Experiment 10: Transistors

EQUIPMENT NEEDED:

– AC/DC Electronics Lab Board: 1 kW Resistor, 100 Ω Resistor, 2N3904 Transistor (NPN), Wire Leads
– (2) D-cell Batteries
– Digital Multimeter (DMM)
– Optional: additional Digital Multimeter

Purpose

The purpose of this lab will be to experimentally determine some of the operating characteristics of a transistor.

Procedure

① Connect the circuit shown in Figure 10.1a using the 2N3904 Transistor you've been supplied. Resistor $\mathbf{R_1}$ = 1 K Ω and resistor $\mathbf{R_2}$ = 100 Ω. Use Figure 10.1b as a reference along with Figure 10.1a as you record your data. Note the leads on the transistor as marked next to the socket in the drawing.

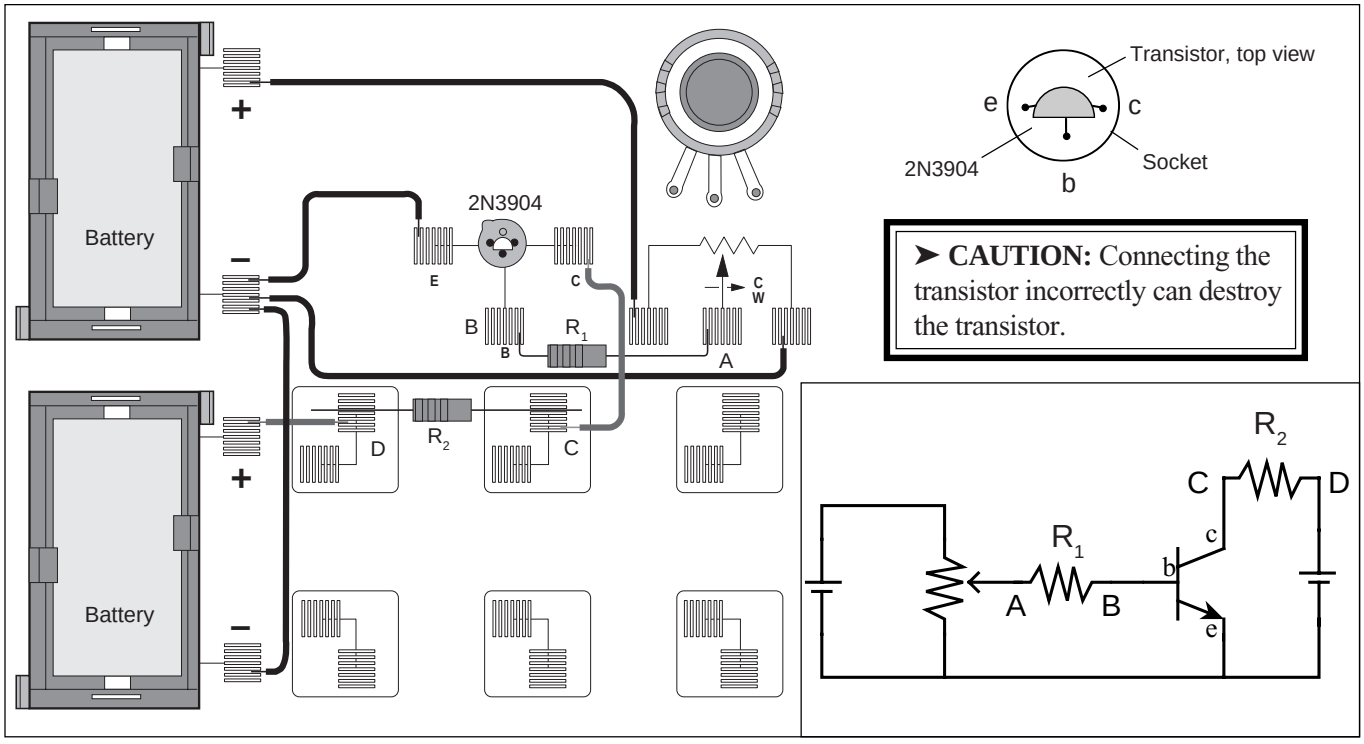

Figure 10.1a **Figure 10.1b**

② Adjust the potentiometer carefully until the reading between points **A** and **B** is approximately 0.002 volt (2.0 mv). Now read the voltage between points **C** and **D**. Record these readings in your data table. Note that $\mathbf{V_{AB}}$ divided by $\mathbf{R_1}$ gives the current flowing to the base of the transistor, while $\mathbf{V_{CD}}$ divided by $\mathbf{R_2}$ gives the current flowing in the collector part of the circuit.

③ Adjust the potentiometer to give $\mathbf{V_{AB}}$ the following readings, each time reading and recording the corresponding $\mathbf{V_{CD}}$: 0.006, 0.010, 0.015, 0.020, 0.025, 0.030, 0.035, 0.040, 0.045, 0.050, 0.055, 0.060, 0.080, 0.100, 0.150, 0.200, 0.250 volts. Also set $\mathbf{V_{AB}}$ to 0.000 volts.

Analysis

① For each of your sets of readings, calculate:

$$I_B = V_{AB} / R_1 \text{ and } I_C = V_{CD} / R_2$$

Record all of your current readings in mA.

② Plot a graph of I_C (vertical axis) vs I_B. If you find an area or areas where you need more points to fill out any curves or sudden changes, simply return to step 2 and make the appropriate measurements.

③ What is the general shape of the graph? Is there a straight-line region? Does it go through the origin? Why or why not? Relate the behavior of the transistor at the beginning of the graph to the behavior of the diode in Experiment 9.

④ What does the leveling off of the graph indicate? Electronics people refer to the transistor as being "saturated". How would you describe saturation based on your experiment?

⑤ Find the slope of the straight-line region of the graph. This ratio - I_C / I_B is referred to as the current amplification of the transistor. It describes how many times greater changes in the collector current are than the changes in the base current. Report the current amplification of your transistor.

Discussion

Discuss the graph and the calculations you did in the Analysis section.

Sample Data Table

Transistor Type _____

Table 10.1

R_1, Ω	V_{AB}, volts	I_B, mA	R_2, Ω	V_{CD}, volts	I_C, mA

Extensions

① What effect would changing the resistance in the collector circuit (R_2) make? Try changing the value to 330 Ω or 560 Ω. Does the graph have the same shape? Is the current amplification the same as before? How does the amplification depend on R_2?

② Obtain a different transistor and repeat the measurements you made in steps 2 & 3. If it is a PNP transistor, you will need to reverse the wires coming from the D-cells as the emitter needs to be positive, not negative, and the collector will be negative.