Name: ______________________

Basic DC Lab - ELEC 101L

LAB #12a: Operational Amplifiers - DC Gain

In this lab the basic knowledge of DC circuits will be used to investigate Operational Amplifiers, or Op-Amps. Op-Amps provide a fundamental building block for analog circuits and have hundreds of different applications. Today a few of those will be explored.

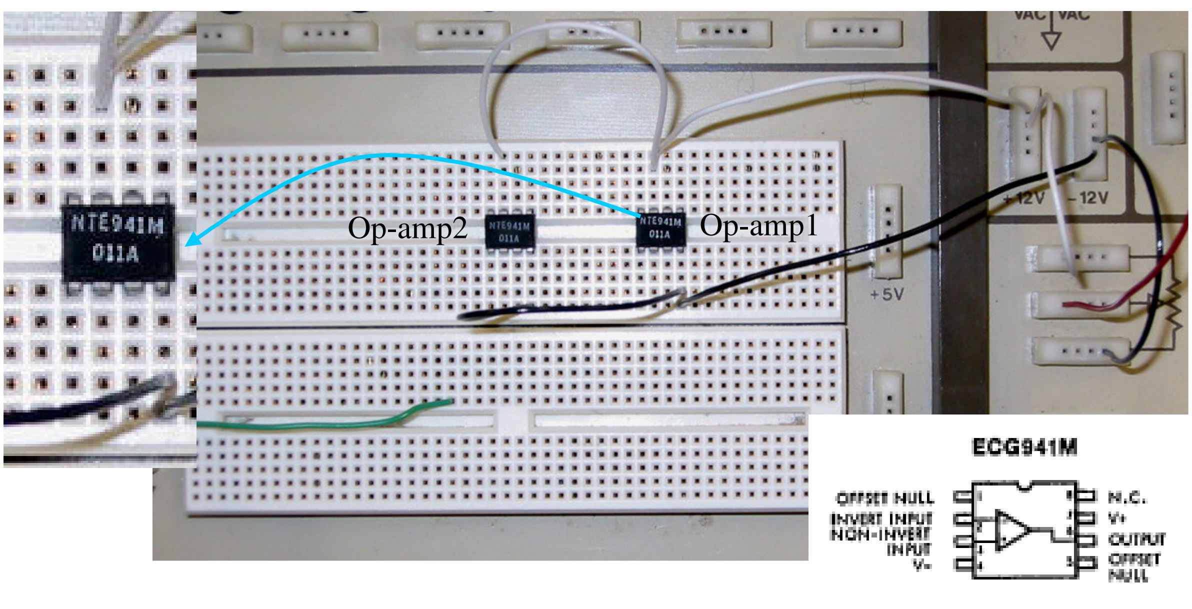
An ideal Op-amp has ∞Ω input resistance (R_{in}), 0Ω output resistance (R_{out}), and ∞ open loop gain (A_v, large-signal voltage gain). On the data sheet provided with this lab find these values from the table on page 2 and record them below.

R_{in} = ____________ R_{out}= ____________ A_v= ____________

This lab will use the Heathkit ET-1000 trainers extensively, and the HP digital multi-meter will be used for all voltage measurements.

Before beginning the experiment, connecting power to the Potentiometer (pot.) and op-amps will be done. Several wires are needed in this lab so if there are not enough at your lab station get some from the instructor. Wire color is not critical, but it is usually a good idea to use the same color for like connections (ex: white wires for +12v, green wires for ground).

Observe the photo below and connect the +12V to the top terminal of the pot, and to pin 7 of op-amp1 and op-amp2. Connect the –12V to the bottom terminal of the pot and to pin 4 of op-amp1 and op-amp2. Also connect the ground terminal to a convenient location on the breadboard so it can be used later. (10 pts)



Turn on the ET-1000 and measure the voltages at pin 7 and pin 4 of the op-amps. If they are correct proceed to Part I of the lab.

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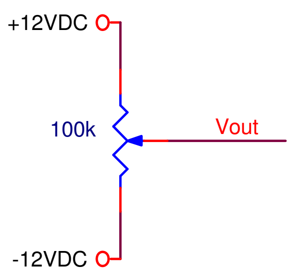
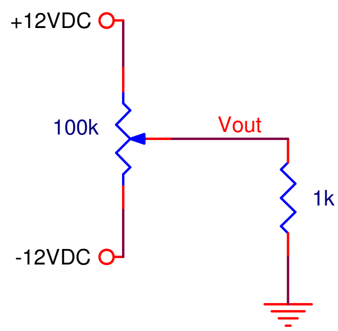
PART I – Unity Gain Buffer (30 pts)

Connect the 100kΩ potentiometer on the to ET-1000 the +12V and –12V power supplies. Adjust the output voltage to approximately 1V (0.9V-1.1V). Record the value below. Now connect a 1kΩ load resistor as shown in the second diagram and describe what happens to the output voltage and why. (10 pts)

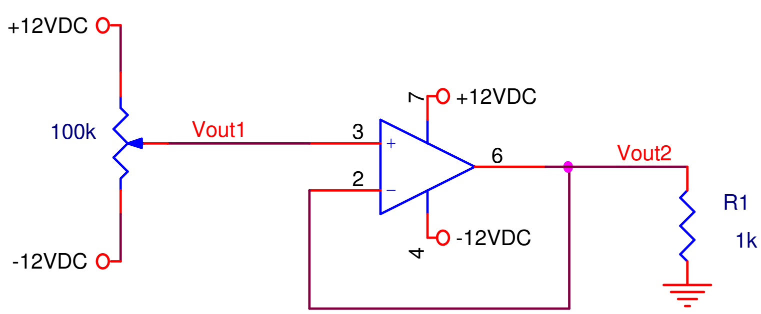




V_{out} = ________ V_{out} = ________

V_{out} changed because:

To eliminate the loading effect of the 1kΩ resistor on the output voltage, a unity gain buffer, or voltage follower will be used. Connect the output voltage of the pot to pin 3 of op-amp1 as shown and add a wire, which connects pin 6 with pin 2. Next connect the 1kΩ resistor to the output, pin 6, and ground. Measure the both the voltage at the Pot output (V_{out1}) and the output of the Op-amp (V_{out2}). Write down the values and describe their relationship.



V_{out1} = __________ V_{out2} = _____________

The relationship between V_{out1} and V_{out2} is:

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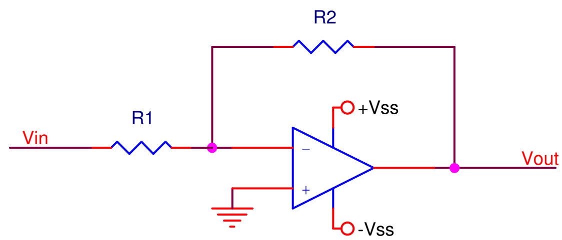
Part II – Inverting Amplifier (30 pts)

In this portion of the lab an inverting amplifier will be investigated. The op-amp circuit shown at right is called an inverting amplifier.

The gain (amount the input is multiplied by) of the circuit is given by: $V_{out} = -\frac{R2}{R1} \times V_{in}$, the output is the opposite sign of the input, and two resistors determine the multiplier.

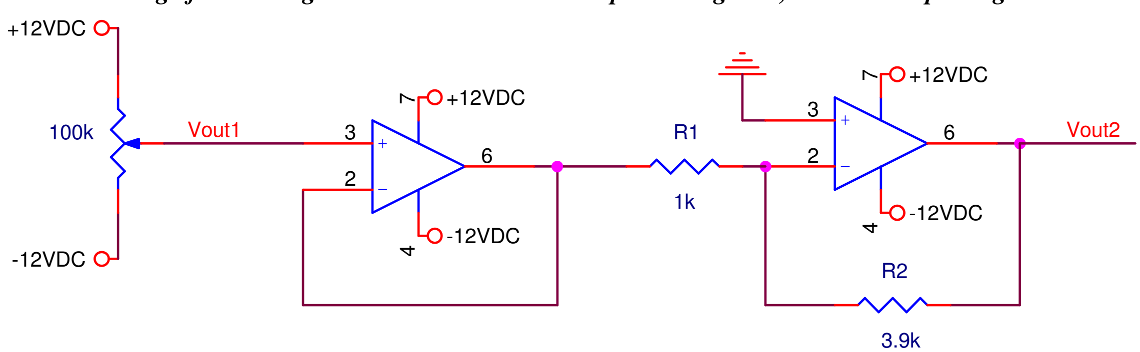


An inverting amplifier connected to the voltage follower is shown below. For the 1kΩ and 3.9kΩ resistors used in the inverting amplifier, calculate the gain of the circuit. Measure the two resistors, write their values and calculate the gain using the formula.

R_1 = ____________ R_2 = ____________ Gain(-R2/R1) = __________

Build the inverting amplifier circuit by adding it to the voltage follower.

Note: the voltage follower signal is connected to the – input through R1, and the + input is grounded.



If V_{out1} is 1V what do you predict V_{out2} of the circuit will be? _________

With V_{out1} set at 1V (0.9V-1.1V) measure V_{out2} and calculate the gain = V_{out2}/ V_{out1}.

V_{out1} = _________ V_{out2} = __________ Gain (V_{out2}/ V_{out1}) = _____

Did the measurement match the prediction? ______ If not why.

If V_{out1} is -4V what do you predict V_{out2} of the circuit will be? _________

Now set V_{out1} to -4V (-3.9V to -4.1V) measure V_{out2} and calculate the gain = V_{out2}/ V_{out1}.

V_{out1} = _________ V_{out2} = __________ Gain (V_{out2}/ V_{out1}) = _____

Did the measurement match the prediction? _______ If not why.

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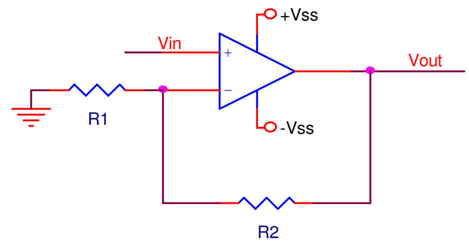
PART III – Non-Inverting Amplifier (30 pts)

In this portion of the lab a non-inverting amplifier will be investigated. The op-amp circuit shown at right is called a non-inverting amplifier.



The gain of the circuit is given by:

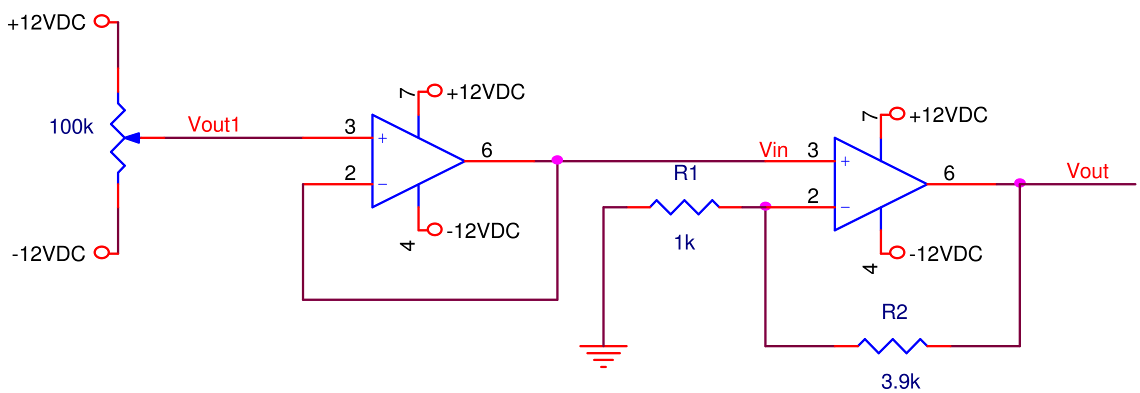
$V_{out} = \left(1 + \frac{R2}{R1}\right) \times V_{in}$, the output is the same sign of the input, and two resistors plus 1 determine the multiplier.

A non-inverting amplifier connected to the voltage follower is shown below. Calculate the gain of the circuit using the resistor values already measured.

Gain(1+R2/R1) = __________

Build the non-inverting amplifier circuit by modifying the inverting amplifier.

Note: the voltage follower is connected directly to the + input, and the - input is grounded through R1.



If V_{out1} is 1V what do you predict V_{out2} of the circuit will be? _________

With V_{out1} set at 1V (0.9V-1.1V) measure V_{out2} and calculate the gain = V_{out2}/V_{out1}.

Vout1 = _________ Vout2 = __________ Gain (V_{out2}/V_{out1}) = _____

Did the measurement match the prediction? ______ If not why.

If V_{out1} is 3V what do you predict V_{out2} of the circuit will be? _________

Now set V_{out1} to 3V (2.9V to 3.1V) measure V_{out2} and calculate the gain = V_{out2}/V_{out1}.

V_{out1} = _________ V_{out2} = __________ Gain (V_{out2}/V_{out1}) = _____

Did the measurement match the prediction? _______ If not why.