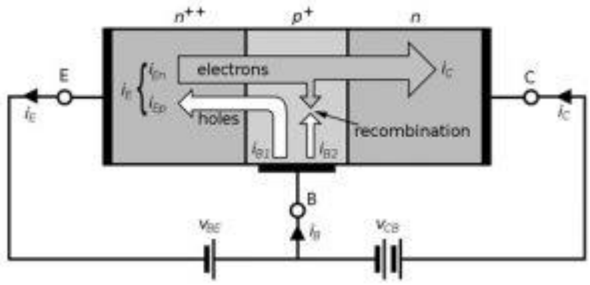
Bipolar Junction Transistor.

The Bipolar junction transistor is a solid-state device and in these transistors, the current flow in two terminals are emitter and collector, and the flow of current controlled by the third terminal is the base terminal.

Construction of Bipolar Junction Transistor

The construction of BJT will determine its working characteristics. So, the construction of BJT can be done through three doped semiconductor sections which are separated through two PN-junctions. This transistor includes three layers namely base, emitter, and collector. These transistors are available in two types namely PNP and NPN and their physical structure is shown below.



Construction of Bipolar Junction Transistor

In NPN, it includes two N-regions separated by one P-region whereas, in PNP, it includes two P-regions and separates with one N-region. In BJT, the term bipolar refers to the utilization of both the charge carriers like electrons and holes within the structure.

When PN-junction connects the base and emitter region then it is known as BE-junction. Similarly, once the pn-junction connects the base & the collector region then it is known as the BC-junction. A wire lead unites to every region and these leads are branded with C, B & E for the collector, base, and emitter respectively.

The base (B) – region is slightly doped & it is extremely thin as compared to the emitter terminal that is heavily doped & the somewhat doped collector region. The schematic symbols of the NPN and PNP BJTs include the following.

Terminals of BJT

The BJT includes three terminals like base, Emitter, and Collector which are discussed in brief. The NPN and PNP transistors symbol representation can be done like the following. The arrow symbol on the emitter terminal is always there and the arrow direction will represent the current flow because of the charge carriers.

Emitter Terminal

The emitter terminal emits the charge carriers like holes or electrons to the other two terminals. The base terminal is always reverse biased with respect to other terminals like emitter so that it can produce huge majority carriers. In BJT, the emitter is the most heavily doped region.

The emitter-base junction must be connected in forwarding bias within both the transistors like PNP & NPN. The emitter terminal provides electrons toward the EB-junction within NPN transistor whereas it supplies charge carriers like holes to the same junction within the PNP transistor.

Collector Terminal

The part on the reverse side of the Emitter terminal will collect the emitted charge carriers called a collector. So, this terminal is heavily doped however the doping level of this terminal is among the base terminal which is a lightly doped & heavily doped emitter terminal. CB-junction must be reversely biased in both the transistors.

The main reason for this biasing is to eliminate charge carriers from the CB-junction. The collector terminal of the NPN transistor is to collects electrons that are emitted through the emitter terminal whereas, in the PNP transistor, it gathers holes that are emitted through the emitter terminal.

Base Terminal

The base terminal is the center part among collector & emitter terminals which forms two PN junctions among them. The base terminal is the most lightly doped segment in the transistor. So, being the central part of the BJT will allow it to manage the charge carriers flow among emitter & collector terminals. The BE junction shows high resistance as this junction can be connected in reversed bias.

Working of BJT

Bipolar junction transistor is classified into two types namely PNP and NPN based on types of doping of the terminals. In NPN transistor, two semiconductor junctions are there which have a thin anode region doped with ‘P’ whereas PNP transistor includes two semiconductor junctions that include a thin cathode region doped with ‘N’.

The flow of charge within a transistor is because of the charge carrier’s diffusion among the two sections which belongs to different concentrations of charge carriers. The emitter section is doped highly as compared to the remaining layers.

Both the layers like base and collector include the same concentrations of charge carriers. So, between these three junctions, the BE junction can be connected in forwarding bias & the BC junction is reverse biased. The operating of BJT can be done in three different regions like active, saturation, and cut-off.

Active Region

In this region, one junction is connected in a forward bias whereas the other one is connected in reverse bias. Here, the base current (Ib) is used to control the quantity of Ic (collector current). So, the active region can be mainly used for the purpose of amplification wherever this transistor performs like an amplifier through a gain ‘β’ with the following equation;

$Ic = \beta \times Ib$

The active region is also called a linear region which lies in between the two regions like the cutoff & the saturation. The typical operation of this transistor happens within this region.

Saturation Region

In this region, the transistors both the junctions are connected in forwarding bias. So this region is mainly used for the ON-state for a switch wherever;

$Ic = Isat$

Here, ‘Isat’ is the saturation current and it is the highest quantity of current flow among the two terminals like emitter as well as collector once this transistor is connected in the saturation region. As these junctions are connected in forwarding bias then the transistor works like a short circuit.

Cutoff Region

In this region, both the transistor junctions are connected in reverse bias. Here this transistor works like the off condition of a switch wherever

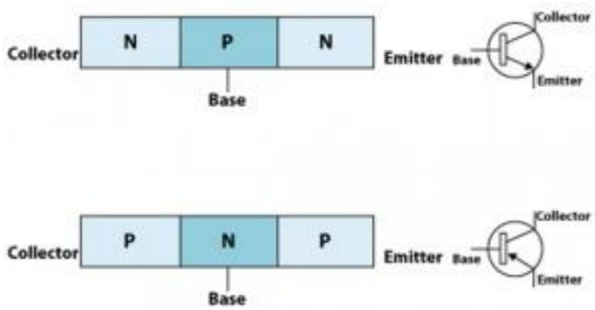
$Ic = 0$

In the cut-off region, the operation is totally reverse as compared to the saturation region. So, there are no exterior supplies connected. If there is no collector current then there is no emitter current.
In this method, the transistor works like an off-state of the switch, and this mode can be achieved by decreasing base voltage to below the voltage of both the emitter as well as collector.
$Vbe < 0.7$

NPN Junction Transistor

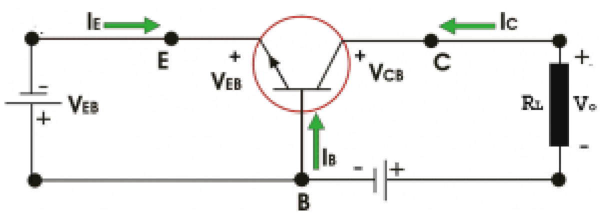
The NPN transistor is exactly opposite to the PNP transistor. The NPN transistor contains three terminals which are the same as the PNP transistor which are emitter, collector, and base. The operation of the NPN transistor is

Generally, the positive supply is given to the collector terminal and the negative supply to the emitter terminal with a resistor either the emitter or collector or emitter circuit. To the base terminal, the voltage is applied and it operated as an ONN/OFF state of a transistor. The transistor is in an OFF state when the base voltage is the same as the emitter. If the base voltage is increased with respect to the emitter then the transistor mode is in an ON state. By using this condition the transistor can act like both applications which are amplifier and switch. The basic symbol and the NPN configuration diagram as shown below.



PNP & NPN Bipolar Junction Transistor

The BE junction is forward bias and the CB is a reverse bias junction. The width of the depletion region of the CB junction is higher than the BE junction. The forward bias at the BE junction decreases the barrier potential and produces electrons to flow from the emitter to the base.



Working Principle of BJT

The base is thin and lightly doped, it has very few holes and less amount of electrons from the emitter about 2% it recombine in the base region with holes, and from the base terminal it will flow out. This initiates the base current flow due to the combination of electrons and holes. The leftover large number of electrons will pass the reverse bias collector junction to initiate the collector current. By using KCL we can observe the mathematical equation

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

The base current is very less as compared to emitter and collector current

$$\mathbf{I_E \sim I_C}$$

Here the operation of the PNP transistor is the same as the NPN transistor the only difference is only holes instead of electrons. The below diagram shows the PNP transistor of the active mode region.