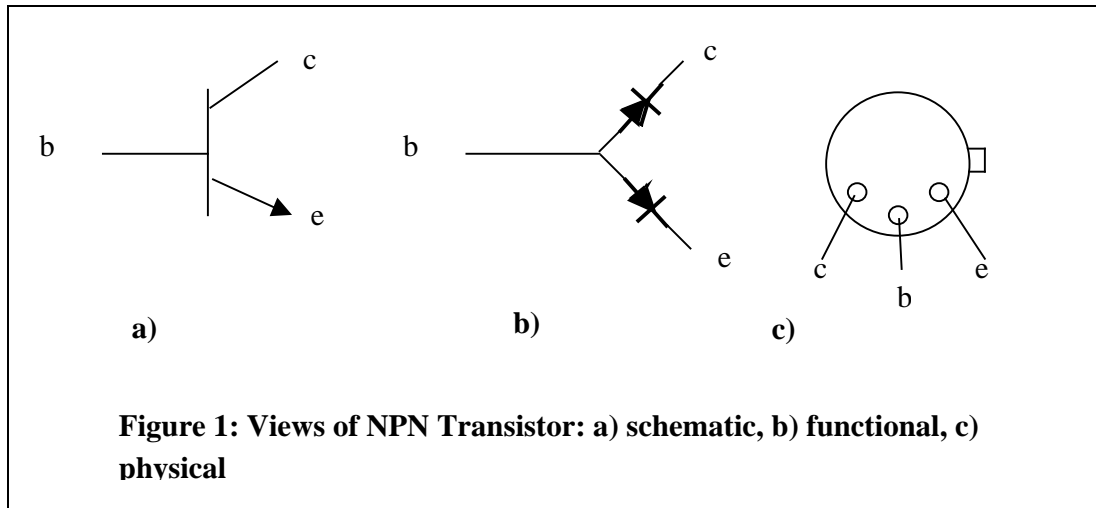


## Bipolar Transistors I

### **The first test of a transistor**

This lab uses an NPN transistor, the 2N2219. Like any NPN transistor, it consists of two PN junctions, as shown in Fig. 1 (b)

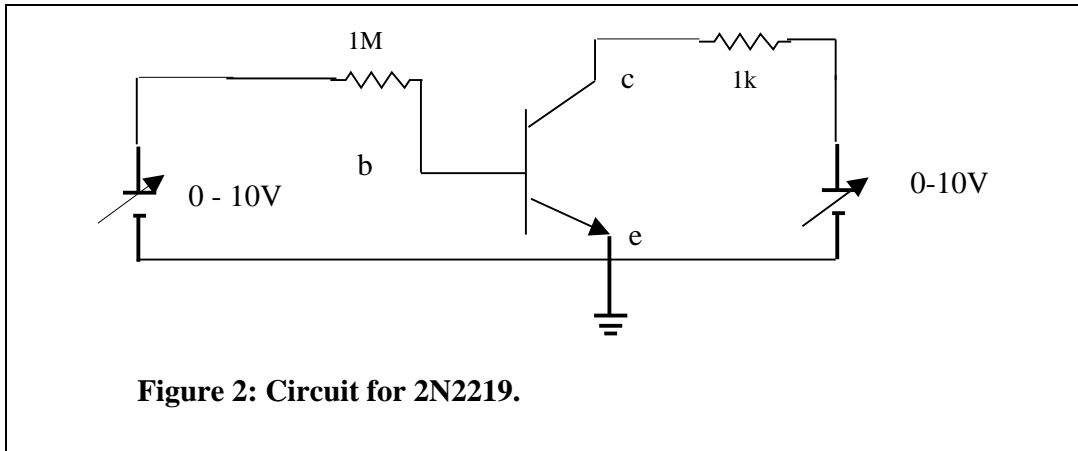


You can make a crude test of a transistor by using the diode test option on a multimeter. This option sets the terminals of the multimeter so as to forward bias the junction and then to read the voltage across it. For a silicon transistor like the 2N2219 you expect to find a forward voltage of 0.6 or 0.7 volts. Test both the base-collector and the base-emitter junctions of your transistor. (Note: With the multimeter in diode-test mode, you can determine which meter lead is positive by connecting the leads to the oscilloscope.)

### **2. Common emitter characteristics**

The goal of this section is to make a plot showing the collector current  $I_C$  vs. the collector-emitter voltage  $V_{CE}$  for several different values of the base current  $I_B$ .

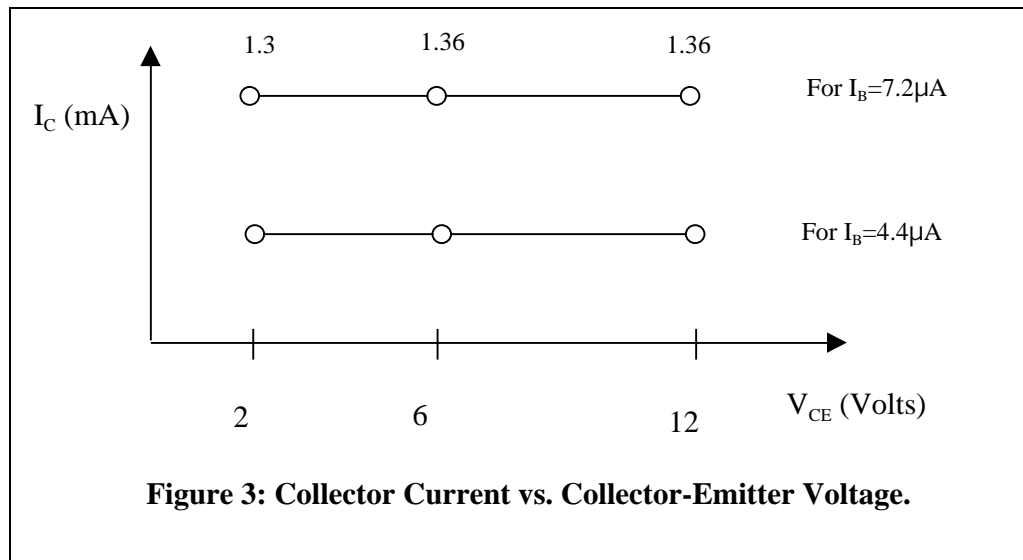
To eliminate some of the repetitious work we will do this using the LabView program Tran\_param.vi. Figure 2 below shows the circuit that is used to do the measurement. The voltage on the collector is swept through a range of values chosen by the student for several values of the base voltage. The collector current is measured by measuring the voltage drop across the (nominally) 1k resistor and the base current is obtained similarly by measuring the voltage drop across the 1M resistor. The resistors should be measured with the Multimeter and their exact values used in the program.



Follow these steps:

- (1) Enter the values of the resistors.
- (2) Choose a range of values for the base voltages and the number of points to measure.
- (3) Similarly select a range of collector voltages and number of points.

The program will return plots similar to the one below with the base currents corresponding to each line given in a register.



**Calculating  $\beta$ :**

The current gain of the transistor,  $\beta$ , is the change in collector current divided by the change in base current. From the data above, choosing  $V_{CE} = 6$  volts as typical, one can calculate  $\beta$  as follows:

$$\beta = \frac{(1.36 - 0.84) \times 10^{-3}}{(7.2 - 4.4) \times 10^{-6}} = 186.$$

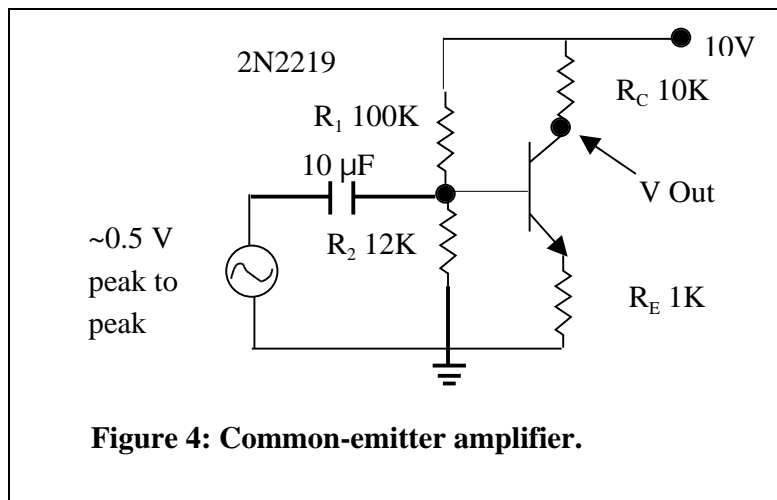
Calculate  $\beta$  for your transistor for a range of base currents and make a plot.

**The transistor as a switch**

Replace the 1K collector resistor in the circuit above by a 10K resistor. Try to make the measurements of the collector characteristics now with this larger collector resistor. Probably you find that when there is any base current at all, the voltage drop on the collector resistor is so large that you can't get  $V_{CE}$  at all close to the supply voltage. You are looking at the switching characteristic of a transistor. The transistor tends to be either **on** (large collector current) or **off** (no collector current).

**The common-emitter amplifier**

Set up the circuit below. The capacitor AC couples the signal generator to the transistor amplifier so that the generator does not upset the DC operating point (quiescent point) adjustment. A better way to put that is to say that the capacitor DC-decouples the signal generator from the amplifier.

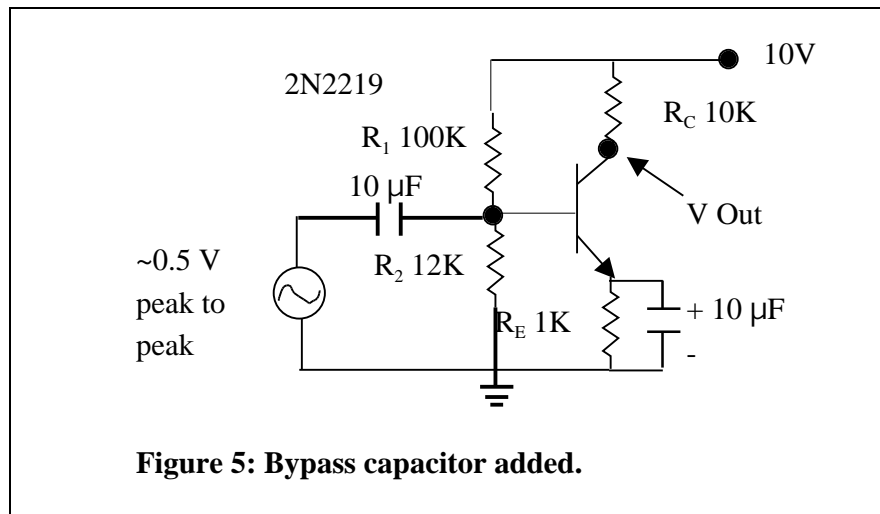


(a) Explain why the gain of this amplifier is about 10.

- (b) Explain why the bias resistors  $R_1$  and  $R_2$  make a sensible voltage divider for biasing the base given the goal of making the quiescent value of  $v_{out}$  5 volts. You may assume that the transistor has  $\beta = 100$  and  $V_{BE} = 0.6\text{V}$
- (c) Measure the voltage gain of the amplifier by comparing the input and output AC signals on a scope. Is the amplifier an inverting amplifier?

### An emitter bypass

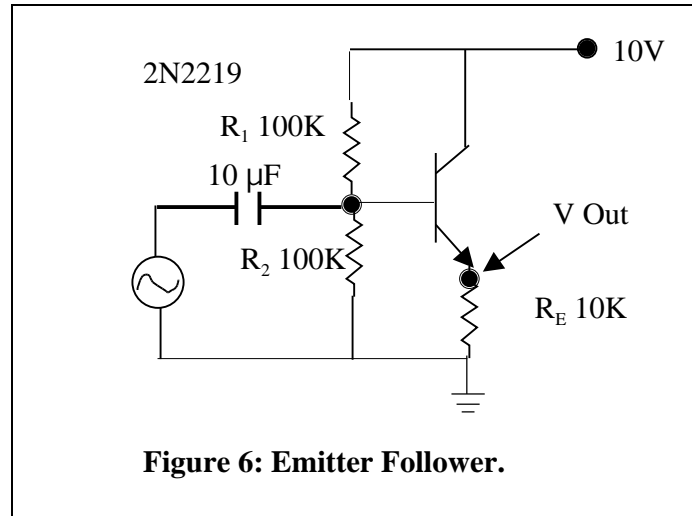
Add a  $10\ \mu\text{F}$  capacitor, observing the correct polarity, to bypass the emitter resistor as shown below and re-measure the gain of the amplifier. It should have increased substantially.



### 7. The emitter follower

A few simple changes to the common emitter circuit above completely changes the character of the amplifier.

- (a) Construct the emitter follower circuit in Figure 6 below:



- (b) Explain why resistors  $R_1$  and  $R_2$  are approximately the same for an emitter follower, given that we would like the quiescent value of  $V_{\text{Out}}$  to be about 5 volts.
- (c) Measure the gain and show that it is close to unity.
- (d) Show that the amplifier is non-inverting.