Title: Study of Transistor Characteristics in Common Emitter Amplifier

Introduction:

A BJT is a three terminal semiconductor device. It is widely used in discrete circuits as well as in integrated circuits. The main applications of BJTs are analog circuits. For example, BJTs are used for amplifiers in particular for high-speed amplifiers. BJTs are also applicable to digital circuits, presently, field effect transistors (FETs) are currently used to create the majority of digital circuits. BJTs can operate in three different ways: active mode (amplifying mode), cut-off mode, and saturation mode. A BJT needs to be operating in the active mode if it is to be used as an amplifier. A BJT must function in both cut-off and saturation modes in order to be used as a digital circuit component.

The main objectives of this experiment are to-

1. become familiar with bipolar junction transistors (BJTs)
2. Study the biasing of a Common Emitter (CE) Amplifier, and
3. Obtain the input and output characteristics of a common-emitter based BJT circuits.

Theory and Methodology:

Device structure of bipolar junction transistors.

Two anti-serially associated diodes construct each BJT. Either a npn transistor or a pnp transistor can be used to implement the BJT. In both instances, the base (B) of the transistor is formed by the central region, while the collector (C) and emitter (E) are formed by the external regions. Through metal (e.g. Aluminum) contacts, external wire connections are connected to the p and n regions (transistor terminals).

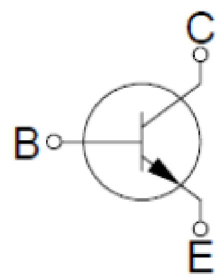
The figure below depicts a cross section of the two different types of BJTs, which include an emitter-base junction and a collector-base junction. Bipolar transistors include npn or pnp transistors. Both types of carriers—holes and electrons—contribute to the total current, npn and pnp transistors are referred to as bipolar transistors. In a field effect transistor, the current flow is controlled by either the electronics or the holes. The current and voltage amplification of a BJT is controlled by the geometry of the device (for example width of the base region) and the doping concentrations in the individual regions of the device. The emitter region typically has a higher doping concentration than the base region in order to achieve a high current amplification. The base controls the flow of charge carriers from the emitter to collector region, and the base is a narrow, lightly doped very thin region between emitter and the collector.

Apparatus:

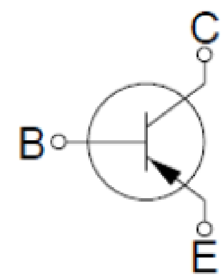
1. Trainer board
2. Transistor
3. Resistors (1kohm, 10Kohm).
4. DC power supply.
5. Multimeter
6. Power supply cable.

Circuit Configuration:

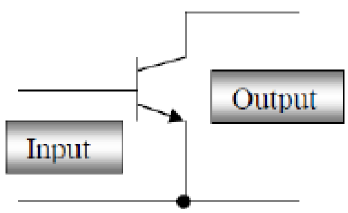
The following figures show the symbol for the npn transistor and pnp transistor. The emitter of the BJT is always marked by an arrow, which indicates whether the transistor is an npn or a pnp transistor.



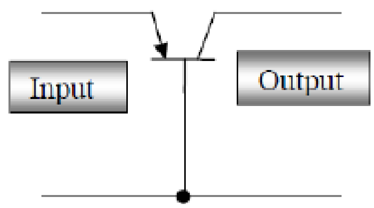
npn BJT symbol



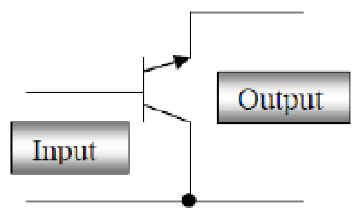
pnp BJT symbol



Common Emitter



Common Base



Common collector

Circuit Diagram

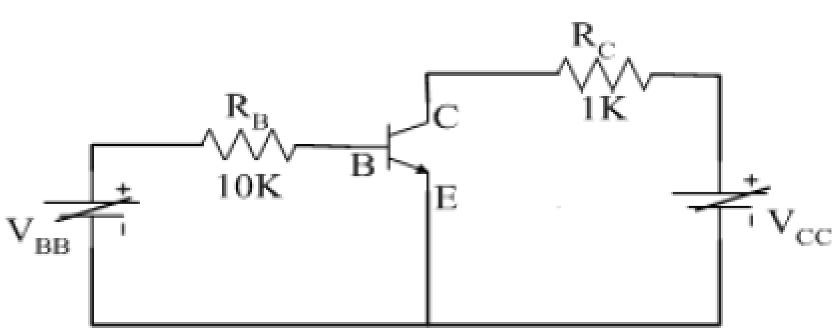


Figure: Transistor Characteristic in CE configuration.

a) Calculation:

1) Now for V_{CC} = 8V and R_B=9.9k ,

$I_{B1} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{0.1-0.09}{9.9K} = 1.01 \times 10^{-3}$ mA

$I_{B2} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{0.5-0.45}{9.9K} = 5.05 \times 10^{-3}$ mA

$I_{B3} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{1-0.64}{9.9K}$ = 0.036 mA

$I_{B4} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{1.5-0.67}{9.9K}$ = 0.084 mA

$I_{B5} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{2-0.68}{9.9K}$ = 0.133 mA

$I_{B6} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{2.5-0.7}{9.9K}$ = 0.181 mA

Now for V_{CC} = 16V and R_B= 9.9k,

$I_{B1} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{0.1-0.09}{9.9K} = 1.01 \times 10^{-3}$ mA

$I_{B2} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{0.5-0.49}{9.9K} = 1.01 \times 10^{-3}$ mA

$I_{B3} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{1-0.64}{9.9K}$ = 0.036 mA

$I_{B4} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{1.5-0.67}{9.9K}$ = 0.084 mA

$I_{B5} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{2-0.68}{9.9K}$ = 0.133 mA

$I_{B6} = \frac{V_{BB} - V_{BE}}{9.9K} = \frac{2.5-0.7}{9.9K}$ = 0.181 mA

2) For I_B = 0μA and $R_C = 1k$,

$I_{C1} = \frac{V_{CC} - V_{CE}}{1K} = \frac{0.2-0.19}{1K}$ = 0.01mA

$I_{C2} = \frac{V_{CC} - V_{CE}}{1K} = \frac{4-3.95}{1K}$ = 0.05mA

$I_{C3} = \frac{V_{CC} - V_{CE}}{1K} = \frac{8-7.94}{1K}$ = 0.06mA

$I_{C4} = \frac{V_{CC} - V_{CE}}{1K} = \frac{12-0.09}{1K}$ = 0.09mA

$I_{C5} = \frac{V_{CC} - V_{CE}}{1K} = \frac{16-15.2}{1K} = 0.08\text{mA}$

For I_B = 50µA and $R_C = 1k$,

$I_{C1} = \frac{V_{CC} - V_{CE}}{1K} = \frac{0.2-0.04}{1K} = 0.16\text{mA}$

$I_{C2} = \frac{V_{CC} - V_{CE}}{1K} = \frac{4-0.65}{1K} = 3.35\text{mA}$

$I_{C3} = \frac{V_{CC} - V_{CE}}{1K} = \frac{8-4.41}{1K} = 3.59\text{mA}$

$I_{C4} = \frac{V_{CC} - V_{CE}}{1K} = \frac{12-8.43}{1K} = 3.57\text{mA}$

$I_{C5} = \frac{V_{CC} - V_{CE}}{1K} = \frac{16-12.34}{1K} = 3.66\text{mA}$

For I_B = 100µA and $R_C = 1k$,

$I_{C1} = \frac{V_{CC} - V_{CE}}{1K} = \frac{0.2-0.02}{1K} = 0.18\text{mA}$

$I_{C2} = \frac{V_{CC} - V_{CE}}{1K} = \frac{4-0.08}{1K} = 3.92\text{mA}$

$I_{C3} = \frac{V_{CC} - V_{CE}}{1K} = \frac{8-0.11}{1K} = 7.89\text{mA}$

$I_{C4} = \frac{V_{CC} - V_{CE}}{1K} = \frac{12-0.14}{1K} = 11.86\text{mA}$

$I_{C5} = \frac{V_{CC} - V_{CE}}{1K} = \frac{16-0.19}{1K} = 15.81\text{mA}$

Conclusion:

A common emitter amplifier circuit is simulated and implemented in this experiment. A common emitter amplifier circuit will first be built and then implemented on a trainer board to verify the transistor input and output characteristics curves. And we successfully verified the transistor input and output characteristics curves. So, in this experiment our goal was successful.

References:

1. Adel S. Sedra, Kennth C. Smith, Microelectronic Circuits, Saunders College Publishing, 3rd ed., ISBN: 0-03-051648-X, 1991.
2. American International University–Bangladesh (AIUB) Electronic Devices Lab Manual.
3. David J. Comer, Donald T. Comer, Fundamentals of Electronic Circuit Design, john Wiley & Sons Canada, Ltd.; ISBN: 0471410160, 2002.