EE321 – Lab 1

Amplifiers, Biasing, and AC Coupling

The purpose of this lab is to measure the characteristics of an amplifier, and to use the characteristics to add a bias circuit at the input.

An amplifier can be represented in many different ways. Figure 1 shows a model for a voltage amplifier. The textbook shows similar models for current, transconductance and transresistance amplifiers. Figure 2 shows a simple block diagram of a generic amplifier. In this lab we will measure the characteristics of the simple voltage amplifier: the input resistance R_i, the output resistance R_o and the voltage gain A_{vo}.

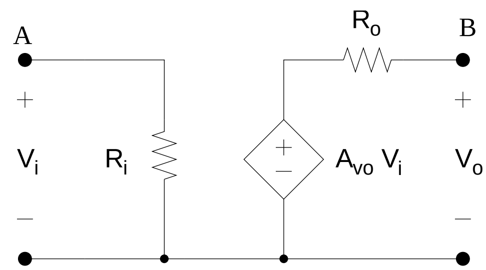

Figure 1.

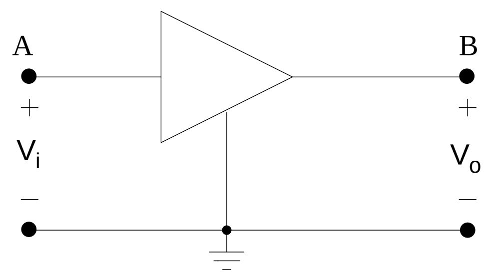

Figure 2.

We will use an op-amp in the circuit in Figure 3 to build a real amplifier, and measure the corresponding parameters of the voltage amplifier model. (Use a 741 or similar op-amp.) As in Figures 1 and 2, the input to our amplifier is at A and the output at B. If we can find the three values R_i, R_o, and A_{vo} we can use the model to accurately predict how the amplifier will work in a circuit. (From your knowledge of op amps, you should be able to determine R_i, R_o and A_{vo} from inspection of Figure 3. Do so as part of the prelab, and compare these values to the values you measure below.)

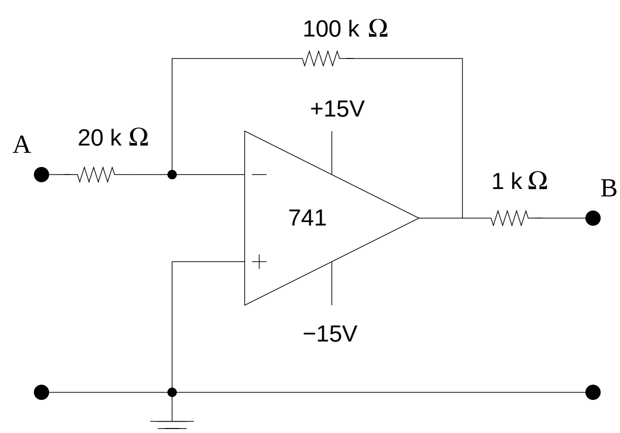

Figure 3.

1. Build the circuit in Figure 3, and verify that it works. If you cannot remember the pinout of a 741 op-amp, look at its datasheet. (How did you verify its operation?)

2. Measure the voltage gain A_{vo} of the amplifier in the following two ways:

   (a) Connect the input of the amplifier to a variable voltage source as shown in Figure 4. Measure and plot V_B vs. V_A using a DVM for a sufficient number of voltages so that your plot is a nice curve. Be sure that your voltage range is sufficiently large that the amplifier saturates. The slope of the linear portion of the curve is the voltage gain A_{vo}. Compare this value to the predicted one for the circuit of Figure 3.

   (b) Use the function generator and scope to trace the transfer function as shown in Figure 5. Store and copy the X-Y plot. Carefully mark the scales. Compare your curve from Part 2(a) with the X-Y plot. What are the saturation voltages for the output?

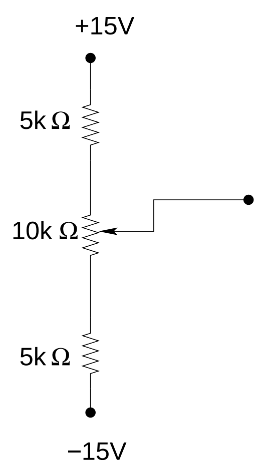

Figure 4.

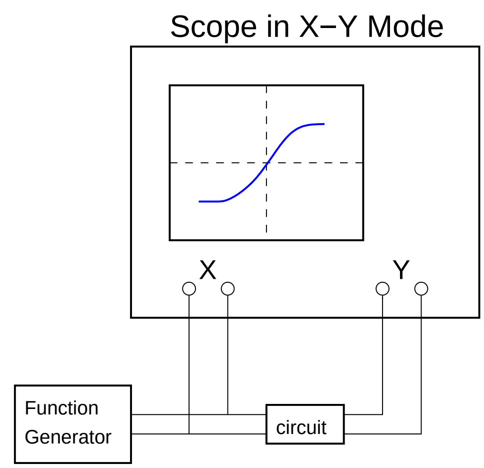

Figure 5.

3. Measure the input resistance R_i of the amplifier model circuit:

   - Using the variable voltage source of Part 2(a) put a test resistor between the voltage source and the input (A).
   - Use a (non-zero) input voltage such that the output is **NOT** saturated.
   - Measure the voltage from your variable source, and the voltage at point A of your amplifier.
   - Compute R_i. How you do this should be easy if you look at the model of Figure 1.
   - If the test resistor is not within a factor of 2 of R_i, change it to one about equal to R_i and make a more accurate determination of R_i. Measure the test resistor with an ohm meter to determine its value accurately.
   - Compare R_i to the value you would expect from the circuit of Figure 3.

4. Measure the output resistance R_o.

   - Shorting the output to ground to measure i_{sc} may damage an actual amplifier, so in general, you should not short the output to try to measure R_o.
   - Set the input voltage so the the output voltage is about 5 V.
   - Place a load resistance from B to ground, and note the decrease of the output voltage. Choose a test resistor of an appropriate size. (What is an appropriate size? Why?)
   - Draw the output half of the circuit including the test resistor, marking measured voltages. Compute R_o.

- Compare R_o to the value you would expect from the circuit of Figure 3.

5. In analog electronics you often are interested in only the AC (changing) part of a signal, and may have to block the DC (constant offset) part. We will do that for this circuit.

   (a) Connect a 5 kHz, 1V p-p sine wave to the input. Display and sketch the input and output.

   (b) Use the function generator to add a 0.1 V offset to the input. What is the effect at the output?

   (c) Add a DC blocking capacitor as shown in Figure 6. (What size of capacitor should you use? Why?) Note that R_S in Figure 6 is the output resistance of the function generator, which is 50 Ω. How is the output affected. Why?

   (d) What effect does varying the input offset have on the output voltage?

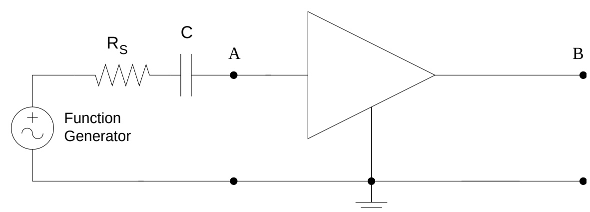

Figure 6.

6. Certain analog circuits need the AC signal to have a specific DC offset to function properly. The process by which the DC offset is added is called biasing the circuit. For example transistor amplifiers usually need a bias voltage to work properly. For this part we want the output to have a DC offset of 2 V.

   - Using the values of R_i, R_o and A_{vo} determined for the model, calculate the appropriate size for R_1 needed to add an offset voltage of 2 V.
   - Add the bias resistor R_1 shown in Figure 8 to change the output operating point to 2 V.
   - With a sine input, sketch the output. What is the effect of the biasing on the output?

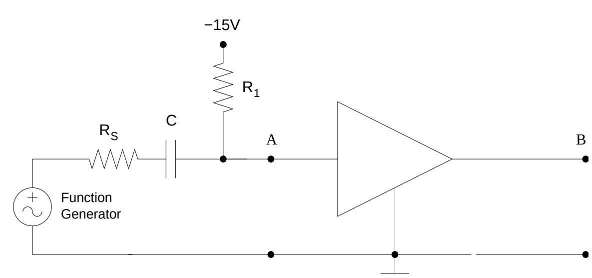

Figure 7.

PRE-LAB

1. Look up the data sheet for the LM741 and add the pin numbers to complete the schematic of Figure 3.
2. Determine the gain, the input resistance, and the output resistance of Figure 3.
3. Calculate the parameters R_i, R_o and G_m of the equivalent transconductance amplifier (Table 1.1 of Sedra & Smith). Draw the transconductance model of the circuit.
4. Determine the approximate size of the capacitor C needed for Part 5.
5. Determine the value of R_1 needed for Part 6.
6. What is the importance of the input resistance of a circuit? When might you want a circuit with a low input resistance? When might you want a circuit with a high input resistance?