Experiment 2: Discrete BJT Op-Amps (Part I)

This is a three-week laboratory. You are required to write only one lab report for all parts of this experiment.

1.0. INTRODUCTION

In this lab, we will introduce and study the properties of a few circuit blocks commonly used to build operational amplifiers. Because we are limited to using discrete components, we will not be able to construct a complete op-amp. This will be done in the op-amp design project later in the semester. In this lab, however, we will ask you to analyze and design circuits commonly used to make integrated circuit operational amplifiers, and you will use these circuits to build a differential amplifier with both resistive and current mirror biasing. Although built with discrete devices, this op-amp uses a classical topology common to most commercial op-amps including the well-known 741.

The operation of these circuits will depend on the use of matched transistors. The CA3083 is a matched NPN transistor array built on a single integrated substrate. To ensure that the transistors are properly isolated, you must connect pin 5 of the array to the most negative point of the circuit (-6 volts). Data sheets for the CA3083, and discrete npn and pnp transistors needed in this lab are attached.

In this lab more than any other so far, neatness counts. Unless you build your circuits neatly, they will not operate. Trim your resistor leads if necessary.

Make sure that you record all the measurements that you make as you proceed, and include these measurements in your lab report.

2.0. MATERIALS REQUIRED

- CA3083 NPN Array
- 2 - 3904 Transistor
- 2 - 3906 Transistor
- Assorted Resistors and Capacitors

3.0. PROCEDURE

3.1 Differential Amplifier

Consider the following circuit:

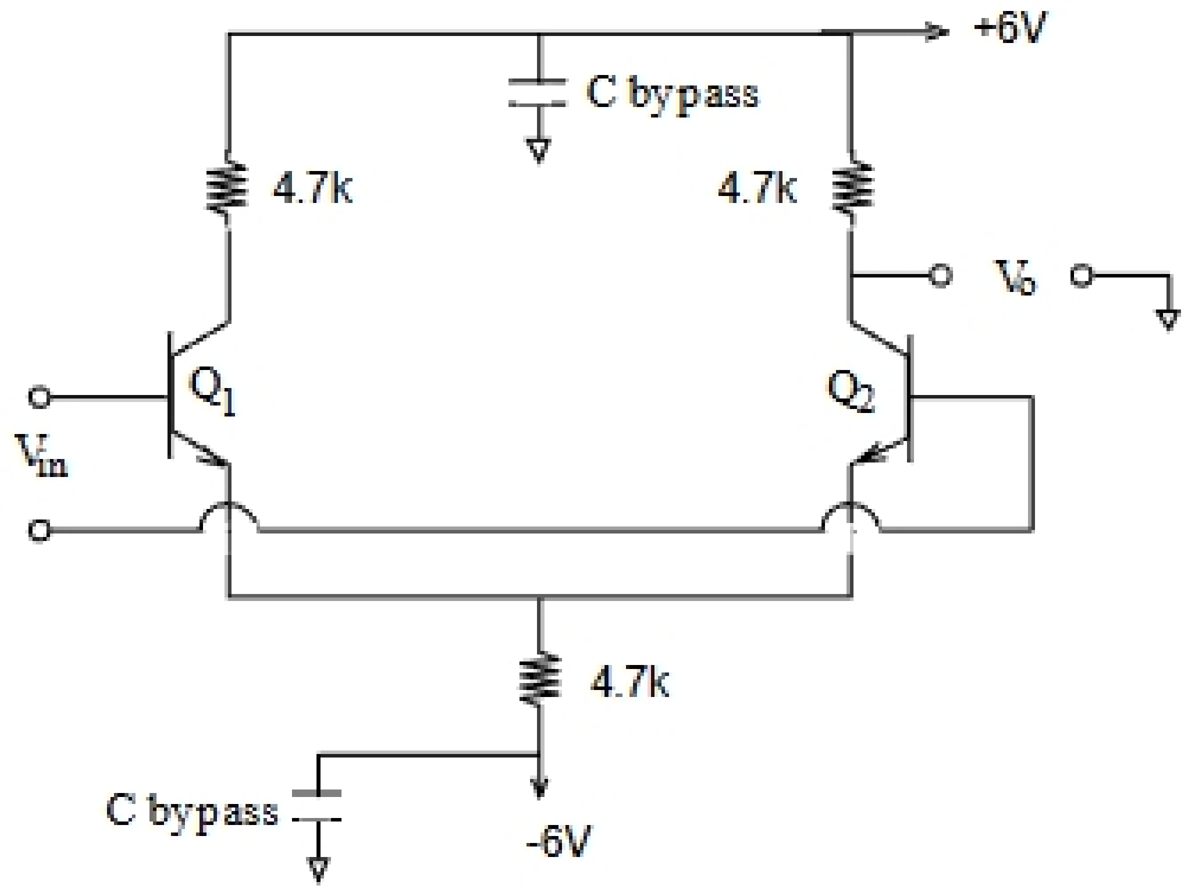

Figure 1

- Assuming that both bases are grounded, compute the expected values of IC1, IC2 and IE. Also calculate values for the differential and common mode gains of this amplifier.
- Using transistors 1 and 2 in the array, construct the circuit in Figure 1. Be sure to connect pin 5 to -6 volts. It is also a good idea to bypass both your power supplies with 100µF capacitors. This will help reduce any power supply noise.

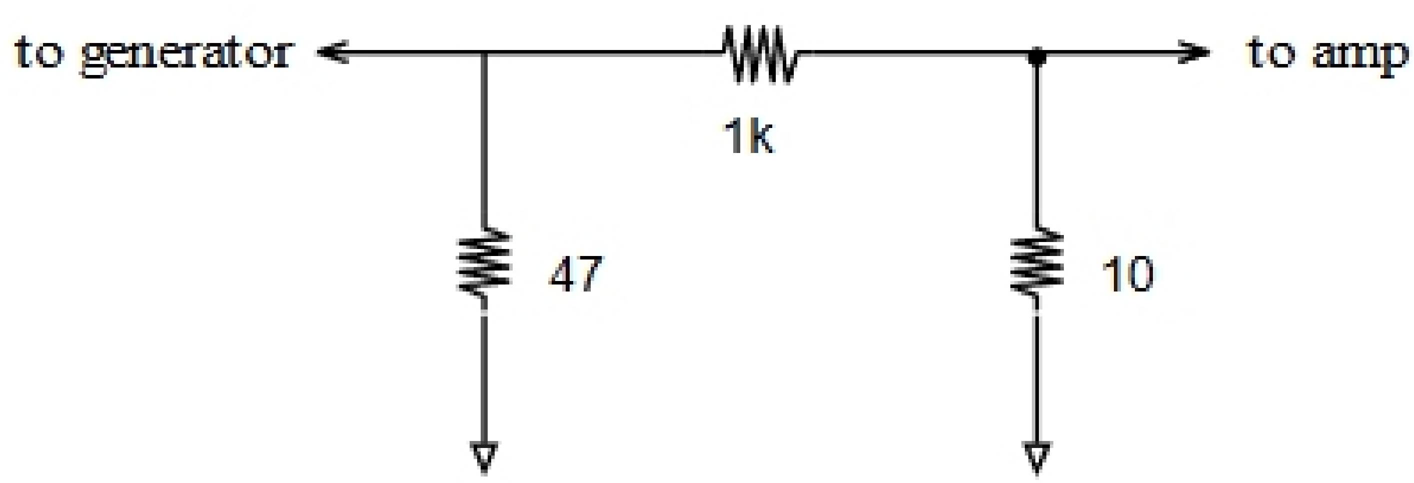

Figure 2

- With both bases grounded, measure the bias point of the circuit.
- Using one generator, measure the mid-band differential (note that the output of the amplifier is taken single-ended from only one collector) and common mode gains of the circuit. You may find that a resistive voltage divider such as the one pictured in Figure 2 is helpful in measuring the differential mode gain. Be careful when measuring the common mode gain, especially when measuring voltages less than 50 mV (remember that the common-mode voltage gain is smaller than 1). Sometimes voltages of this magnitude are severely corrupted by ground currents from large signals on the board (such as the input to the amplifier) while making a common mode gain measurement). In any case, you should not use the input divider for common mode measurements, because your common-mode signal will likely be a large signal.

After making these measurements, do not disconnect your circuit. You will need it later.

3.2. Simple Current Mirrors

The circuits depicted in Figure 3 are the simple and the Widlar current mirrors. Fig. 3a shows the simple current mirror circuit. Its operation is simple and has been discussed in the lecture. Note that Vbe is identical for both transistors. Neglecting base current, IC3 = (12-Vbe3-Vbe3b)/R. Since Vbe3 = Vbe4, assuming that VC4 is large enough to keep Q4 in the active region, IC4 = IC3. More transistors can be connected in parallel to Q4 and (neglecting base currents) their IC will be identical to that of Q3. Thus, Q3's collector current is "mirrored" by Q4.

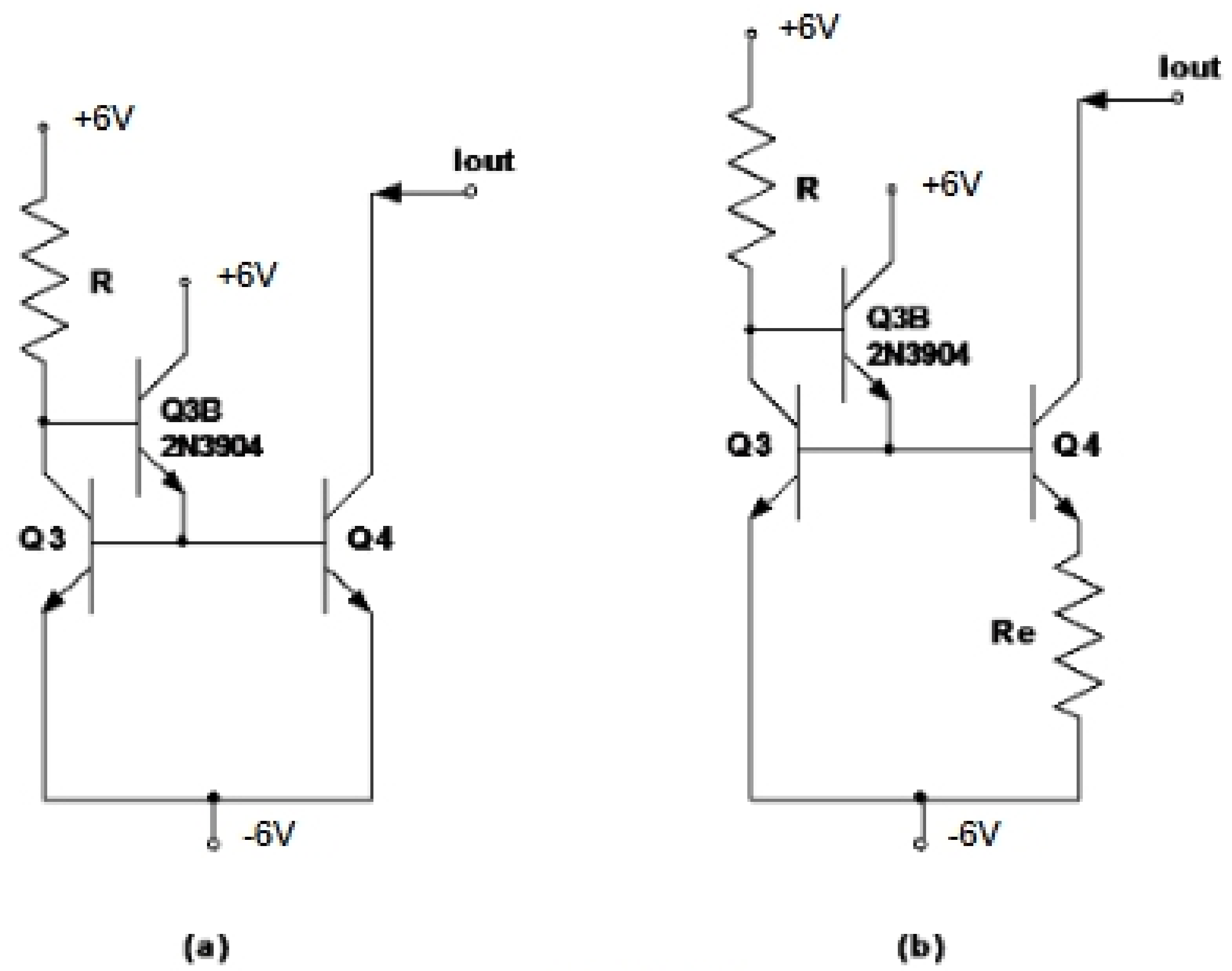

Figure 3