EE 255
ELECTRONICS I LABORATORY
EXPERIMENT 4
TRANSISTOR BIAS DESIGN AND STABILITY

OBJECTIVES

In this experiment you will

- Design a bias network for a common-emitter amplifier.
- Observe how close actual circuit currents and voltages compare to design values.
- See how negative feedback improves bias design.

INTRODUCTION

You will recall from your study of BJT amplifiers that each transistor must be biased so that they will be operating in the active (linear) region. If this step is omitted, the output signal will be distorted.

In this experiment, you will see how the selection of the bias network components directly affects the accuracy and stability of the bias point against component tolerances and transistor parameter variations. One of your designs will be used in Experiment #5.

PRELIMARY CALCULATIONS

(a) For the circuit in Fig. 1, we wish to bias the transistor so that I_{CQ} = 10 mA and V_{CEQ} = 8 Volts. As a starting point, let V_{RE} = 20% of V_{CC}. Calculate the values needed for R_E and R_C. Assume β is about 100. Select the nearest standard 5% values for the two resistors.

(b) Referring to Fig. 2, set $R_{th} = \frac{(\beta+1)}{10}$ (R_E) and calculate the values of R_1 and R_2. (See your textbook, if you haven't discussed this yet.) Select the nearest standard values. Recalculate the value of I_C. (This will be design #1, but also your bias design for Experiment #5.)

(c) Repeat the above procedure, except design for V_{RE} = 40% V_{CC}. This will be design #2.

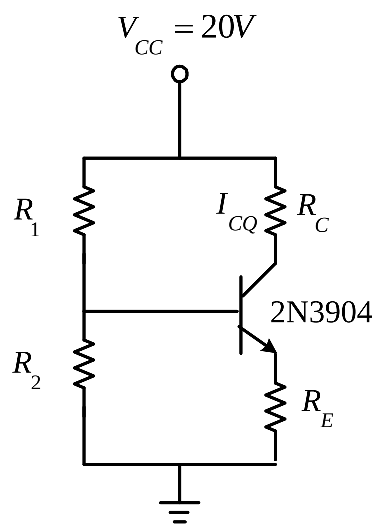

Fig. 1. The basic biasing circuit for the BJT amplifier.

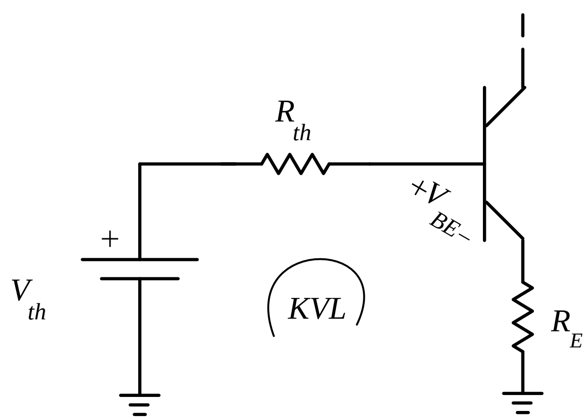

Fig. 2. The equivalent circuit of the input bias circuit.

EXPERIMENT

1. Select two or three 2N3904 transistors from the lab stock. You will use one at a time.
2. Using a breadboard, construct design #1. After checking the connections, apply V_{CC} measure V_{CEQ} and V_{RE}. Calculate I_C.

3. Turn off the power and replace the transistor with another one. Repeat the measurements and calculation of Step 2. Note any differences. (If you have time, measure the actual DC β of each transistor on the curve tracer. You should see that the presence of negative feedback in the form of R_E makes the actual circuit currents and voltages about the same, even though the β of each transistor is different.)

4. Now, construct the circuit again using the values calculated for Design #2. Repeat Steps 2 and 3. What can you conclude about making R_E larger.

5. Look over the results you have obtained and state any observations or conclusions you feel are important.

COMMENTARY

If the temperature of the circuit changes, the negative feedback provided by R_E will help stabilize the bias point against changes due to the temperature dependence of β, V_{BE}, and I_{CBO}. In special cases where I_C must be very stable against temperature changes, diode compensation may be used as shown in Fig. 3. The idea is that as temperature increases, V_{BE} decreases, but so does the diode voltage V_D. If two diodes are used as in Fig. 3(b), it is possible to almost completely compensate for temperature changes. The disadvantage of this technique, though, is that it decreases the input resistance of the amplifier. This is not a problem in some circuits such as constant current sources used in integrated circuits. Do you see why?

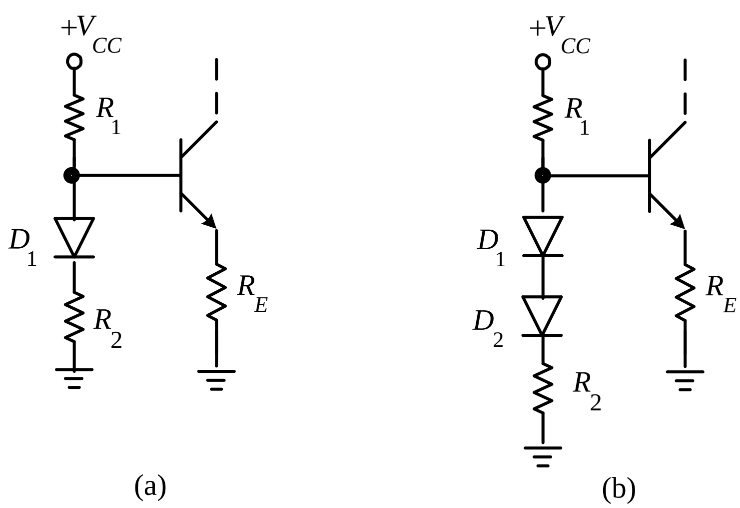

Fig. 3. (a) Single-diode temperature compensation; (b) Two-diode compensation.