ECE112 - Lab 8

Purpose

- Observe ”one-way” diode behavior
- Use some LEDs in conventional and non-conventional ways
- Use BJT transistors as amplifiers and switches

Parts/tools needed:

- Soldering iron and hand tools
- Parts available in lab
- Power supply
- DMM

Note: This lab is a little longer than others. Read through the steps and do what you can before coming to lab.

Observe ”one-way” diode behavior

In general, diodes only conduct current in one direction. In fact, almost all semiconductor devices exhibit some degree of *polarity*. In some cases semiconductors such as transistors may be damaged when excessive voltage is applied in the incorrect direction. Because of this, electronic devices that use batteries show explicitly how to put the batteries in to avoid damaging the device.

An LED exhibits polarity as well. Its positive terminal is indicated by being slightly longer than the other lead.

Figure 1: LED - Positive lead (anode) is slightly longer

Let’s first observe the diode’s *one-way* behavior by constructing the circuit below on a big pad protoboard. Use your power supply set to 5V output and a red LED for D2.

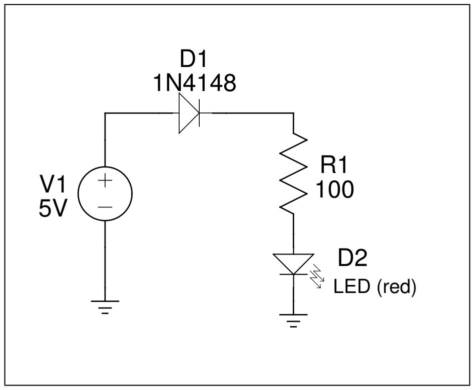

Figure 2: Diode Experiment One

Once powered up, the LED should light. Measure the forward voltage V_d across the regular diode D1 and the LED, D2 with your DMM.

1N4148 forward voltage: ____________

Red LED forward voltage: ____________

The 1N4148 is a normal silicon diode and exhibits a V_d of roughly $0.7V$. However, LEDs exhibit much higher forward voltage. The V_f for red LEDs averages about 2.2 volts. Green and yellow exhibit more. Measure the forward voltage of a yellow, green and white LED by replacing the red LED with each of the following:

Yellow LED V_f: ____________

Green LED V_f: ____________

White LED V_f: ____________

(Note: Always have a resistor of at least 100Ω *in series with your LEDs. They will be permanently damaged otherwise.)*

Now, with any color LED still in place and illumined, reverse the polarity of the power supply.

Is the LED still illuminated? ______________

Is any current flowing in the circuit? ______________

Explain what you are observing. ____

____

The *swizzle* circuit

It is possible to use some diodes oriented so that it makes no difference which way batteries are installed. In this experiment, we will use four diodes to allow a battery to power the LED circuit regardless of how the battery is connected by using the ”one-way” behavior in a clever way.

The incomplete schematic below shows a circuit where a 5 volt source could be applied in either direction to a circuit that lights an LED. Actually, the LED can withstand considerable reverse voltage without damage, but let’s allow it to represent some polarity sensitive circuit. If voltage is applied in a backwards fashion, a *swizzle* circuit orients the positive and negative supply voltages so that it’s always applied to the circuit correctly.

Complete the circuit schematic given to produce a *swizzle* circuit and then build it on your big pad protoboard. Be sure to clearly show your connection dots on the schematic. There are two missing wires. Your circuit drawing should be clear. The cathode ends of the 1N4148 diodes are marked with a black band.

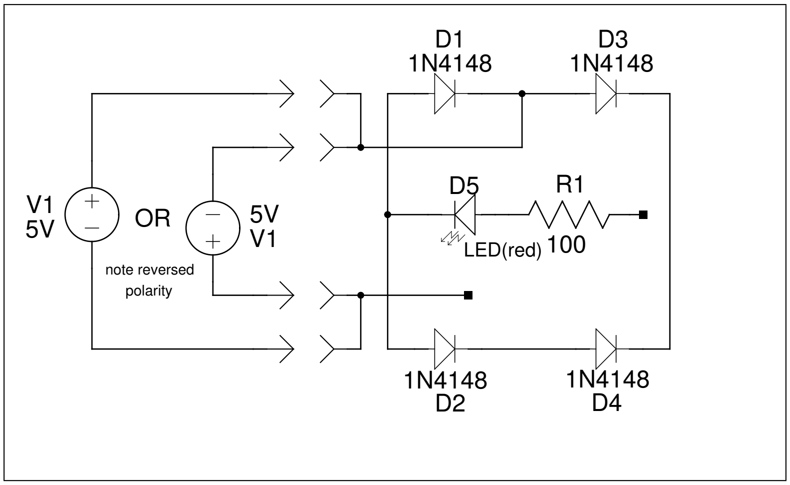

Figure 3: *Swizzle* Schematic to be Completed

Once your circuit is complete, try to light the LED with both polarities. If you have it designed and wired it correctly, the LED will light under both polarities. If not, figure out your mistake, redraw the circuit and fix your circuit until it works properly.

Measure the voltage between the right side of R1 (+ lead of DMM) and the cathode of the LED (- lead of DMM).

Is it equal to the supply voltage? ______________

How much less is it? ______________

Explain the difference. ____

BJT as a sensitive amplifier

We have seen in class how a BJT can operate as a current amplifier. Some BJT transistors have exceptionally high current gain due to a special internal structure. We will use a *super-beta* transistor with a current gain (beta) of about 5000 to build a touch sensor.

The touch sensor uses the tiny current path through the pad of your finger to provide the current path from the positive supply to the base terminal of a BJT. The BJT will amplify the current and turn it fully on. If an LED is placed in the collector to supply branch, a touch actuated LED switch is formed. A finger touch on the two pads will supply the current, and the LED will turn on.

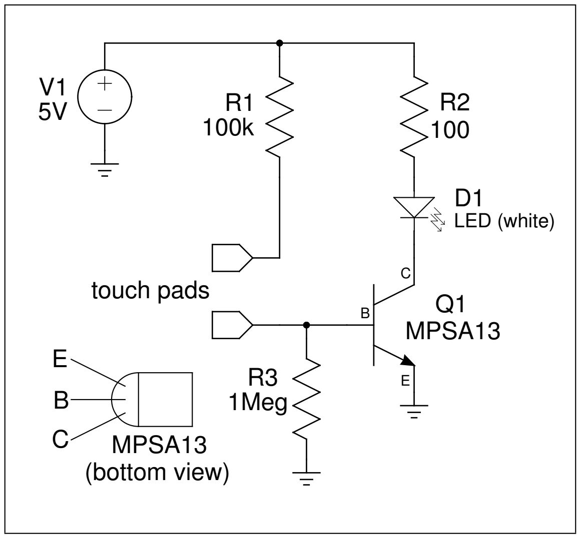

Figure 4: Touch Sensor Schematic

Build the circuit on the blue protoboard. Use a white LED for D1. You can use two unconnected wires or the protoboard pads as your touch pads. Make sure your circuit operates correctly.

Does the LED brightness change when you push harder on the touch pads or use moistened fingers on the touch pads?

____

Explain why: ____

Have your TA check off the operation of your touch switch:

____

Using an LED as a photo-detector (not a photo-emitter!)

Most all semiconductor devices are sensitive to light, infrared through X-rays. This is why most are encapsulated in black epoxy or metal cases. LEDs are also sensitive to light. Since they are in transparent cases, they can both emit and detect light. LEDs are optimized to emit light, but they can still allow a small *leakage* current to pass when they are reverse biased and light is applied to their PN junction.

Look at the schematic in figure 5. It is similar to the touch sensor circuit except a green LED is put in the place of the touch pads for your finger. If light is applied to LED D1, a small leakage current flows into the base of Q1, turning it on. When fully on, the collector of Q1 will be at about 0.2 volts. Since the collector of Q1 is connected to the gate of MOSFET Q2 which has a threshold voltage of about 2.5 volts, Q2 will be *off*. When Q2 is *off*, it passes no current from drain to source, thus LED D2 will remain off. For this circuit configuration, you can see that when Q1 is *on*, Q2 is *off*. When Q1 is *off*, Q2 will be *on*.

However, if no light falls on the sensor LED D1, there is no base current into Q1 and it will be *off*. Under this situation, the collector of Q1 as well as the gate of Q2 is at 5 volts. This turns on Q2 allowing it to pass current from drain to source, thus illuminating LED D2.

What we have created is a light source that comes on only when the lights go off; an automatic night light.

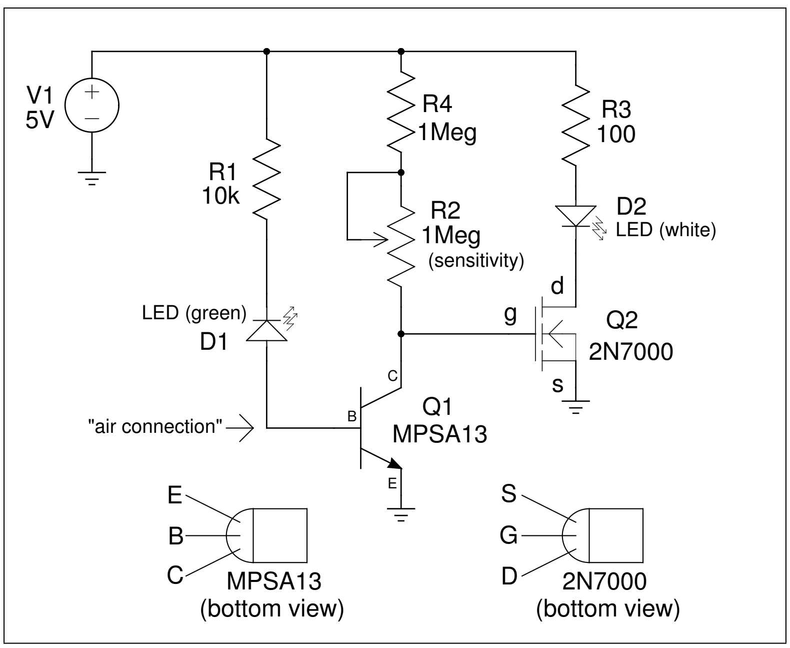

Figure 5: Automatic *Night Light* Schematic

Build the circuit on the blue big pad board. However, the connection between the D1's anode and the base of the MPSA13 **must** be made in the air. Using the pad on the board allows the tiny diode current to leak away from the base onto the board and to ground. See figure 6.

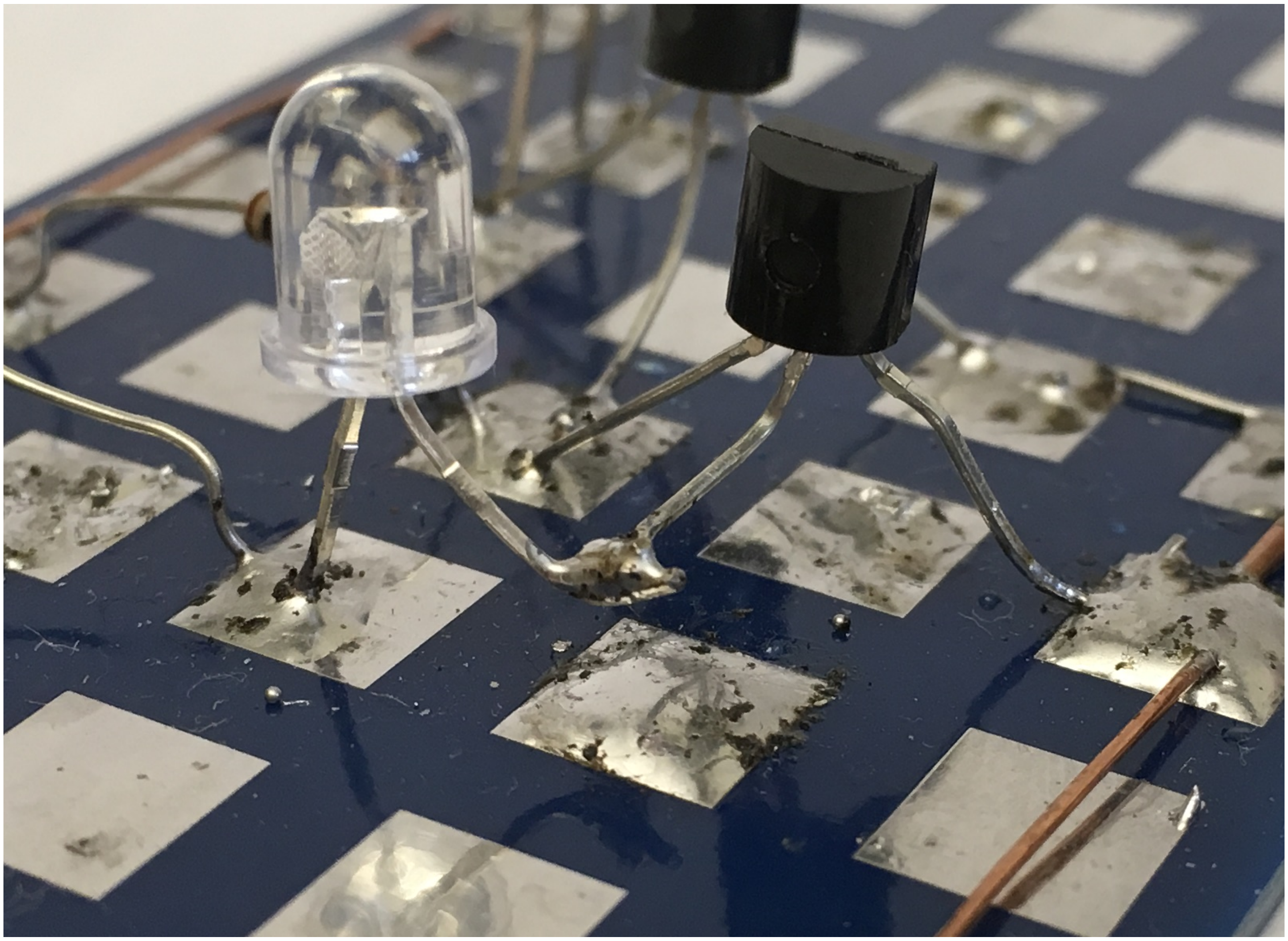

Figure 6: Connection Made in the Air

Once built, see that it works correctly by covering D1 with your fingers. You can use the white LED you already used for D2. You can vary the sensitivity of the circuit by adjusting R2. You can also tailor the light wavelengths the circuit is sensitive to by using yellow or red LEDs. You can use multiple sensor LEDs in parallel to make it more sensitive to different wavelengths of light.

Show your working circuit to your TA.

Circuit works? ____________