Analog electronics

Second lecture

Transistor, PNP, NPN, common emitter dc-analysis

Dr. Mohammed Hashim

MS. Noor Hayder

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Department of medical physics

Al-Mustaqbal University-College

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Outline

1. Transistor
2. PNP
3. NPN
4. Common Emitter dc-Analysis
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2.1 What is a Transistor?

A transistor is a miniature semiconductor that regulates or controls current or voltage flow in addition amplifying and generating these electrical signals and acting as a switch/gate for them. Typically, transistors consist of three layers, or terminals, of a semiconductor material, each of which can carry a current.

Advantages of transistor:

- ✓ It is used for fast switching applications.
- ✓ Smaller mechanical sensitivity.
- ✓ It is used as a current controlled current gain.
- ✓ It is available at very low cost.
- ✓ It is very smaller in size.
- ✓ Fast switching.
- ✓ It has a longer life low operating voltage for greater safety, lower costs and tighter clearances.

2.2 Types of Transistors

1. Bipolar junction transistor (BJT)
2. Field-effect transistor (FET)

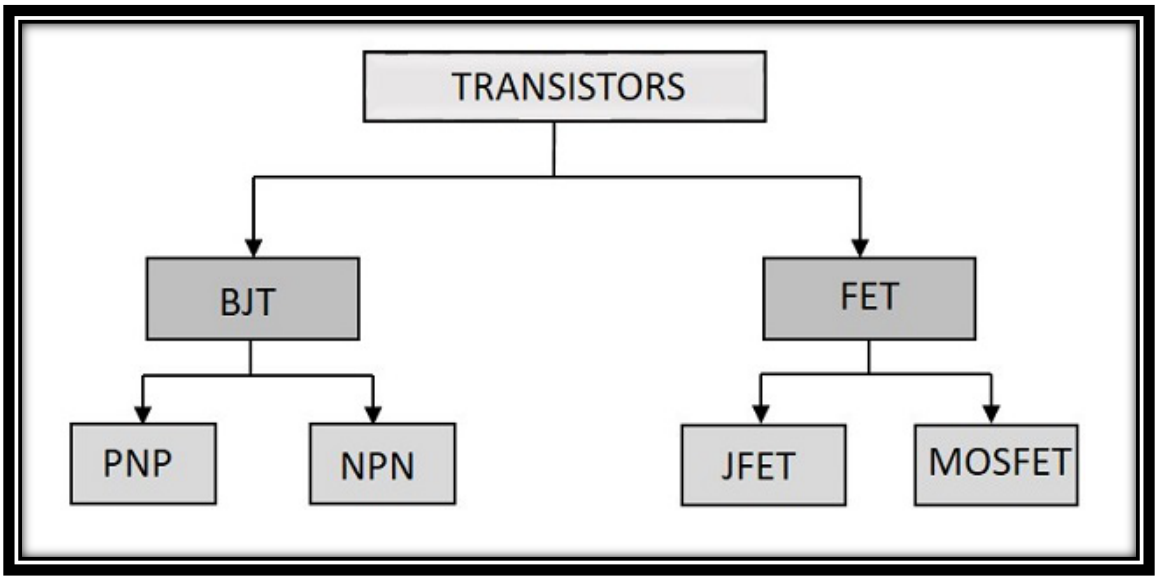


Figure 1: Types of transistors.

2.3 PNP Transistor

The **PNP transistor** is a bipolar junction transistor; In a PNP transistor, the first letter P indicates the polarity of the voltage required for the emitter; the second letter N indicates the polarity of the base. In this type of transistor, the majority charge carriers are holes. The PNP transistor bias setup is shown in the below figure. The base-collector terminals of the PNP transistor are always reversed-biased, then the negative voltage must be used for the collector. Therefore, the base terminal of the PNP transistor must be negative with respect to the emitter terminal, and the collector must be negative than the base.

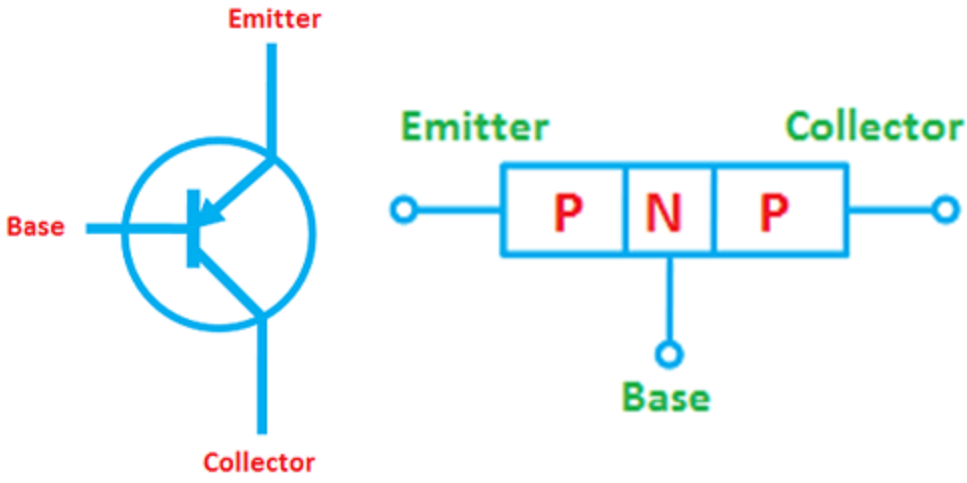


Figure 2: PNP Transistor.

2.3 NPN Transistor

The NPN transistor is a bipolar junction transistor, In an NPN transistor, the first letter N indicates a negatively charged layer of material and a P indicates a positively charged layer. These transistors have a positive layer, which is located in-between two negative layers. NPN transistors are generally used in circuits for switching, amplifying the electrical signals that pass through them. These transistors comprise three terminals namely, base, collector and emitter and these terminals connect the transistor to the circuit board. When the current flows through the NPN transistor, the transistor **base terminal** receives the electrical signal, the **collector** makes a stronger electric current than the one passing through the base, and the **emitter** passes this stronger current on to the rest of the circuit. In this transistor, the current flows through the collector terminal to the emitter.

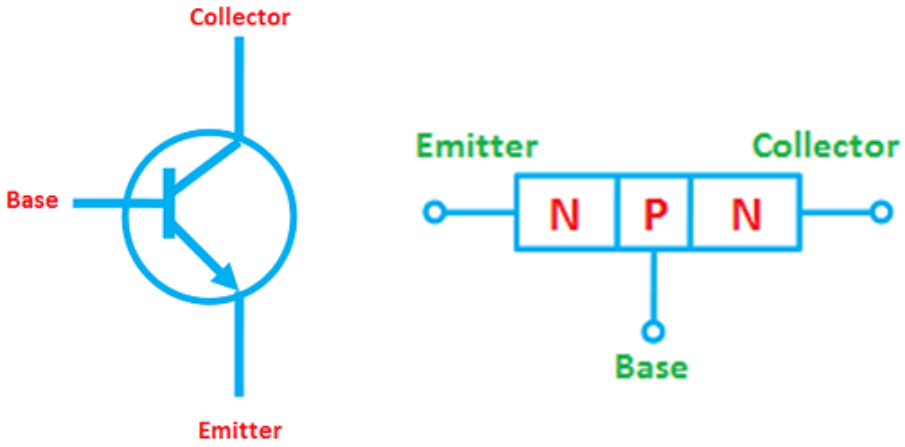


Figure 3: NPN Transistor.

2.4 Difference Between NPN and PNP Transistor

NPN	PNP
1-The current flows from collector terminal to emitter terminal.	1-The current flows from emitter to collector terminal.
2-One P-type semiconductor is sandwiched between the two N-type semiconductors.	2- One N-type semiconductor is sandwiched between the two P-type semiconductors.
3-The current flow from the collector is generated by keeping a +ve voltage there	3-The current flow from the emitter to collector is generated at emitter terminal by keeping a +ve voltage there.
4-The transistor switches ON with the increase in current in the base terminal	4-The transistors switch ON when there is no current flow at the base terminal
5-When the current is reduced in the base, the transistor doesn't function across the collector terminal and switches OFF	5-When a current is present at the base of a PNP transistor, then the transistor switches OFF.

2.5 Common Emitter dc-Analysis

The common emitter amplifier is a three basic single-stage bipolar junction transistor and is used as a voltage amplifier. The input of this amplifier is taken from the base terminal, the output is collected from the collector terminal and the emitter terminal is common for both the terminals. The basic symbol of the common emitter amplifier is shown below.

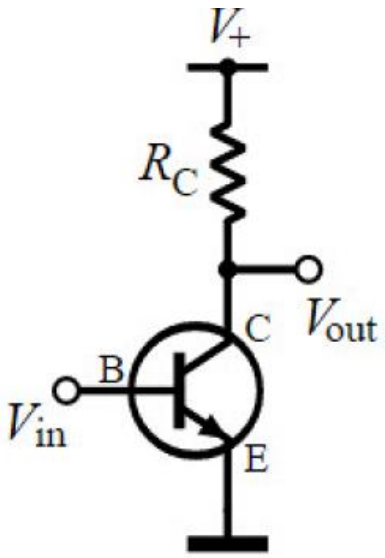


Figure 4: Common Emitter Amplifier.

In electronic circuit design, there are three kinds of transistor configurations are used like common emitter, common base, and common collector, In that, the most frequently used one is common emitter due to its main qualities.

When a signal is applied across the emitter-base junction, the forward bias across this junction increases, this leads to an increase in the flow of electrons from the emitter to a collector through the base, hence increases the collector current. The increasing collector current makes more voltage drops across the collector load resistor. The below circuit diagram shows the working of the common emitter amplifier circuit.

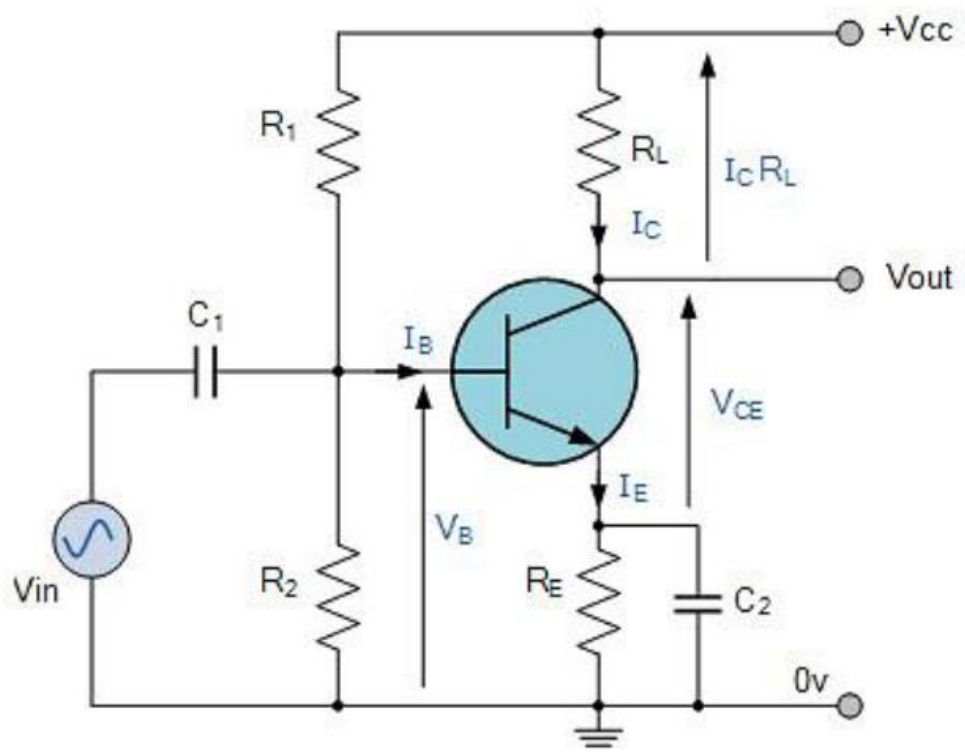


Figure 5: Common Emitter Amplifier Circuit.

Perform the DC analysis and determine the conditions for the desired operating point. The common emitter amplifier circuit elements and their functions are discussed below:

1. Input Capacitor (C1): The capacitor C1 is used to couple the signal to the base terminal of the BJT.
2. Coupling Capacitor (C2): The coupling capacitor C2 couples one stage of amplification to the next stage. This technique used to isolate the DC bias settings of the two coupled circuits.
3. CE Amplifier Circuit Currents

❖ **Base current** iB = IB +ib where,

IB = DC base current when no signal is applied.

ib = AC base when AC signal is applied.

iB = total base current.

❖ **Collector current** iC = IC+ic where,

iC = total collector current.

IC = zero signal collector current.

ic = AC collector current when the AC signal is applied.

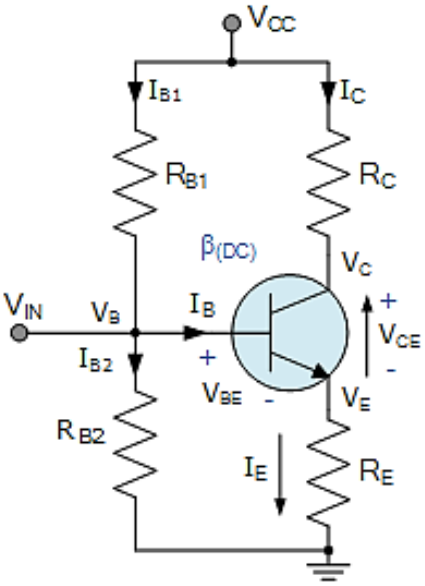
❖ **Emitter Current** iE = IE + ie where,

IE = Zero signal emitter current.

Ie = AC emitter current when AC signal is applied.

iE = total emitter current.

Biasing Circuit/ Voltage Divider: The resistances R1, R2, and RE used to form the voltage biasing and stabilization circuit.



$$V_C = V_{CC} - R_C I_C = (V_E + V_{CE})$$
$$V_E = I_E R_E = V_B - V_{BE}$$
$$V_{CE} = V_C - V_E = V_{CC} - (I_C R_C + I_E R_E)$$
$$V_B = V_{BE} + V_E = V_{RB2} = \left(\frac{R_{B2}}{R_{B1}+R_{B2}}\right) V_{CC}$$
$$I_{B2} = \frac{V_B}{R_{B2}}$$
$$I_{B1} = I_B + I_{B2} = \frac{V_{CC} - V_B}{R_{B1}}$$
$$R_B = \frac{R_{B1} \times R_{B2}}{R_{B1}+R_{B2}} \qquad I_B = \frac{V_B - V_{BE}}{R_B + (1+\beta) R_E}$$
$$I_C = \beta_{(DC)} I_B$$
$$I_E = I_C + I_B = \frac{V_E}{R_E}$$

Figure 6: Voltage Divider Transistor Biasing.

The **applications of a common emitter amplifier** include the following:

- ✓ The common emitter amplifiers are used in the low-frequency voltage amplifiers.
- ✓ These amplifiers are used typically in the Radio Frequency (RF) circuits.
- ✓ In general, the amplifiers are used in the Low noise amplifiers
- ✓ The common emitter circuit is popular because it's well-suited for voltage amplification, especially at low frequencies.
- ✓ Common-emitter amplifiers are also used in radio frequency transceiver circuits.
- ✓ Common emitter configuration commonly used in low-noise amplifiers.

2.6 References

Electronics principles (fourth edition) by Malvino.