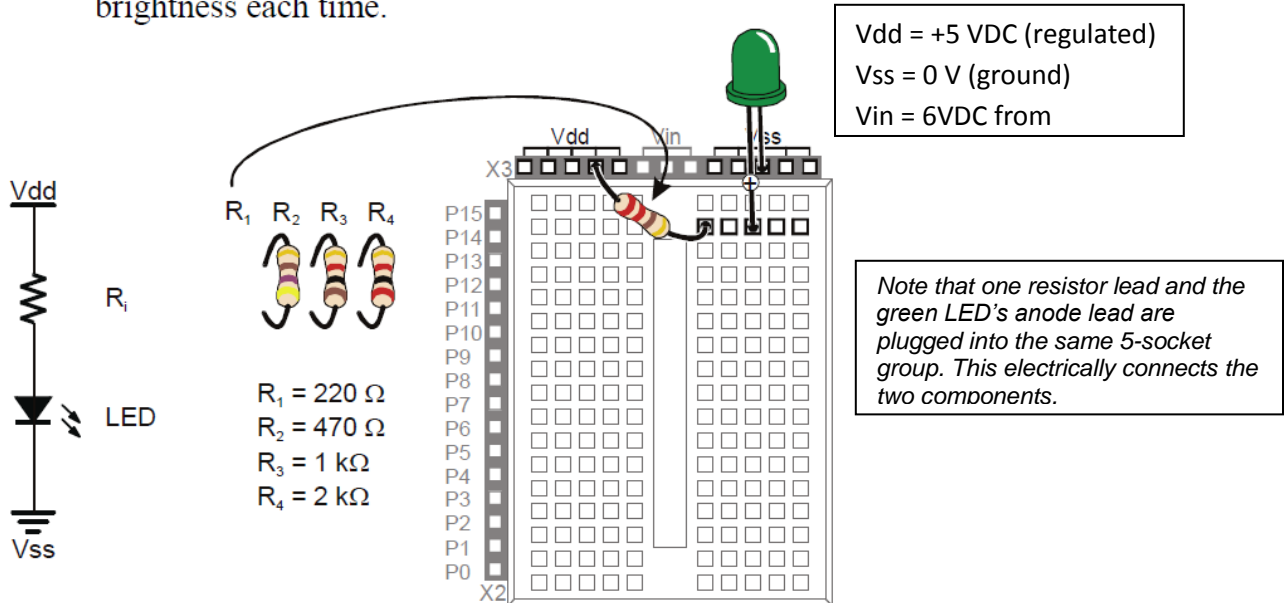
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Test Circuit

The resistance value of R_i in Figure B-1 can be changed. Lower resistance allows more current through the LED, and it glows more brightly. Higher resistance values will cause the LED to look dim because they do not allow as much current to pass through the circuit.

- ✓ Disconnect power from your Board of Education or HomeWork Board whenever you modify the circuit.
- ✓ Build the circuit shown in Figure B-1 starting with a 220 Ω resistor.
- ✓ Modify the circuit by replacing the 220 Ω resistor with a 470 Ω resistor. Was the LED less bright?
- ✓ Repeat using the 1 k Ω resistor, then the 2 k Ω resistor, checking the change in brightness each time.



CS 257 Lesson 2

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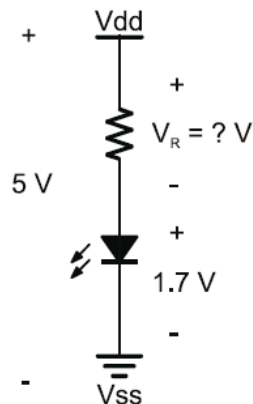
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Calculating how much current a red LED circuit draws takes two steps:

1. Figure out the voltage across the resistor
2. Use Ohm's Law to figure out the current through the resistor.

Figure B-2 shows how to calculate the voltage across the resistor. The voltage supplied is on the left; it's 5 V. The voltages used by each component are to the right of the circuit. The voltage we don't know at the start is V_R , the voltage across the resistor. But, we do know that the voltage across the LED is going to be about 1.7 V (the red light emitting diode's forward voltage). We also know that the voltage across the parts has to add up to 5 V because of Kirchhoff's Voltage Law. The difference between 5 V and 1.7 V is 3.3 V, so that must be the voltage across the resistor V_R .

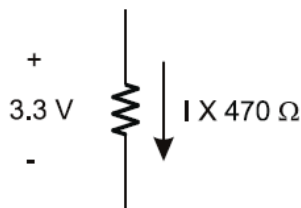


$$V_R + 1.7V = 5V$$

$$V_R = 5V - 1.7V$$

$$V_R = 3.3V$$

Figure B-2
Voltage Across
the Circuit,
Resistor, and
LED



$$V = I \times R$$

$$3.3V = I \times 470 \Omega$$

$$I = \frac{3.3V}{470 \Omega}$$

$$I \approx 0.00702 \text{ V}/\Omega$$

$$I = 0.00702 \text{ A}$$

$$I = \frac{7.02}{1000} \text{ A}$$

$$I = 7.02 \text{ mA}$$

Figure B-3
Calculating
Current through
the Resistor

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Kilo is metric for 1000. The metric way of saying 1000 is kilo, and it's abbreviated with the lower-case k. Instead of writing $1000\ \Omega$, you can write $1\ \text{k}\Omega$. Either way, it's pronounced one-kilo-ohm. Likewise, $2000\ \Omega$ is written $2\ \text{k}\Omega$.

Milli is metric for 1/1000, and it is abbreviated with a lower-case m. If the BASIC Stamp supplies an LED circuit with 3.3 thousandths of an amp, that's 3.3 milliamps, or 3.3 mA.

What's a mA? Pronounced milliamp, it's the notation for one-one-thousandth-of-an-amp. The "m" in mA is the metric notation for milli, which stands for 1/1000. The "A" in mA stands for amps. Put the two together, and you have milliamps, and it's very useful for describing the amount of current drawn by the BASIC Stamp and the circuits connected to it.

Activity & Worksheet

1. Draw a circuit which uses one LED as shown above. Label all of your parts.
2. The supply voltage will be 5 volts DC and the LED has a forward voltage of 1.8 volts.
3. The LED should draw 12mA of current.

Your circuit goes here

A large, empty rectangular box with an orange border, intended for the student to draw their circuit diagram.

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Questions

1. What is the calculated resistor value? _____ ohms
2. How much current does this circuit use? _____ mA
3. What resistor would I need if my supply voltage is now 12VDC? _____ ohms
4. If you use a 1K ohm resistor in your circuit, how much will the LED draw? _____ mA
5. If your resistor is 220 ohms, how much will the LED draw? _____ mA

Home Lighting Examples

The power (voltage) in our homes is 117VAC (volts AC or alternating current). Suppose you want to know how much current a 75Watt bulb uses. Power = IE. (watts = current * volts) and $I = P/E$. Using the second formula, we can see that Current (I) = Power in watts / Voltage .

So, $I = 75 / 117 = .64$ amps. If I turn on 5 lamps in my room with 75 watt bulbs each, I will be using $5 * .64$ amps = 3.2 amps. Since most circuits in our homes are limited to 20A, I will not overload my circuit by using only 3.2 amps.

The total wattage used is $P = IE$ or $P = 3.2 * 117$ or 375 watts.