LAB #07

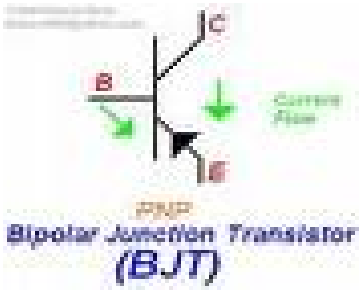
Objectives

1. To graph the collector characteristics of a transistor.
2. To measure AC and DC voltages in a common-emitter amplifier.

Theory

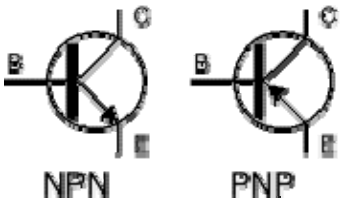
BJT

A **bipolar (junction) transistor** (**BJT**) is a three-terminal electronic device constructed of doped semiconductor material and may be used in amplifying or switching applications. *Bipolar* transistors are so named because their operation involves both electrons and holes.



Types of transistor

There are two types of standard transistors, **NPN** and **PNP**, with different circuit symbols. The letters refer to the layers of semiconductor material used to make the transistor. Most transistors used today are NPN because this is the easiest type to make from silicon. If you are new to electronics it is best to start by learning how to use NPN transistors.

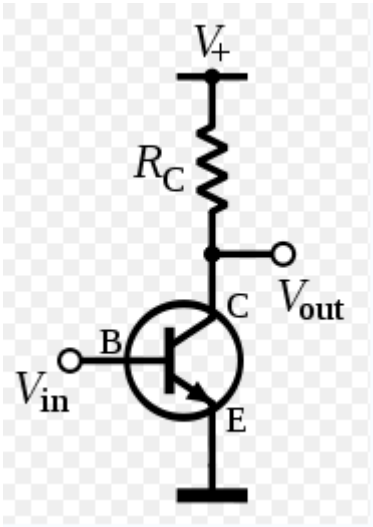


Transistor circuit symbols

The leads are labeled **base** (B), **collector** (C) and **emitter** (E).

Common Emitter Amplifier

Common-emitter amplifier is one of three basic single-stage bipolar-junction-transistor (BJT) amplifier topologies, typically used as a voltage amplifier. In this circuit the base terminal of the transistor serves as the input, the collector is the output, and the emitter is *common* to both (for example, it may be tied to ground reference or a power supply rail), hence its name.



Preparatory Exercise

Q1) Name the 3 categories of materials based on their ability to conduct electricity.

Q2) Explain why semiconductors have different electrical properties from metals?

Q3) What characteristic clearly distinguishes semiconductors from metals and nonmetals?

Q4) Why is the collector current I_C increasing when you increase the base current I_B in a bipolar transistor? Explain the physics behind it:

Requirement

Instruments

1. 1 DC Power Supply
2. 3 Digital Multimeter (DMM)
3. 1 Function Generator
4. 1 Oscilloscope

Components

1. Capacitors: 15 µF, 100 µF
2. Resistors: 1 kΩ, 3 kΩ, 10 kΩ, 33 kΩ, 330 kΩ, 10 kΩ potentiometer, 1MΩ potentiometer
3. Transistors: 2N3904

Procedure

Part A: The Collector Characteristics (BJT)

1. Construct the circuit of *Fig. 8.1*. Vary the 1MΩ potentiometer to set I_B = 10 µA as in Table 8.1.

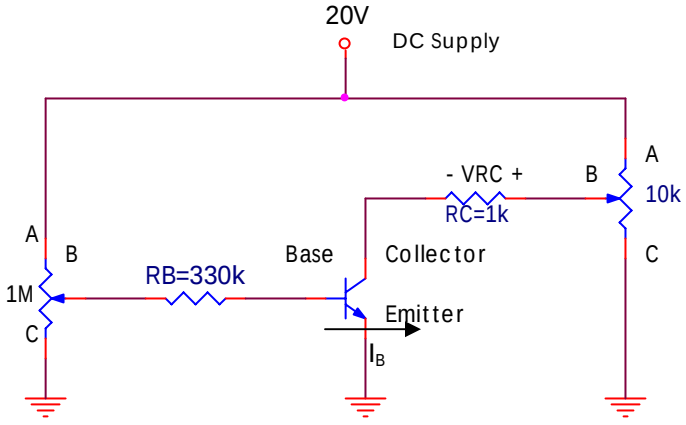


Fig. 8.1

2. Set the V_{CE} to 2V by varying the 10kΩ potentiometer as required by the first line of Table 8.1.
3. Record the V_{RC} and V_{BE} values in Table 8.1.
4. Vary the 10 kΩ potentiometer to increase V_{CE} from 2V to the values appearing in Table 8.1. (Note: I_B should be maintained at 10 µA for the range of V_{CE} levels.)
5. Record V_{RC} and V_{BE} values for each of the measured V_{CE} values. Use the mV range for V_{BE}.

6. Repeat step 2 through 5 for all values of I_B indicated in Table 8.1.
7. Compute the values of I_C (from $I_C = V_{RC}/R_C$) and I_E (from $I_E = I_B+I_C$). Use measured resistor value for R_C.
8. Using the data of Table 8.1, plot the collector characteristics of the transistor on a graph paper. (Plot I_C versus V_{CE} for the various values of I_B. Choose an appropriate scale for I_C and label each I_B curve).

Part B: Common-Emitter DC Bias

1. Measure all resistor values (R_1, R_2, R_C and R_E) from circuit in *Fig. 8.2* using DMM.
2. Calculate DC Bias values (V_B, V_E, V_C and I_E) and record them.
3. Calculate AC dynamic resistance, r_e.
4. Construct circuit as of *Fig. 8.2* and set V_{CC} = 10 V.
5. Measure the DC bias values (V_B, V_E, V_C and I_E) and record them.
6. Calculate I_E using values obtained in Step 5.
7. Calculate r_e using the value of I_E from Step 6.
8. Compare value of r_e obtained both from Step 3 & 7.

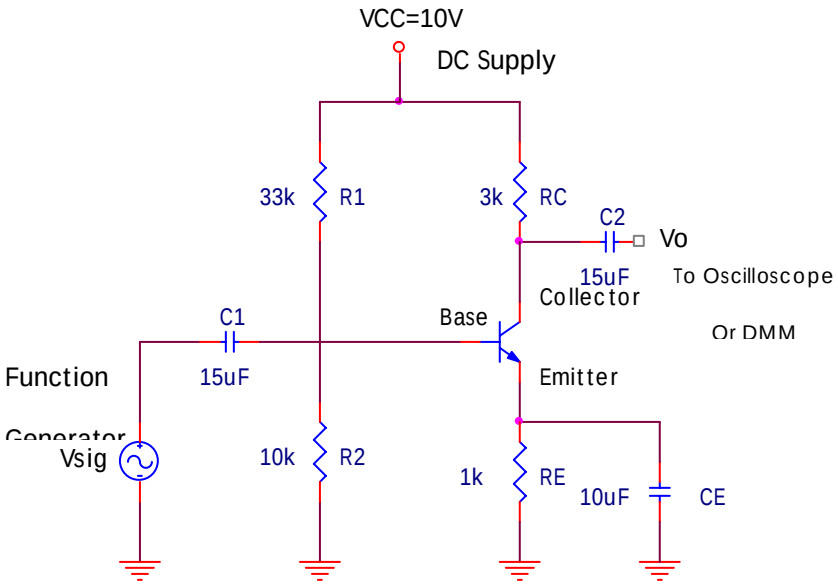


Fig. 8.2

Observation

Results and Calculations

Part A

I_B (μA)	V_{CE} (V) meas	V_{RC} (V) meas	I_C (mA) (calc)	V_{BE} (V) meas	I_E (mA) (calc)
	2				
	4				
10	6				
	8				
	2				
	4				
30	6				
	8				
	2				
50	4				
	6				
	8				

Table 8.1

Graph I_C versus V_{CE} for each value of I_B (use graph paper).

Part B

1. R_1 (measured) = _____, R_2 (measured) = _____,

   R_C (measured) = _____, R_E (measured) = _____

2. V_B (calculated) = _____, V_E (calculated) = _____

   V_C (calculated) = _____, I_E (calculated) = _____

3. r_e (calculated) = _____

$$r_e = \frac{26(mV)}{I_E \ (mA)}$$

4. V_B (measured) = _____, V_E (measured) = _____

   V_C (measured) = _____,

5. I_E (calculated) using measured values of V_E and R_E = _____

$$I_E = V_E / R_E$$

6. r_e (measured) = _____, using I_E from Step 6.