Department of Electrical and Computer Engineering
University of California, Santa Barbara
ECE 2B, Lab 3

BIPOLAR JUNCTION TRANSISTOR AMPLIFIER

OBJECTIVE

To study and learn how to use a common-emitter BJT configuration to amplify an AC signal.

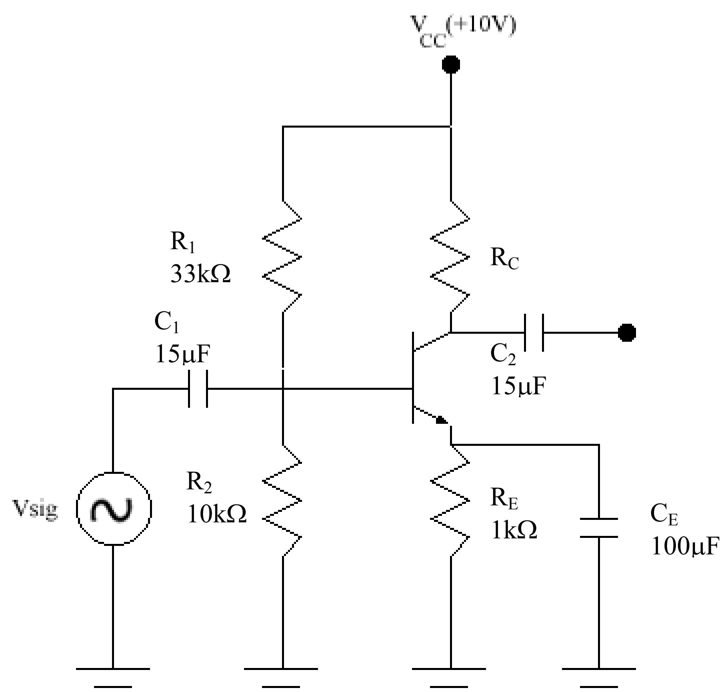
INTRODUCTION

In previous labs you have studied DC characteristics of BJT circuits. In this lab, you will be using a biased circuit to amplify an AC signal. The common-emitter amplifier that you will be using provides large voltage gain with moderate input and output impedance. You have learned how to calculate voltage gain, input impedance and output impedance, however, techniques for measuring these values may prove to be more difficult and will require more thought.

PROCEDURE

1. Analyzing the Amplifier

(a) The wiring of the BJT will follow the circuit diagram shown below.



(b) Choose a value for R_C for your circuit so that V_{CE} is approximately 5 V. Why is this a good bias point to choose?

(c) Calculate the value of the DC emitter current, I_E.

(d) Draw in your lab notebook the AC model of the circuit above.

(e) Calculate the input and output impedances Z_i, Z_o, of the circuit. The input impedance of the amplifier is the impedance of the amplifier as 'seen' by the input signal. The output impedance is the impedance as 'seen' looking form the load into the output of the amplifier.

(f) Calculate the expected voltage gain, A_V.

2. Making the Measurements

Materials Required: one 1 kΩ resistor, one 10kΩ resistor, one 33kΩ resistor, one resistor of value determined in the previous section, two 15μF capacitors, one 100μF capacitor, one 2N3904 NPN BJT

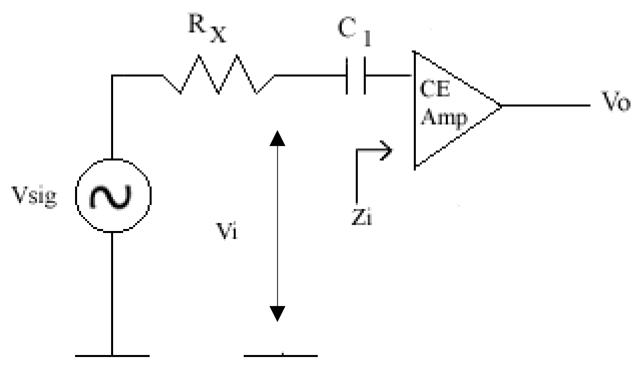
(a) Build the circuit shown above. Use the value you choose for R_C.

(b) Apply Vs, an AC signal with an amplitude of approximately 20mV (RMS) and frequency of approximately 2kHz.

(c) Measure the output waveform on the oscilloscope. Check to see that there is no distortion in the output waveform. If there is distortion, how would you 'fix it'?

(d) Calculate your circuit voltage gain, using V_o/V_s. Compare the value you obtain with the value calculated for voltage gain in part 1-(f). Are there differences between your measured values and your calculated values? If so, why? Do the input voltage and the output voltage have the same measured phase? What phase difference did you expect?

(e) Measure the input impedance, Z_i. To do this, you can use the circuit diagram shown below. The BJT and its biasing resistors have been modeled as a C-E amplifier, represented symbolically by the triangle. Use the same input AC signal and measure the output voltage just as you did in (d). The difference now, as can be seen in the diagram is that a 'probe resistor', R_x, with a value of 1kΩ has been added.



(f) Measure the value of V_i. Set up an equation relating V_s and V_i. Use that equation to solve for the value of the AC input impedance, Z_i. Compare the value you measure with the value you calculated previously. How good is the agreement between the two values? How would you explain any discrepancies?

(g) Measure the output impedance, Z_o. To do this, remove the R_x resistor from the circuit. Add a load resistor, R_L, with a value of 3 kΩ. (Think carefully if how you would add the load resistor to the circuit!) Measure the value of the output voltage without the load resistor in place and call it V_o. Measure the value of the output voltage with the load resistor in place and call this value V_L.

(h) Set up an equation relating V_L and V_O and use that equation to solve for the value of the AC output impedance, Z_o. Compare the value you measure with the value you calculated previously. How good is the agreement between the two values? How would you explain any discrepancies?