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ELEN 50L – 47347
F: 2:15 - 5:00 pm
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Lab #4: Operational Amplifier Circuits

1. **Objectives**
   a. Utilize what we learned in class to design and implement an inverting amplifier.
   b. Understand how an operational amplifier (inverting specifically) works

2. **Laboratory Procedure**

Part A:

Step 1: Assemble the inverting amplifier on the breadboard as designed in the pre-lab with power supplies adjusted to ± 15V.

Step 2: Connect a third power supply to adjusted to +1V to the input of the amplifier and measure the output voltage
V = 7.9350V

Step 3: Calculate the DC voltage gain.
voltage gain = 7.9350V - 1V = 6.9350V

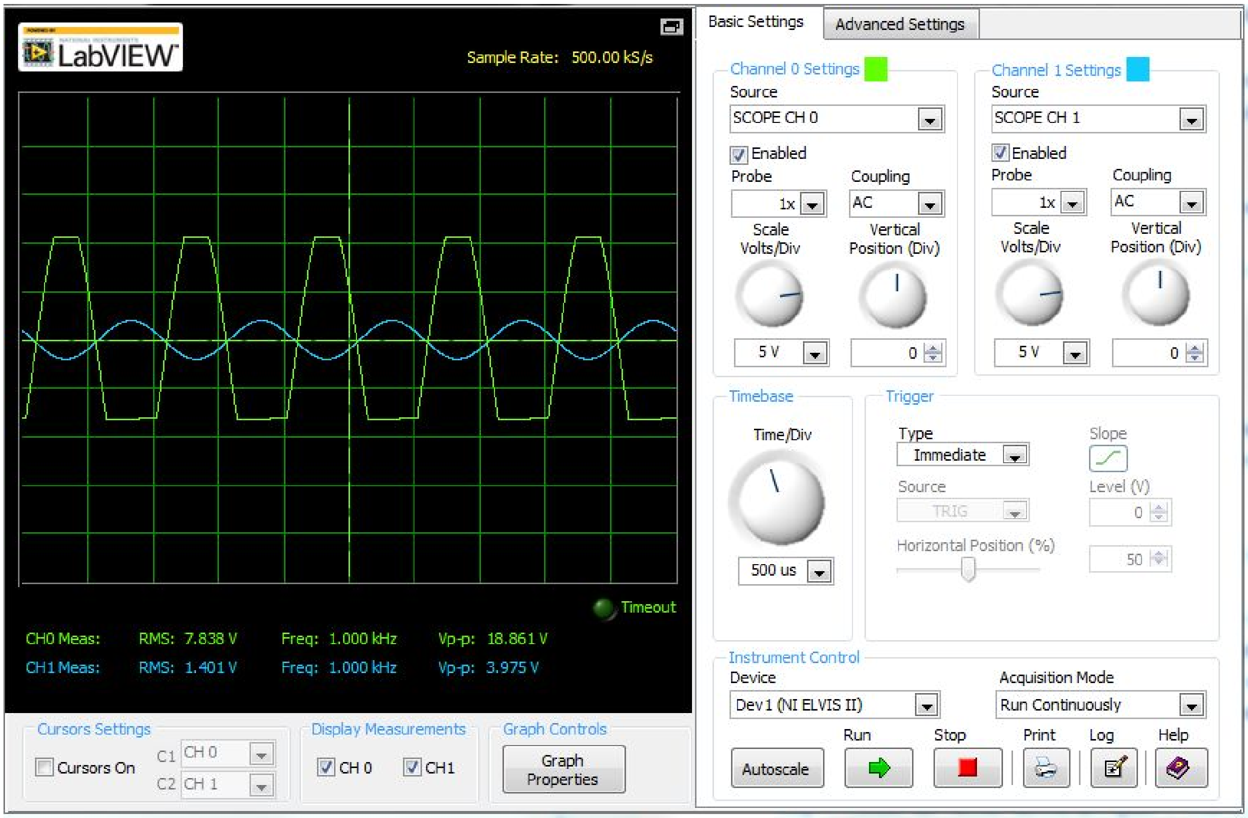
Step 4: Measure the current flowing into the inverting amplifier circuit and find the input resistance of the circuit by the ratio of input voltage to current.
I_s = 0.00065A
$R_s = V_s/I_s$ = 1/0.00065 = 1538.5 Ω

Step 5: With the input voltage set to 0 (shorted out) measure the output "error" voltage.
V_0 = -1.823V

Step 6: Replace the DC input voltage source with a sinusoidal input source at a frequency of 1 kHz and an amplitude of 1V. View this input voltage and the amplifier output voltage on an oscilloscope. Slowly increase the amplitude of the sinusoidal input until the output no longer looks sinusoidal. What causes this change in the output?

As we increase the amplitude of the sinusoidal input, we are trying to increase the output voltage. As the output voltage approaches the value of the power supply, which is +15V and -15V, the curve will saturate, because the actual output cannot exceed the power provided, hence the output will no longer looks sinusoidal.

The graph should become saturated at +15 V and -15V because those are the limits of Vcc. For some reason, our voltage output saturates early at around -9 V and +11 V. A possible reason is that our input voltage may be slightly lower than +15V and higher than -15V, in this case, the saturation may be earlier.



Part B:

Step 1: Create the circuit shown in Figure 1 with R_1 equal to the value you calculated in the prelab, which is 5k and use a power supply voltages of ±15 V for V_{cc+} and V_{cc-}.

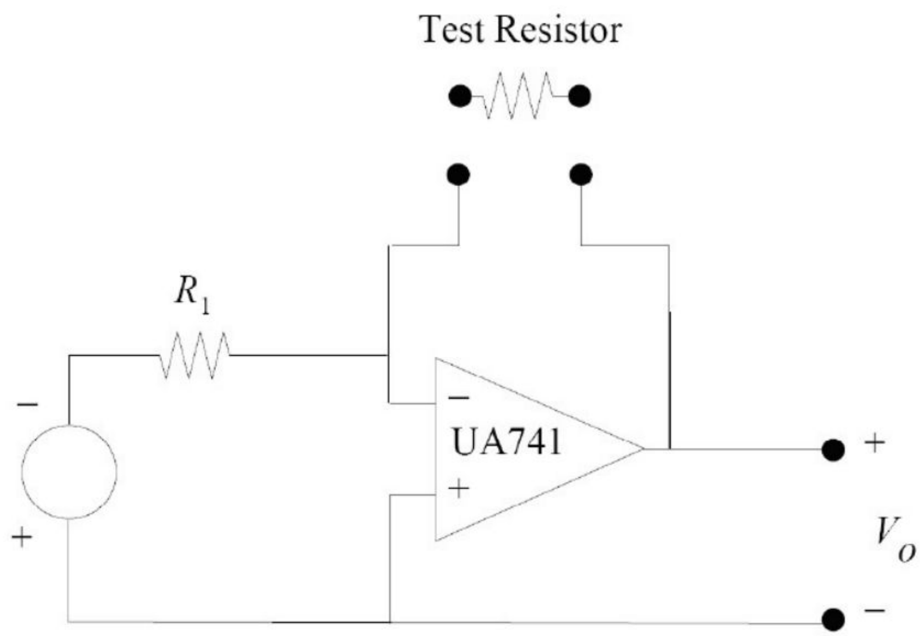


Fig. 1

Step 2: Using a DMM, measure the resistances of five different resistors between 500Ω and 10kΩ.

R_a = 499.5Ω

R_b = 599.2Ω

R_c = 698.8Ω

R_d = 798.8Ω

R_e = 898.4Ω

Step 3: Measure the resistance of each of the five resistors using you op-amp ohmmeter when the voltage source is 5V. Using 4.7kΩ instead of 5KΩ

$V_0 = -R_f/R_s * V_s$

$R_f = -V_0/V_s * R_s$

R_a' = 0.534/5*5000 = 534.0534

R_b' = 640Ω

R_c' = 748Ω

R_d' = 855Ω

R_e' = 962Ω

Our calculations are off by 50Ωs because we are using a 4.7 kΩ instead of a 5kΩ.

Step 4: Calculate the percentage error in resistance measurements between your op-amp ohmmeter and the DMM for each of the five resistors.

$\%R_a = -6.91\%$

$\%R_b = -6.81\%$

$\%R_c = -7.04\%$

$\%R_d = -7.04\%$

$\%R_e = -7.08\%$

3. Observation and Analysis

By the rule of saturation, we notice from the oscilloscope that the sinusoidal curve only oscillates between +15 and -15.

4. Questions

No questions asked by lab and/or answered them in their respective section.

5. Conclusions

By using operational amplifier, we are able to obtain relatively large output voltage through a small input voltage, which can be very useful if we need a very large output voltage when we don't have a large enough input voltage, all we need to do is to modify the ratio of R_f and R_s.