EE101 Laboratory 8 (FL03) Name ______________________________

Date ______________________ Partner's name ______________________________

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

- Follow a wiring diagram to properly construct a prototype circuit containing two operational amplifiers.
- Use a voltage divider circuit to provide the input signal to the prototype, two-amplifier circuit.
- Observe and follow signals through the circuit using the oscilloscope.
- Learn fundamentals of soldering and practice soldering (for those unfamiliar with soldering electronic components).

Description and Background

This lab experiment uses two operational amplifiers. We will be using the LM358 operational amplifier in a dual IC package. This dual package allows for a single voltage supply pin and a single ground, and then each amplifier has two input signal pins (one negative and one positive) and one output pin, for a total of 8 pins in this dual op amp package.

Applying a (sufficiently small) positive voltage signal to the *inverting* (negative) input pin on an operational amplifier tends to produce a *negative* output voltage signal on the output pin, whereas applying a positive voltage to the *non-inverting* (positive) input pin tends to produce a *positive* output voltage on the output pin. Thus if two input voltages are applied to the two input pins, with one slightly greater that the other, then the output voltage will be positive if the voltage on the positive input pin is the greatest. On the other hand, if the voltage on the negative input pin is greatest, then the output voltage will be negative.

Cascading two operational amplifiers in series allows for signal isolation (isolating the output electrical load from the input signal, for example) and for possibly greater amplification or other signal conditioning than would be possible when using only one operational amplifier circuit.

The operational amplifier circuits we are using today employ the use of feedback, where the output pin is coupled to an input pin through a "feedback" resistor. Note that the feedback resistor connects from the output pin back to the *inverting* input pin of the amplifier. This is referred to as *negative feedback*, and provides a reliable and stable gain for the entire circuit even if the internal voltage gain of the op amp varies.

We can use simple resistor voltage divider circuits to create a source of smaller voltage from one of a larger voltage. The voltage divider circuit will be used for testing our amplifier circuit and analyzing the amplifier circuit gain. This allows a steady input signal, from the signal generator, instead of a variable signal as from an actual microphone for example. Later during another laboratory session we will use the actual microphone in your kit.

Soldering allows for components to be permanently connected in electronic circuits. Soldering principles are important to understand since this is commonly used in commercial manufacturing processes; however, commercial processes generally use automated methods, and we will be applying manual soldering techniques in this class.

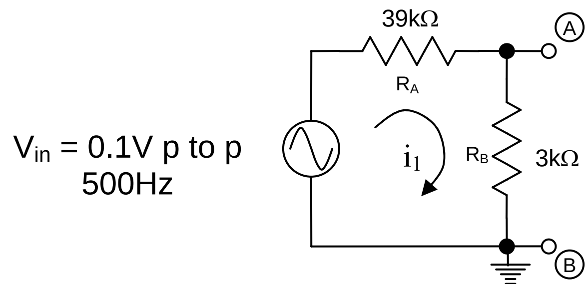
Equipment

Your own circuit prototype board and lab kit, miscellaneous components from the lab bins, the LM358 operational amplifier, your own resistor color code chart, alligator clips from your lab kit, function generator, lab power supply and oscilloscope, plus meter cables furnished in the lab for connections.

Procedures

P1. Create the circuit for Figure 1 on your prototype board.

Figure 1: Input Circuit: Voltage Divider Network



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

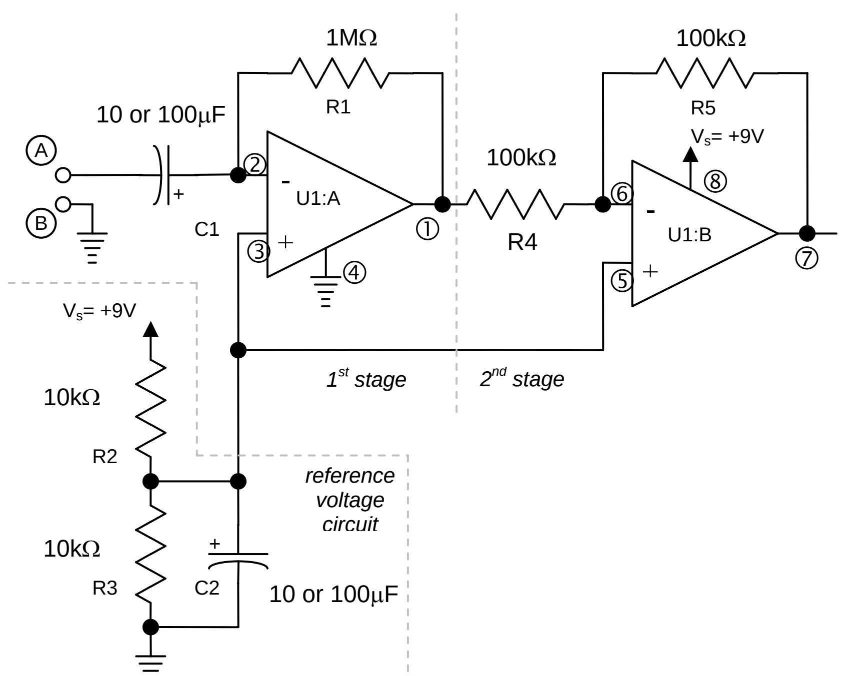
$|V_{AB}| = |i_1| \cdot R_B$

($R_{Thevenin}$= 2.79kΩ, $V_{Thevenin}$= 7.14mV)

→ Set the signal generator voltage and frequency as shown in the figure (use the low amplitude range switch (0-2V) on the signal generator), using the oscilloscope to view the signal amplitude. Measure the peak-to-peak voltage between A and B (ground) for the circuit of Figure 1. Determine the expected output voltage for the simple circuit and compare it to your measured value. Explain.

V_{AB} peak to peak measured: ______________ V_{AB} expected: _____________

Figure 2: Double Op Amp Circuit



P2. Now carefully assemble the circuit of Figure 2 on your prototype board. Systematically check all wiring **before** turning on the power supply. Also before connecting the power supply to your circuit, set the power supply voltage to the required 9 V by measuring with the multimeter.

Next, connect A and B of the input circuit (Figure 1) to the corresponding A and B on the op amp circuit (Figure 2).

→ Measure the peak-to-peak output (pin 1) of the 1st stage amplifier, using AC coupling with the scope. The *voltage gain* (v_o/v_{in}) of the 1st stage alone is the ratio of the output voltage (pin 1) to the input voltage (function generator). Calculate the 1st stage gain using your measured values.

V peak to peak at pin 1 (1st stage output): _______________

1st stage gain ($V_{pin\ 1}$ / $V_{func\ gen}$): __________________

P3. Measure the peak-to-peak output voltage of the 2nd stage amplifier (pin 7).

→ Using the measured voltages, calculate the gain of stage 2, from the 2nd stage input (pin 1) to the 2nd stage output (pin 7)

2nd stage gain ($V_{pin\ 7}$ / $V_{pin\ 1}$): _____________

→ Use both channels of the oscilloscope to determine the following. Is the 2nd stage output voltage (pin 7) in phase with the output voltage of 1st stage (pin 1)? Is the 2nd stage output voltage in phase with the input voltage from the function generator?

P4. Determine the overall gain of the 2-stage amplifier, from the signal generator to the 2nd stage output (pin 7).

Overall gain ($V_{pin\ 7}$ / $V_{func\ gen}$): __________________

How do the two gains from P2 and P3 compare with the overall 2-stage gain? How does the overall gain compare to the expected value: (1M/2.79k)*[3k/(3k+39k)]=25.6 ?.

P5. What does the complete two-stage circuit of Figure 2 accomplish? Discuss, using complete sentences.