

## LAB 0

### A SIMPLE ALARM SYSTEM: BREADBOARDS, RESISTORS and LEDS

<b>Objectives</b>	To understand the test equipment you will use in this course, and to construct a simple alarm system that breaks an infrared beam to trigger a light.
<b>Preparation</b>	Read Lab 0 and the function generator and oscilloscope tutorial web pages.
<b>Tools</b>	Prototyping breadboard, power supply, multimeter, wire cutter/stripper, and oscilloscope.

#### 1. Introduction

This lab will introduce you to most of the equipment at your workstation. You will gain experience with power supplies, breadboards, multimeters, LEDs, and oscilloscopes.

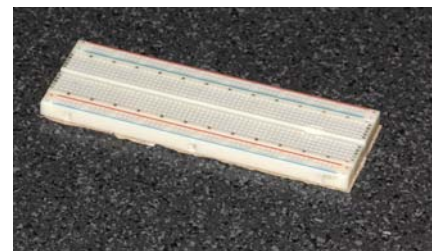
#### 2. Use an ohmmeter and a voltmeter to understand two different breadboards

**MEASURE WITH AN OHMMETER ONLY WHEN THE POWER IS OFF**  
**Measure with a voltmeter when the power is on**

An ohmmeter uses its own internal power supply to apply a voltage across a component. Its internal circuitry compares the resistance of the component with a known resistance (inside the ohmmeter) to determine the resistance of the component. This means that an ohmmeter will not function correctly – and can be damaged – if it is used to make measurements on a circuit that has power.

In almost all cases, you will use a voltmeter to make measurements when the power to a circuit is on. Occasionally you will use an ammeter, but it is generally easier to measure voltages than currents. In contrast to an ohmmeter, neither a voltmeter nor an ammeter need their own internal power supplies (at least, in their simplest versions).

When working with protoboards (also called breadboards), you should use solid – not stranded – 22 AWG wire (22 wire gauge; wires get bigger as the gauge decreases). Cut the wire from the spool and use your wire stripper to strip off approximately 1/4 inch of the insulation at each end of the wire. Keep things neat by cutting wires to length so that they run vertically or horizontally and lie flat on the breadboard.



#### Tasks:

- a. We will begin by working with the "small" protoboard shown in the figure. To determine whether one part of a circuit is electrically continuous with another we do what is called a "continuity check." Use an ohmmeter to perform a continuity check across the holes of the small protoboard. To test whether one hole on the breadboard is electrically continuous with

another, you can stick a wire out of the breadboard, attach an alligator clip, and attach the alligator clip at the other end of the cable to the multimeter probe. On your answer sheet, draw lines that indicate which holes are continuous with which other holes.

- b. Now we will work with the large protoboard that has its own power supply built in, as shown in the figure. Leave the power off until you have made all of your connections (steps i and ii below), and verified that your breadboard matches the figure provided at the end of this lab.



- i. First, connect the ground and +5V lines to the two top distribution strips. Use solid black wire for ground and solid red wire for +5V.
- ii. Now, connect the +15 and -15 lines to the two right distribution columns. Again, use solid 22 AWG wire. There is one color that you should definitely NOT use for either of these two connections. On your answer sheet, indicate what that color is. Also indicate what colors might be good ones to use.
- iii. After you have verified that your connections match those shown in figure at the end of this lab, turn the power on to the breadboard.
- iv. Using your voltmeter to make measurements, turn the regulator knobs on the protoboard to adjust the +15 and -15 lines until the lines are outputting +8 and -12 volts, respectively

**Now use the voltmeter to make measurements to help answer the questions on page 1 of your answer sheet. You may not need to measure every point to get the correct answers.**

### 3. Light up a visible LED

When you use an LED, it is important to limit the current that runs through it. Otherwise it will burn out. With a 5-volt supply, we typically use a 330 ohm resistor in series with the LED in order to limit the current to the LED. It is useful to memorize the fact that you should use a 330 ohm resistor with a 5-volt supply to power a typical LED.

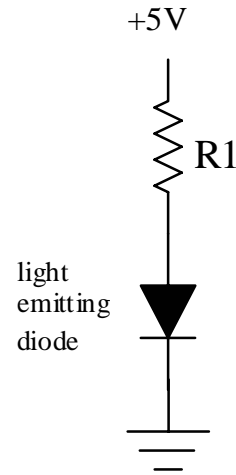
In this lab, it is okay if you accidentally burn out some LEDs. It is better to burn out some LEDs and understand things thoroughly, rather than being too tentative and not understanding things.

LEDs typically have a voltage drop that is independent of current, so long as the current is finite.

**Tasks:**

- a. Examine the figure to the right. Assuming that the voltage drop across the LED is 1 volt and that  $R1 = 330$  ohms,
- i. Calculate the current that runs through resistor R1.
  - ii. Calculate the voltage drop across R1
  - ii. Calculate the current that runs through the LED.

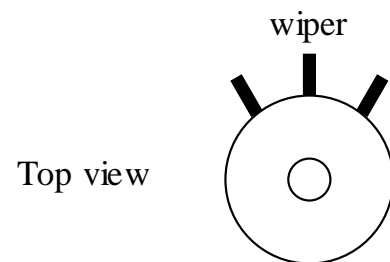
Show your calculations and write your answers on your answer sheet



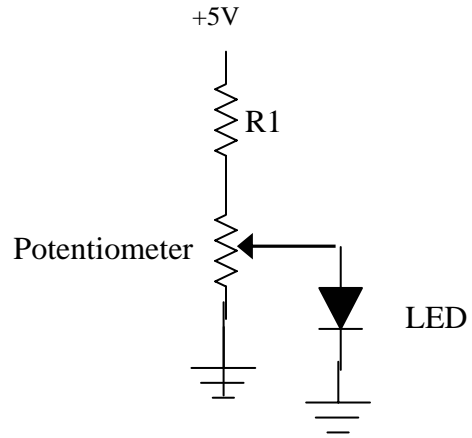
- b. Obtain a red, green, or yellow LED. Use your breadboard to construct the circuit shown in the figure. Make  $R1 = 330$  ohms.
- i. Measure the actual voltage drop across the LED
  - ii. Measure the actual voltage drop across the resistor R1.
  - iii. Using your measured values, calculate the current that runs through resistor R1.
  - iv. Using your measured values, calculate the current that runs through the LED
  - v. What happens if you switch the positions of R1 and the LED? Given that there is no resistor before the LED, will the LED burn out? Why or why not? If you're not sure, try it. It is okay if you accidentally burn out the LED.

Write your answers on your answer sheet

- c. Obtain a potentiometer (pot) from the TA. Using your multimeter, **measure** the total resistance of the pot. Also, look at the resistance between one end of the pot and the wiper terminal as you rotate the knob.



d. Add the pot into the circuit you have already constructed on your breadboard to build the circuit shown in the figure. In general, you should always turn the power off on the breadboard as you add components to a circuit.

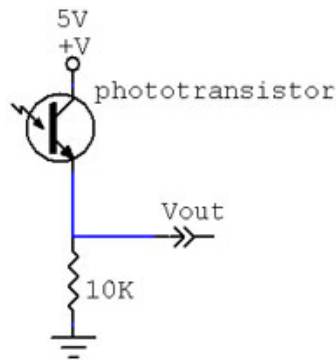
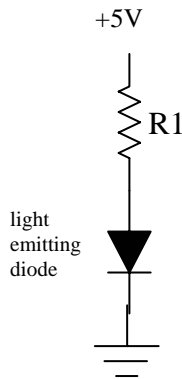


i. On your answer sheet, draw a graph of the voltage  $V_1$  as a function of potentiometer knob angle. You will probably need to use a fine Sharpie marker to mark a "zero" point on your potentiometer knob

ii. On your answer sheet, write a sentence that describes what happens as you turn the pot

#### 4. Construct an infrared (IR) emitter/detector circuit

a. Obtain an IR LED from the TA and construct the following two circuits on your breadboard. The circuit on the left is the same as you built in part 3b, except that you have replaced the visible LED with an IR LED. The circuit on the right is an IR detector. When you construct these circuits, make sure the IR emitter is facing the emitter.

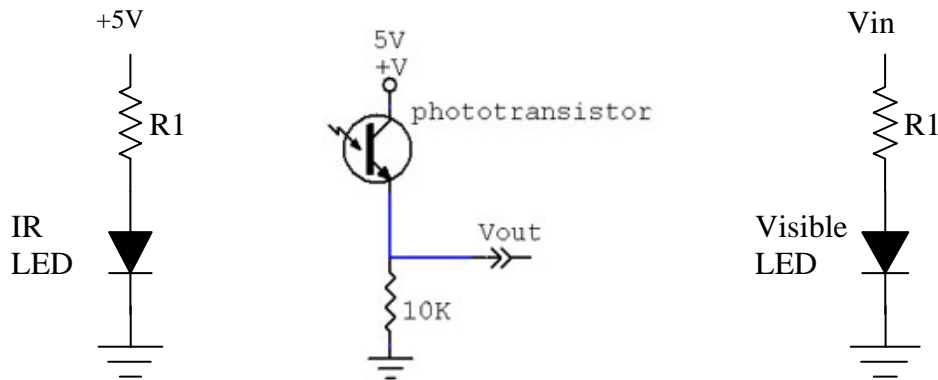


b. Use the oscilloscope to monitor the voltage across the detector. On your answer sheet, draw a graph of voltage versus time as you break the beam with your hand.

## 5. Use the output of the IR detector circuit to trigger a visual alarm when the beam is broken.

Tasks:

a. Construct a third circuit on your breadboard as shown in the figure. Connect the output of the detector to  $V_{in}$ . Continue to monitor the output of the detector on the oscilloscope.



b. On your answer sheet, describe the behavior of the visible LED as you break the IR beam with your hand.

c. On your answer sheet, describe why the output of the detector isn't a very good signal to send to the visible LED.

d. On your answer sheet, draw a graph of a better signal (voltage versus time) to send to the visible LED. In future labs, we will construct circuits that "clean up" signals to make better triggers.

## 6. Workstation Checkoff

Tasks

a. Return all tools to their original location and make sure all equipment is turned off, except for the computer. Do this after each time you use your workstation.

