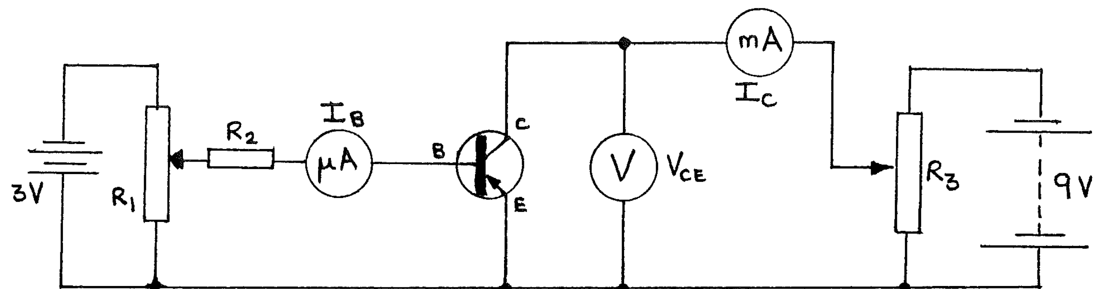
G2-1: Transistor Characteristics

Apparatus

3V battery; 9V battery; 2 rheostats (high resistance); resistor R_2 (approx. 50 kΩ); voltmeter (0–5 Vdc); ammeter ($\approx 50 \mu$A *fsd*); ammeter ($\approx$ 3 mA *fsd*); transistor (pnp); connecting leads (12 short); 2 sheets graph paper.



C = collector, B = base, E = emitter

Instructions

Set up the circuit as above, but do not connect the batteries until a teacher has checked the circuit (to avoid damaging the ammeters or transistor). In the experiment, when not taking readings, leave the batteries disconnected.

EXPERIMENT 1

To investigate the 'transfer characteristics' of the transistor. The transistor acts as a current amplifier: the size of the large current I_C depends on the size of the small current I_B. The circuit used above is called a 'common emitter' circuit.

1: Procedure

1. Set V_{CE} to 4V using rheostat R_3. Ensure that this remains constant (adjust R_3 again later as necessary).
2. Set I_B to 0 using R_1. Read and note I_B and I_C.
3. Increase I_B a little using R_1, and read and note I_B and I_C. Continue increasing I_B and reading the ammeters until I_C = 3 mA.
4. Tabulate the readings of I_E, I_C, and the value of V_{CE}.

1: Analysis

1. Plot a graph of I_C against I_B, labelling the curve with the value of V_{CE} used.
2. Find the gradient of the straight-line section of the curve. Then:

$$\text{Current gain } \beta = \frac{\Delta I_C}{\Delta I_B} = \text{gradient}$$

EXPERIMENT 2

To study how I_C varies when V_{CE} is changed, for certain fixed values of I_B. The graph obtained is called the 'output characteristic' of the transistor.

2: Procedure

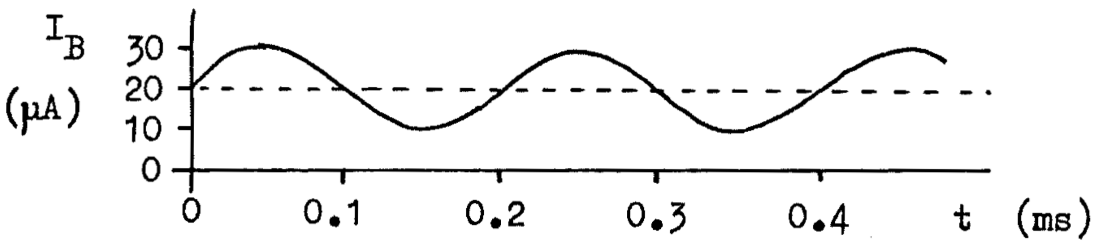
1. Set $I_B = 0$ using R_1. Starting with $V_{CE} = 0$, and little by little increasing V_{CE} up to 5V, take a set of readings of I_C and V_{CE} and note the value of $I_B = 0$.
2. Increase I_B to 10μA, and obtain another set of readings of I_C and V_{CE} as in step 1.
3. Repeat the procedure with $I_B = 20\mu$A then 30μA.
4. Tabulate the sets of readings of I_C and V_{CE}, noting the value of I_B for each set.

2: Analysis

1. Plot a graph of I_C vs. V_{CE} to obtain four curves. Label each curve with the appropriate value of I_B used.

Questions

1. When $I_B = 0$, I_C should be zero for all V_{CE}. However all transistors have some 'leakage current.' What is the value of the leakage current I_C when $V_{CE} = 4\text{V}$?
2. What is the approximate minimum V_{CE} so that a variation in I_B between 0 and $30\mu A$ produces a large change in I_C? (In practice the supply voltage is usually set between this value and a certain maximum. The maximum depends on the 'breakdown voltage' of the junctions).
3. In use as an amplifier, an AC input voltage makes I_B vary with time. For example:



   a. Use the value of β to make a graph of I_C against time.

   b. If a resistor $\mathrm{R} = 1\text{k}\Omega$ is connected in

      series with the collector C, so that I_C flows through it; draw a graph of the potential difference (p.d.) across this resistor against time.

   c. What is the frequency of these AC currents and p.d.?

4. Draw a diagram to show while the pnp transistor is conducting:

   a. Electron flows and conventional currents through the three terminals.

   b. Electron & hole movements inside the transistor (may be simplified).