Phy 415 Lab #10 2009 Blinky thing

Prelab due at the start of class

1. Consider the circuit of Figure 1.

a) If the output is initially at +15 V, what is the voltage at A?

b) If the output is initially at +15 V, and the capacitor is initially charged to -7.5 V (the voltage at B is -7.5 V), what is the initial charging current through R_f?

c) As the capacitor charges, at what capacitor voltage does the output go negative (to -15 V)?

c) Show that the voltage on a capacitor connected to 15 V through a resistor R_f, with an initial voltage of -7.5V, is

$V(t) = D + Ee^{-\frac{t}{R_f C}}$, and find D and E.

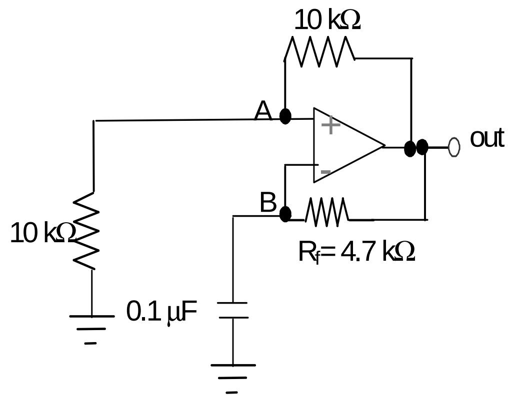

Figure 1. Relaxation Oscillator: Op amp with positive and frequency dependent negative feedback.

d) How long does it take the voltage on the capacitor to rise from -7.5 V to the point (in part c) at which the output goes negative?

e) Find a new D and E (for a capacitor which starts at 7.5 V, and is connected to -15 V), and determine how long it will take the capacitor to drop to a voltage at which the op amp output will go positve again.

f) What is the frequency of oscillation of this circuit?

g) Using a 4.7 µF capacitor, what value for R_f will make the frequency less than 10 Hz?

You are going to solder a circuit to take home with you. The soldered circuit should be done individually, rather than in teams, but the breadboarded circuit can be done in groups. We will use a 555 oscillator chip instead of the relaxation oscillator above.

__1. Breadboarding

___1.1. General

Even though it seems like an unnecessary step, it always takes less time to breadboard a circuit first, then solder a duplicate on a vector board. It is tedious to unsolder components and to debug a circuit which

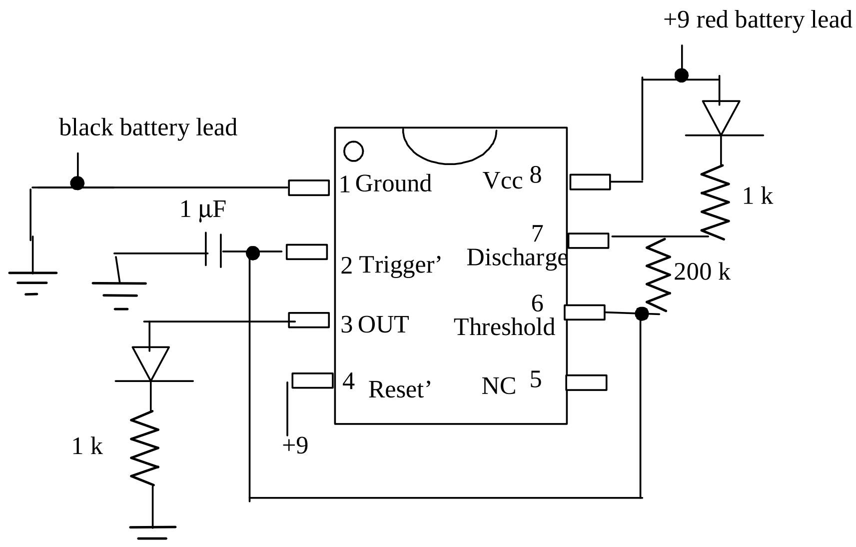

Figure 2. Oscillator circuit with 2 LEDs, top view

might not be working because of bad solder joins or because you have not verified it is capable of working in the first place.

___1.2. The 555 Oscillator

The circuit you are building is similar to the ones you built with op amps, except that it uses a special purpose 555 timing chip (which contains op amps). It is shown in Figure 2. Build this on a breadboard using the 20V power supply set at 9 Volts. Pick the color LEDs you want, and adjust the frequency by changing the 200 k resistor; you can use a potentiometer to have an adjustable frequency if you want. *Remember* $T=0.693(R_A+2R_B)C$*: the capacitor charges through* R_A *(200 k*Ω*) and* R_B *(1 k*Ω*), as shown in* Figure 3 *until the threshold voltage reaches 2/3* V_{cc}*, then the discharge line is grounded (by the chip), and the capacitor discharges through* R_B *until it reaches* $V_{cc}/3$ *and the cycle starts over.*

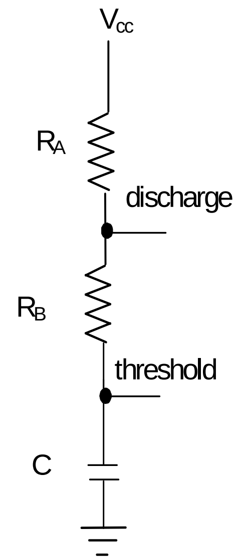

Figure 3. Discharge and threshold part of the circuit.

___1.3. Test the components

Test the actual 555 chip, resistors, LEDs, capacitors that you will be building into your circuits by simply swapping components into the working circuit.

___1.4. Test with the battery

When it is working, disconnect the power supply and make sure the circuit works with a 9V battery as the power source.

__2.Soldering

___2.1.Heat hurts

You should be aware of where the hot part of the soldering iron is at all times. (This sounds obvious, but when you are holding two things to be connected, the solder, and the iron, it is easy to burn yourself.) The heat is also bad for many non-human components. This is why you will solder a socket that the chip plugs into rather than the chip itself.

___2.2.Vector board

You will be using a piece of vector board. It has metal on one side, with rows and columns connected, much like the breadboard, but exposed and visible. Put the components on the other side, and wires on this side. Pick one column to use for ground and one for +9.

___2.3.Tin the soldering iron tip

Heat the soldering iron. When the remains of solder on it turn molten, wipe it on a wet sponge or paper towel to clean it. When it is hot again, barely touch the solder to the iron and let a little solder flow onto the iron.

___2.4.Practice “tinning” a wire

If you have never soldered before, it is good practice to solder two wires together. First “tin” both wires: hold the soldering against one wire. Touch the solder to a different part of the wire. DO NOT touch the solder to the iron (dropping molten solder onto a wire creates what is called a “cold” solder join—you get a mechanical connection, but it doesn’t conduct electricity). The solder should wick up the wire and coat it. Repeat with the second wire. Let it cool slightly. To solder the two wires together, touch them together and to the soldering iron. They should attach without needing much if any more solder.

___2.5.Solder the Socket

Start with the socket. It should NOT have the chip in it yet. Set it on the board, hold it in place (with your fingers), turn the board over and make sure the pins are coming through on the rows, not the columns. You are going to solder the eight pins of socket to the board. With the board metal side up and resting on the socket flat on the table, touch the point of the soldering iron to the intersection of the metal pad and one of the 8 pins. Barely touch the solder to the other side of the pin. The solder should flow to the hot pin and metal pad. Be careful not to use so much solder that you obscure the neighboring holes, or worse, bridge to a neighboring pad—see below.

___2.6. Fixes

If you have a small amount of solder joining two pads, you can scrape it away with the specially designed scraping tool. If you have too much solder you can remove solder by heating it with the iron and touching the metal braid (called solder wick) to it. To remove a wire or one side of a component like a resistor, heat the wire and pull gently from the other side. (You can use needle nose pliers if it is too hot to pull on).

___2.7. Test

Use an ohm meter to make sure that the pins are shorted to the pads, but not to each other.

___2.8.Solder the Battery Leads

Without attaching the battery, push the red and black battery leads through from the front, turn the board over and make sure that the are coming through on the chosen columns, and solder them. The solder should wick up onto the hot stranded wire from the hot pad if you touch solder to the pad near it. Test that the battery clips are shorted to the columns but not each other.

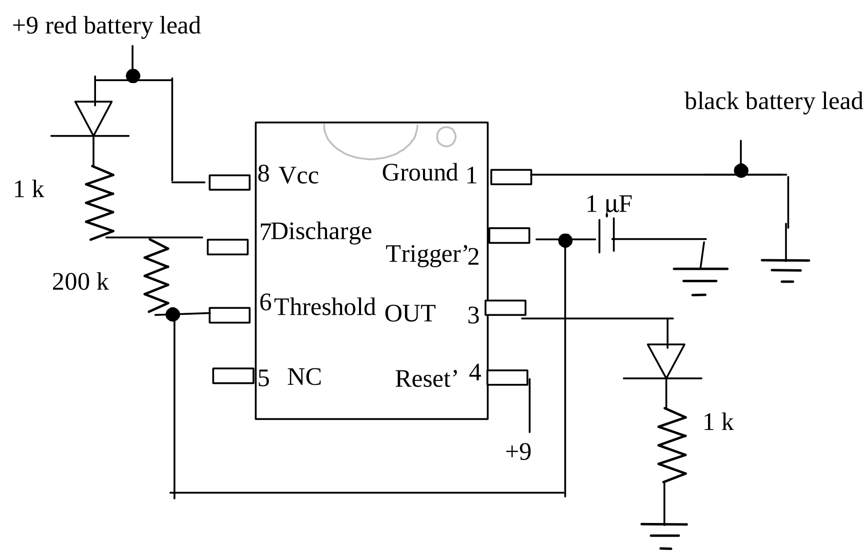

Figure 4. **Bottom** **view**

___2.9. Arrange the components

Turn the board over and WITHOUT soldering them, insert all the components (except the 555 chip and battery) and wires to build the circuit. Bend the component wires slightly to keep them from falling out. This allows you to work out which holes you want to use for which components and wires. Turn the board over as you insert each component to make sure its wires are inserted into the right holes. It can be helpful to draw a bottom view circuit, as shown in Figure 4. Remember that you won't be able to insert the chip if you run the wire from pin 2 directly to pin 6—you need to go around the socket, not over it. Double check the circuit from the back, and then from the front.

___2.10. Solder the components

Turn the board over again, and working systematically around in a circle, solder components. Check the bottom view circuit diagram as you go to make sure you are not missing anything. Take care not to overheat the LEDs. You can clip a heat sink on the LED wire near the plastic, but it is simpler to keep you finger on the plastic LED and simply not heat the wire longer than necessary.

___2.11.Test with an Ω meter

Working from the top view figure, use an ohm meter to make sure that each pin is shorted to the appropriate components, but not to any pin or component it shouldn't be. Verify that there is not a direct short between the battery leads.

___2.12.Test

Insert the 555 chip (making sure to put it in the right orientation). Plug in the battery. If the circuit doesn't work, try removing the chip and measuring voltages (switch the meter to voltage setting first).