EE101 Laboratory 10 **(SP03)** **Name ______________________________**

Date ______________________ **Partner's name ______________________________**

Instructional Objectives (at the end of this lab you should be able to:)

- Each student has successfully soldered all components properly onto the printed circuit board in his/her kit.
- Verify proper operation of the soldered, two-amplifier op amp portion of the printed circuit board kit.
- Connect the correct microphone circuit to the input terminals and the LED circuit to the output terminals and observe the behavior of the completed circuit.
- Measure the typical duration of the "on" time for the LED indicator light.

Description and Background

The sound-activated circuit can be viewed as three sub-circuits. The first is the amplifier stage consisting of the two operational amplifiers and associated resistors and capacitors. This sub-circuit amplifies the incoming signal to a level of sufficient magnitude to be useful for easy detection.

The middle sub-circuit converts the amplified AC input voltage signal to a rectified (DC) voltage signal that is used to charge capacitor C4. C4 can discharge through resistor R7. The voltage held for a short time across capacitor C4 is applied to the third sub-circuit that consists of transistors and resistors. This third sub-circuit is a solid-state switch (no moving parts!) that provides power to terminals E&F. This output signal can be used to turn on an indicator light in response to sound picked up by the input microphone.

The duration of the "on" signal at the output is controlled by the RC time constant of the second sub-circuit (C4 and R7). The rectified signal from the op amps causes current to flow forward through diode D2 into capacitor C4, and the resulting stored charge creates a voltage across the capacitor. When the voltage from the op amps becomes less than the capacitor voltage, diode D2 prevents current flowing back from the capacitor to the op amp, so the only path for the current is to flow through resistor R7, thereby gradually discharging the capacitor. The capacitance C4 (10 μF) and the resistance R7 (220 kΩ) determine the discharge rate.

An indication of the discharge time is given by a quantity called the *time constant*, which is equal to the product R×C. In this case,

$$\text{RC} = [\text{220k ohms}] * [\text{10 microfarads}] = [220\times10^{3}]*[10\times10^{-6}] = \boxed{\text{2.2 seconds}}.$$

You may recall from Lab #3 that the time constant is the time for the capacitor to discharge to $\mathbf{e}^{-1} = 0.368$ of the initial voltage across the capacitor. See section 20.4 of the textbook for a review of capacitors and the RC time constant.

As the capacitor discharges through the resistor the capacitor voltage follows the mathematical form $V_C = V_{INITIAL}\,\mathbf{e}^{-t/(RC)}$, where $V_{INITIAL}$ is the starting (or initial) voltage across the capacitor, and t is time in seconds. Thus when the elapsed time t is equal to the time constant RC, the capacitor voltage is $\mathbf{e}^{-1}\,V_{INITIAL}$.

Equipment

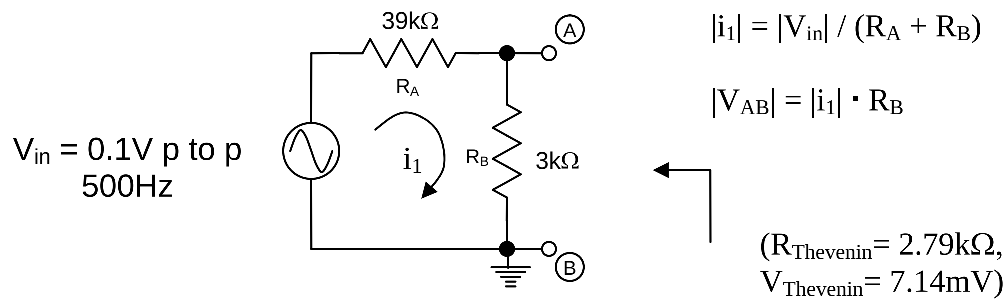
Your own lab kit printed circuit board, with all components specified in Lab #9 soldered in place, alligator clips from your lab kit, lab DC power supply, lab signal generator and oscilloscope.

Procedures

NOTE: If you did not complete the steps of Lab #9 during the last lab session, please complete Lab #9 first before finishing the steps of Lab #10. Every student (not just each team) is to complete the soldering, assembly, and Lab #9 testing, then proceed to complete Lab #10.

P1. Connect 9V DC to terminals C and D, OBSERVING THE CORRECT POLARITY! As before, construct the circuit shown below in **Figure 1** on your breadboard, and attach it to the PCB using the wires you have soldered into terminal points A and B. Using both channels of the oscilloscope, show the input signal (function generator) on one channel and the two-amplifier output signal (appropriate pin on the op amp chip) on the other channel. Does the two amplifier circuit work properly?

Figure 1: Input Circuit: Voltage Divider Network



$|i_1| = |V_{in}| / (R_A + R_B)$

$|V_{AB}| = |i_1| \cdot R_B$

P2. Turn off the signal generator and power supply.

? Now solder capacitor C3 onto your circuit board. Capacitor C3 connects the op amp portion of the circuit to the peak detector portion of the circuit.

Turn on the power supply first, then turn on the signal generator and use the oscilloscope to observe the signal across capacitor C4.

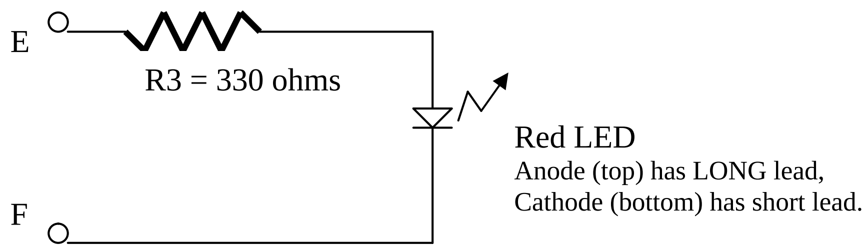
? Approximately what is the maximum positive voltage across C4? Approximately what is the minimum voltage? Does this voltage signal contain both positive and negative values (that is, does it extend both above and below zero)?

? Sketch the voltage signal across C4.

Observe the voltage across C4 as you vary the input amplitude. Does the C4 voltage change?

P3. Assemble the LED circuit of Figure 2 on your breadboard. Turn off the signal generator and the DC power supply and then attach the E&F wires from your PCB to the corresponding connections of the Figure 2 circuit on your breadboard.

Figure 2: LED Circuit

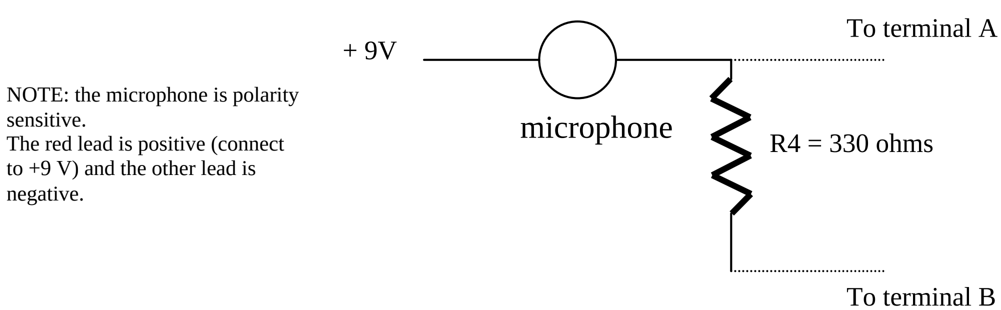


? Turn on the +9V power supply and signal generator and observe the LED: it should light up. If not, check your connections and try varying the signal generator amplitude.

? Now vary the frequency as well as the amplitude of the signal generator. Can you find a setting of the signal generator that causes the LED to flicker on and off momentarily at a very low frequency? Describe. At about what frequency (or frequency range) does this occur?

P4. Construct the circuit shown in **Figure 3** on your breadboard using the microphone and a resistor. Remove the Figure 1 input circuit and instead connect wires A & B to the corresponding nodes of the Figure 3 circuit.

Figure 3: Microphone Circuit



? Test the complete working sound-activated lab kit. Describe the results: does it work? Does sound cause the LED to light up? For a short loud sound (hand clap), what is the longest duration that the LED stays on? It is possible to measure the length of time using a slow sweep rate and the start/stop feature of the oscilloscope (ask the instructor how to do this).

? Demonstrate your kit for the lab instructor. *Instructor initials*: ___________________