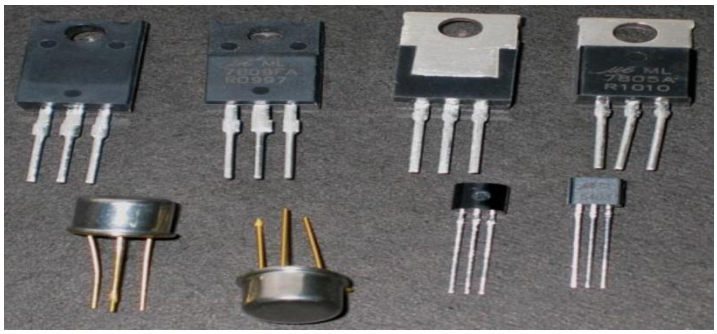
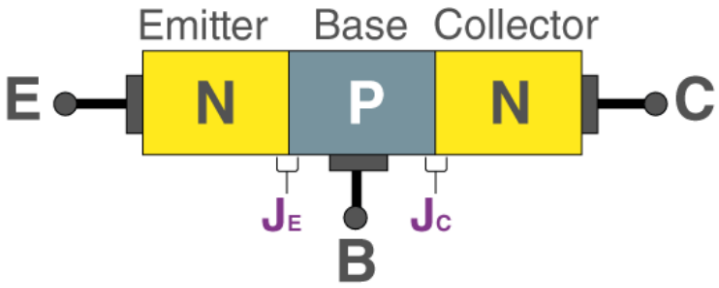
Bipolar Junction Transistor (BJT):

- A bipolar junction transistor is a three-terminal semiconductor device that consists of two p-n junctions which are able to amplify or magnify a signal.
- The three terminals of the BJT are the base, the collector, and the emitter.
- It is a current controlled device.
- A signal of a small amplitude applied to the base is available in the amplified form at the collector of the transistor. This is the amplification provided by the BJT.



Bipolar Junction Transistor Symbol:



Construction of Bipolar Junction Transistor:

BJT is a semiconductor device that is constructed with 3 doped semiconductor Regions i.e. Base, Collector & Emitter separated by 2 p-n Junctions.

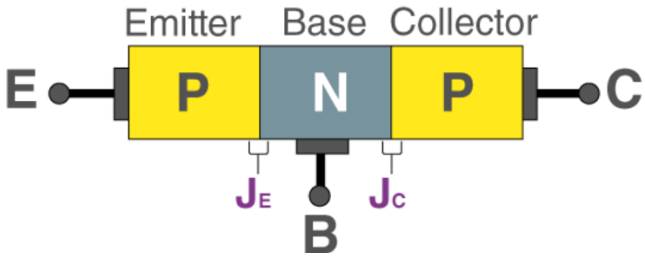
Bipolar transistors are manufactured in two types, **PNP** and **NPN**, and are available as separate components, usually in large quantities.

The prime use or function of this type of transistor is to amplify current. This makes them useful as switches or amplifiers. They have a wide application in electronic devices like mobile phones, televisions, radio transmitters, and industrial control.

PNP BJT:

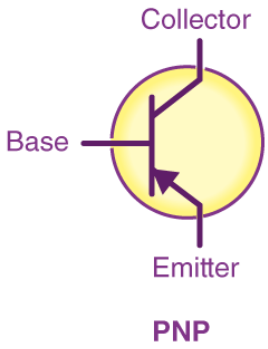
In PNP BJT, the n-type semiconductor is sandwiched between the two p-type semiconductors. The two p-type semiconductors act as emitter and collector respectively while the n-type semiconductor acts as a base.

This is shown in the figure below.



The current enters the transistor through the emitter such that the emitter-base junction is forward biased and the collector-base junction is reverse biased.

In the symbol of an PNP BJT transistor, the direction of the arrow on the emitter is the direction of the current flow,

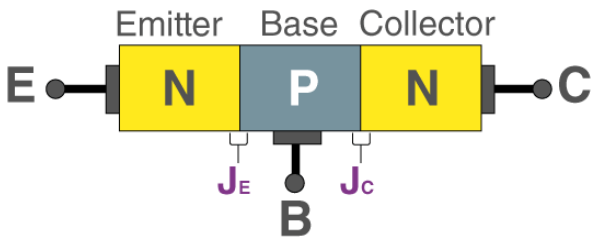


PNP

NPN BJT :

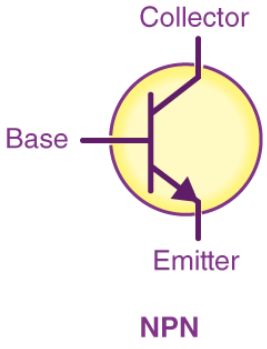
In NPN BJT, p-type semiconductor is sandwiched between the two n-type semiconductors. The two n-type semiconductors act as emitter and collector respectively while the p-type semiconductor acts as a base.

This is shown in the figure below.



Current entering the emitter, base, and collector has the sign convention of positive while the current that leaves the transistor has the sign convention of negative.

In the symbol of an NPN BJT transistor, the direction of the arrow on the emitter is the direction of the current flow,



NPN

Operation of Bipolar Junction Transistor :

There are three operating regions of a bipolar junction transistor:

- **Active region:** The region in which the transistors operate as an amplifier.
- **Saturation region:** The region in which the transistor is fully on and operates as a switch such that collector current is equal to the saturation current.
- **Cut-off region:** The region in which the transistor is fully off and collector current is equal to zero.

Table				
Condition		*Emitter Junction*	*Collector Junction*	*Region of Operation*
I	FR	Forward-biased	Reverse-biased	Active
II	FF	Forward-biased	Forward-biased	Saturation
III	RR	Reverse-biased	Reverse-biased	Cutoff
IV	RF	Reverse-biased	Forward-biased	Inverted

Doping profile of physical dimension of BJT:

- The emitter region is heavily doped, and the base region is lightly doped, and is made physically very thin.
- The doping of the collector region is intermediate between the emitter and the base.
- The collector region is made physically larger than the emitter since it requires to dissipate more amount of heat.
- Although the emitter and the collector regions are of same type but there functions cannot be interchanged, as two regions have different physical and electrical properties.

BJT Working Principle:

The NPN transistor is a biased active region. Here, the base-emitter junction is forward biased and the collector-base junction is reversed biased. So, the width of the depletion region of the base-emitter junction is small, while compared to the width of the collector-base junction. The forward biased Base-Emitter junction will reduce the barrier potential and help the current to flow from the emitter to the base.

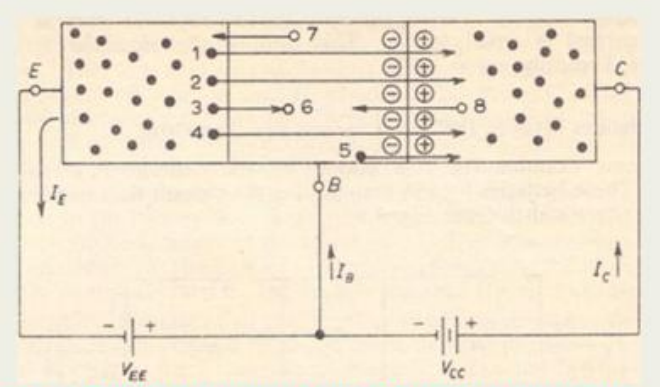


Fig. : An NPN transistor biased for active operation.

Usually, the base of NPN transistors are thin and lightly doped, so it has fewer holes while compared with the electrons in the emitter. The recombination of holes in the base with electrons in the emitter region will constitute the flow of the base current. Usually, the direction of conventional current flow will remain opposite to the flow of electrons. Then the remaining large number of electrons in the emitter will cross the reverse-biased collector junction in the form of collector current.

According to Kirchhoff's Current Law, the emitter current is equal to the sum of collector current and base current. Generally, the base current I_B will remain small when compared to the emitter current I_E and the collector current I_C

$$\mathbf{I_E = I_C + I_B}$$

Note:

- The ratio of electron current I_{nE} to the total emitter current I_E is known as **emitter injection ratio or emitter efficiency**. It is denoted by γ. Typically,

$$\gamma = \frac{InE}{IE}$$

- The ratio of number of electrons arriving at the collector to the number of emitted electros is known as **base transportation factor**. It is denoted by β'. Typically,

$$\beta' = 0.995$$