Ministry of Higher Education and Scientific Research

Al-Mustaqbal University College

Department of Medical Physics

Analog Electronics

Lecture 3

Transistor, PNP, NPN, common emitter dc-analysis

By

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Transistor

A transistor is a device that regulates current or voltage flow and acts as a switch or gate for electronic signals. Transistors consist of three layers of a semiconductor material, each capable of carrying a current. A transistor consists of three layers of a semiconductor material, each capable of carrying a current. A semiconductor is a material such as germanium and silicon that conducts electricity.

The semiconductor material is given special properties by a chemical process called doping. The doping results in a material that either adds extra electrons to the material (which is then called N-type for the extra negative charge carriers) or creates "holes" in the material's crystal structure (which is then called P-type because it results in more positive charge carriers). The transistor's three-layer structure contains an N-type semiconductor layer sandwiched between P-type layers (a PNP configuration) or a P-type layer between N-type layers (an NPN configuration).

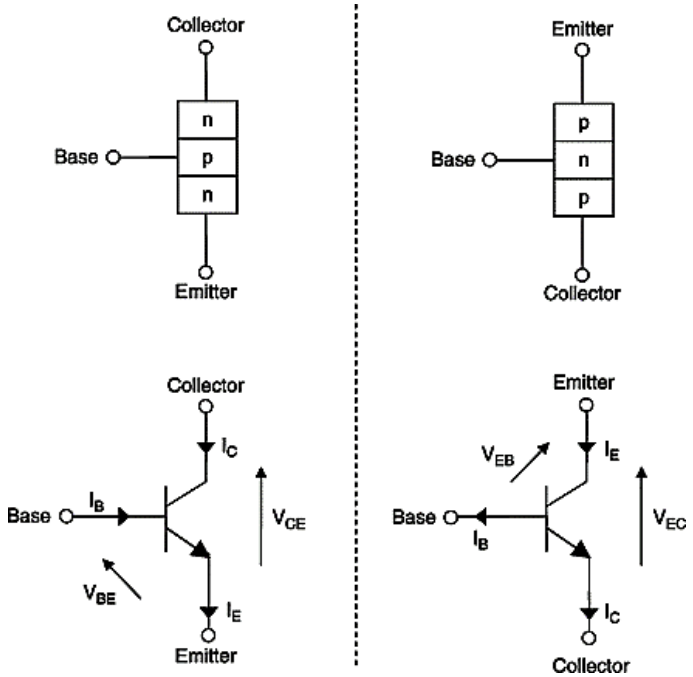


Figure (21) Types of Transistor.

NPN and PNP transistors are bipolar junction transistors, and it is a basic electrical and electronic component which is used to build many electrical and electronic projects. The operation of these transistors involves both electrons and holes. The PNP and NPN transistors allow current amplification. These transistors are used as switches, amplifiers or oscillators. Bipolar junction transistors can be found either as large numbers as parts of integrated circuits or in discrete components. In PNP transistors, majority charge carriers are holes, whereas in NPN transistors, electrons are the majority charge carriers. But, field effect transistors have only one type of charge carrier.

The main difference between the NPN and PNP transistor is, an NPN transistor turns on when the current flows through the base of the transistor. In this type of transistor, the current flows from the collector (C) to the emitter (E). A PNP transistor turns ON, when there is no current at the base of the transistor. In this transistor, the current flows from the emitter (E) to the collector (C).Thus, knowing this, a PNP transistor turns ON by a low signal (ground), where NPN transistor turns ON by a high signal (current).

Construction of Transistor

Transistor is formed by merge the two diodes provided that one terminal is common, the resulting device will comprise of three terminals.This is how a transistor is constructed. We can use either sandwiched P-type layer of the semiconductor between two N-type semiconductors or by sandwiching N-type layer between two P-type semiconductor. The transistor formed in the former case will be NPN transistor and that formed in the latter case is PNP transistor.

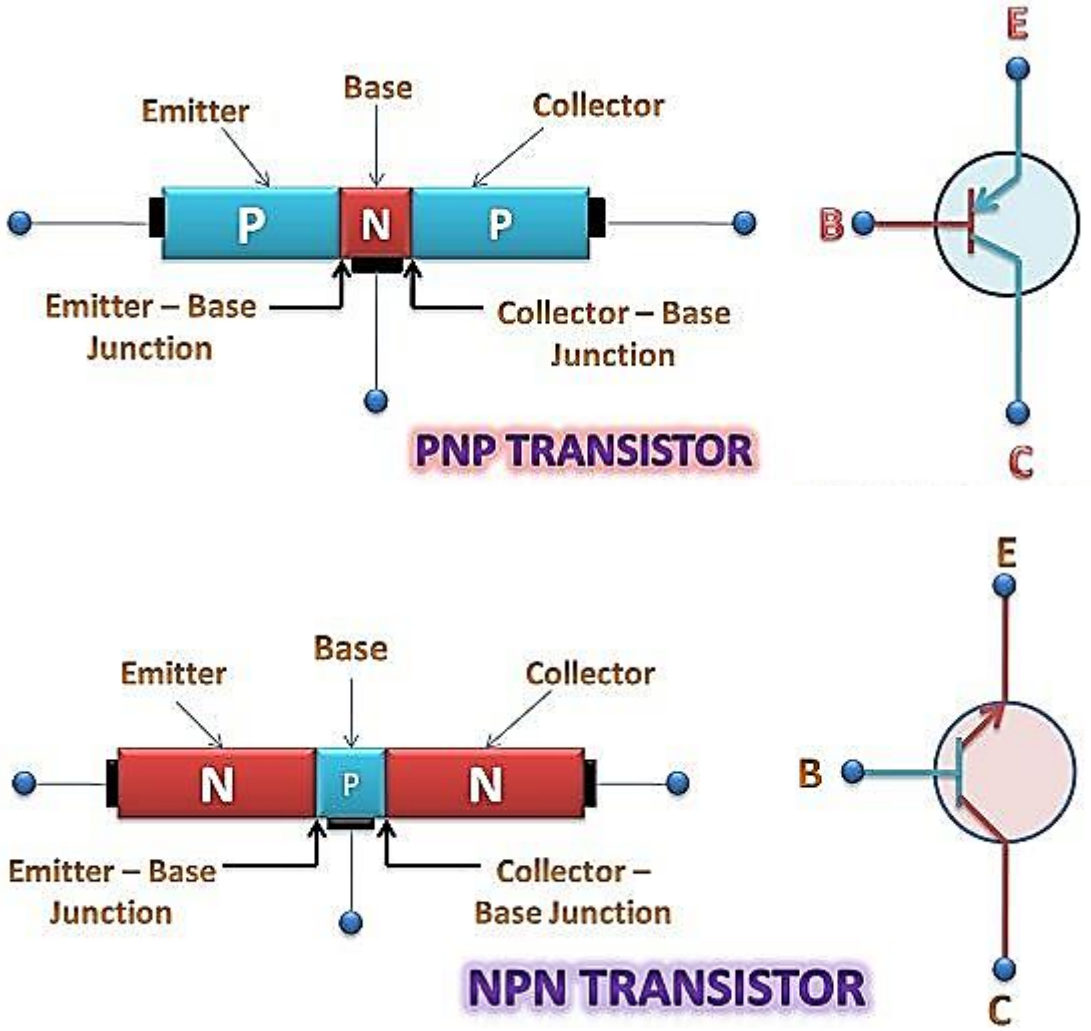


Figure (22) Transistor formation.

The three terminals have specific names that are as follow:

- **Emitter:** is the heavily doped region as compared two base and collector. This is because the work of the emitter is to supply charge carrier to the collector via the base. The size of the emitter is more than base but less than the collector.
- **Base:** The size of the base region is extremely small, it is less than emitter as well as the collector. The size of the base is always kept small so that charge carriers coming from the emitter and entering base will not recombine in the base region and will be directed towards the collector

region. The doping intensity of base is also less than emitter and collector for the same reason mentioned above.

- **Collector:** The collector terminal is moderately doped, and the size of the collector region is slightly more than emitter region because all the charge carriers coming from the emitter recombine at base and heat is released in this process. Thus, it is necessary for the collector terminal to be large enough so that it can dissipate the heat and the device may not burn out.

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. The working of PNP transistor is the exact opposite to the NPN transistor. In this type of transistor, the majority charge carriers are holes. Basically, this transistor works the same as the NPN transistor. The materials which are used to construct the emitter, base and collector terminals in the PNP transistor are different from those used in the NPN transistor. 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.

The p-n-p transistors are formed with n-type present in between the p-types. The majority of the carriers those are responsible for the generation of the current are in this transistor are holes. The working operation is similar to that of n-p-n.

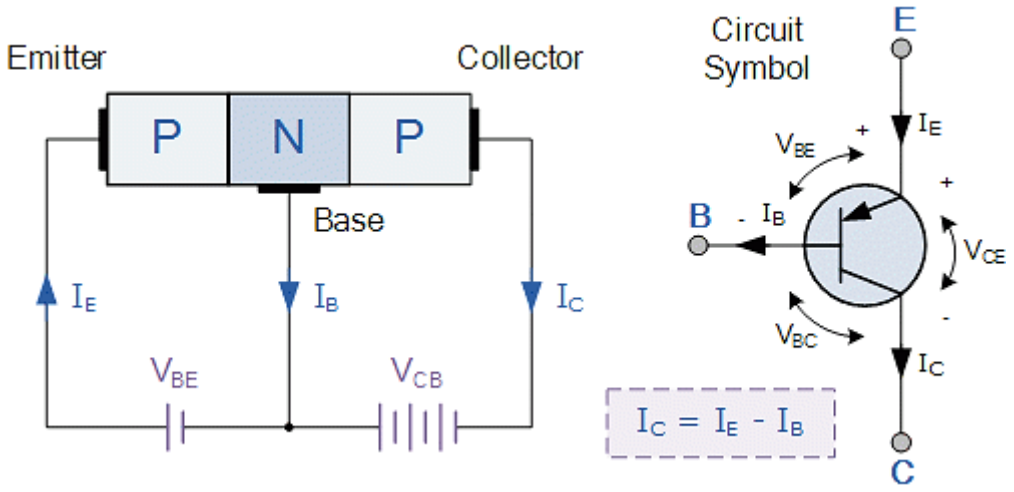


Figure (23) PNP Transistor.

The fundamental difference between a PNP and a PN transistor is the proper biasing of the transistor junctions; the current directions and the voltage polarities are always opposite to each other.

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.

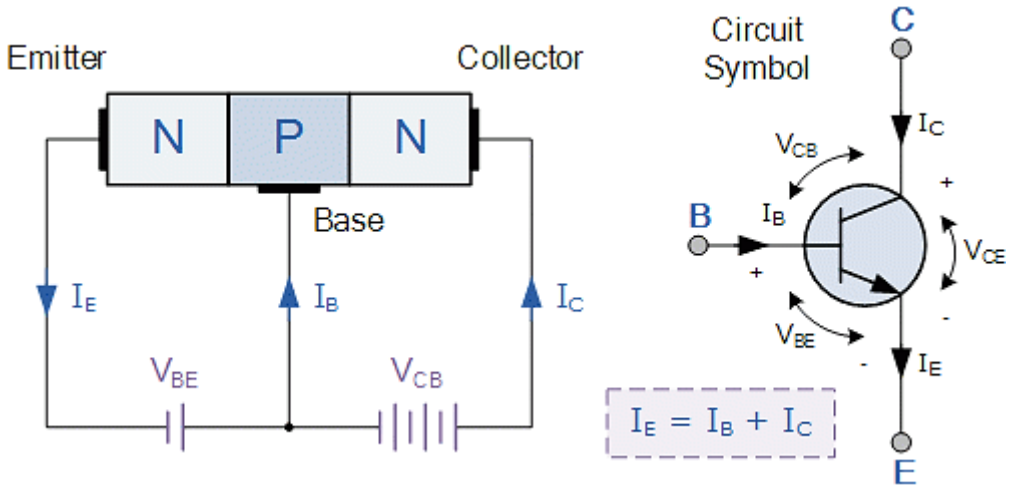


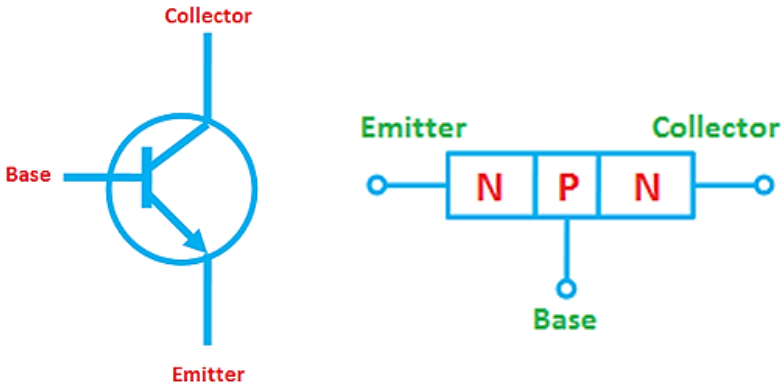
Figure (23) NPN Transistor.

The construction of an NPN transistor is shown below. The voltage at the base terminal is positive and negative at the emitter terminal because of an NPN transistor. The base terminal is always positive with respect to the emitter terminal, and also collector supply voltage is positive with respect to the emitter terminal.

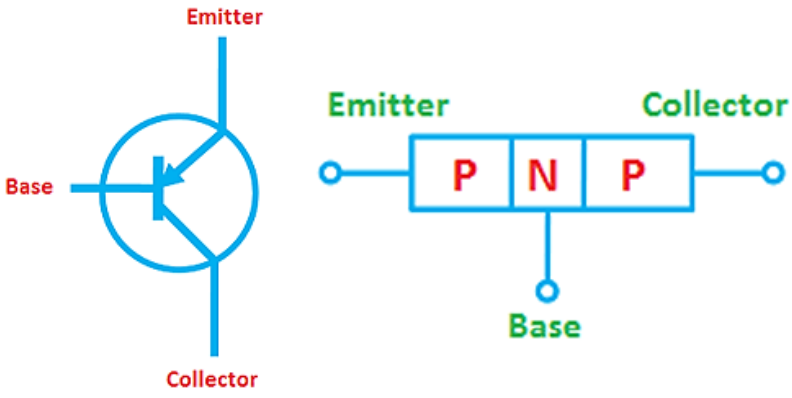
Different between N-P-N and P-N-P Transistor

1. In this the majority of n-types are present.
1. In this the majority of p-type materials are present.
2. The majority of the concentrations of the carriers are electrons.
2. The majority of the concentrations of the carriers in this type of transistors are holes.

3. In this if the terminal base is supplied with the increased amounts of current then the transistor gets switch to ON mode.
3. In this case for the low values of the currents the transistor is ON. Otherwise for high values of currents transistors it is OFF.
4. The symbolic representation of n-p-n transistor is:



4. The symbolic representation of p-n-p transistor is:



5. In the n-p-n transistor the flow of current is evident from the collector to the emitter terminals.
5. In the p-n-p transistor the flow of current can be seen from the terminals of the emitter to the collector.
6. In this transistor the arrow is pointing out.
6. In this transistor the indication of arrow is always pointing in.

Common Emitter Amplifier

The circuit shown on Figure (24) is called the common emitter amplifier circuit. The important subsystems of this circuit are:

- The biasing resistor network made up of resistor R_1 and R_2 and the voltage supply V_{CC}.
- The coupling capacitor C_1.
- The balance of the circuit with the transistor and collector and emitter resistors.

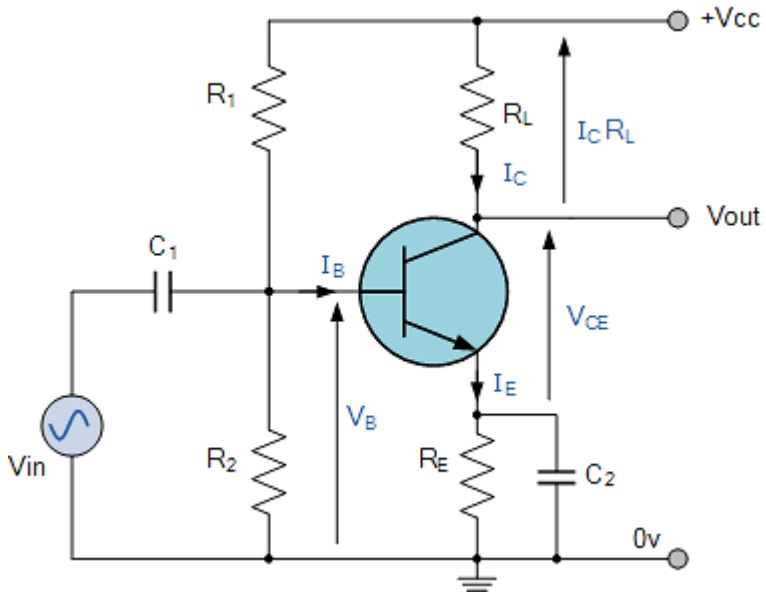


Figure (24) The common emitter amplifier circuit.

The common emitter amplifier circuit is the most often used transistor amplifier configuration. The procedure to follow for the analysis of any amplifier circuit is as follows:

- Perform the DC analysis and determine the conditions for the desired operating point (the Q-point).
- Develop the AC analysis of the circuit. Obtain the voltage gain.