

EE 3101 ELECTRONICS I LABORATORY

EXPERIMENT 5 LAB MANUAL

BJT AMPLIFIER DESIGN AND ANALYSIS

OBJECTIVES

In this experiment you will

- Analyze a BJT amplifier design and verify its operation.
- Learn how to measure the output resistance of an amplifier.
- See how important the emitter bypass capacitor is.
- See how the design can be modified to reach your design goals.

LAB NOTEBOOKS

The format of lab notebooks should be such that the information can be used to reproduce the lab, including what values were used in a circuit, why the values were used, how the values were determined, and any results and observations made. This lab manual will be used as a guide for what calculations need to be made, what values need to be recorded, and various other questions. The lab notebook does not need to repeat everything from the manual verbatim, but it does need to include enough information for a 3rd party to be able to use the notebook to obtain the same observations and answers. In the following numbered sections there are **bolded words and/or lines**. These bolded words and/or lines are statements and/or questions that the lab TA will be looking for an answer either in the lab preliminary, or lab notebook.

INTRODUCTION

In Experiment 4, a BJT amplifier design was started by designing the biasing network, given a desired quiescent point. Figure 1 shows the amplifier with coupling and bypass capacitors added. **Write in the values for R_C , R_E , R_1 , and R_2 that you used for Design 1 in Experiment 4.** The capacitors have been selected so that the lower cutoff frequency should be near 320 Hz.

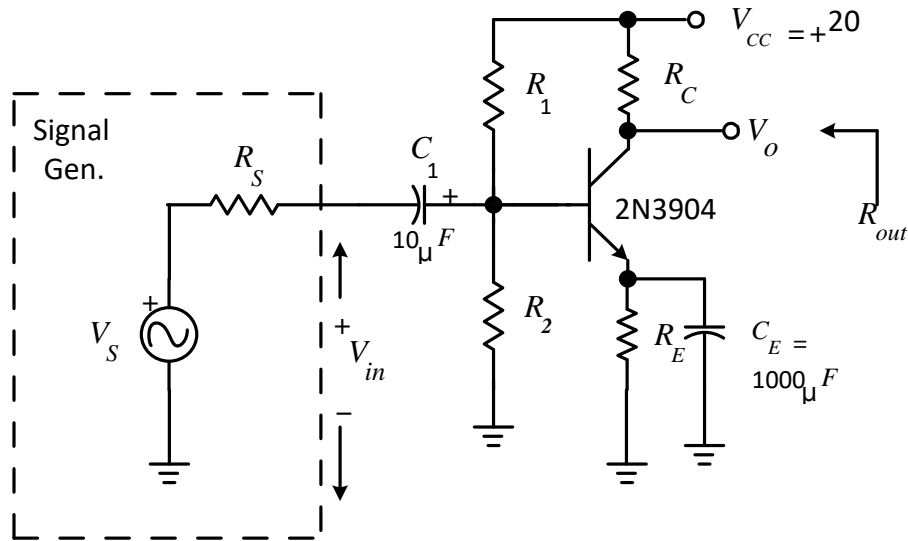


Figure 1: The common-emitter amplifier for this experiment.

PRELIMINARY

Draw the mid-band equivalent circuit for the amplifier of Figure 1. Using your design value of I_C from Experiment 4, **calculate g_m , r_{π} , and the expected voltage gain V_o/V_{in}** . Note that V_{in} is taken at the input of the amplifier. Most signal generators have an output resistance of 50Ω .

EXPERIMENT

- Using a multi-meter, **measure the exact resistance of the resistor you will use for R_C** . (This value will be important later on.) Using a breadboard, construct the circuit of Figure 1. Be sure to observe the polarity of the electrolytic capacitors. Before connecting the signal generator, **apply dc power and check the dc bias voltages of the circuit to ensure they are reasonable**.
- Turn down the amplitude of the signal generator and set the frequency to 3 kHz. Connect the generator to the input of the amplifier. With the oscilloscope set to AC coupling and connected to the amplifier output, adjust the signal generator amplitude until the output signal is 6 V peak-to-peak. If the waveform is distorted, recheck your circuit.
- Connect the oscilloscope probe to the amplifier input and **measure (save the oscilloscope screen wave for the report) V_{in}** by increasing the oscilloscope sensitivity. **Calculate the voltage gain, V_o/V_{in} and compare to your predicted value**.

Q1. What factors could contribute to a difference?

4. Reduce oscilloscope gain and reconnect the probe to the output. **Reduce the frequency of the signal generator until the amplifier output drops to 0.707 of its 6 V value (4.24 V) and note the frequency.** If the input signal remained constant, this is the lower 3 dB cutoff frequency. Increase the frequency to above 3 kHz to make sure that 3 kHz is still in the mid-band.
5. **Measure the output resistance of the amplifier** by returning the generator frequency to 3 kHz and make sure that the output is still 6 V peak-to-peak. Connect a decade box through a $10\ \mu\text{F}$ capacitor as shown in Figure 2. Change the decade box resistance until the output is exactly half (i.e., 3 V peak-to-peak). **The resistance of the decade box will equal the output resistance of the amplifier.**

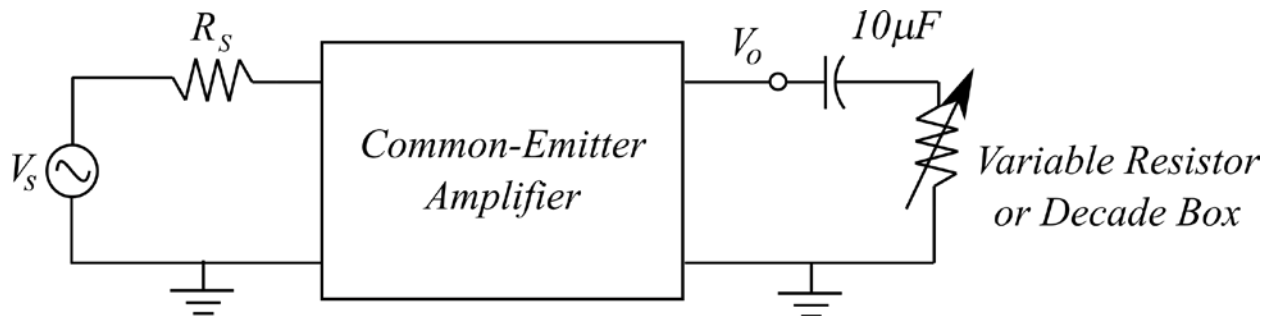


Figure 2: The decade box must be capacitively coupled as shown.

6. **Knowing R_C and R_{out} , calculate the apparent value of r_o .**

Q2. Discuss whether this value is reasonable or not.

7. The last part of this experiment demonstrates the purpose of C_E . With the decade box and capacitor removed and the output still at 6 V, carefully disconnect one end of C_E . **Carefully measure the output voltage and calculate the new voltage gain.**

Q3. Compare this value with the approximation mentioned in your textbook ($-R_C/R_E$).

Q4. Explain how splitting the emitter resistance as shown in Figure 3, would allow you to fix the ac gain at a value between the values you obtained with and without C_E .

8. If you have time, you could try this with your circuit. If not, it would be instructive to try it out later on paper.

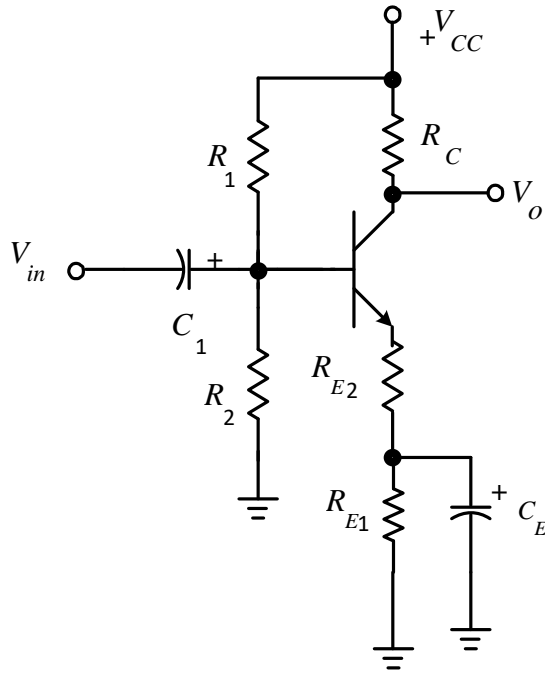


Figure 3: Splitting the emitter resistor to set the ac voltage gain.

COMMENTARY

The voltage gain of the CE amplifier is highly dependent upon the value of R_C . In actual practice, you will first need to consider the load, the required output resistance and the required gain in order to set the bias point and select R_C . This also affects the input resistance, since the input bias resistors and stability are related to R_E . If the required gain, output resistance, etc. cannot be obtained with a single stage, consider a different active device. If the design goals are still unobtainable, you may have to add additional amplifier stages.